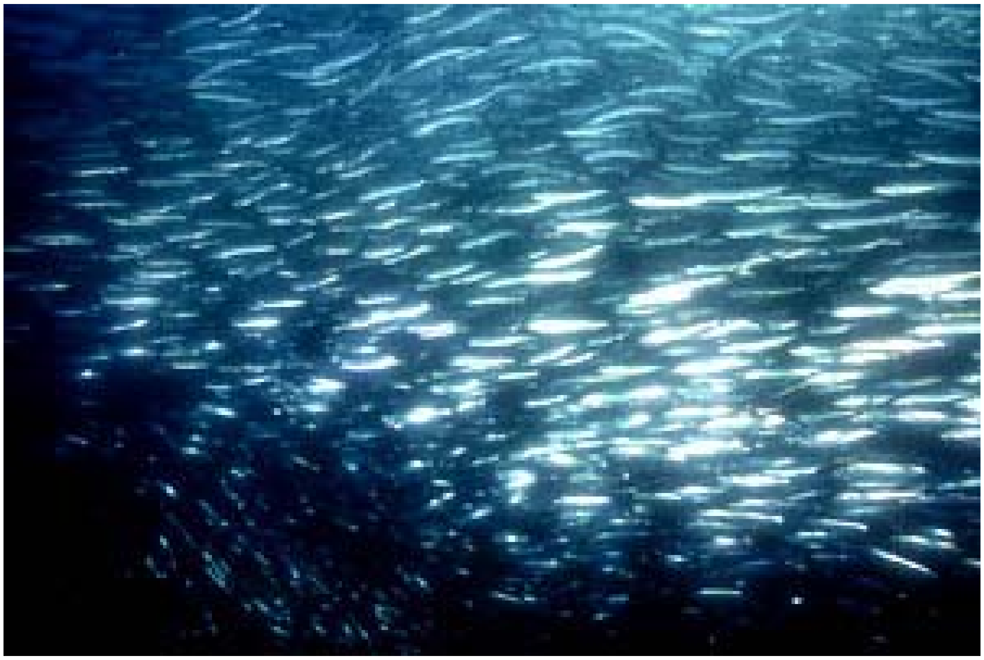
DRAFT

ENVIRONMENTAL IMPACT STATEMENT FOR MINIMIZING IMPACTS OF THE ATLANTIC HERRING FISHERY ON ESSENTIAL FISH HABITAT



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July 1 2004

National Marine Fisheries Service
National Oceanic and Atmospheric Administration
DEPARTMENT OF COMMERCE

Prepared by: NOAA's National Marine Fisheries Service

Draft EIS: July 1 2004

RESPONSIBLE AGENCY:

Assistant Administrator for Fisheries
National Oceanic and Atmospheric Administration
U.S. Department of Commerce
Washington, DC 20235

PROPOSED ACTION:

No action is required to minimize adverse effects of the Atlantic herring fishery on essential fish habitat of any species

ABSTRACT:

This draft envirionmental impact statement (DEIS) evaluates management alternatives to minimize impacts of the Atlantic herring fishery on essential fish habitat (EFH). The alternatives considered include: (1) No Action, which is also the status quo option and the preferred alternative; (2) Modifications to the regulatory definition of midwater trawl gear; (3) Prohibit the use of midwater trawl gear in Habitat Closed Areas; and (4) Prohibit the use of midwater trawls in the Gulf of Maine, the area to coincide with herring management Area 1. The analysis of the alternatives supports the conclusion that gears used in the directed Atlantic herring fishery, primarily purse seine and midwater trawl gear, generate habitat impacts that are minor and no more than temporary in nature. As such, the need to implement management measures to minimize the impacts of the Atlantic herring fishery on essential fish habitat does not exist and the No Action alternative is identified as the preferred alternative.

TYPE OF STATEMENT:

(**X**) DRAFT ( ) FINAL

FOR FURTHER INFORMATION CONTACT:

Peter Colosi
Assistant Regional Administrator for Habitat Conservation
National Marine Fisheries Service, Northeast Region
One Blackburn Drive
Gloucester, MA 01930
978-281-3332

GUIDANCE FOR SUBMITTING COMMENTS:

Comments on the DEIS may be submitted by e-mail to: HerringDEIS@noaa.gov

Comments on the DEIS must be received within 90 days of the publication of the Notice of Availability.

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Introduction

This draft environmental impact statement (DEIS) for the Essential Fish Habitat Components of the Atlantic Herring Fishery Management Plan (FMP) evaluates management alternatives to minimize impacts of the Atlantic herring fishery on essential fish habitat (EFH). It is prepared by the National Marine Fisheries Service (NMFS) and is developed in accordance with the National Environmental Policy Act (NEPA) and the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA, M-S Act), the latter being the primary domestic legislation governing fishery management of the nation's marine fisheries and resources. In 1996, Congress passed the Sustainable Fisheries Act (SFA), which amended and re-authorized the M-S Act and introduced new emphasis on rebuilding overfished fisheries, ending overfishing, minimizing bycatch and bycatch mortality, and minimizing to the extent practicable the adverse impacts of fishing activity on essential fish habitat (EFH).

Purpose of This Document

The purpose of this DEIS is to comply with section 303(a)(7) of the MSFCMA. More specifically, the purpose is to evaluate the potential adverse effects of fishing on Atlantic herring EFH and on the EFH of other species, and to minimize to the extent practicable any adverse effects which are more than minimal and not temporary in nature. This action is being undertaken to ensure the conservation and enhancement of EFH as required under the MSFCMA.

The EFH components of the Atlantic Herring FMP were developed as part of an Omnibus Amendment prepared by the New England Fishery Management Council for all NEFMC managed species (NEFMC 1998a). The EFH Omnibus Amendment was approved for Atlantic herring by the Secretary of Commerce on October 27, 1999. The final rule implementing the Atlantic herring FMP to allow for the development of a sustainable Atlantic herring fishery was published on December 11, 2000 (65 FR 77450).

During the NEFMC's development of the Atlantic Herring FMP, a lawsuit brought by several environmental organizations (American Oceans Campaign (AOC) *et al*. v. Daley et al.) resulted in a ruling by the U.S. District Court for the District of Columbia (Court) on September 13, 2000. In that ruling, the Court enjoined the Federal Defendants from enforcing the EFH amendments that were challenged in the suit (which included amendments to all of the New England Council's fishery management plans) until such time as they performed "a new and thorough EA or EIS" for each of the EFH amendments, in compliance with NEPA. On December 5, 2001, the Plaintiffs and the Federal Defendants proposed to the Court a Joint Stipulation and Order (Stipulation), which was accepted by the Court on December 17, 2001. In that Stipulation, the Federal Defendants, acting through the National Marine Fisheries Service (NMFS) were ordered to:

1) Prepare EISs for all fisheries challenged in the lawsuit.
2) Comply with the requirements of all applicable statues, including NEPA; the Council on Environmental Quality (CEQ) NEPA implementing regulations, 40 C.F.R. Parts 1500-1508; and the National Oceanic and Atmospheric Administration (NOAA) Administrative Order 216-6.

3) Include analyses of environmental impacts of fishing on EFH, including direct and indirect effects, as defined in the EFH regulations at 50 C.F.R. 600.810, and analyses of the environmental impacts of alternatives for implementing the requirement of the M-S Act, that the FMP "minimize, to the extent practicable, adverse effects on [EFH] caused by fishing."
4) Consider a range of reasonable alternatives for minimizing the adverse effects (as defined by the EFH regulations to be "any reduction in the quality or quantity of EFH") of fishing on EFH, including potential adverse effects. This range of alternatives will include "no action" or status quo alternatives and alternatives set forth specifying fishery management actions that can be taken by NMFS under the M-S Act. The alternatives may include a suite of fishery management measures, and the same fishery management measures may appear in more than one alternative.
5) Identify one preferred alternative, except that, in the draft EIS, NMFS may elect, if it deems appropriate, to designate a subset of the alternatives considered in the draft EIS, as the preferred range of alternatives, instead of designating only one preferred alternative.
6) Present the environmental impacts of the alternatives in comparative form, thus sharply defining the issues and providing a clear basis for choice among the options, as set forth in CEQ regulation 40 C.F.R. 1502.14.

The Stipulation established requirements regarding process and time deadlines, including a requirement to provide at least a 90 day public comment period for the draft environmental impact statement (DEIS). The Stipulation also required that NMFS approve an amendment, if required, to the Atlantic Herring FMP and implementing measures by no later than September 10, 2005. NMFS is preparing this separate DEIS to fulfill terms of the Stipulation. Therefore, this DEIS evaluates the potential adverse effects of fishing on Atlantic herring EFH, including the effects of Atlantic herring fishing on the EFH of other species, and evaluates management measures to minimize to the extent practicable any adverse effect by the Atlantic herring fishery on EFH that is more than minimal and not temporary in nature.

Overview of the EFH Elements of the DEIS

Based in part on the issues identified during scoping, this DEIS includes an evaluation of the potential effects of the directed Atlantic herring commercial fishery on EFH for Atlantic herring and other federally-managed species in the Northeast region of the U.S. and evaluates alternatives to minimize to the extent practicable the adverse effects on EFH from herring fishing. It also includes an evaluation of the effects of non-fishing activities and of non-MSA-regulated fisheries on Atlantic herring EFH. The analysis considers the no-action alternative, along with a range of other reasonable alternatives. Information from the 1998 EA (included in the Atlantic herring FMP) is reflected in this analysis. However, additional information and the selection of alternatives come from a review of the best scientific information available, including new information made available since the fishery management plan was originally completed.

Herring Fishery Impacts on EFH

Larval, juvenile, and adult herring are pelagic. Herring eggs are demersal and are deposited on bottom habitats with a substrate of gravel, sand, cobble, shell fragments, and aquatic macrophytes (see table on next page). Adult herring travel in schools and migrate to discrete spawning grounds prior to spawning. Mature adult herring do not feed and remain near the bottom until they spawn.

The two primary gear types used in the Atlantic herring fishery are mid-water trawls and purse seines. Mid-water trawls are towed either by a single boat or by two boats that operate in “pairs” (thus the term “pair trawls”). These are the only gears used to directly harvest herring in federal waters of the Northeast region. Bottom trawls only accounted for about 2% of total landings in recent years. Herring catches in bottom trawls are incidental in other fisheries such as the whiting, northern shrimp, and mackerel fisheries. Some of the herring taken as bycatch in these fisheries is landed and sold, primarily as lobster bait. A very small amount of herring is harvested with “fixed gear” (stop seines and weirs) in state waters on the eastern Maine coast.

Herring are extremely sensitive to noise and schools are known to disperse when approached by vessels or when disturbed by mid-water nets or purse seines. This disturbance could be interpreted as a potential impact on the pelagic spawning habitat of juvenile or adult herring. The effect, however, is known to be temporary: schools of herring that are dispersed by vessels or mid-water trawls re-form quickly after passage of the boat or the net, within a matter of minutes. This may adversely affect the pelagic habitat for juvenile and adult herring, but the effects are minimal and temporary in nature and do not need to be minimized.

The other potential impact of mid-water trawls and purse seines on Atlantic herring EFH is on the habitat for herring eggs. In order for herring egg EFH to be more than minimally impacted by these gears, the gears would have to 1) contact bottom habitats that are used by herring for spawning, and 2) disturb the bottom in a way that reduces its functional value as an egg habitat. According to information obtained from fishermen, bottom contact occasionally occurs on smooth sand or mud bottom when herring are very close to the bottom and can not be caught unless the net is towed just above the bottom. This happens primarily during the winter fishery in southern New England, may occur in certain locations on Georges Bank, but not in the Gulf of Maine because the gear is not designed to withstand contact with rocky substrates. When contact occurs, it is by chains attached to the footrope and by two heavy weights attached to the wings of the net. The trawl doors do not contact the bottom.

Because any bottom contact by mid-water trawls used in the Northeast U.S. Atlantic herring fishery is expected to be limited to mud and sand substrates, and because herring do not deposit eggs on mud, the only habitats utilized as herring egg EFH that are likely to be vulnerable to impacts from mid-water trawls or purse seines are in sandy bottom areas. However, herring fishing gears only contact the bottom occasionally and many sand bottom habitats where herring spawn (e.g., on Georges Bank) are located in fairly shallow depths that are subject to scouring action by strong bottom currents. Therefore, if there are any adverse impacts of mid-water trawls in sandy bottom habitats, they are not more than minimal or temporary in nature and therefore do not need to be minimized.

Atlantic herring EFH - vulnerability to effects of bottom-tending fishing gears.

Life Stage	Geographic Area of EFH	Depth (m)	Seasonal Occurrence	EFH Description	EFH Vulnerability				
					OT	**SD**	**CD**	**PT**	**NL**
Eggs	GOME, GB and following estuaries: Englishman/Machias Bay, Casco Bay, and Cape Cod Bay	20 - 80	July through November	Bottom habitats with a substrate of gravel, sand, cobble, shell fragments, and aquatic macrophytes, tidal currents 1.5 - 3 knots	L	L	0	L	L
Larvae	GOME, GB, Southern NE and following estuaries: Passamaquoddy Bay to Cape Cod Bay, Narragansett Bay, and Hudson R./ Raritan Bay	50 - 90	Between August and April, peaks from September to November	Pelagic waters	NA	NA	NA	NA	NA
Juveniles	GOME, GB, Southern NE and Middle Atlantic south to Cape Hatteras and following estuaries: Passamaquoddy Bay to Cape Cod Bay; Buzzards Bay to Long Island Sound; Gardiners Bay to Delaware Bay	15 - 135		Pelagic waters and bottom habitats	NA	NA	NA	NA	NA
Adults	GOME, GB, southern NE and middle Atlantic south to Cape Hatteras and following estuaries: Passamaquoddy Bay to Great Bay; Mass. Bay to Cape Cod Bay; Buzzards Bay to Long Island Sound; Gardiners Bay to Delaware Bay; and Chesapeake Bay	20 - 130		Pelagic waters and bottom habitats	NA	NA	NA	NA	NA
Spawning Adults	GOME, GB, southern NE and middle Atlantic south to Delaware Bay and Englishman/Machias Bay Estuary	20 - 80	July through November	Bottom habitats with a substrate of gravel, sand, cobble, and shell fragments, also on aquatic macrophytes	L	L	0	L	L

Rationale: Atlantic herring (*Clupea harengus*) is a coastal pelagic species ranging from Labrador to Cape Hatteras in the western Atlantic (Reid *et al*. 1999; Munroe 2002). For most pelagic life stages (larvae, juveniles, adults) EFH vulnerability to bottom-tending fishing gear s is not applicable. Atlantic herring eggs are laid in high-energy, benthic habitats on rocky, pebbly, gravelly or shell substrates or macrophytes (Reid *et al*. 1999; Munroe 2002). These habitats are less susceptible to fishing gear impacts since they have evolved under a high-energy disturbance regime (strong bottom currents). Vulnerability of herring egg EFH to scallop dredges and otter trawls is considered low. Although these gears may directly affect the eggs, only the effect of the gear on the functional value of the habitat was considered for this evaluation. EFH vulnerability from clam dredges was considered to be none since this gear does not operate in areas of herring egg EFH. Spawning adults are closely associated with the bottom. Effects on the functional value of habitat from mobile gears are unknown and were rated as low since spawning occurs on the bottom. EFH vulnerability from clam dredges was rated as none for the reasons described above. Spawning could be disrupted by noise associated with these gears, but this issue was not addressed as a habitat related issue.

Definitions: GOME - Gulf of Maine; GB - Georges Bank; NE - New England; HAPC - Habitat Area of Particular Concern; YOY - Young-of-Year; OT - Otter Trawls; SD - New Bedford Scallop Dredge; CD - Hydraulic Clam Dredge; PT- Pots and Traps; NL - Gill Nets and Longlines. NA - not applicable; 0 - No vulnerability; L - Low vulnerability; M - Moderate vulnerability; H - High vulnerability; EFH - essential fish habitat.

Bottom contact by mid-water trawls may occasionally occur in certain gravel or sand substrate spawning locations on Georges Bank that are free of rocks. However, any kind of infrequent disturbance of bottom sediments that provide a substrate for herring eggs would not reduce the functional value of the habitat as EFH for the eggs. The only exception to this would be benthic macrophytes or emergent epifauna – attached algae, bryozoans, etc. – that herring eggs also stick to and which are easily damaged or removed from the bottom by bottom-tending fishing gear. This type of egg substrate is not very common, however. There is no evidence to indicate that herring are less likely to deposit their eggs on bottom habitats composed of gravel, sand, cobble, and shell fragments that have been disturbed by fishing gear than on un-disturbed substrate, or that eggs deposited on disturbed substrates would have a reduced survival rate.

Purse seines are used almost exclusively in the Gulf of Maine in coastal and offshore waters. Because they are so deep (up to 50 meters), they sometimes contact the bottom when they are first set out, before they are "pursed." Before the net is pursed, the bottom lead lines can be pushed across the bottom for short distances by tidal currents, causing disturbance to benthic organisms and substrates. If there are impacts to benthic habitats, they would be more pronounced in complex, rocky bottom areas which are more vulnerable to disturbance. Although purse seines may occasionally contact gravel and coarse sand benthic habitats that serve as substrate for herring eggs in the Gulf of Maine, the potential adverse impacts of this gear are also minimal and temporary in nature because there is no evidence to suggest that disturbance of bottom substrates reduced the quality of herring egg EFH. Noise produced by herring fishing vessels and gear may adversely affect pelagic EFH for juvenile and adult herring, but these effects are also minimal and temporary.

Additional information supporting the conclusion that mid-water trawls and purse seines do not contact the bottom to any significant degree is provided by bycatch data available from observers place aboard commercial herring fishing vessels. For this analysis, bycatch data were sorted into three categories: pelagic species that occupy the water column, "semi-demersal" species that live near the bottom, but do not normally rest on the bottom), and demersal species that are in direct contact with the bottom <u>most</u> of the time. Data were obtained from 110 mid-water (single boat and pair trawlers) and 31 purse seine trips, representing catches of 41 million lbs (18,660 metric tons) and 5 million lbs (2,317 mt) of Atlantic herring, respectively. The results indicate that 1.8% of the mid-water trawl catch and 1.5% of the purse seine catch was composed to species other than herring. Almost all of the bycatch taken by purse seines was composed of pelagic species (spiny dogfish). Bycatch in mid-water trawls was almost equally divided between pelagic and semi-demersal species: demersal species accounted for .0003% (140 lbs out of 41 million pounds of herring). Most of the semi-demersal catch was composed of silver hake, a species that leaves the bottom at night in pursuit of prey. The primary non-target pelagic species caught in herring mid-water trawls were Atlantic mackerel, spiny dogfish, alewives, and blueback herring. These results support the conclusion that any contact of the bottom by herring mid-water trawls or purse seines is negligible.

<u>Conclusion</u>:
There are indications that mid-water trawls and purse seines do occasionally contact the seafloor and may impact benthic habitats utilized by a number of federally-managed species, including EFH for Atlantic herring eggs. However, after reviewing all the available information, the NMFS concludes that <u>if</u> the quality of EFH is reduced as a result of this contact, the impacts are

minimal and/or temporary and, pursuant to MSA, do not need to be minimized. The following information supports this conclusion.

- Bottom contact by mid-water trawls is limited to occasional contact by “tickler” chains that hang down in short loops from the footrope, or the footrope itself, the belly of the net, or the two weights that are attached to the wire trawl warps that extend from the bottom of the net to the doors – the doors and the codend do not touch bottom.

- The lead lines of purse seines may occasionally contact the bottom when the net is first set, but not once the net is “pursed.”

- Mid-water trawls are not designed to fish in contact with the bottom and are easily damaged if they hit an obstacle (rocks) or if the nylon netting in the belly drags over any kind of bottom substrate. Repairs are costly.

- Bottom contact, when it occurs, is much more likely to occur on flat sand or mud bottom, not on structurally complex and more sensitive hard bottom. Bottom contact is most likely to occur in southern New England during the winter, and to a lesser extent on sandy bottom areas on Georges Bank.

- Bycatch of fully demersal fish species in 110 trips made by mid-water trawlers and 31 trips made by purse seiners was insignificant, accounting for .0003% of the mid-water trawl catch and .0001% of the purse seine catch.

- Use of bottom trawls and dredges in southern New England and on the northern edge of Georges Bank is much more intensive. Overall, throughout the entire NE region, herring mid-water trawls only accounted for 1.1% of all days absent from port by mobile gear vessels during 1997-2002.

Impacts of the Herring Fishery on EFH for Other Species

It is possible that occasional bottom contact by mid-water herring trawls could potentially affect EFH for benthic life stages of species in the Northeast region, especially those that occupy sand and mud habitats that may be disturbed from time to time by mid-water trawls. Purse seines could have similar effects in a variety of benthic habitat types. Most of the species and life stages with benthic EFH that has been determined to be vulnerable to adverse effects of mobile, bottom-tending gears inhabit sand or mud bottom. EFH for these species and life stages could possibly be vulnerable to any bottom disturbance caused by mid-water trawls or purse seines as well. Because any bottom contact by herring mid-water trawls is limited primarily to sand and mud bottoms, no adverse impacts are expected on rocky or gravel substrates. If the quality of benthic EFH for other species in the NE region is reduced as a result of bottom contact by herring fishing gear, the effects are no more than minimal or temporary in nature.

Impacts of Other MSA Fisheries on Atlantic Herring EFH

The following bottom-tending fishing gears could potentially affect herring egg EFH: bottom otter trawls that catch fish and northern shrimp, scallop dredges, lobster pots, fish and hagfish pots, bottom gill nets, and bottom longlines. However, EFH for Atlantic herring eggs and spawning adults in the Northeast region has been ranked low in terms of its vulnerability to the effects of bottom otter trawls, scallop dredges, pots and traps, and bottom gill nets and longlines (see table). Essential fish habitats with a low vulnerability rank are not considered to be adversely impacted to a degree that is more than minimal or temporary in nature.

Disturbance of bottom sediments that serve as substrates for herring eggs by any kind of bottom-tending gear is not likely to cause a reduction in the functional value of the habitat. There is no evidence to indicate that herring are less likely to deposit their eggs on bottom habitats composed of gravel, sand, cobble, and shell fragments that have been disturbed by any kind of mobile, bottom-tending fishing gear than on un-disturbed substrate, or that eggs deposited on disturbed substrates would have a reduced survival rate.

In conclusion, bottom-tending mobile gears used in other MSA fisheries may have adverse effects on benthic EFH for herring eggs or pelagic EFH for juvenile and adult herring, but they are not more than minimal or temporary in nature.

Overall Gear Effects Determination

The fishing gear effects evaluation has lead to a determination that gear used in the directed Atlantic herring fishery (mid-water trawls and purse seines) has a potential adverse effect on EFH that is no more than minimal and temporary in nature. Therefore, the MSA does not require implementation of management measures to minimize impacts on EFH. In addition, the evaluation concluded that fishing gear used in other northeast fisheries (otter trawls and dredges) has a potential adverse effect on Atlantic herring EFH that is no more than minimal and temporary in nature. Therefore, the MSA does not require implementation of management measures to minimize impacts on herring EFH.

Description of Management Alternatives

Although the fishing gear effects evaluation concludes that there are no adverse effects on EFH that are more than minimal and not temporary (requiring no management measures pursuant to the MSA), this DEIS went an additional step and analyzed a range of alternatives that might provide benefits to EFH to fulfill the requirements of the Court Order and Joint Stipulation.

Alternative 1 - No Action Alternative (Preferred Alternative)

Under this alternative, no action would be taken that would affect existing Atlantic herring fishing activities. This alternative includes the existing regulatory definition of mid-water trawls (see Alternative 2).

Rationale: The fishing gears utilized in the directed Atlantic herring fishery are pelagic mid-water trawls and purse seines that only occasionally contact the seafloor. Because neither of these gears is designed to fish in contact with the bottom and because the impacts of the gears are minimal and temporary, there are no adverse effects to benthic EFH that need to be minimized.

Alternative 2 - Modifications to the Regulatory Definition of Midwater Trawls

There are three distinct options to modify the regulatory definition of midwater trawl gear for the herring fishery. These are "stand alone" alternatives that could be implemented independently of either Alternative 3 or 4. A modified mid-water trawl definition would apply at all times throughout the range of the U.S. Atlantic herring fishery. The existing definition, which would remain in place if none of the modifications were implemented, is as follows:

Midwater trawl gear means trawl gear that is designed to fish for, is capable of fishing for, or is being used to fish for pelagic species, no portion of which is designed to be or is operated in contact with the bottom at any time.

Rationale: The intent of changing the regulatory definition of midwater trawl gear would be to improve the enforceability of the regulation, thus making it more effective at eliminating any bottom contact by the gear.

Option 2A. Modification to Midwater Trawl Gear Definition

Under this option, the regulatory definition of midwater trawl gear would be modified to reflect a 1999 recommendation of the NEFMC's Enforcement Committee as follows:

Midwater trawl gear means trawl gear that is designed to fish for, is capable of fishing for, or is being used to fish for pelagic species, no portion of which is designed to be or is operated in contact with the bottom at any time. The gear may not include discs, bobbins, or rollers on its footrope or chafing gear as part of the net.

Option 2B. Modification to Midwater Trawl Gear Definition

Under this alternative, the regulatory definition of midwater trawl gear would be modified to reflect the definition used in the West Coast Groundfish Management Plan (Pacific Management Council). The regulatory definition would be revised as follows:

Midwater trawl gear means trawl gear that is designed to fish for, is capable of fishing for, or is being used to fish for pelagic species, no portion of which is designed to be or is operated in contact with the bottom at any time. Midwater trawl nets must have unprotected footropes at the trawl mouth, and must not have rollers, bobbins, tires, wheels, rubber discs, or any similar device anywhere in the net. The footrope of midwater trawl gear may not be enlarged by encircling it with chain or by any other means. Ropes or lines running parallel to the footrope of midwater trawl gear must be bare and may not be suspended with chains or any other materials. Sweepings, including the bottom leg of the bridle, must be bare. For at least 20 ft. (6.15 m) immediately behind the footrope or headrope, bare rope or mesh of 16-inch may encircle the net under transfer cables, lifting of splitting straps (chokers), but must be: over riblines and restraining straps; the same mesh size and coincide knot-to-knot with the net to which it is attached; and no wider than 16 meshes.

Option 2C. Modification to Midwater Trawl Gear Definition

Under this alternative, the regultory definition of midwater trawl gear would be modified as follows:

Midwater trawl gear means trawl gear that is designed to fish for, is capable of fishing for, or is being used to fish for pelagic species, no portion of which is designed to be or is operated in contact with the bottom at any time. The gear may not include bobbins, rollers, rockhoppers on its footrope or as part of the net.

Alternative 3 - Prohibit the Use of Midwater Trawls in Habitat Closed Areas

Recent amendments to the NEFMC Sea Scallop and Multispecies Fishery Management Plans created seven habitat closed areas on Georges Bank and in the Gulf of Maine that are closed to all mobile, bottom-tending fishing gears. These areas overlap considerably with areas that were closed in 1994, 1998, and 2001 to any gear capable of catching groundfish. Because they are pelagic gears that do not catch significant amounts of groundfish (<5%), mid-water trawls and purse seines are currently allowed to fish in the groundfish closed areas and in the habitat closed areas. Under this alternative, the list of prohibited gears in the habitat closed areas (HCAs) would be extended to include herring midwater trawls.

Rationale: Prohibition of mid-water trawling in the HCAs would extend the protection for benthic habitats to include any potential impacts caused by mid-water trawls, to the extent that any exist.

Alternative 4 - Prohibit the Use of Midwater Trawls in the Gulf of Maine

Under this alternative, midwater trawls would be prohibited from use in Herring Management Area 1 (1A and 1B) in the Gulf of Maine on a year-round basis. Herring vessels would still be allowed to transit Area 1 as long as their nets were properly stowed according to the regulations.

Rationale: Prohibition of mid-water trawling in Area 1would protect benthic habitats against any potential impacts caused by mid-water trawls, to the extent that any exist.

Summary of Impacts of the Alternatives

Alternative 1: No-Action Alternative (Preferred Alternative)

Impacts on Atlantic Herring
No net positive or negative impacts are expected to the Atlantic herring resource. Existing environmental conditions support healthy Atlantic herring stock production.

Impacts on Protected Species
No net positive or negative impacts are expected to protected species. The status quo condition would continue.

Impacts on Essential Fish Habitat

No net positive or negative impacts are expected to EFH, as the status quo condition would continue. The gear impacts evaluation found there to be no adverse impact that is more than minimal or temporary in nature of gear used in the directed herring fishery (purse seines and mid-water trawls) on EFH in for Atlantic herring or for other species in federal waters.

Impacts on Human Environment
No net positive or negative impacts are expected to the Atlantic herring fishery or human communities under the No Action Alternative.

Alternative 2: Modifications to the Regulatory Definition of Mid-water Trawls

Impacts on Atlantic Herring
No net positive or negative impacts are expected to Atlantic Herring if the definition of mid-water trawl gear is modified. The amount of herring removed by fishing will not be impacted, and no stock-level impacts are anticipated.

Impacts on Protected Species
No net positive or negative impact is expected to Protected Species if the definition of mid-water trawl gear is modified. As mid-water trawl gear and purse seine gear does, in fact, occasionally contact the bottom and if the gear definition is modified such that enforcement of zero bottom contact is maintained, there would be no impact to endangered species and marine mammals. There is no indication that any marine mammals or endangered species are more vulnerable to fishing by mid-water trawls that are fishing near the bottom than mid-water trawls that are fishing higher in the water column.

Impacts on Essential Fish Habitat
While the overall impact to herring EFH or EFH for other species would be positive if no bottom contact occurred as a result of herring fishing by mid-water trawl vessels, it has been determined that the impacts of herring mid-water trawling do not need to be minimized, based upon the gear effects evaluation. Moreover, EFH for herring larvae, juvenile and adults is pelagic, and would experience no impacts, positive or negative, if the definition of mid-water trawl gear were modified. Species that inhabit sand and mud substrates in the HCA's may benefit if bottom contact by mid-water trawls is reduced, but the benefits are not likely to be measurable.

Impacts on Human Environment
The gear could be fished differently as a result of a change in the regulatory definition of the gear, but this would have little to no effect on the total amount of herring landed or the ability of the fishermen to harvest the quota. There may be a localized effect in southern New England and the mid-Atlantic where herring are more likely to occur near the bottom in the winter. If a modified mid-water trawl definition is effective at reducing or eliminating bottom contact, the efficiency of the winter fishery could be negatively affected, requiring more fishing effort and higher costs to catch the same amount of fish.

Alternative 3: Prohibit the Use of Mid-water Trawls in Habitat Closed Areas

Impacts on Atlantic Herring
No net positive or net negative impacts are expected on Atlantic Herring if mid-water trawling is prohibited in the HCAs. While mid-water trawls would be prohibited from fishing in habitat

closed areas, these vessels would be free to pursue herring elsewhere, thereby displacing the 12% of the fishing effort that occurs in HCAs to other areas. The result would be neither a negative nor a positive impact to the herring resource.

Impacts on Protected Species
A minor positive impact is expected to marine mammals and endangered species that inhabit HCAs, as they would be released from any stress or disturbance created by mid-water trawl fishing pressure. However, the net effect to protected species would be neutral, as the fishing effort previously focused on HPAs would be redirected to areas outside the HCAs.

Impacts on Essential Fish Habitat
Prohibiting any use of mid-water trawls in habitat closed areas would ensure that no disturbance of benthic habitats would occur from mid-water trawls, as well as from mobile, bottom-tending gears that are currently prohibited from the HCAs. Approximately 10 % of the area designated as herring egg EFH is inside the HCAs. However, occasional bottom contact by mid-water trawls is not considered to reduce the functional value of herring egg EFH by any measurable amount. Mid-water trawling does not affect pelagic EFH for Atlantic herring larvae and effects to EFH for juveniles and adults are minimal and temporary. By prohibiting mid-water trawling in HCAs, there will be no net positive or negative effects relative to the No Action alternative (Alternative 1).

Prohibiting mid-water trawling in HCAs could result in small improvements in the quality of benthic EFH for species and life stages of fish and shellfish that utilize sand and mud substrates in these areas. In contrast, the prohibition of mid-water trawling in the HCAs would probably lead to an increased use of fixed gear such as lobster pots which could have cumulative negative impacts on EFH for benthic species. Overall, the EFH impacts of this alternative are neutral.

Impacts on Human Environment
No net positive or negative impacts are expected to human communities or the Atlantic herring fishery. Herring mid-water trawlers are highly mobile and, if prohibited from the HCAs, would redirect fishing to areas outside the HCAs.

Alternative 4: Prohibit the Use of Mid-water Trawl Gear in the Gulf of Maine

Impacts on Atlantic Herring
A positive impact is expected to Atlantic herring if mid-water trawl gear is prohibited in Area 1, since purse seiners are not expected to harvest the amount of fish historically taken by mid-water trawlers.

Impacts on Protected Species
A positive impact would be experienced by marine mammals and endangered species if mid-water trawls were prohibited from fishing in Area 1. As herring is an important prey species for some marine mammals, the competition for the resource would be reduced, as would the threat of capture or disturbance by mid-water trawl gear, which is known to take marine mammals. Protected species that are vulnerable to capture in herring mid-water trawls in Area 1 during the time of year when the fishery is operating there are harbor seals, harbor porpoises, minke whales, pilot whales, and leatherback turtles.

Impacts on Essential Fish Habitat

Prohibiting mid-water trawling from the Gulf of Maine would remove the threat of occasional disturbance to herring egg EFH from this gear. However, any minor positive result of prohibiting mid-water trawl gear would be limited to the habitat closed areas, where mobile, bottom-tending gears are prohibited. Mid-water trawling does not affect pelagic EFH for Atlantic herring larvae and effects on EFH for juveniles and adults are minimal and temporary. Prohibiting mid-water trawling in Area 1 could result in small improvements in the quality of benthic EFH for species and life stages of fish and shellfish that inhabit the WGOM, JB, and CL HCAs, especially those that utilize sand and mud substrates, but not in the rest of Area 1 that is adversely affected by bottom trawls and dredges.

Impacts on Human Environment

This alternative would have a significant negative economic impact on fishing communities in Area 1 and on the Atlantic herring fishery. In 2003, 64% of the herring catch came from Area 1 and mid-water trawl gear harvested 70% of that amount. In order to access the fishery in Area 1 during the spring and summer (when a large percentage of the herring resource inhabits Area 1), mid-water trawl fishermen would need to either refit their vessels to fish with purse seines or travel to Areas 2 or 3. Some of the negative impacts would be offset by the added opportunities for purse seiners to fish in Area 1. Indirect effects to fishing communities in along the western Gulf of Maine coast could include shortages or price changes in lobster bait, socioeconomic impacts on fishing communities, and changes in the supply to certain processing plants.

Cumulative Impacts Analysis

The direct and indirect impacts of each alternative on four primary valued environmental components were evaluated in combination with the impacts of past and present actions, reasonably-foreseeable future actions, and non-fishing activities. The results are summarized in the following table. The results support the conclusion that none of the alternatives would have any cumulative impact on Atlantic herring EFH and a low negative impact on EFH for other species in the Northeast region.

Comparison of Cumulative Impacts of Alternatives

	Herring	Protected Species	EFH	Human Environment
Alternative 1	Neutral	Mammals: Neutral Leatherback: Low Negative	Herring EFH: Neutral Other Species EFH: Low Negative	Neutral
Alternative 2	Neutral	Mammals: Neutral Leatherback: Low Negative	Herring EFH: Neutral Other Species EFH: Low Negative	Neutral
Alternative 3	Neutral	Mammals: Neutral Leatherback: Low Negative	Herring EFH: Neutral Other Species EFH: Low Negative	Low – Moderately Negative
Alternative 4	Low Positive	Low Positive	Herring EFH: Neutral Other Species EFH: Low Negative	Moderately - High Negative

Selection of Preferred Alternative and Practicability Analysis

The analyses in this document show that none of the proposed management measures have any measurable benefit to EFH. There are no socio-economic costs associated with Alternative 2, neutral to low negative costs associated with Alternative 3, and high negative costs associated with Alternative 4. While Alternative 1 and Alternative 2 appear to be practicable to implement based solely upon the cost/benefit analysis, Alternative 2 is not necessary because there are no adverse effects to EFH from herring fishing gear that need to be minimized as part of an Atlantic herring FMP. Alternative 3 is not practicable because it would not benefit EFH and has some associated economic costs. Alternative 4 is not practicable because it would not benefit EFH and would have high socioeconomic costs. In addition, Alternatives 1 and 2 would have no effects on protected species, while Alternatives 3 and 4 would have only low positive effects.

The no action alternative has been selected as the preferred alternative for two reasons. First, this analysis has determined that the Atlantic herring fishery on EFH for Atlantic herring has little or no adverse effect on herring EFH and none of the alternatives would provide any measurable benefit to EFH for Atlantic herring or any other federally-managed species in the Northeast region. Second, the continuation of status quo conditions within the range of the Atlantic herring fishery already benefit EFH for Atlantic herring and other species that might be affected by gears used in the herring fishery.

Summary of costs and benefits associated with each alternative and valued ecosystem component and the practicability of each alternative.

	Cost/benefit of Alternative on VEC				Practicability [1]	Necessary to Implement per MSA
	Herring	EFH	Protected Species	Human Environment		
Alt 1	Neutral	Neutral	Neutral	Neutral	Practicable	Implementation not required
Alt 2	Neutral	Neutral	Neutral	Neutral	Practicable	No – impacts do not need to be minimized
Alt 3	Neutral	Neutral	Neutral	Low Negative	Not Practicable	No – impacts do not need to be minimized
Alt 4	Low Positive	Neutral	Low Positive	High Negative	Not Practicable	No – impacts do not need to be minimized

[1] Practicability evaluation does not include impacts to protected species

1.0 INTRODUCTION

This draft environmental impact statement (DEIS) for the Essential Fish Habitat Components of the Atlantic Herring Fishery Management Plan (FMP) evaluates management alternatives to minimize impacts of the Atlantic herring fishery on essential fish habitat (EFH). It is prepared by the National Marine Fisheries Service (NMFS) and is developed in accordance with the National Environmental Policy Act (NEPA) and the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA, M-S Act), the latter being the primary domestic legislation governing fishery management of the nation's marine fisheries and resources. In 1996, Congress passed the Sustainable Fisheries Act (SFA), which amended and re-authorized the M-S Act and introduced new emphasis on rebuilding overfished fisheries, ending overfishing, minimizing bycatch and bycatch mortality, and minimizing to the extent practicable the adverse impacts of fishing activity on essential fish habitat (EFH).

2.0 PURPOSE AND NEED FOR ACTION

The purpose of this DEIS is to comply with section 303(a)(7) of the MSFCMA. More specifically, the purpose is to evaluate the potential adverse effects of fishing on Atlantic herring EFH and on the EFH of other species, and to minimize to the extent practicable any adverse effects which are more than minimal and not temporary in nature. This action is being undertaken to ensure the conservation and enhancement of EFH as required under the MSFCMA.

The EFH components of the Atlantic Herring FMP were developed as part of an Omnibus Amendment prepared by the New England Fishery Management Council for all NEFMC managed species (NEFMC 1998a). The EFH Omnibus Amendment was approved for Atlantic herring by the Secretary of Commerce on October 27, 1999. The final rule implementing the Atlantic herring FMP to allow for the development of a sustainable Atlantic herring fishery was published on December 11, 2000 (65 FR 77450).

During the NEFMC's development of the Atlantic Herring FMP, a lawsuit brought by several environmental organizations (American Oceans Campaign (AOC) *et al*. v. Daley et al.) resulted in a ruling by the U.S. District Court for the District of Columbia (Court) on September 13, 2000. In that ruling, the Court enjoined the Federal Defendants from enforcing the EFH amendments that were challenged in the suit (which included amendments to all of the New England Council's fishery management plans) until such time as they performed "a new and thorough EA or EIS" for each of the EFH amendments, in compliance with NEPA. On December 5, 2001, the Plaintiffs and the Federal Defendants proposed to the Court a Joint Stipulation and Order (Stipulation), which was accepted by the Court on December 17, 2001. In that Stipulation, the Federal Defendants, acting through the National Marine Fisheries Service (NMFS) were ordered to:

7) Prepare EISs for all fisheries challenged in the lawsuit.
8) Comply with the requirements of all applicable statues, including NEPA; the Council on Environmental Quality (CEQ) NEPA implementing regulations, 40 C.F.R. Parts 1500-1508; and the National Oceanic and Atmospheric Administration (NOAA) Administrative Order 216-6.

9) Include analyses of environmental impacts of fishing on EFH, including direct and indirect effects, as defined in the EFH regulations at 50 C.F.R. 600.810, and analyses of the environmental impacts of alternatives for implementing the requirement of the M-S Act, that the FMP "minimize, to the extent practicable, adverse effects on [EFH] caused by fishing."
10) Consider a range of reasonable alternatives for minimizing the adverse effects (as defined by the EFH regulations to be "any reduction in the quality or quantity of EFH") of fishing on EFH, including potential adverse effects. This range of alternatives will include "no action" or status quo alternatives and alternatives set forth specifying fishery management actions that can be taken by NMFS under the M-S Act. The alternatives may include a suite of fishery management measures, and the same fishery management measures may appear in more than one alternative.
11) Identify one preferred alternative, except that, in the draft EIS, NMFS may elect, if it deems appropriate, to designate a subset of the alternatives considered in the draft EIS, as the preferred range of alternatives, instead of designating only one preferred alternative.
12) Present the environmental impacts of the alternatives in comparative form, thus sharply defining the issues and providing a clear basis for choice among the options, as set forth in CEQ regulation 40 C.F.R. 1502.14.

The Stipulation established requirements regarding process and time deadlines, including a requirement to provide at least a 90 day public comment period for the draft environmental impact statement (DEIS). The Stipulation also required that NMFS approve an amendment, if required, to the Atlantic Herring FMP and implementing measures by no later than September 10, 2005. NMFS is preparing this separate DEIS to fulfill terms of the Stipulation. Therefore, this DEIS evaluates the potential adverse effects of fishing on Atlantic herring EFH, including the effects of Atlantic herring fishing on the EFH of other species, and evaluates management measures to minimize to the extent practicable any adverse effect by the Atlantic herring fishery on EFH that is more than minimal and not temporary in nature.

2.1 Notice of Intent and Scoping Process

In response to the stipulation, and in cooperation with the NEFMC, the NMFS issued, on September 10, 2001, a Notice of Intent (66 FR 46979) to prepare SEISs in accordance with NEPA for the EFH components for Atlantic herring, Monkfish, and Atlantic salmon. NMFS notified the public that it would accept written comments to determine the range of management alternatives to be addressed in the SEISs to describe and identify EFH, minimize to the extent practicable the adverse effects of fishing on EFH, and identify other actions to encourage the conservation and enhancement of EFH, through November 9, 2001. A subsequent notice (66 FR 48996) was issued to extend the public comment period through November 21, 2001 and to schedule a public hearing on November 7, 2001 in Gloucester, MA. NMFS informed the public that the SEISs would consider EFH and Habitat Areas of Particular Concern (HAPC), as well as fishing and non-fishing threats to EFH; the need to revise EFH designations for Atlantic herring, monkfish and Atlantic salmon based upon any available new scientific information; potential HAPC designations; and a range of alternatives to minimize adverse effects of fishing activities on EFH. The public was also informed that the analysis and subsequent management alternatives could be presented as one NEPA document for all three species, as two or more separate NEPA documents, or as part of a combined NEPA document that also addresses other fisheries management issues for one or more of these species. At the conclusion of the 72 day public scoping process no public comments were received and there was no attendance at the public scoping meeting. NMFS has decided to produce a separate DEIS to fulfill the terms of the Stipulation which would evaluate the potential adverse effects of fishing on Atlantic herring EFH, including the effects of Atlantic herring fishing on the EFH of other species, and evaluate management measures to minimize to the extent practicable any adverse effect by the Atlantic herring fishery on EFH that is more than minimal and not temporary in nature. These issues were also recently evaluated as part of Amendment 13 to the Northeast Multispecies FMP as well as Amendment 10 to the Atlantic Sea Scallop FMP.

NEPA provides a mechanism for identifying and evaluating the full spectrum of environmental issues associated with Federal actions, and for considering a reasonable range of alternatives to avoid or minimize adverse environmental impacts. NMFS will consider any new information and alternatives discussed in the DEIS to determine whether changes to the EFH provisions of the Atlantic herring fishery management plan previously approved by NMFS is warranted.

2.2 Overview of the EFH Elements of the DEIS

Based in part on the issues identified during scoping, this DEIS includes an evaluation of the potential effects of the directed Atlantic herring commercial fishery on EFH for Atlantic herring and other federally-managed species in the Northeast region of the U.S. and evaluates alternatives to minimize to the extent practicable the adverse effects on EFH from herring fishing. It also includes an evaluation of the effects of non-fishing activities and of non-MSA-regulated fisheries on Atlantic herring EFH. The analysis considers the no-action alternative, along with a range of other reasonable alternatives. Information from the 1998 EA (included in the Atlantic herring FMP) is reflected in this analysis. However, additional information and the selection of alternatives come from a review of the best scientific information available, including new information made available since the fishery management plan was originally completed.

2.3 The Future – Habitat Omnibus Amendment Components

In the spring of 2003, the Council initiated a Habitat Omnibus Amendment that will be considered Amendment 2 to the Atlantic herring FMP. It will also amend the Northeast Multispecies (Amendment 14) the Sea Scallop (Amendment 11), Monkfish (Amendment 3), Skate (Amendment 1), Red Crab (Amendment 1) and Atlantic Salmon (Amendment 1) FMPs. This omnibus amendment will fulfill the 5 year EFH review and revision requirement specified in 50 CFR Section 600.815(a)(10) and will contain the following components:

- **Description and identification of EFH**
  Review of EFH designation methodology and consideration of options to revise existing EFH designations where supported by new, scientifically sound, information.

- **Non-Magnuson-Stevens Act fishing activities that may adversely affect EFH**
  Update current section on identifying any fishing activities that are not managed under the MSA that may adversely effect EFH.

- **Non-fishing related activities that may adversely affect EFH**

Update current section on identifying activities other than fishing that may adversely affect EFH. For each activity, the FMP should describe known and potential adverse effects to EFH.

- **Conservation and enhancement**

Update current section on identifying actions to encourage the conservation and enhancement of EFH, including recommended options to avoid, minimize, or compensate for the adverse effects, especially in HAPCs.

- **Prey Species**

Review and update the current list the major prey species for the species in the fishery management unit and discuss the location of prey species' habitat. Consider adverse effects on prey species and their habitats that may result from actions that reduce their availability, either through direct harm or capture, or through adverse effects to prey species' habitats.

- **Research and Information Needs**

Review and update the current recommendations, in priority order, for research effects necessary to improve upon the description and identification of EFH, the identification of threats to EFH from fishing and other activities ad the development of conservation and enhancement measures for EFH.

- **Identification of habitat areas of particular concern (HAPCs)**

This will be done through the HAPC process approved by the Council and included in a formal RFP. The RFP will be initiated in NOI for the Omnibus Amendment 2 and terminated 6 months later.

- **Consideration and identification of Dedicated Habitat Research Areas**

May consider using the same type of process as the HAPC process and work closely with the Research Steering Committee on this effort.

3.0 DESCRIPTION OF MANAGEMENT ALTERNATIVES

3.1 Alternative 1 - No Action Alternative (Preferred Alternative)

Under this alternative, no action would be taken that would affect existing Atlantic herring fishing activities. This alternative includes the existing regulatory definition of mid-water trawls (see Alternative 2).

Rationale: The fishing gears utilized in the directed Atlantic herring fishery are pelagic mid-water trawls and purse seines which only occasionally contact the seafloor. Because neither of these gears is designed to fish in contact with the bottom and because the impacts of the gears are minimal and temporary, there are no adverse effects to benthic EFH that need to be minimized.

3.2 Alternative 2 - Modifications to the Regulatory Definition of Midwater Trawls

There are three distinct options to modify the regulatory definition of midwater trawl gear for the herring fishery. These are “stand alone” alternatives that could be implemented independently of either Alternative 3 or 4. A modified mid-water trawl definition would apply at all times throughout the range of the U.S. Atlantic herring fishery. The existing definition, which would remain in place if none of the modifications were implemented, is as follows:

Midwater trawl gear means trawl gear that is designed to fish for, is capable of fishing for, or is being used to fish for pelagic species, no portion of which is designed to be or is operated in contact with the bottom at any time.

Rationale: The intent of changing the regulatory definition of midwater trawl gear would be to improve the enforceability of the regulation, thus making it more effective at eliminating any bottom contact by the gear.

Option 2A. Modification to Midwater Trawl Gear Definition

Under this option, the regulatory definition of midwater trawl gear would be modified to reflect a 1999 recommendation of the NEFMC’s Enforcement Committee as follows:

Midwater trawl gear means trawl gear that is designed to fish for, is capable of fishing for, or is being used to fish for pelagic species, no portion of which is designed to be or is operated in contact with the bottom at any time. The gear may not include discs, bobbins, or rollers on its footrope or chafing gear as part of the net.

Option 2B. Modification to Midwater Trawl Gear Definition

Under this alternative, the regulatory definition of midwater trawl gear would be modified to reflect the definition used in the West Coast Groundfish Management Plan (Pacific Management Council). The regulatory definition would be revised as follows:

Midwater trawl gear means trawl gear that is designed to fish for, is capable of fishing for, or is being used to fish for pelagic species, no portion of which is designed to be or is operated in contact with the bottom at any time. Midwater trawl nets must have unprotected footropes at the trawl mouth, and must not have rollers, bobbins, tires, wheels, rubber discs, or any similar device anywhere in the net. The footrope of midwater trawl gear may not be enlarged by encircling it with chain or by any other means. Ropes or lines running parallel to the footrope of midwater trawl gear must be bare and may not be suspended with chains or any other materials. Sweepings, including the bottom leg of the bridle, must be bare. For at least 20 ft. (6.15 m) immediately behind the footrope or headrope, bare rope or mesh of 16-inch may encircle the net under transfer cables, lifting of splitting straps (chokers), but must be: over riblines and restraining straps; the same mesh size and coincide knot-to-knot with the net to which it is attached; and no wider than 16 meshes.

Option 2C. Modification to Midwater Trawl Gear Definition

Under this alternative, the regultory definition of midwater trawl gear would be modified as follows:

Midwater trawl gear means trawl gear that is designed to fish for, is capable of fishing for, or is being used to fish for pelagic species, no portion of which is designed to be or is operated in contact with the bottom at any time. The gear may not include bobbins, rollers, rockhoppers on its footrope or as part of the net.

3.3 Alternative 3 - Prohibit the Use of Midwater Trawls in Habitat Closed Areas

Recent amendments to the NEFMC Sea Scallop and Multispecies Fishery Management Plans (NEFMC 2003a, b, and c) created seven habitat closed areas on Georges Bank and in the Gulf of Maine that are closed to all mobile, bottom-tending fishing gears (Figure 3.1). These areas overlap considerably with areas that were closed in 1994, 1998, and 2001 to any gear capable of catching groundfish. Because they are pelagic gears that do not catch significant amounts of groundfish (<5%), mid-water trawls and purse seines are currently allowed to fish in the groundfish closed areas and in the habitat closed areas. Under this alternative, the list of prohibited gears in the habitat closed areas (HCAs) would be extended to include herring midwater trawls.

Rationale: Prohibition of mid-water trawling in the HCAs would extend the protection for benthic habitats to include any potential impacts caused by mid-water trawls, to the extent that any exist.

3.4 Alternative 4 - Prohibit the Use of Midwater Trawls in the Gulf of Maine

Under this alternative, midwater trawls would be prohibited from use in Herring Management Area 1 (1A and 1B) in the Gulf of Maine on a year-round basis (Figure 3.2). Herring vessels would still be allowed to transit Area 1 as long as their nets were properly stowed according to the regulations.

Rationale: Prohibition of mid-water trawling in Area 1would protect benthic habitats against any potential impacts caused by mid-water trawls, to the extent that any exist.

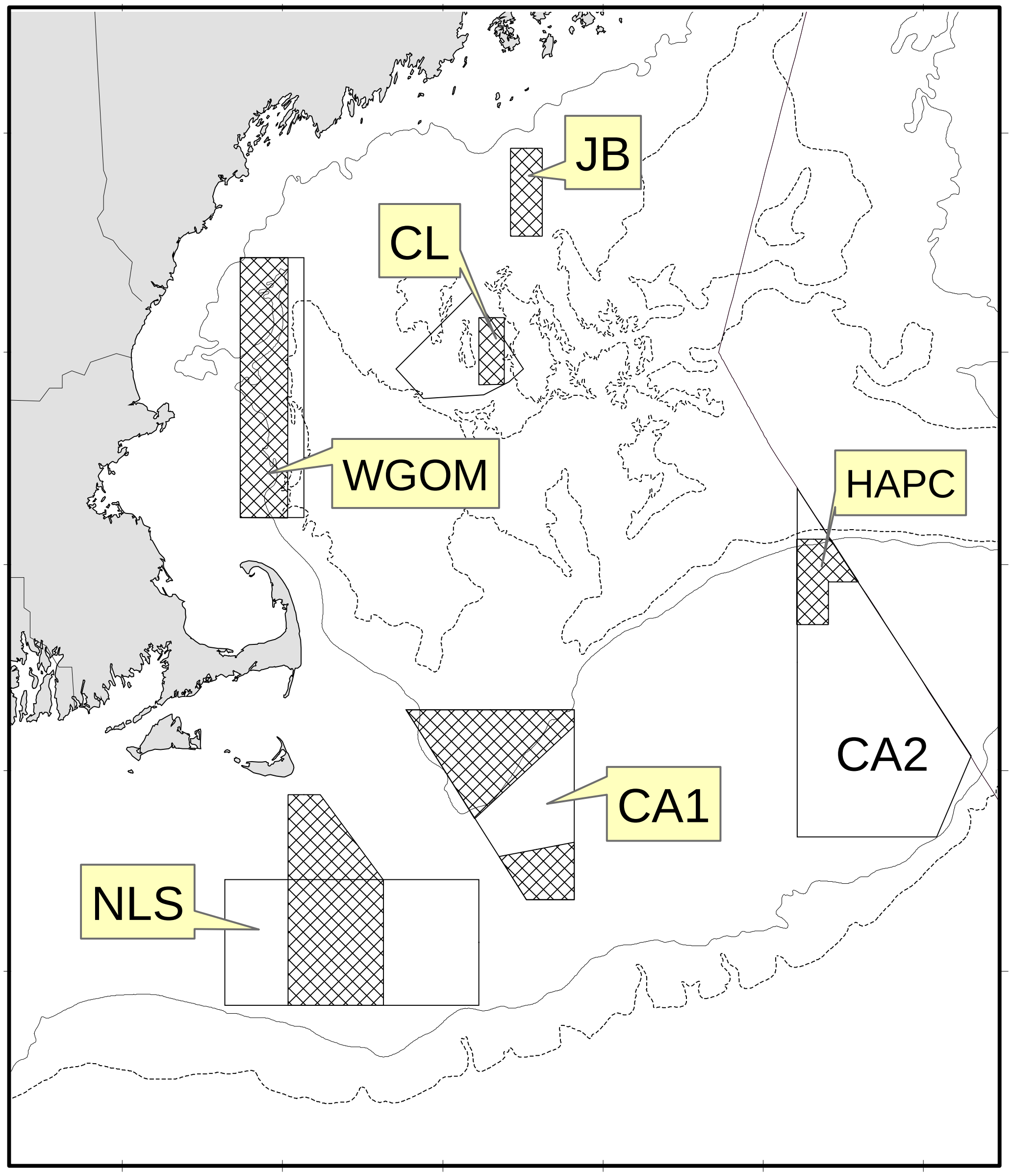


Figure 3.1. Map of Georges Bank and the Gulf of Maine showing location of habitat closed areas (hatched) and groundfish closed areas (open). NLS = Nantucket Lightship, CA1 = Closed Area 1, CA2 = Closed Area 2, CL = Cashes Ledge, JB = Jeffreys Bank, and WGOM = Western Gulf of Maine.

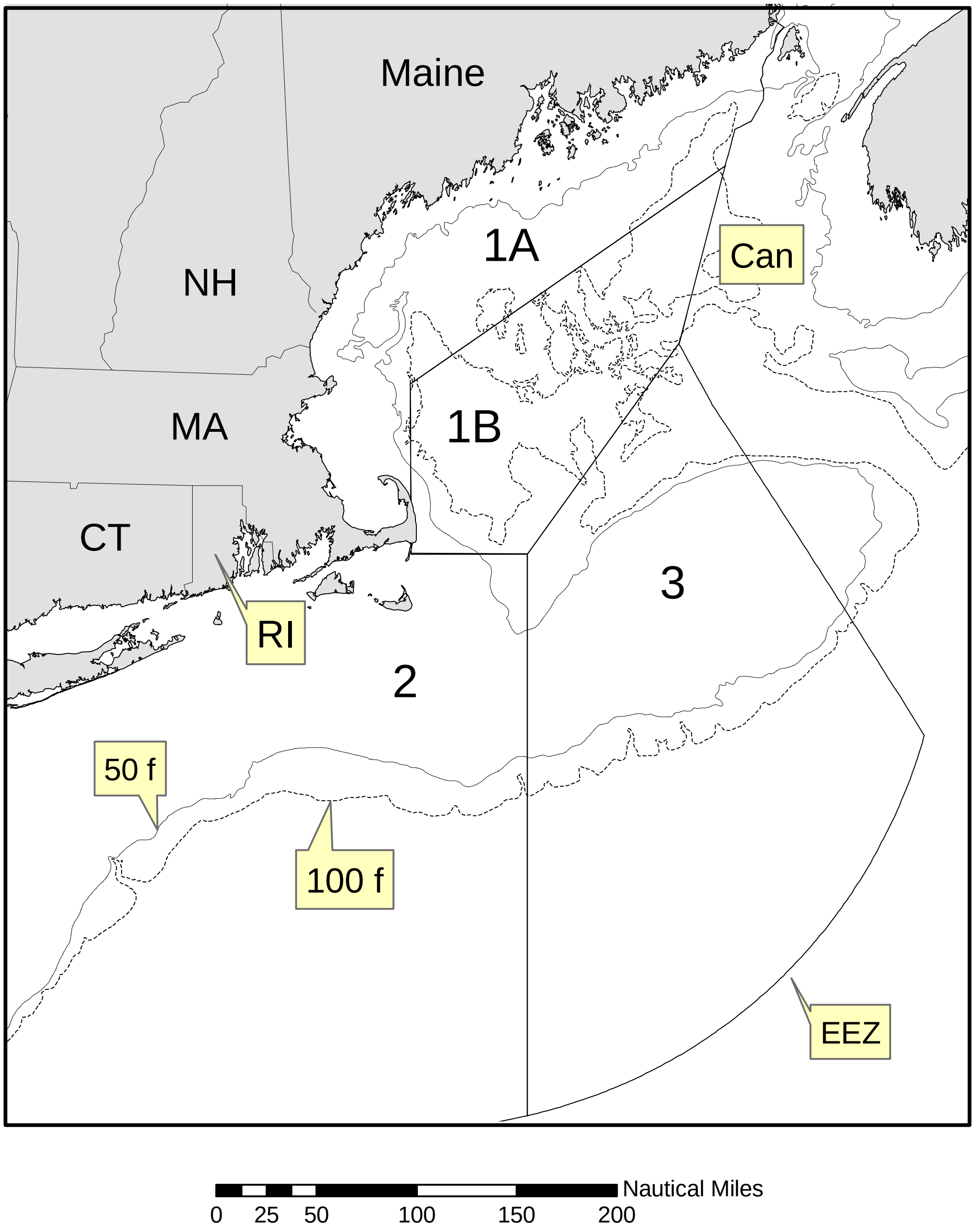


Figure 3.2. Map of Georges Bank and the Gulf of Maine showing Atlantic herring management areas.

4.0 AFFECTED ENVIRONMENT

This section of the DEIS describes components of the physical, biological, and human evironments that could potentially be affected by the proposed management measures. The valued environmental components (VECs) that have been identified are: 1) the Atlantic herring resource; 2) protected species; 3) essential fish habitat (EFH) for Atlantic herring and other federally-managed species in the Northeast region of the U.S.; and 4) human communities, including fishing communities and the Atlantic herring fishery. In addition to providing a description of these VECs, this section of the DEIS also includes background information on the physical and biological environment in the region for context purposes.

4.1 Physical Environment

This section contains a description of the physical environment of the Atlantic Herring fishery, including oceanographic and physical habitat conditions in the Gulf of Maine – Georges Bank region and the area south of New England.

The Northeast U.S. Shelf Ecosystem (Figure 4.1) has been described as including the area from the Gulf of Maine south to Cape Hatteras, extending from the coast seaward to the edge of the continental shelf, including the slope sea offshore to the Gulf Stream (Sherman *et al.* 1996). The continental slope includes the area east of the shelf, out to a depth of 2000 m. Four distinct subregions comprise the NOAA Fisheries Northeast Region: the Gulf of Maine, Georges Bank, the Mid-Atlantic Bight, and the continental slope. Occasionally another subregion, Southern New England, is described; however, we incorporated discussions of any distinctive features of this area into the sections describing Georges Bank and the Mid-Atlantic Bight.

The Gulf of Maine is an enclosed coastal sea, characterized by relatively cold waters and deep basins, with a patchwork of various sediment types. Georges Bank is a relatively shallow coastal plateau that slopes gently from north to south and has steep submarine canyons on its eastern and southeastern edge. It is characterized by highly productive, well-mixed waters and strong currents. The Mid-Atlantic Bight is comprised of the sandy, relatively flat, gently sloping continental shelf from southern New England to Cape Hatteras, NC. The continental slope begins at the continental shelf break and continues eastward with increasing depth until it becomes the continental rise. Because Atlantic herring do not commonly occur over the continental slope, a detailed description of this subregion is not included in this document.

Pertinent physical and biological characteristics of each of these subregions are described below. Source references used to describe the general physical features of these subregions are not cited in the text, below, but do include the following: Backus 1987; Schmitz *et al*. 1987; Tucholke 1987; Wiebe *et al*. 1987; Cook 1988; Reid and Steimle 1988; Stumpf and Biggs 1988; Abernathy 1989; Townsend 1992; Mountain et al. 1994; Beardsley *et al*. 1996; Brooks 1996; Sherman *et al*. 1996; Dorsey 1998; Kelley 1998; NEFMC 1998a; Steimle *et al*. 1999a. In some cases, recent or specific research results are cited in the text. Following the characterizations of each subregion is a short section on coastal features.

4.1.1 Gulf of Maine

Although not obvious in appearance, the Gulf of Maine (GOM) is actually an enclosed coastal sea, bounded on the east by Browns Bank, on the north by the Nova Scotian (Scotian) Shelf, on the west by the New England states, and on the south by Cape Cod and Georges Bank (Figure 4.4). The GOM was glacially derived, and is characterized by a system of deep basins, moraines and rocky protrusions with limited access to the open ocean. This geomorphology influences complex oceanographic processes that result in a rich biological community.

The GOM is topographically unlike any other part of the continental border along the U.S. Atlantic coast. The GOM's geologic features, when coupled with the vertical variation in water properties, result in a great diversity of habitat types. It contains twenty-one distinct basins separated by ridges, banks, and swells. The three largest basins are Wilkinson, Georges, and Jordan (Figure 4.4). Depths in the basins exceed 250 m, with a maximum depth of 350 m in Georges Basin, just north of Georges Bank. The Northeast Channel between Georges Bank and Browns Bank leads into Georges Basin, and is one of the primary avenues for exchange of water between the GOM and the North Atlantic Ocean.

High points within the Gulf include irregular ridges, such as Cashes Ledge, which peaks at 9 m below the surface, as well as lower flat-topped banks and gentle swells. Some of these rises are remnants of the sedimentary shelf that was left after most of it was removed by the glaciers. Others are glacial moraines and a few, like Cashes Ledge, are outcroppings of bedrock. Very fine sediment particles created and eroded by the glaciers have collected in thick deposits over much of the GOM, particularly in its deep basins (Figure 4.5). These mud deposits blanket and obscure the irregularities of the underlying bedrock, forming topographically smooth terrains. Some shallower basins are covered with mud as well, including some in coastal waters. In the rises between the basins, other materials are usually at the surface. Unsorted glacial till covers some morainal areas, as on Sewell Ridge to the north of Georges Basin and on Truxton Swell to the south of Jordan Basin. Sand predominates on some high areas and gravel, sometimes with boulders, predominates on others.

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

An intense seasonal cycle of winter cooling and turnover, springtime freshwater runoff, and summer warming influences oceanographic and biologic processes in the GOM. The Gulf has a general counterclockwise nontidal surface current that flows around its coastal margin (Figure 4.6). It is primarily driven by fresh, cold Scotian Shelf water that enters over the Scotian Shelf and through the Northeast Channel, and freshwater river runoff, which is particularly important in the spring. Dense relatively warm and saline slope water entering through the bottom of the Northeast Channel from the continental slope also influences gyre formation. Counterclockwise gyres generally form in Jordan, Wilkinson, and Georges Basins and the Northeast Channel as well. These surface gyres are more pronounced in spring and summer; with winter, they weaken and become more influenced by the wind.

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

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

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

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

4.1.1 Georges Bank

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

Glacial retreat during the late Pleistocene deposited the bottom sediments currently observed on the eastern section of Georges Bank, and the sediments have been continuously reworked and redistributed by the action of rising sea level, and by tidal, storm and other currents (Figure 4.7). The strong, erosive currents affect the character of the biological community. Bottom topography on eastern Georges Bank is characterized by linear ridges in the western shoal areas; a relatively smooth, gently dipping sea floor on the deeper, easternmost part; a highly energetic peak in the north with sand ridges up to 30 m high and extensive gravel pavement; and steeper and smoother topography incised by submarine canyons on the southeastern margin. The interaction of several environmental factors, including availability and type of sediment, current speed and direction, and bottom topography, has formed seven sedimentary provinces on eastern Georges Bank (Valentine and Lough 1991), which are described in Table 4.1 and depicted in Figure 4.7. The gravel-sand mixture is usually a transition zone between coarse gravel and finer sediments.

The central region of the Bank is shallow, and the bottom is characterized by shoals and troughs, with sand dunes superimposed upon them. The two most prominent elevations on the ridge and trough area are Cultivator and Georges Shoals. This shoal and trough area is a region of strong currents, with average flood and ebb tidal currents greater than 4 km/h, and as high as 7 km/h. The dunes migrate at variable rates, and the ridges may also move. In an area that lies between the central part and Northeast Peak, Almeida *et al.* (2000) identified high-energy areas as between 35 - 65 m deep, where sand is transported on a daily basis by tidal currents, and a low-energy area at depths > 65 m that is affected only by storm currents.

The area west of the Great South Channel, known as Nantucket Shoals (Figure 4.4) is similar in nature to the central region of the Bank. Currents in these areas are strongest where water depth is shallower than 50 m. This type of traveling dune and swale morphology is also found in the Mid-Atlantic Bight, and further described in that section of the document. The Great South Channel separates the main part of Georges Bank from Nantucket Shoals. Sediments in this region include gravel pavement and mounds, some scattered boulders, sand with storm-generated ripples, and scattered shell and mussel beds. Tidal and storm currents range from moderate to strong, depending upon location and storm activity (Valentine, pers. comm.).

Oceanographic frontal systems separate water masses of the GOM and Georges Bank from oceanic waters south of the Bank. These water masses differ in temperature, salinity, nutrient concentration, and planktonic communities, which influence productivity and may influence fish abundance and distribution. Currents on Georges Bank include a weak, persistent clockwise gyre around the Bank, a strong semidiurnal tidal flow predominantly northwest and southeast, and very strong, intermittent storm induced currents, which all can occur simultaneously (Figure 4.6). Tidal currents over the shallow top of Georges Bank can be very strong, and keep the waters over the Bank well mixed vertically. This results in a tidal front that separates the cool waters of the well mixed shallows of the central Bank from the warmer, seasonally stratified shelf waters on the seaward and shoreward sides of the Bank. The clockwise gyre is instrumental in distribution of the planktonic community, including larval fish. For example, Lough and Potter (1993) describe passive drift of Atlantic cod and haddock eggs and larvae in a southwest residual pattern around Georges Bank. Larval concentrations are found at varying depths along the southern edge between 60 - 100 m.

4.1.1 Mid Atlantic Bight

The Mid-Atlantic Bight includes the shelf and slope waters from Georges Bank south to Cape Hatteras, and east to the Gulf Stream (Figure 4.3). Like the rest of the continental shelf, the topography of the Mid-Atlantic Bight was shaped largely by sea level fluctuations caused by past ice ages. The shelf's basic morphology and sediments derive from the retreat of the last ice sheet, and the subsequent rise in sea level. Since that time, currents and waves have modified this basic structure.

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

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

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

The "cold pool" is an annual phenomenon particularly important to the Mid-Atlantic Bight. It stretches from the Gulf of Maine along the outer edge of Georges Bank and then southwest to Cape Hatteras. It becomes identifiable with the onset of thermal stratification in the spring and lasts into early fall until normal seasonal mixing occurs. It usually exists along the bottom between the 40 and 100 m isobaths and extends up into the water column for about 35 m, to the bottom of the seasonal thermocline. The cold pool usually represents about 30% of the volume of shelf water. Minimum temperatures for the cold pool occur in early spring and summer, and range from 1.1 - 4.7ºC.

The shelf slopes gently from shore out to between 100 and 200 km offshore where it transforms to the slope (100 - 200 m water depth) at the shelf break. In both the Mid-Atlantic and on Georges Bank, numerous canyons incise the slope, and some cut up onto the shelf itself. The primary morphological features of the shelf include shelf valleys and channels, shoal massifs, scarps, and sand ridges and swales (Figure 4.8 and Figure 4.9).

Most of these structures are relic except for some sand ridges and smaller sand-formed features. Shelf valleys and slope canyons were formed by rivers of glacier outwash that deposited sediments on the outer shelf edge as they entered the ocean. Most valleys cut about 10 m into the shelf, with the exception of the Hudson Shelf Valley that is about 35 m deep. The valleys were partially filled as the glacier melted and retreated across the shelf. The glacier also left behind a lengthy scarp near the shelf break from Chesapeake Bay north to the eastern end of Long Island (Figure 4.8 and Figure 4.9). Shoal retreat massifs were produced by extensive deposition at a cape or estuary mouth. Massifs were also formed as estuaries retreated across the shelf.

The sediment type covering most of the shelf in the Mid-Atlantic Bight is sand, with some relatively small, localized areas of sand-shell and sand-gravel. On the slope, silty sand, silt, and clay predominate.

Some sand ridges (Figure 4.8) are more modern in origin than the shelf's glaciated morphology. Their formation is not well understood; however, they appear to develop from the sediments that erode from the shore face. They maintain their shape, so it is assumed that they are in equilibrium with modern current and storm regimes. They are usually grouped, with heights of about 10 m, lengths of 10 - 50 km and spacing of 2 km. Ridges are usually oriented at a slight angle towards shore, running in length from northeast to southwest. The seaward face usually has the steepest slope. Sand ridges are often covered with smaller similar forms such as sand waves, megaripples, and ripples. Swales occur between sand ridges. Since ridges are higher than the adjacent swales, they are exposed to more energy from water currents, and experience more sediment mobility than swales. Ridges tend to contain less fine sand, silt and clay while relatively sheltered swales contain more of the finer particles. Swales have greater benthic macrofaunal density, species richness and biomass, due in part to the increased abundance of detrital food and the physically less rigorous conditions.

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

Sediments are uniformly distributed over the shelf in this region (see Figure 4.5). A sheet of sand and gravel varying in thickness from 0 - 10 m covers most of the shelf. The mean bottom flow from the constant southwesterly current is not fast enough to move sand, so sediment transport must be episodic. Net sediment movement is in the same southwesterly direction as the current. The sands are mostly medium to coarse grains, with finer sand in the Hudson Shelf Valley and on the outer shelf. Mud is rare over most of the shelf, but is common in the Hudson Shelf Valley. Occasionally relic estuarine mud deposits are re-exposed in the swales between sand ridges. Fine sediment content increases rapidly at the shelf break, which is sometimes called the "mud line," and sediments are 70 - 100% fines on the slope.

The northern portion of the Mid-Atlantic Bight is sometimes referred to as southern New England. Most of this area was discussed under Georges Bank; however, one other formation of this region deserves note. The mud patch is located just southwest of Nantucket Shoals and southeast of Long Island and Rhode Island (Figure 4.5). Tidal currents in this area slow significantly, which allows silts and clays to settle out. The mud is mixed with sand, and is occasionally resuspended by large storms. This habitat is an anomaly of the outer continental shelf.

Artificial reefs are another significant Mid-Atlantic habitat, formed much more recently on the geologic time scale than other regional habitat types. These localized areas of hard structure have been formed by shipwrecks, lost cargoes, disposed solid materials, shoreline jetties and groins, submerged pipelines, cables, and other materials (Steimle and Zetlin 2000). While some of materials have been deposited specifically for use as fish habitat, most have an alternative primary purpose; however, they have all become an integral part of the coastal and shelf ecosystem. It is expected that the increase in these materials has had an impact on living marine resources and fisheries, but these effects are not well known. In general, reefs are important for attachment sites, shelter, and food for many species, and fish predators such as tunas may be attracted by prey aggregations, or may be behaviorally attracted to the reef structure. The overview by Steimle and Zetlin (2000) used NOAA hydrographic surveys to plot rocks, wrecks, obstructions, and artificial reefs, which together were considered a fairly complete list of nonbiogenic reef habitat in the Mid-Atlantic estuarine and coastal areas (Figure 4.10).

4.1.1 Coastal Habitats

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. For example, coastal areas and estuaries are important for nutrient recycling and primary production, and certain features serve as nursery areas for juvenile stages of economically important species. Salt marshes are found extensively throughout the region. Tidal and subtidal mud and sand flats are general salt marsh features and also occur in other estuarine areas. Salt marshes provide nursery and spawning habitat for many finfish and shellfish species. Salt marsh vegetation can also be a large source of organic material that is important to the biological and chemical processes of the estuarine and marine environment.

Rocky intertidal zones are periodically submerged, high-energy environments found in the northern portion of the northeast system. Sessile invertebrates and some fish inhabit rocky intertidal zones. A variety of algae, kelp, and rockweed are also important habitat features of rocky shores. Fishery resources may depend upon particular habitat features of the rocky intertidal that provide important levels of refuge and food.

Sandy beaches are most extensive along the western Gulf of Maine coast south of Portland, ME, on Cape Cod, Long Island, and the coastal states of the mid-Atlantic region. Different zones of sandy beaches present suitable habitat conditions for a variety of marine and terrestrial organisms. For example, the intertidal zone presents suitable habitat conditions for many invertebrates, and transient fish find suitable conditions for foraging during high tide. Several invertebrate and fish species are adapted for living in the high-energy subtidal zone adjacent to sandy beaches.

Table 4.1 Sedimentary provinces and associated benthic landscapes of Georges Bank. Sediment provinces as defined by Valentine *et al*. (1993) and Valentine and Lough (1991), with additional comments by Valentine (pers. comm.) and benthic assemblages assigned by Theroux and Grosslein (1987).

Sedimentary Province	**Depth (m)**	**Description**	**Benthic Assemblage**
Northern Edge / Northeast Peak (1)	40 - 200	Dominated by gravel with portions of sand, common boulder areas, and tightly packed pebbles. Representative epifauna (bryozoa, hydrozoa, anemones, and calcareous worm tubes) are abundant in areas of boulders. Strong tidal and storm currents.	Northeast Peak
Northern Slope and Northeast Channel (2)	200 - 240	Variable sediment type (gravel, gravel-sand, and sand) scattered bedforms. This is a transition zone between the northern edge and southern slope. Strong tidal and storm currents.	Northeast Peak
North /Central Shelf (3)	60 - 120	Highly variable sediment type (ranging from gravel to sand) with rippled sand, large bedforms, and patchy gravel lag deposits. Minimal epifauna on gravel due to sand movement. Representative epifauna in sand areas includes amphipods, sand dollars, and burrowing anemones.	Central Georges
Central and Southwestern Shelf - shoal ridges (4)	10 - 80	Dominated by sand (fine and medium grain) with large sand ridges, dunes, waves, and ripples. Small bedforms in southern part. Minimal epifauna on gravel due to sand movement. Representative epifauna in sand areas includes amphipods, sand dollars, and burrowing anemones.	Central Georges
Central and Southwestern Shelf - shoal troughs (5)	40 - 60	Gravel (including gravel lag) and gravel-sand between large sand ridges. Patchy large bedforms. Strong currents. (Few samples – submersible observation noted presence of gravel lag, rippled gravel-sand, and large bedforms.) Minimal epifauna on gravel due to sand movement. Representative epifauna in sand areas includes amphipods, sand dollars, and burrowing anemones.	Central Georges
Southeastern Shelf (6)	80 - 200	Rippled gravel-sand (medium and fine grained sand) with patchy large bedforms and gravel lag. Weaker currents; ripples are formed by intermittent storm currents. Representative epifauna includes sponges attached to shell fragments and amphipods.	Southern Georges
Southeastern Slope (7)	400 - 2000	Dominated by silt and clay with portions of sand (medium and fine) with rippled sand on shallow slope and smooth silt-sand deeper.	none

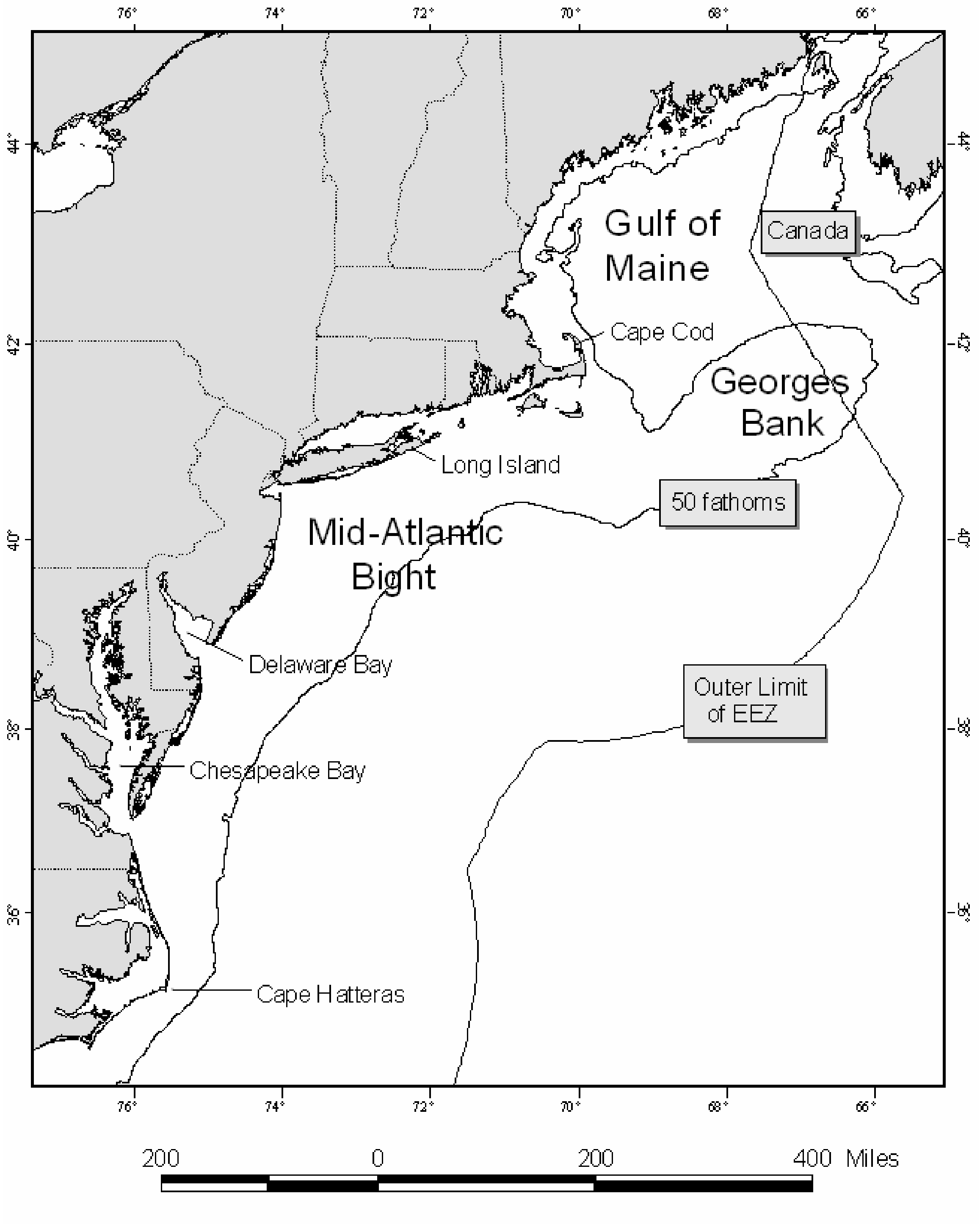


Figure 4.3. Northeast U.S. Shelf Ecosystem.

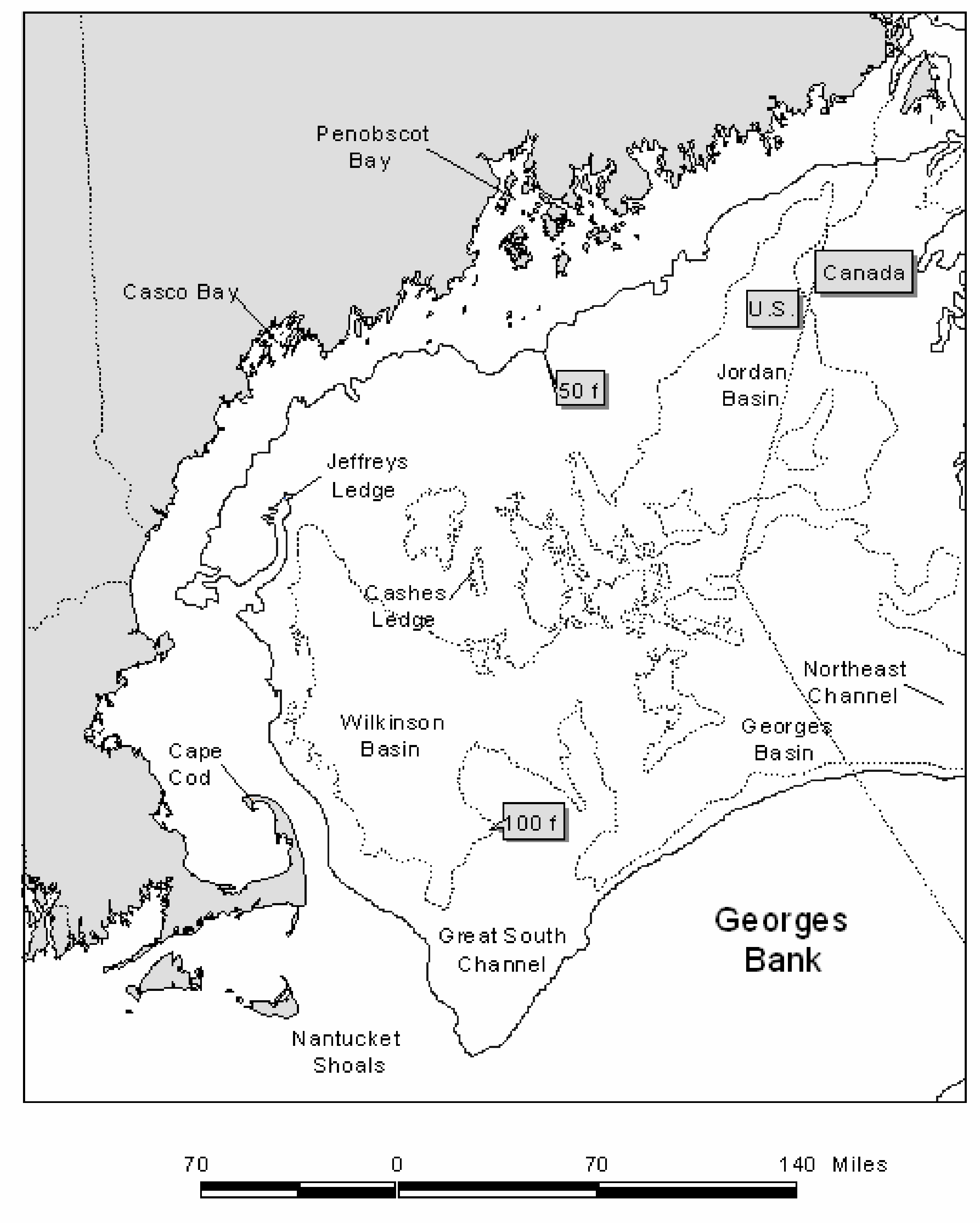


Figure 4.4. Gulf of Maine.

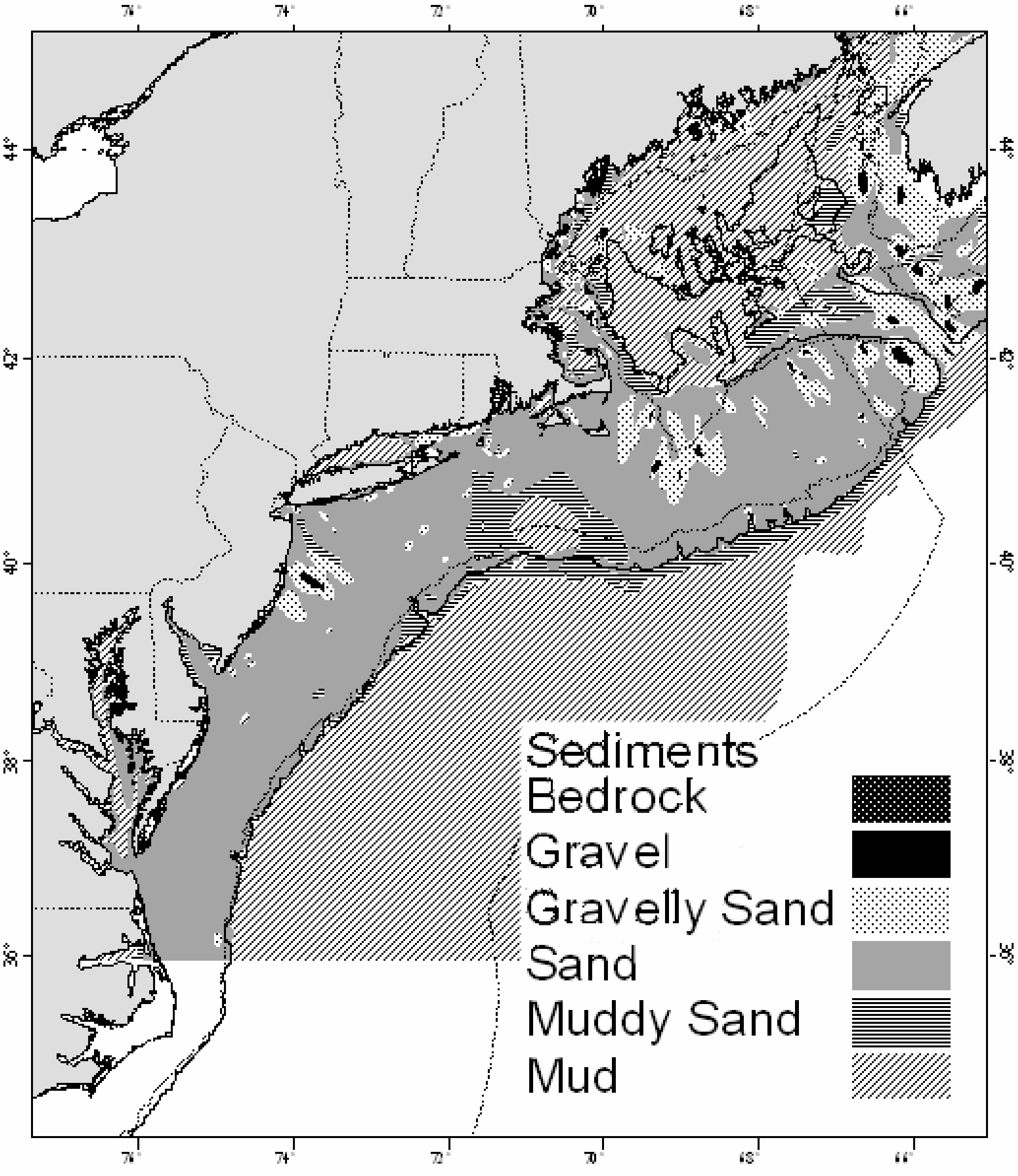


Figure 4.5. Distribution of Northeast region substrate types, modified from Poppe *et al*. (1989, 1994).

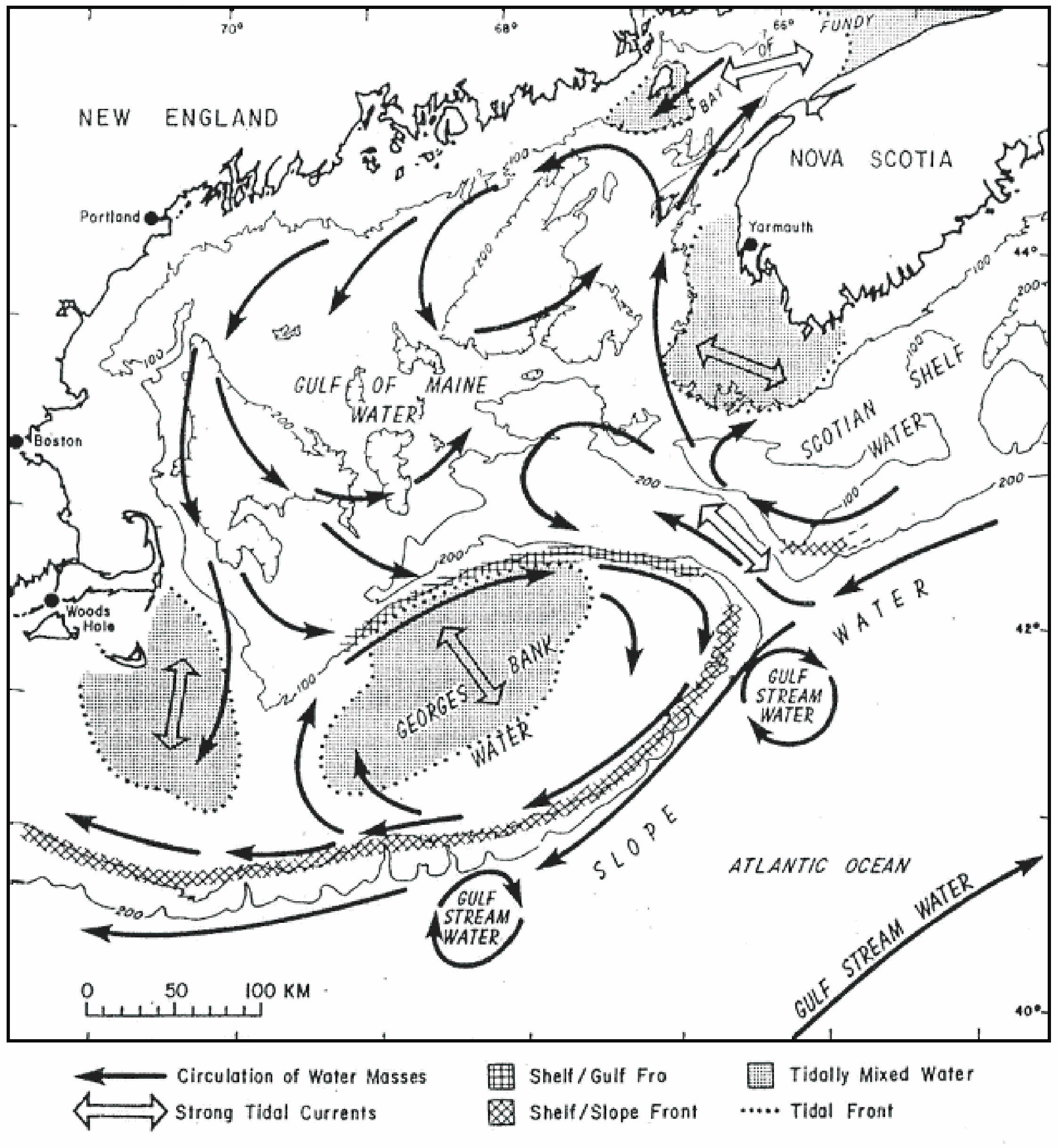


Figure 4.6. Water mass circulation patterns in the Georges Bank - Gulf of Maine region. Depth in meters. Source: Valentine and Lough (1991).

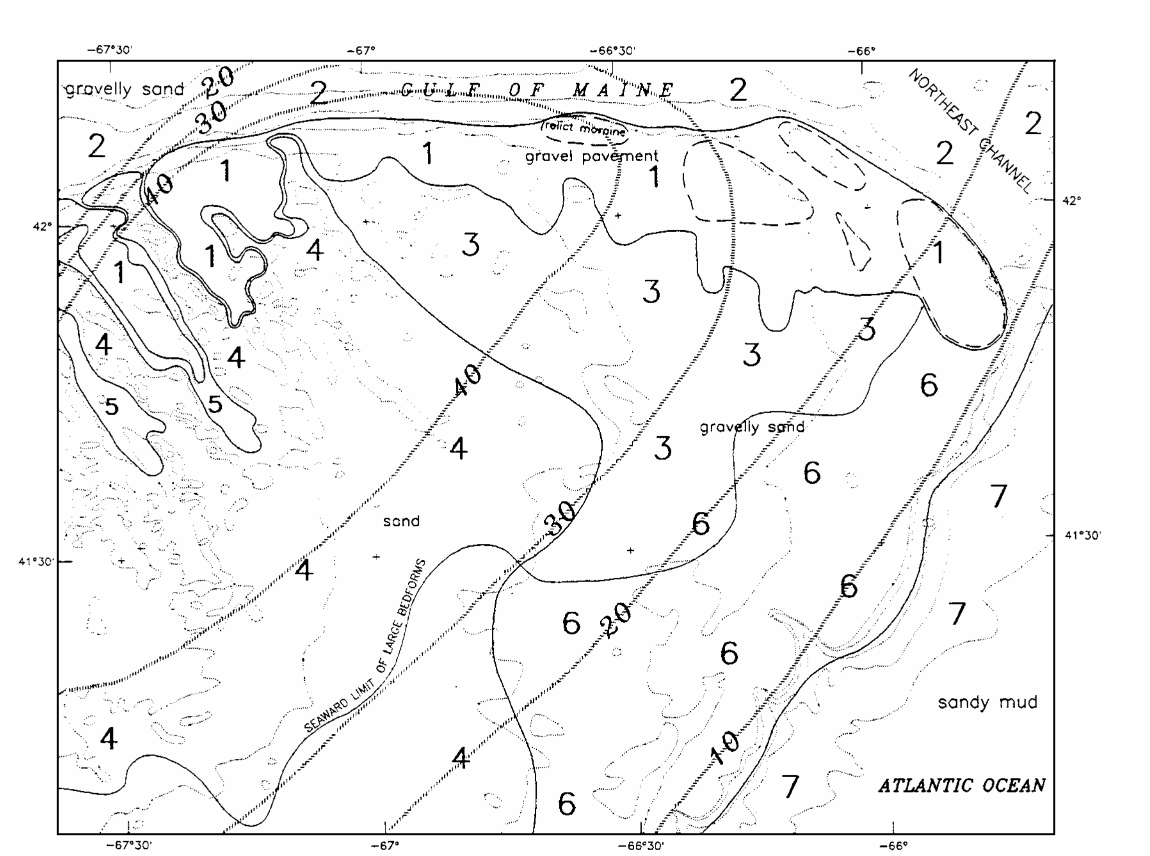
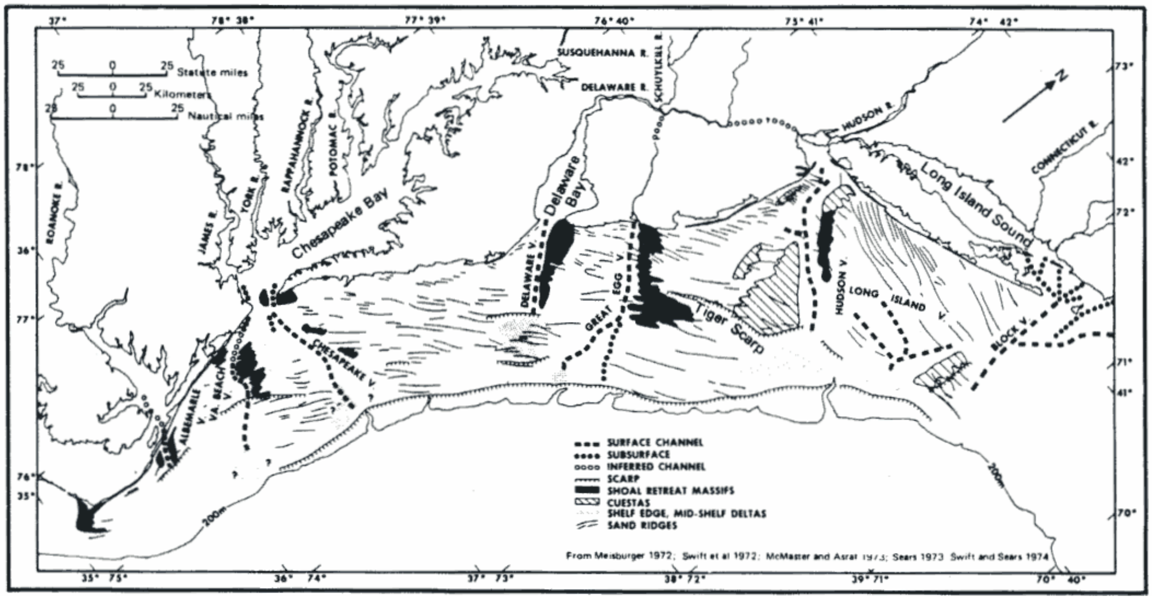


Figure 4.7. Sedimentary provinces of eastern Georges Bank. Based on criteria of sea floor morphology, texture, sediment movement and bedforms, and mean tidal bottom current speed (cm/s). Relict moraines (bouldery seafloor) are enclosed by dashed lines. See Table 4.1 for descriptions of provinces. Source: Valentine and Lough (1991).



From Meisburger 1972; Swift et al 1972; McMaster and Asrat 1973; Sears 1973 Swift and Sears 1974

Figure 4.8. Mid-Atlantic Bight submarine morphology. Source: Stumpf and Biggs (1988).

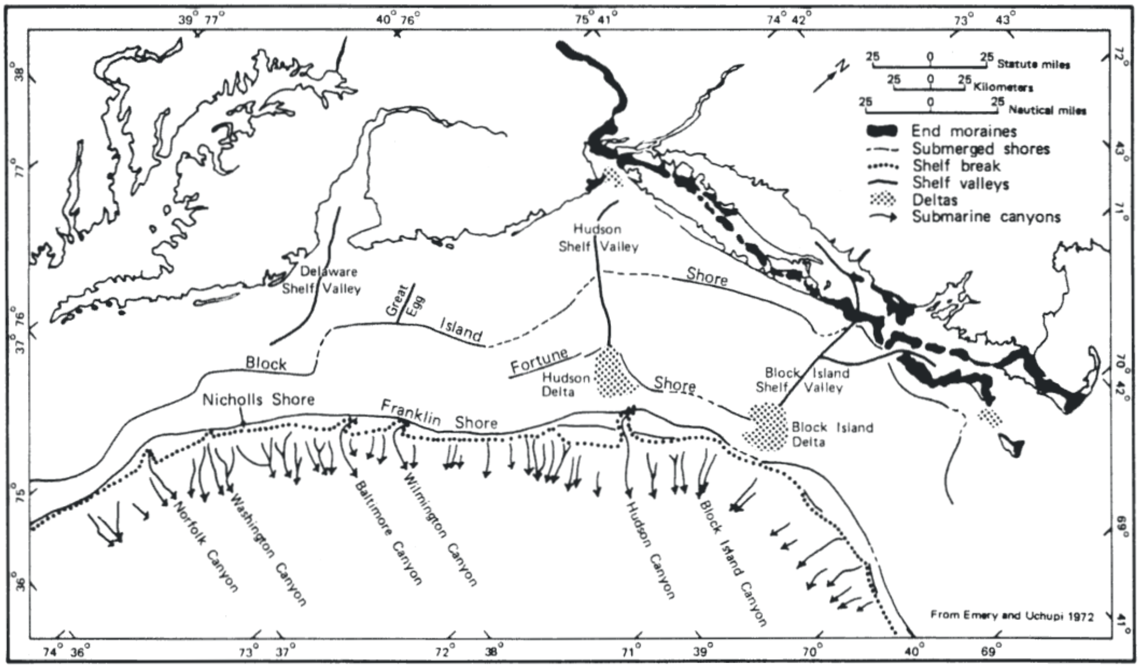


Figure 4.9. Major features of the mid-Atlantic and southern New England continental shelf. Source: Stumpf and Biggs (1988).

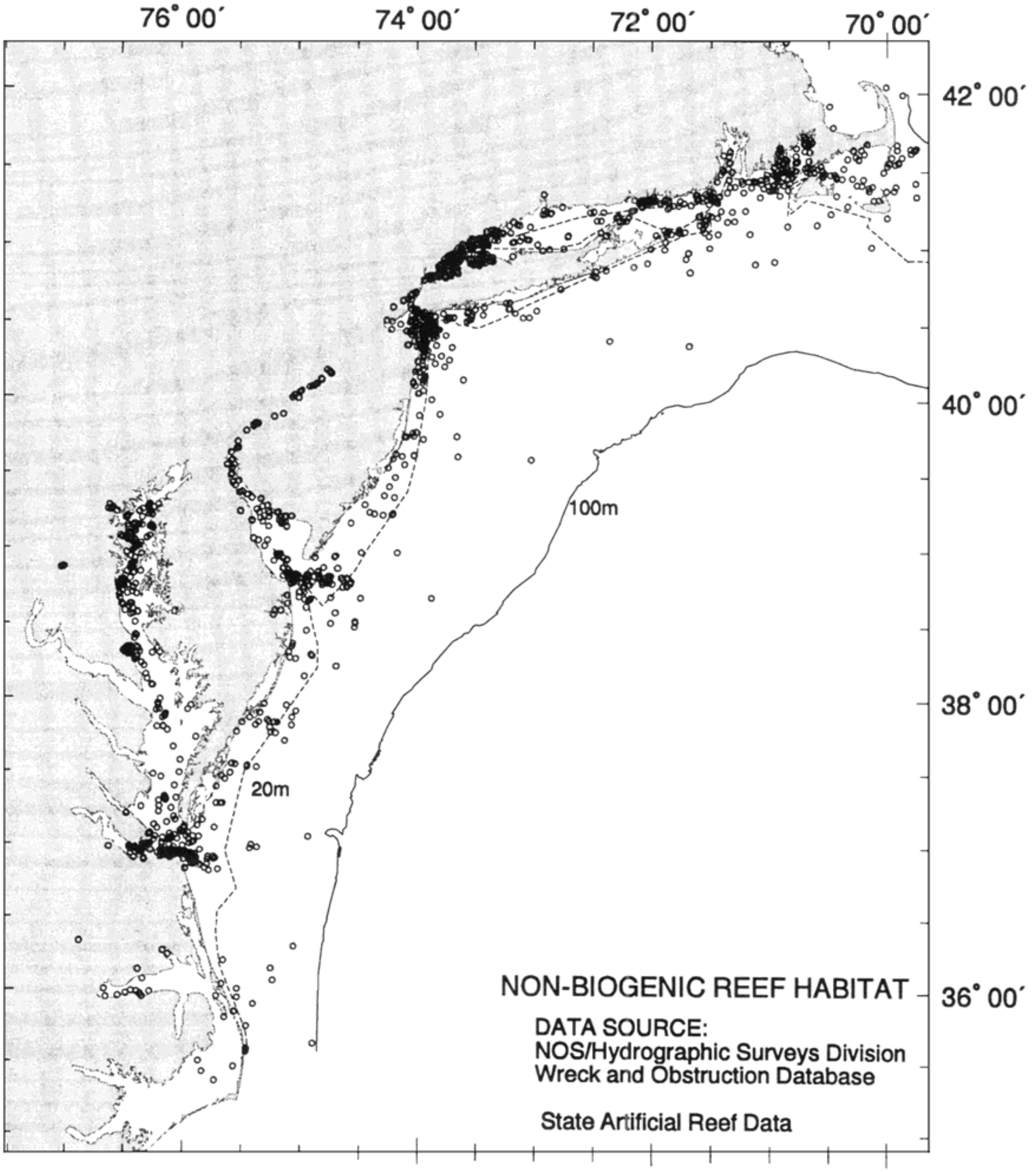


Figure 4.10. Non-biogenic reef habitats (excludes mussel and oyster beds) in the Mid-Atlantic Bight. Source: Steimle and Zetlin (2000).

4.2 Biological Environment

4.2.1 Habitat Characteristics of Regional Systems

4.2.1.1 Gulf of Maine

Based on 303 benthic grab samples collected in the GOM during 1956-1965, Theroux and Wigley (1998) reported that, in terms of numbers, the most common groups of benthic invertebrates in the GOM were annelid worms (35%), bivalve mollusks (33%), and amphipod crustaceans (14%). Biomass was dominated by bivalves (24%), sea cucumbers (22%), sand dollars (18%), annelids (12%), and sea anemones (9%). Watling (1998) used numerical classification techniques to separate benthic invertebrate samples into seven bottom assemblages. These assemblages are identified in Table 4.2 and their distribution is indicated in Figure 4.13. This classification system considers predominant taxa, substrate types, and seawater properties.

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

Demersal fish assemblages for the GOM and Georges Bank were part of broad scale geographic investigations conducted by Gabriel (1992) and Mahon *et al.,* (1998). Both these studies and a more limited study by Overholtz and Tyler (1985) found assemblages that were consistent over space and time in this region. In her analysis, Gabriel (1992) found that the most persistent feature over time in assemblage structure from Nova Scotia to Cape Hatteras was the boundary separating assemblages between the GOM and Georges Bank, which occurred at approximately the 100 m isobath on northern Georges Bank. Overholtz and Tyler (1985) identified five assemblages for this region. The Gulf of Maine-deep assemblage included a number of species found in other assemblages, with the exception of American plaice and witch flounder, which was unique to this assemblage. Results of these two studies are compared in Table 4.3. Auster *et al.,* (2001) went a step further and related species clusters on Stellwagen Bank to reflectance values of different substrate types in an attempt to use fish distribution as a proxy for seafloor habitat distribution. They found significant reflectance associations for twelve of twenty species, including American plaice (fine substrate), and haddock (coarse substrate). Species clusters and associated substrate types are given in Table 4.4.

4.2.1.2 Georges Bank

Amphipod crustaceans (49%) and annelid worms (28%) numerically dominated the contents of 211 samples collected on Georges Bank during 1956-1965 (Theroux and Wigley 1998). Biomass was dominated by sand dollars (50%) and bivalves (33%). Theroux and Grosslein (1987) utilized the same database to identify four invertebrate assemblages. They noted that the boundaries between assemblages were not well defined because there is considerable intergrading between adjacent assemblages. Their assemblages are associated with those identified by Valentine and Lough (1991) in Table 4.1.

The Western Basin assemblage (Theroux and Grosslein 1987) is found in the upper Great South Channel region at the northwestern corner of the Bank, in comparatively deepwater (150 - 200 m) with relatively slow currents and fine bottom sediments of silt, clay and muddy sand. Fauna are comprised mainly of small burrowing detritivores and deposit feeders, and carnivorous scavengers. Representative organisms include bivalves (*Thyasira flexuosa, Nucula tenuis, Musculus discors*), annelids (*Nephtys incisa, Paramphinome pulchella, Onuphis opalina, Sternaspis scutata*), the brittle star *Ophiura sarsi*, the amphipod *Haploops tubicola*, and red crab (*Geryon quinquedens*). Valentine and Lough (1991) did not identify a comparable assemblage; however, this assemblage is geographically located adjacent to Assemblage 5 as described by Watling (1998) (Figure 4.13).

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

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

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

Along with high levels of primary productivity, Georges Bank has been historically characterized by high levels of fish production. Several studies have attempted to identify demersal fish assemblages over large spatial scales. Overholtz and Tyler (1985) found five depth related groundfish assemblages for Georges Bank and the GOM that were persistent temporally and spatially. Depth and salinity were identified as major physical influences explaining assemblage structure. Gabriel (1992) identified six assemblages, which are compared with the results of Overholtz and Tyler (1985) in Table 4.3. Mahon *et al.,* (1998) found similar results.

4.2.1.3 Mid-Atlantic Bight

Wigley and Theroux (1981) reported on the faunal composition of 563 bottom grab samples collected in the Mid-Atlantic Bight during 1956-1965. Amphipod crustaceans and bivalve mollusks accounted for most of the individuals (41% and 22%, respectively), whereas mollusks dominated the biomass (70%). Three broad faunal zones related to water depth and sediment type were identified by Pratt (1973). The “sand fauna” zone was defined for sandy sediments (1% or less silt) that are at least occasionally disturbed by waves, from shore out to 50 m (Figure 4.14). The “silty sand fauna” zone occurred immediately offshore from the sand fauna zone, in stable sands containing a small amount of silt and organic material. Silts and clays become predominant at the shelf break and line the Hudson Shelf Valley, and support the “silt-clay fauna.”

Building on Pratt’s work, the Mid-Atlantic shelf was further divided by Boesch (1979) into seven bathymetric/morphologic subdivisions based on faunal assemblages (Table 4.5). Sediments in the region studied (Hudson Shelf Valley south to Chesapeake Bay) were dominated by sand with little finer materials. Ridges and swales are important morphological features in this area. Sediments are coarser on the ridges, and the swales have greater benthic macrofaunal density, species richness, and biomass. Faunal species composition differed between these features, and Boesch (1979) incorporated this variation in his subdivisions. Much overlap of species distributions was found between depth zones, so the faunal assemblages represented more of a continuum than distinct zones.

Demersal fish assemblages were described at a broad geographic scale for the continental shelf and slope from Cape Chidley, Labrador to Cape Hatteras, North Carolina (Mahon *et al.,* 1998) and from Nova Scotia to Cape Hatteras (Gabriel 1992). Factors influencing species distribution included latitude and depth. Results of these studies were similar to an earlier study confined to the Mid-Atlantic Bight continental shelf (Colvocoresses and Musick 1984). In this study, there were clear variations in species abundances, yet they demonstrated consistent patterns of community composition and distribution among demersal fishes of the Mid-Atlantic shelf. This is especially true for five strongly recurring species associations that varied slightly by season (Table 4.6). The boundaries between fish assemblages generally followed isotherms and isobaths. The assemblages were largely similar between the spring and fall collections, with the most notable change being a northward and shoreward shift in the temperate group in the spring.

Steimle and Zetlin (2000) described representative epibenthic/epibiotic, motile epibenthic, and fish species associated with sparsely scattered reef habitats that consist mainly of manmade structures (Table 4.7).

Table 4.2. Gulf of Maine benthic assemblages as identified by Watling (1998). Geographical distribution of assemblages is shown in Figure 4.11.

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

Table 4.3. Comparison of demersal fish assemblages of Georges Bank and Gulf of Maine identified by Overholtz and Tyler (1985) and Gabriel (1992).

Overholtz & Tyler (1984)		**Gabriel (1992)**	
Assemblage	**Species**	**Species**	**Assemblage**
Slope & Canyon	Offshore hake Blackbelly rosefish Gulf stream flounder Fourspot flounder Monkfish, Whiting White hake, Red hake	Offshore hake Blackbelly rosefish Gulf stream flounder Fawn cusk-eel, Longfin hake, Armored sea robin	Deepwater
Intermediate	Whiting Red hake Monkfish Atlantic cod, Haddock, Ocean pout, Yellowtail flounder, Winter skate, Little skate, Sea raven, Longhorn sculpin	Whiting Red hake Monkfish Short-finned squid, Spiny dogfish, Cusk	Combination of Deepwater Gulf of Maine/Georges Bank & Gulf of Maine-Georges Bank Transition
Shallow	Atlantic cod Haddock Pollock Whiting White hake Red hake Monkfish Ocean pout	Atlantic cod Haddock Pollock	Gulf of Maine-Georges Bank Transition Zone
	Yellowtail flounder Windowpane Winter flounder Winter skate Little skate Longhorn sculpin Summer flounder Sea raven, Sand lance	Yellowtail flounder Windowpane Winter flounder Winter skate Little skate Longhorn sculpin	Shallow Water Georges Bank-Southern New England
Gulf of Maine-Deep	White hake American plaice Witch flounder Thorny skate Whiting, Atlantic cod, Haddock, Cusk Atlantic wolffish	White hake American plaice Witch flounder Thorny skate, Redfish	Deepwater Gulf of Maine-Georges Bank
Northeast Peak	Atlantic cod Haddock Pollock Ocean pout, Winter flounder, White hake, Thorny skate, Longhorn sculpin	Atlantic cod Haddock Pollock	Gulf of Maine-Georges Bank Transition Zone

Table 4.4. Substrate associations of five finfish groups on Stellwagen Bank, Gulf of Maine. Mean number per tow for ten dominant species in each group. (Auster *et al*. 2001).

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

Table 4.5. Mid-Atlantic habitat types as described by Pratt (1973) and Boesch (1979) with characteristic macrofauna as identified in Boesch (1979).

Habitat Type [after Boesch (1979)]	**Description**		
	Depth (m)	**Characterization [Pratt (1973) faunal zone]**	**Characteristic Benthic Macrofauna**
Inner shelf	0 - 30	characterized by coarse sands with finer sands off MD and VA (sand zone)	Polychaetes: *Polygordius, Goniadella, Spiophanes*
Central shelf	30 - 50	(sand zone)	Polychaetes: *Spiophanes, Goniadella* Amphipod: *Pseudunciola*
Central and inner shelf swales	0 - 50	occurs in swales between sand ridges (sand zone)	*Polychaetes: Spiophanes, Lumbrineris, Polygordius*
Outer shelf	50 - 100	(silty sand zone)	Amphipods: *Ampelisca vadorum, Erichthonius* Polychaetes: *Spiophanes*
Outer shelf swales	50 - 100	occurs in swales between sand ridges (silty sand zone)	Amphipods: *Ampelisca agassizi, Unciola, Erichthonius*
Shelf break	100 - 200	(silt-clay zone)	not given
Continental slope	> 200	(none)	not given

Table 4.6. Major recurrent demersal finfish assemblages of the Mid-Atlantic Bight during spring and fall as determined by Colvocoresses and Musick (1984).

Season	**Species Assemblage**				
	Boreal	**Warm temperate**	**Inner shelf**	**Outer shelf**	**Slope**
Spring	Atlantic cod Little skate Sea raven Goosefish Winter flounder Longhorn sculpin Ocean pout Silver hake Red hake White hake Spiny dogfish	Black sea bass Summer flounder Butterfish Scup Spotted hake Northern searobin	Windowpane	Fourspot flounder	Shortnose greeneye Offshore hake Blackbelly rosefish White hake

Fall	White hake Silver hake Red hake Goosefish Longhorn sculpin Winter flounder Yellowtail flounder Witch flounder Little skate Spiny dogfish	Black sea bass Summer flounder Butterfish Scup Spotted hake Northern searobin Smooth dogfish	Windowpane	Fourspot flounder Fawn cusk eel Gulf stream flounder	Shortnose greeneye Offshore hake Blackbelly rosefish White hake Witch flounder

Table 4.7. Mid-Atlantic reef types, location, and representative flora and fauna as described in Steimle and Zetlin (2000).

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

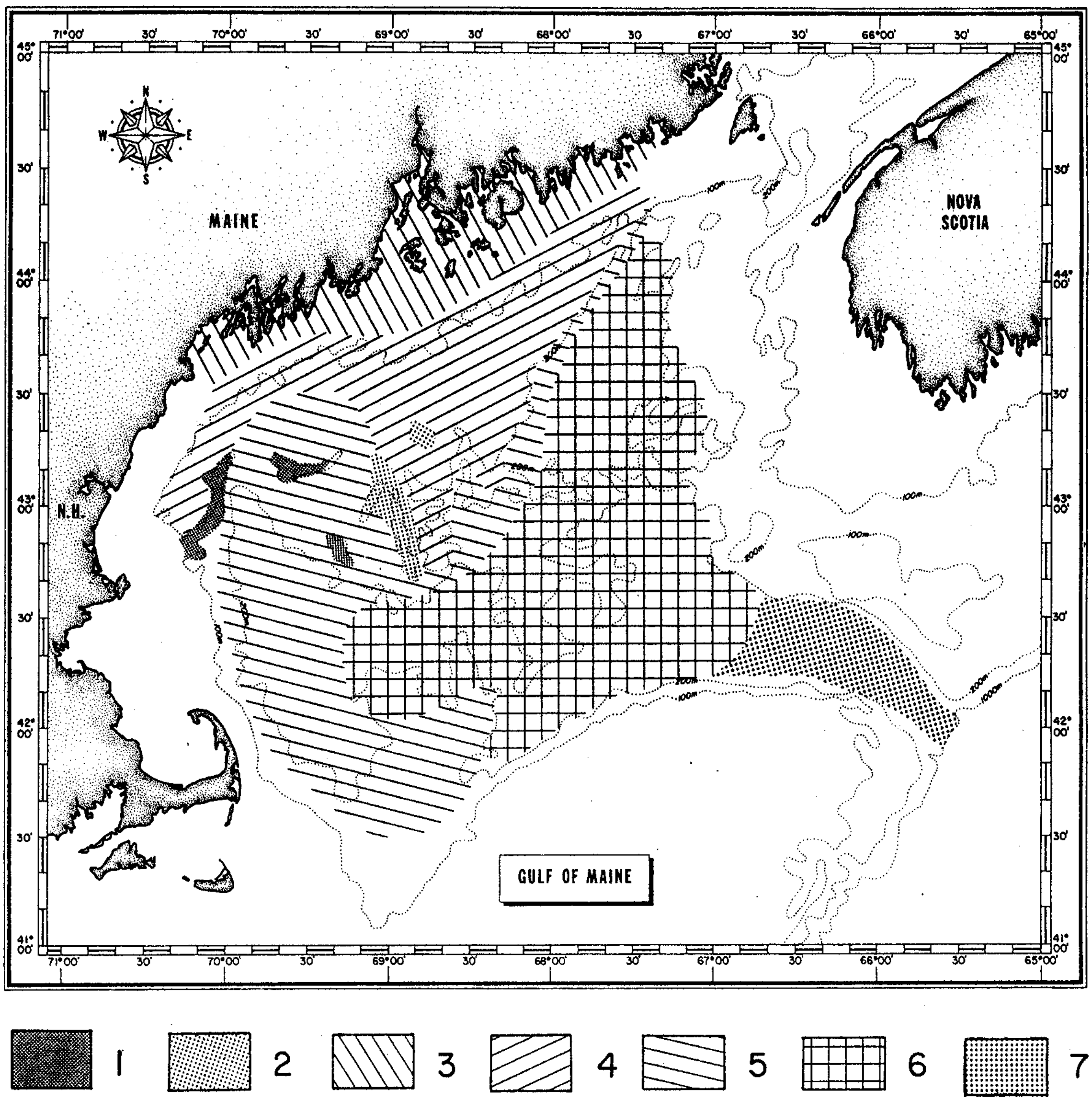


Figure 4.11. Distribution of the seven major benthic assemblages in the Gulf of Maine as determined from both soft bottom quantitative sampling and qualitative hard bottom sampling.

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

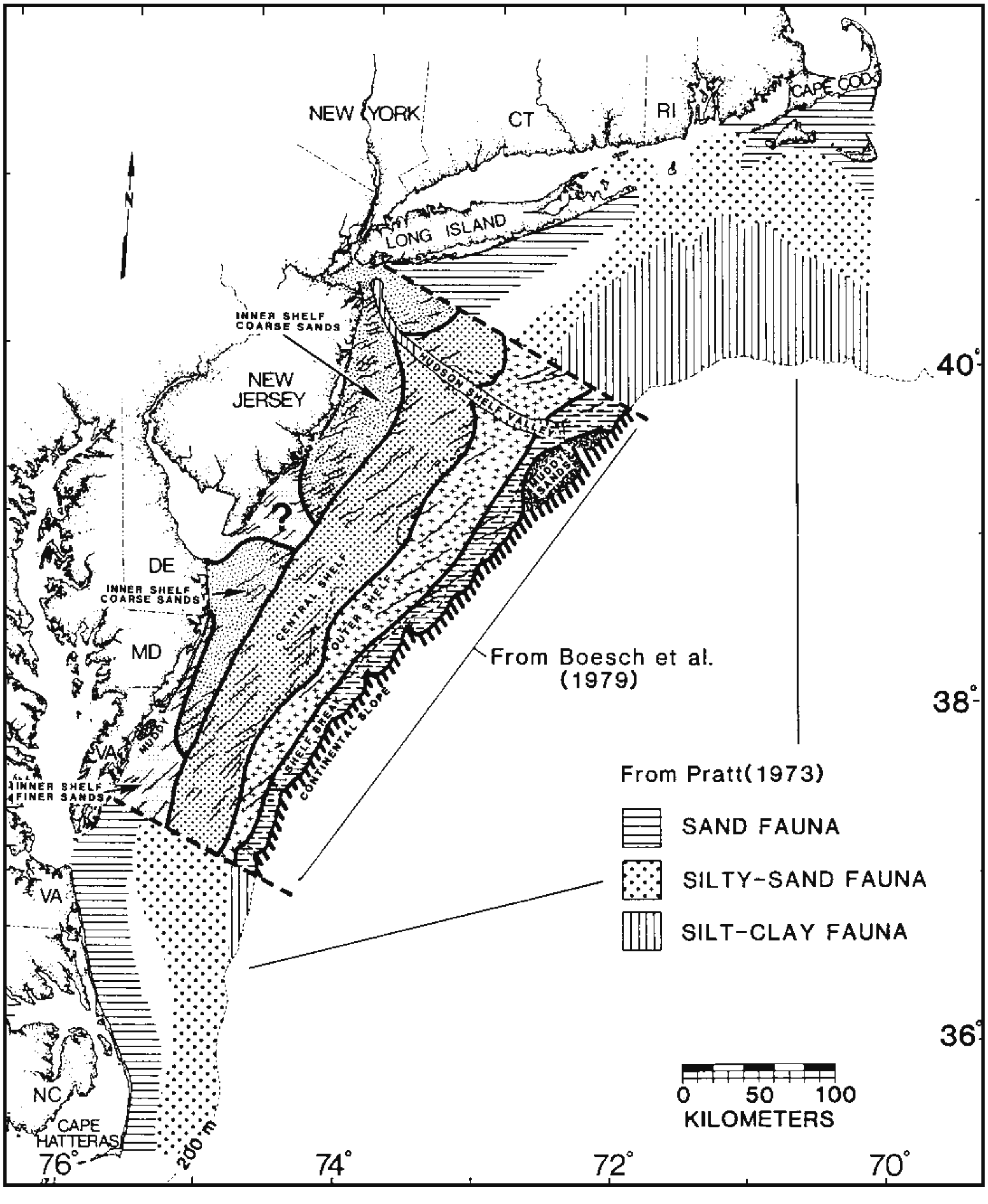


Figure 4.12. Schematic representation of major macrofaunal zones on the mid-Atlantic shelf. Approximate location of ridge fields indicated. Source: Reid and Steimle (1988).

4.2.2 Description of Atlantic Herring

4.2.2.1 Distribution

Herring are found in cold-temperature and boreal waters of the Northern Hemisphere on both sides of the Atlantic. In the western Atlantic, herring range from southwest Greenland to northern Labrador and south to Cape Hatteras in North Carolina. Herring can be found in every major estuary from the northern Gulf of Maine to the Chesapeake Bay. They are most abundant north of Cape Cod and become increasingly scarce south of New Jersey (Kelly and Moring 1986) with the largest and oldest fish found in the southern most portion of the range (Bigelow and Schroeder 1953). All life stages of Atlantic herring can be found in high abundance in the Gulf of Maine (Bigelow and Schroeder 1953), and in lower abundance in the mid-Atlantic, but only adult herring are found to be abundant south of Narragansett Bay (Reid et al 1999; Stone et al 1994).

Adult Atlantic herring are found in shallow inshore waters, 20 meters deep, to offshore waters up to 200 meters deep (NEFMC 1999; Bigelow and Schroeder 1953), but seldom migrate to depths more than 50 fathoms (300 ft or 91.4 meters) (Kelly and Moring 1986). They prefer water temperatures of 5^o – 9^o C (Bigelow and Schroeder 1953; Zinkevich 1967), but may overwinter at temperatures as low as 0^o C (Reid et al 1999). The lower salinity limit for adult herring is 28ppt, with a preference for increasing salinities with increasing fish age.

Juvenile Atlantic herring are usually found in water depths of 15-135 meters (NEFMC 1998a). They prefer water temperatures of 8^o –12^o C, and a salinity range of 26 - 32 ppt, although they can tolerate salinities as low as 5 ppt for short periods (Bigelow and Schroeder 1953; Kelly and Moring 1986; Brawn 1960a; Stickney 1969; Reid et al 1999). This salinity tolerance allows juvenile herring to penetrate the inshore waters of estuaries and bays. There are records of juveniles being found as far as 68 km up the Hudson River (Able and Fahay 1998; Smith 1985).

Information compiled by Stone at al. (1994) and Jury et al. (1994) for NOAA's Estuarine Living Marine Resource Program (ELMR) was used to designate essential fish habitat for species of marine fish in inshore estuaries and embayments along the Atlantic coast of the U.S. Examination of the information for Atlantic herring in inshore areas south of Cape Cod reveals that adults are common in more northern locations throughout the year, but are more abundant in the fall and winter (Figure 4.13). Further south, from New York to Chesapeake Bay, they are absent in the summer and never abundant. Juveniles are common in more northern areas throughout the year and in all locations except Chesapeake Bay in the spring (Figure 4.14). They are not abundant anywhere at any time. Looking at months of the year and locations when both life stages are present (Figure 4.15), it is clear that there is a progression from north to south, with adults and juveniles in the northern estuaries and embayments throughout the year, neither life stage in more southern locations in the summer, only juveniles in Great South Bay (Long Island) and along the New Jersey coast and Delaware Bay in the spring, and only adults in the south in the winter.

4.2.2.2 Reproduction and Early Life History

Atlantic herring have a tendency to return to natal spawning grounds throughout their lifetime to spawn (Ridgway 1975, Sindermann 1979). This behavior is fundamental to the species' ability to maintain discrete spawning aggregations and is the basis for hypotheses concerning stock structure in the northwest Atlantic (Section 4.2.1.5). Evidence for this homing behavior is provided by a tagging study in Newfoundland which showed a 73% return rate of adult Atlantic herring to the same spawning grounds where they were tagged (Wheeler and Winters 1984) and by observations of year-to-year changes in the abundance and age composition of spawning aggregations on discrete banks and shoals off southwest Nova Scotia (Stephenson et al. 1998).

Spawning occurs in specific locations in the Gulf of Maine in depths of 20 to 50 meters (about 60-300 feet), on coastal banks such as Jeffreys Ledge and Stellwagen Bank located 8-40 km offshore, along the eastern Maine coast between the U.S.-Canada border and Jonesport (44º 32' N), and at various other locations along the western Gulf of Maine coast (Reid et al. 1999, Munroe 2002). In Canada, spawning also occurs south of Grand Manan Island (in the entrance to the Bay of Fundy) and on various banks and shoals south of Nova Scotia. Herring also spawn on Nantucket Shoals and Georges Bank, but not further south (see Figure 4.17). Spawning occurs in the summer and fall, starting earlier along the eastern Maine coast and southwest Nova Scotia (August – September) than in the southwestern Gulf of Maine (early to mid-October in the Jeffreys Ledge area) and as late as November – December on Georges Bank) (Reid et al. 1999). Herring in the Gulf of Maine region usually reproduce at relatively high temperatures (10-15º C) and at high salinities (Munroe 2002). They do not spawn in brackish water.

Atlantic herring spawn on the bottom in discrete locations by depositing adhesive eggs which stick to any stable bottom substrate, including lobster pots and anchor lines. In some cases, the same spawning sites are used repeatedly, sometimes more than once a year (Stevenson 1989). Eggs are laid in layers and form mats or carpets. In the Gulf of Maine region, egg mats as thick as 4-5 cm have been observed in discrete egg beds that have varied in size from 0.3 to 1.4 km^2 (Table 5.25). One very large egg bed surveyed on Georges Bank in 1964 covered an area of about 65 km^2 (Noskov and Zinkevich 1967). Herring eggs in the Gulf of Maine region are deposited on gravel and rocky substrate, but are also found on sand, shells and shell fragments, and occasionally on macroalgae (Table 5.25). Drapeau (1973) reported that gravel is the preferred substrate on Georges Bank. Spawning sites are located in areas with strong bottom currents (1.5-3 knots) which prevent the accumulation of fine sediment and provide circulation to supply oxygen and remove metabolites (Reid et al. 1999). Hatching success remains relatively high down to 20-25% dissolved oxygen levels (Aneer 1987).

Herring are synchronous spawners, producing eggs once a year once they reach maturity. Depending on their size and age, female herring can produce from 55,000 to 210,000 eggs (Kelly and Stevenson 1983). Underwater video observations have shown that female herring deposit their eggs on the bottom after the males release milt (Messieh 1988). Once they are laid on the bottom, herring eggs are preyed upon by a number of fish species, including cod, haddock, red hake, sand lance, winter flounder, smelt, tomcod, cunner, pollock, sculpins, skates, mackerel, and even herring themselves (Munroe 2002). Egg predation and adverse environmental conditions often result in high egg mortalities. Egg incubation periods are temperature dependent and range from 10-15 days in the Gulf of Maine (Munroe 2002). Hatching success is also temperature dependent: in experimental studies, all eggs held at 15ºC hatched, and none hatched at 0-5ºC or at 20º C (MacFarland 1931).

The pelagic larval phase is relatively long in Atlantic herring, lasting 4-8 months in the Gulf of Maine, depending on the timing of spawning (Reid et al. 1999). Larvae are transported long distances from spawning grounds and over-winter in coastal bays and estuaries. In the Gulf of Maine, the prevailing surface currents flow to the westward, transporting larvae that hatch in eastern Maine to the Sheepscot estuary in mid-coast Maine, a straight-line distance of about 150 km (Graham 1982; Townsend 1992). Boyar et al. (1973) reported that most of the recently-hatched larvae from the southern end of Jeffreys Ledge are transported shoreward. In some years, a few larvae that hatch later in the year in this area of the Gulf of Maine are transported eastward and enter the Sheepscot estuary (Lazzari and Stevenson 1992). Herring larvae from Nantucket Shoals and Georges Bank are widely dispersed and tend to drift to the southwest (Sindermann 1979; Lough et al. 1980; Grimm 1983). Atlantic herring larvae have been collected from inshore waters as far south as New Jersey (Able and Fahay 1998). Surveys conducted during the years when there was little or no spawning activity on Georges Bank have shown that larvae from Nantucket Shoals disperse to the east on to Georges Bank (Smith and Morse 1993). Metamorphosis occurs in the spring at a length of about 40 mm (1.5 in). Schooling behavior begins in the late larval and early juvenile, or “brit” stages.

The persistence of discrete aggregations of larvae for several months after hatching over tidally mixed continental shelf spawning grounds in the Gulf of Maine and elsewhere, despite the presence of fairly strong currents, has provided the basis for a larval "retention hypothesis" (Iles and Sinclair 1982). This hypothesis states that Atlantic herring stock structure in an area like the Gulf of Maine is determined by the number, location, and extent of geographically stable retention areas. Such retention areas have been described off southwest Nova Scotia, around Grand Manan Island, on Georges Bank (Iles and Sinclair 1982), and in eastern Maine coastal waters (Chenoweth et al. 1989).

4.2.2.3 Age and Growth

In U.S. waters, Atlantic herring reach a maximum length of about 39 cm (15.6 inches) and an age of about 15-18 years (Anthony 1972). Male and female herring grow at about the same rate and become sexually mature beginning at age 3, with most maturing by age 4 (Munroe 2002). Growth rates vary greatly from year to year, and to some extent from stock to stock, and appear to be influenced by many factors, including temperature, food availability, and population size. Juvenile growth is rapid during the first year of life, with a marked slowing at the onset of maturity. Juveniles in coastal Maine waters reach 90-125 mm by the end of their first year of life. There has been a marked reduction in size and weight-at-age of adult herring in U.S. waters of the northwest Atlantic beginning in the mid-1980s (Overholtz et al. 2004), a trend that appears to be related to increased population size and recovery of the Georges Bank spawning stock (Section 4.2.2.8).

4.2.2.4 Feeding

Atlantic herring prey upon a variety of planktivorous organisms. They are visual particulate feeders with diverse feeding behaviors, often switching between filtering and biting in response to light intensity and the size of available food (Bigelow and Schroeder 1953; Battle 1934; Blaxter 1966; Batty et al. 1990). All life stages of herring are opportunistic feeders, and will take advantage of whatever prey of the appropriate size is available (Reid et al 1999; Sherman and Perkins 1971, Bigelow and Schroeder 1953; Sherman and Honey 1971). Their diet can vary with season, fish age, and geography. As juveniles they primarily consume *copepods* with the addition of larval *decapods* in spring, larval *cirripeds* in spring and summer, larval *pelecypods* in summer, and *cladocerans* in summer and autumn (Kelly and Moring 1986; Sherman and Perkins 1971). The diet of adult herring is dominated by *euphausiids*, with the addition of *chaetognaths* and *copepods* (Reid et al 1999; Bigelow and Schroeder 1953; Sherman and Honey 1971; Kelly and Moring 1986; Maurer and Bowman 1975). Adults have also been known to occasionally consume fish eggs and larvae, including herring, although they are not usually piscivourous (Bigelow and Schroeder 1953). The stomach contents of Atlantic herring sampled in the Scotian Shelf area were comprised of greater than 90% by weight of crustaceans other than decapods (Bowman et al 2000).

The spring and summer are the most intense feed times for both juvenile and adult herring. Adult herring cease feeding when spawning begins in late summer and early autumn. Feeding occurs primarily at dawn and dusk in the upper water layers due to the diurnal vertical migrations of herring in response to changes in light intensity (Bigelow and Schroeder 1953; Sinderman 1979; Kelly and Moring 1986; Stickney 1972). They rise to the surface to feed at dusk and then sink toward the seabed at dawn (Bigelow and Schroeder 1953; Blaxter 1990).

4.2.2.5 Herring as a Prey Species

Herring is an important species in the food web of the northwest Atlantic. Herring eggs are deposited on the bottom and incubate for about 10 days. They are subject to predation by a variety of demersal fish species, including winter flounder, cod, haddock and red hake. Juvenile herring, especially “brit” (age-1 juveniles) are preyed upon heavily due to their abundance and small size.

Atlantic herring is an important prey species for a large number of piscivorous fish, elasmobranchs (sharks and skates), marine mammals, and seabirds in the northeastern U.S. Unlike other pelagic fishes such as Atlantic mackerel, herring are smaller and vulnerable to predation over most, if not all, of their life (Overholtz *et al*. 2000). Estimates of the percent composition of Atlantic herring – or of two broader taxonomic groups that include Atlantic herring, menhaden, shad, and river herring – in the diets of 15 species of elasmobranchs and finfish in the northeast shelf ecosystem are summarized in Table 4.8. Stomach content data compiled from fish collected after 1990 are more indicative of current conditions since the Atlantic herring stock was in a collapsed state during the 1980s and started to recover in the early 1990s (see Figure 4.16). The trends in the percentage of herrings in the diet of Atlantic cod follow this change in the population sizes for Atlantic herring.

According to the diet composition data in Table 4.8, the major finfish and elasmobranch species that feed heavily on Atlantic herring (or on clupeid species as a group) are Atlantic cod, silver hake, thorny skate, bluefish, goosefish, weakfish, summer flounder, white hake, and – in certain locations and times of year – Atlantic bluefin tuna. Other species that feed on herring are spiny dogfish, Atlantic halibut, red hake, striped bass, dusky shark, and black sea bass. Spiny dogfish is, however, a much more important predator on Atlantic herring than is indicated by diet composition data. Link et al. (2002a) estimated that spiny dogfish consumed an average of 67,660 metric tons (mt) of Atlantic herring a year during 1977-1998, with a range of 15,526 to

148,197 mt (). Thus, in some years, spiny dogfish consumed a greater quantity of herring biomass than was taken in the commercial fishery.

For many of the predator species listed in Table 4.8, herring made up a larger percentage of the diets of the larger size classes. This was the case for silver hake, summer flounder, white hake, bluefish, and goosefish. Link and Garrison (2002) reported that the percentages of herring in the stomachs of Atlantic cod increased from about 13% in 51-60 cm cod to 28% in 81-90 cm cod and then declined again to 6% in 111-120 cm cod. They also showed that herring made up a larger percentage of the diet of Atlantic cod in the Gulf of Maine than on Georges Bank or in southern New England. Garrison and Link (2000) reported higher percentages of Atlantic herring in the diet of silver hake on Georges Bank than in the Gulf of Maine or in southern New England. Bowman et al. (2000) reported similar results for silver hake and Atlantic cod. Chase (2002) reported very high percentages of Atlantic herring in bluefin tuna diets on Jeffreys Ledge and in the Great South Channel, but very low percentages in three other locations. Less dramatic spatial variations were reported for striped bass by Nelson et al. (2003).

Overholtz *et al*. (2000) estimated the consumption of Atlantic herring by 10 species of predatory fish in northeastern U.S. waters from 1977 to 1997, and found that the amount of herring consumed varied in response to changes in the abundance of herring and the abundance of predator populations in the late 1980s and throughout the 1990s. Consumption of Atlantic herring by these predatory fish peaked at over 200,000 metric tons (mt) during 1992 and 1993, declining to less than 100,000 mt in 1997 (Table 4.9). By far the most important predator on herring was spiny dogfish, followed by silver hake, cod, white hake, and bluefish. The declines in consumption of herring in the late 1990s were coincident with the declines in the abundance of these five species.

Read and Brownstein (2003) used survey-based estimates of abundance for eight species of marine mammals between 1991 and 1997 to estimate the total annual consumption of Atlantic herring by these species. Their estimates of marine mammal consumption ranged from about 94,000 to 190,000 mt of herring per year. Their results show that minke whales, harbor porpoises, and white-sided dolphins are major predators on Atlantic herring because of high proportions of herring (34-51%) in their diets, whereas fin and humpback whales consume large quantities of herring to sustain their large body mass. Despite a three-fold increase in the harbor seal population in the Gulf of Maine between 1981 and 1997, herring only make up 13% of their diet. Consequently, the mean consumption estimate for harbor seals is below 5,000 mt a year.

Read and Brownstein's (2003) mean (or "best") estimate of Atlantic herring consumed annually by marine mammals during 1991-1997 was about 140,000 mt, with a range of 93,000-200,000 mt. Adding these estimates to the most current (1997) estimate of 100,000 mt of Atlantic herring consumed by fish and elasmobranch predators reported by Overholtz et al. (2000) produces a total mean estimate of 240,000 mt, with a range of 193,000-300,000 mt. During the 1990s, the total amount of herring consumed by all predators could have been as high as 400-450,000 mt.

Atlantic herring stock assessments are performed using an annual 20% natural mortality rate. Biomass estimates for the most recent years (2000 and 2001) from a Canadian and U.S. assessment (0.6 and 1.8 million mt, Section 4.2.2.8) can be used to define the upper and lower population size estimates for the resource. Multiplying these numbers by 20% generates a range of 120,000 to 360,000 mt as a forage base for predators. Thus, according to the results of the U.S. assessment, the supply of herring to feed predatory fish and marine mammals is sufficient, but according to the Canadian assessment, the supply is deficient. Until more certain stock size estimates are available, this question will not be resolved.

These calculations suggest that even if the Atlantic herring resource was being fully utilized, a sufficient biomass is being reserved to feed species of finfish, elasmobranchs, and marine mammals that rely on the resource for food. That was not the case during the early 1990s when predation rates were higher (Overholtz et al. 2000) and herring were less abundant. It would also not be true if the current estimates of herring population size are too high. However, because the Atlantic herring resource is currently under-utilized (Section 4.2.2.8), a greater quantity of herring are available as food for predators than is provided by the natural mortality "reserve." Because of the uncertainty associated with the recent stock size estimate, however, the amount of "surplus" herring biomass that is currently available as forage for predators is not known.

4.2.2.6 Stock Structure

Some degree of stock differentiation was achieved with early enzyme electrophoresis research Ridgway et al. 1970, 1971), but more recent attempts to differentiate geographically isolated fall spawning stocks in eastern Canada and the northeast U.S. on the basis of genetic characteristics have been unsuccessful (Kornfield et al. 1982, Kornfield & Bogdanowicz 1987; Safford and Brooke 1992). Nevertheless, discrete spawning stocks occupy three fairly distinct locations in the Gulf of Maine region – on Georges Bank and Nantucket Shoals, in coastal waters of the Gulf of Maine, and off southwest Nova Scotia. Historically, herring that aggregate in these areas in the summer and fall to spawn have been treated as separate stocks and assessed separately. Evidence for separate stocks is based on discrete larval distribution patterns (Iles and Sinclair 1982), differences in spawning times and locations (Boyar et al. 1973, Haegele and Schweigert 1985), distinct biological characteristics - such as growth rates (Anthony and Waring 1980), meristic and morphometric characteristics (Anthony 1981, Safford 1985) - and the incidence of parasites (McGladdery and Burt 1985). Despite their differences, herring that spawn on Georges Bank, Nantucket Shoals, and in coastal waters of the Gulf of Maine, have been assessed in the U.S. as a single coastal stock complex (Section 4.2.2.8).

Each of these major spawning areas is composed of a number of smaller, discrete, spawning sites. Herring that spawn on these individual sites have been observed to have distinct age compositions and their abundance from year to year changes in response to the amount of fishing that occurs at each site. These observations tend to confirm the view that each of these areas supports a discrete spawning aggregation (or sub-stock) of herring (Stephenson 1998). Some of these discrete spawning sites are located within 10-15 miles of each other (e.g., Trinity Ledge and Lurcher Shoals, off the southwest coast of Nova Scotia).

The most compelling evidence supporting the existence of separate Gulf of Maine and Georges Bank-Nantucket Shoals stocks was the collapse of the large Georges Bank-Nantucket Shoals stock in the early 1970s after several years of heavy exploitation by foreign fishing fleets. This stock remained in a depressed state for about ten years, during which time the smaller Gulf of Maine stock continued to support a strong coastal fishery. Both of these stocks are transboundary stocks since adult herring occupy both sides of the U.S.-Canada boundary on Georges Bank and because juvenile and adult herring on the New Brunswick shore of the Bay of Fundy are believed to originate from spawning grounds in U.S. and Canadian waters (Stephenson et al. 1998).

4.2.2.7 Migrations

Adult herring make extensive seasonal migrations between summer spawning grounds on Georges Bank and in the Gulf of Maine and overwintering areas in southern New England and the mid-Atlantic region. Thermal oceanic fronts between colder, and less saline continental shelf water and, warmer, more saline continental slope water provide an abundance of plankton and other food sources and greatly influence the migratory behavior of this species (Sindermann 1979; Kelly and Moring 1986).

There are distinct migratory patterns for each spawning stock off the northeast coast of the US.

- The Nova Scotia stock spends the summer and fall months in southwest Nova Scotia and overwinters in Chedabucto Bay in northeastern Nova Scotia, but also mixes to some extent with the two southern stocks.
- The Georges Bank/ Nantucket Shoals stock overwinters south of Cape Cod, can be found feeding in the Gulf of Maine in the spring and early summer, and spawn southeast of Nantucket or on Georges Bank in the fall (Tupper et al 1998; Bigelow and Schroeder 1953; Sindermann 1979). After spawning, adults from Georges Bank move south again to overwinter, with the oldest and largest fish migrating as far south as Chesapeake Bay.
- The migration patterns of the coastal Gulf of Maine herring stock is not as well documented. It is believed that they may migrate southwest along the coast after spawning to overwinter south of Cape Cod, in Massachusetts Bay and other coastal areas of southern New England (Reid et al 1999; Tupper et al 1998). The waters off Cape Cod seem to constitute a mixing area for these stocks, where different groups pass at various times of the year (Sindermann 1979).

Migration patterns of individual herring stocks are usually persistent year to year and (Reid et al 1999; Creaser and Libby 1988). The spatial and temporal isolation of these different stocks occurs chiefly during spawning, with intermixing of these groups occurring during the non-spawning phases of migration (Reid et al 1999; Sinclair and Iles 1985; Bigelow and Schroeder 1953; Creaser et al 1984; Stobo 1983). Adults from the two U.S. stocks mix during their winter migration to southern New England and mid-Atlantic waters and separate out onto their respective spawning grounds following a return northward migration in the spring. Adults that spawn off southwest Nova Scotia (the 4WX stock) for the most part migrate north after spawning and are not believed to mix to any significant degree with herring that spawn on Georges Bank or in the Gulf of Maine (Stephenson et al. 1998).

Juvenile herring in all stocks tend to remain in coastal areas throughout the year (Stewart and Arnold 1994). Juveniles overwinter closer to the coast than adult herring, moving into the deeper waters of bays or offshore in the winter, where they stay close to the bottom (Reid et al 1999; Overholtz et al. 2004). Smaller fish have greater temperature tolerances (Brawn 1960b), and juvenile Atlantic herring have been found to produce higher levels of antifreeze proteins (AFP's) than adults, adaptations that may allow them to withstand the colder coastal waters in the winter (Bigelow and Schroeder 1953). Tagging studies have also indicated that juveniles migrate little during the summer (Overholtz et al 2004; Spiers 1977, Anthony and Waring 1980, Waring 1981, Stobo 1983). Juveniles from several populations may mix in a given area (Stewart and Arnold 1994), and aggregations of juvenile herring along the coast of Maine and New Brunswick are likely derived from a variety of spawning grounds (Overholtz et al. 2004).

4.2.2.8 Stock Status

The U.S. Atlantic herring coastal stock complex has been defined to include all herring occupying continental shelf waters over the entire range of the species between the Gulf of Maine and North Carolina, including Canadian waters on Georges Bank and in New Brunswick (Bay of Fundy) (NEFMC 1999). The stock complex comprises separate spawning components on Georges Bank, Nantucket Shoals, and in coastal waters and on nearshore banks in the Gulf of Maine (Section 4.2.1.5). The aggregation of biologically discrete spawning stocks into a single stock complex was first adopted in the fall of 1991 (NEFSC 1992) and since then has been the convention for U.S. herring assessments. The decision to combine the two stocks was based on the fact that there were insufficient data to support independent assessments for individual spawning components. The coastal Gulf of Maine stock component was defined to include juvenile herring harvested in the New Brunswick fixed gear fishery because they were believed to originate from spawning grounds located in U.S. waters, not from spawning grounds located off southwest Nova Scotia (Stephenson et al. 1995).

Because the Atlantic herring stock complex occupies U.S. and Canadian waters in the northwest Atlantic, fisheries scientists from the two countries met in February 2003 to try and reach agreement on a single stock assessment model and biological reference points (e.g., maximum sustainable yield) for this resource. Results of two models were presented. The Canadian assessment utilized a virtual population analysis (VPA) and a program called ADAPT; the U.S. assessment utilized a forward projection analysis (FPA) and a program called KLAMZ. In general, the VPA works backwards in time through a population of fish based on the latest information about age structure, and the FPA projects forwards through a population based on more sources of information, including acoustic surveys. Results of the two models were very different and no consensus was reached. Age 2+ stock biomass estimates in the two assessments are the same until about 1985 and diverge from that point onwards (Figure 4.16). According to the U.S. assessment, age 2+ biomass was about 1.8 million metric tons (mt) in 2001 while the Canadian assessment shows age 2+ biomass to be about 600,000 mt in 2002 (Overholtz et al. 2004).

At the time this DEIS was drafted, no scientifically-accepted estimate of biomass or MSY was available. No consensus was reached at the Transboundary Resource Assessment Committee (TRAC) Meeting in February 2003, and the New England Fishery Management Council’s Scientific and Statistical Committee (SSC) did not fully endorse the results of either assessment model. The SSC agreed that some level of recovery has occurred in the herring stock complex, but that it might not be at the level suggested by the U.S. assessment. They also concluded that stock size was probably not as low as suggested by the Canadian assessment. Maximum sustainable yield (MSY) estimates from the U.S. assessment were 222,000 mt or 243,000 mt, based on two alternative surplus production model formulations (Overholtz et al. 2004). The Canadian assessment did not provide reference points. The previous (1998) estimate of MSY was 317,000 mt.

The Herring PDT has recommended a “proxy” MSY of 200,000 mt and a target fishing mortality rate of 20% as the basis for management decisions that will be considered in Amendment 1 to the Atlantic Herring FMP. According to the U.S. assessment, current fishing mortality rates in the fishery are below 10%, indicating that the resource is significantly under-utilized. There is concern, however, that the inshore (Gulf of Maine) component of the stock, which is heavily exploited, is being over-harvested.

Section 4.2.2 – Tables and Figures

Table 4.8. Percentage of Atlantic herring (or “herrings”) in the diets of 15 predatory fish and elasmobranch species in the Northeast continental shelf ecosystem of the U.S.

Predator species	Size (cm)	Percent herring in diet		Years	Location	Number stomachs examined	Taxon			Source
		By wt	By vol				C. harengus	Herrings	Clupeidae	
Atlantic cod	51-120+	15		1973-1975	NE shelf	8,176 over entire time period		✓		Link & Garrison 2002
		17		1976-1980	"			✓		"
		2		1981-1985	"			✓		"
		11		1986-1990	"			✓		"
		25		1991-1998	"			✓		"
	61-70	4.4		1977-1980	"	86			✓	Bowman et al. 2000
	71-80	9.7		"	"	52			✓	"
	81-90	6.5		"	"	91			✓	"
Silver hake	<20		4	1973-1997	NE shelf	8,722	✓		✓	Garrison & Link 2000
	20-50		9	"	"	26,070	✓		✓	"
	>50		25	"	"	1,037	✓		✓	"
	26-30	4.0		1977-1980	"	323	✓		✓	Bowman et al. 2000
	31-35	11.1		"	"	373	✓			"
	41-45	20.5		"	"	72	✓		✓	"
	>45	23.3		"	"	75	✓		✓	"
Summer flounder	41-45	5.5		1977-1980	NE shelf	80			✓	Bowman et al. 2000
	56-60	13.4		"	"	44			✓	"
	Mean=36	8		1990-2000	"	na		✓		Link et al. 2002b
Atlantic halibut	41-50	11.1		1977-1980	"	26			✓	Bowman et al. 2000
	Mean=58	4		1973-1998	"	155		✓		Link et al. 2002b
Spiny dogfish	51-60	2.5		1977-1980	NE shelf	235			✓	Bowman et al. 2000
	61-70	1.6		"	"	207			✓	"
	71-80	8.3		"	"	697	✓		✓	"
	81-90	0.3		"	"	368			✓	"
	91-100	1.3		"	"	423	✓			"
White hake	20-50+		20	1991-1997	"	na	✓		✓	Garrison & Link 2000
	20-50		2	1973-1997	"	5,341	✓		✓	"
	>50		13	"	"	6,049	✓		✓	"

Red hake	>50		2	"	"	1,713			✓	"
Bluefin tuna	Mean=221	87.2		1988-1992	Jeffreys Ledge	147	✓			Chase 2002
	Mean=221	48.4		"	Great South Channel	210	✓			"
	Mean=240	6		"	Stellwagen Bank	111	✓			"
	Mean=251	3.1		"	Cape Cod Bay	273	✓			"
	Mean=124	2.5		"	South of Martha’s Vineyard	57	✓			"
Bluefish	“Adults”	11.3		1994	Georges Bank	50	✓			Buckel et al. 1999
	"	17.6		1995	"	44	✓			
	21-30	2.7		1977-1980	NE shelf	239			✓	Bowman et al. 2000
	31-40	2.3		"	"	71	✓			"
Striped bass	30-120	3.4		1997-2000	North shore MA	1,536	✓			Nelson et al. 2003
	25-120	0.2		"	Cape Cod Bay	1,019	✓			
	30-120	0		"	Nantucket Sound	451	✓			
Dusky shark	91-100	1.5		1977-1980	NE shelf	18			✓	Bowman et al. 2000
Thorny skate	61-70	36.5		"	"	36	✓			"
	71-80	25.5		"	"	42	✓			"
	>90	20.8		"	"	18	✓			"
Goosefish	51-60	1.9		"	"	104			✓	"
	81-90	1.2		"	"	86			✓	"
	>90	15.0		"	"	103	✓		✓	"
Black sea bass	21-25	2.3		"	"	188	✓			"
Weakfish	21-30	11.2		"	"	196			✓	"

Table 4.9. Annual consumption estimates (metric tons) of Atlantic herring by finfish, elasmobranchs, and marine mammal predators.

Fish and Elasmobranch Predators		Marine Mammal Predators	
Species	Estimated Annual Consumption, 1977-1997	Species	Estimated Annual Consumption, 1991-1997
Spiny Dogfish	36,000-214,000	Fin Whale	16,081-62,362
Silver Hake	11,500-36,000	Minke Whale	11,648-22,108
Georges Bank Cod	1,900-13,000	Humpback Whale	31,046-35,507
White Hake	500-20,000	Pilot Whale	149-512
Bluefish	500-13,600	Harbor Porpoise	20,863-27,655
Fluke	200-3,100	White-sided Dolphin	7,852-35,591
Pollock	200-3,100	Harbor Seal	4,853
Red Hake	200-3,100	Gray Seal	1,310
Goosefish	200-3,100		
Winter Skate	200-3,100		
Gulf of Maine Cod	200-3,100		
	Estimated Annual Consumption, 1977-1998		
Spiny Dogfish	15,526-148,197 (mean = 67,660)		
Winter Skate	20-2,329 (mean = 928)		

Sources: Overholtz et al. 2000 (finfish and elasmobranchs, 1977-1997), Link et al. 2002a (finfish and elasmobranchs, 1977-1998), Read and Brownstein 2003 (marine mammals).

Figure 4.13. Adult herring distribution in estuaries and embayments south of Cape Cod.

Month: **Bay:**	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Buzzards Bay	x	x	x	x	x					x	x	x
Narragansett Bay	**x**	**x**	**x**	**x**	x	x	x	x	x	x	x	x
Long Island Sound	**x**	**x**	**x**	**x**	**x**	x	x	x	x	**x**	**x**	**x**
Gardiners Bay			x	x	x	x	x	x				
Great South Bay	**x**	**x**	x								**x**	**x**
Hudson River/ Raritan Bay	x	x	x	x	x							
Barnegat Bay	x	x								x	x	x
New Jersey Inland Bays	x	x								x	x	x
Delaware Bay	x	x								x	x	x
Chesapeake Bay	x	x	x	x	x						x	x

Common: x Abundant: **x**

Sources: Stone et al. 1994 and Jury et al. 1994

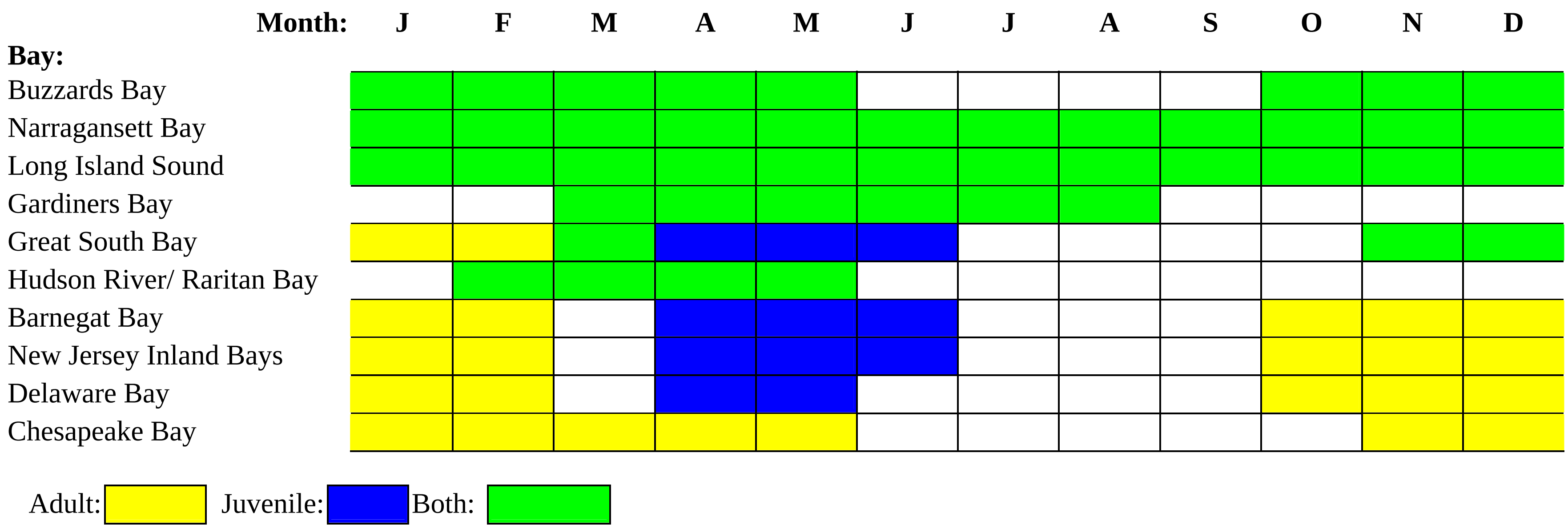
Figure 4.14. Juvenile herring distribution in estuaries and embayments south of Cape Cod.

Month:	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Bay:												
Buzzards Bay	x	x	x	x	x					x	x	x
Narragansett Bay	x	x	x	x	x	x	x	x	x	x	x	x
Long Island Sound	x	x	x	x	x	x	x	x	x	x	x	x
Gardiners Bay			x	x	x	x	x	x				
Great South Bay			x	x	x	x					x	x
Hudson River/ Raritan Bay	x	x	x	x	x							
Barnegat Bay				x	x	x						
New Jersey Inland Bays				x	x	x						
Deleware Bay				x	x							

Common: x   Abundant: **x**

Sources: Stone et al. 1994 and Jury et al. 1994

Figure 4.15. Juvenile and adult herring distribution in estuaries and embayments south of Cape Cod.



Bay: / **Month:**	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Buzzards Bay	🟩	🟩	🟩	🟩	🟩					🟩	🟩	🟩
Narragansett Bay	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
Long Island Sound	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
Gardiners Bay			🟩	🟩	🟩	🟩	🟩	🟩				
Great South Bay	🟨	🟨	🟩	🟦	🟦	🟦					🟩	🟩
Hudson River/ Raritan Bay		🟩	🟩	🟩	🟩							
Barnegat Bay	🟨	🟨		🟦	🟦	🟦				🟨	🟨	🟨
New Jersey Inland Bays	🟨	🟨		🟦	🟦	🟦				🟨	🟨	🟨
Delaware Bay	🟨	🟨		🟦	🟦					🟨	🟨	🟨
Chesapeake Bay	🟨	🟨	🟨	🟨	🟨						🟨	🟨

Adult: 🟨 Juvenile: 🟦 Both: 🟩

Sources: Stone et al. 1994 and Jury et al. 1994

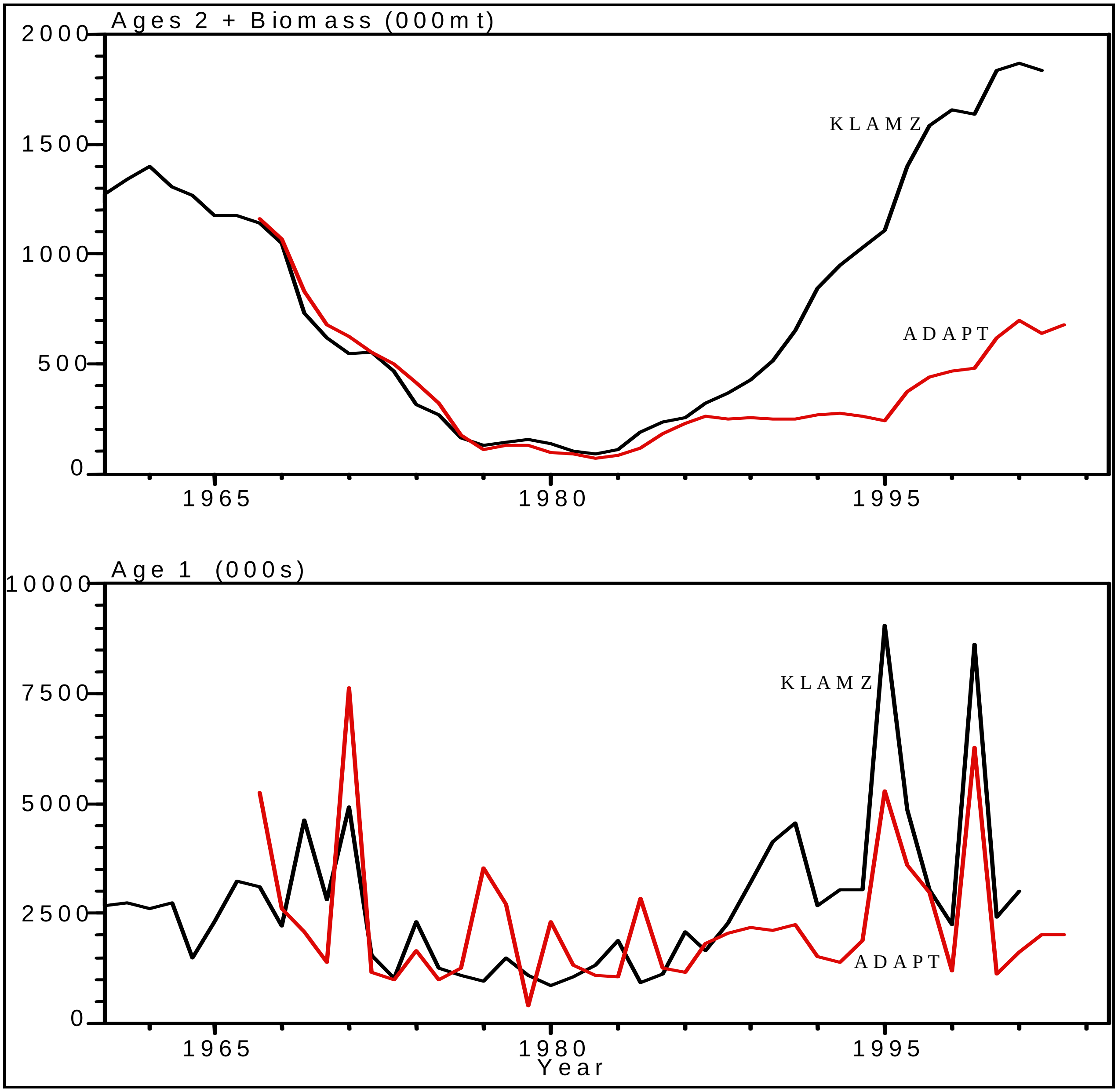


Figure 4.16. Herring Biomass Estimates Resulting from the US (KLAMZ) and Canadian (ADAPT) Assessment Models.

Source: Overholtz et al. 2004.

4.2.3 Protected Species

The following list of species protected either by the Endangered Species Act of 1973 (ESA), the Marine Mammal Protection Act of 1972 (MMPA), or the Migratory Bird Act of 1918 (MBA) may be found in the environment utilized by the U.S. Atlantic herring fishery and therefore may be affected by the management measures that are proposed in this EIS.

Cetaceans

Northern right whale (*Eubalaena glacialis*)	MMPA/ESA (endangered)
Humpback whale (*Megaptera novaeangliae*)	MMPA/ESA (endangered)
Fin whale (*Balaenoptera physalus*)	MMPA/ESA (endangered)
Blue whale (*Balaenoptera musculus*)	MMPA/ESA (endangered)
Sei whale (*Balaenoptera borealis*)	MMPA/ESA (endangered)
Sperm whale (*Physeter macrocephalus*)	MMPA/ESA (endangered)
Minke whale (*Balaenoptera acutorostrata*)	MMPA
Harbor porpoise (*Phocoena phocoena*)	MMPA
Risso's dolphin (*Grampus griseus*)	MMPA
Long-finned pilot whale (*Globicephala melas*)	MMPA
Short-finned pilot whale (*Globicephala macrorhynchus*)	MMPA
White-sided dolphin (*Lagenorhynchus acutus*)	MMPA
Common dolphin (*Delphinus delphis*)	MMPA
Atlantic spotted dolphin (*Stenella frontalis*)	MMPA
Striped dolphin (*Stenella coeruleoalba*)	MMPA
White-beaked dolphin (*Lagenorhynchus albirostris)*	MMPA
Bottlenose dolphin (*Tursiops truncatus*)	MMPA

Seals

Harbor seal (*Phoca vitulina*)	MMPA
Gray seal (*Halichoerus grypus*)	MMPA
Harp seal (*Phoca groenlandica*)	MMPA
Hooded seal	MMPA
Harbor porpoise	ESA (candidate)

Sea Turtles

Leatherback sea turtle (*Dermochelys coriacea*)	ESA (endangered)
Kemp's ridley sea turtle (*Lepidochelys kempii*)	ESA (endangered)
Green sea turtle (*Chelonia mydas*)	ESA (threatened/endangered)
Loggerhead sea turtle (*Caretta caretta*)	ESA (threatened)

Fish

Shortnose sturgeon (*Acipenser brevirostrum*)	ESA (endangered)
Atlantic salmon (*Salmo salar*)	ESA (endangered)
Barndoor skate (*Dipturus laevis*)	ESA (candidate sp)

Birds

Roseate tern (*Sterna dougallii dougallii*)	MBA (endangered species)

Piping plover (*Charadrius melodus*)	MBA (endangered)

Although these species all occur in the U.S. Northeast region, they may not all interact with the Atlantic herring fishery for several different reasons. Some protected species may inhabit more inshore or offshore areas than those affected by the fishery, prefer a different depth or temperature zone, or may occupy the area affected by the fishery at times of year when fishing is being conducted elsewhere or not at all. Seasonal distributions of protected species in the NE region are particularly important for evaluating the potential impacts of the herring fishery because the fishery operates in the Gulf of Maine and on Georges Bank in the spring, summer, and fall and in southern New England and the Mid-Atlantic region in the winter, in response to the seasonal migrations of adult herring (Section 4.2.2.7). Inshore-offshore distribution patterns of protected species are not so important because the Atlantic herring fishery is a highly mobile fishery and operates in nearshore as well as offshore waters on the edge of the continental shelf. In addition, although a protected species may be vulnerable to capture or entanglement in certain types of fishing gear, it may not be vulnerable to capture or entanglement in the gears used in the herring fishery. The two gears of primary concern in this evaluation are mid-water trawls and purse seines, since these are the two gears used in the directed herring fishery in federal waters.

Therefore, we have broken out the above species list into two groups. The first group contains those species not likely to be affected by any of the management measures proposed in this EIS. The second group includes the species that could potentially be affected by the management measures considered in this EIS. The second group was evaluated in terms of the probability that they could be taken as incidental by-catch in herring mid-water trawls and purse seines. A key factor in the analysis was by-catch data for fisheries in the NE region that currently utilize, or have utilized in the past, these two gears. However, the absence of any documented by-catch of protected species in mid-water trawls and purse seines was not accepted as evidence that the Atlantic herring fishery could not take these species. Any species that inhabits the same general geographic range as the fishery at the same time of year was considered to potentially be affected.

4.2.3.1 Protected Species Not Likely To Be Affected

Species that are not likely to be affected by any of the management measures being considered in this EIS are the shortnose sturgeon, the Gulf of Maine distinct population segment (DPS) of Atlantic salmon, barndoor skates, roseate terns, piping plovers, the hawksbill sea turtle, and the blue whale. Critical habitats for the Atlantic right whale are also not likely to be affected. The reasons for these determinations are given below.

Shortnose Sturgeon

The shortnose sturgeon is benthic fish that mainly occupies the deep channel sections of several Atlantic coast rivers. They can be found in most major river systems from St. Johns River, Florida to the Saint John River in New Brunswick, Canada. The species is considered truly anadromous in the southern portion of its range (*i.e.*, south of Chesapeake Bay). However, they spend the majority of their life history within the fresh water sections of the northern rivers with only occasional forays into salt water, and are thus considered to be “freshwater amphidromous” (NMFS 1998a).

Atlantic Salmon

The wild populations of Atlantic salmon found in rivers and streams from the lower Kennebec River north to the U.S.-Canada border are considered to be endangered. These rivers include the Dennys, East Machias, Machias, Pleasant, Narraguagus, Ducktrap, and Sheepscot Rivers and Cove Brook. Atlantic salmon are anadromous, with spawning and juvenile rearing occurring in freshwater rivers followed by migration to the marine environment. Juvenile salmon in New England rivers typically migrate to sea in May after a two to three year period of development in freshwater streams, and remain at sea for two winters before returning to their U.S. natal rivers to spawn from mid October through early November. While at sea, salmon generally undergo an extensive northward migration to waters off Canada and Greenland. BJuvenile salmon “smolts” are vulnerable to capture in the herring fishery during their seaward migration, but there is no clear evidence that this is occurring.

Barndoor Skate

Barndoor skate is considered a candidate species under the ESA as a result of two petitions to list the species as endangered or threatened that were received in March and April 1999. In June 1999, the agency declared the petitioned actions to be warranted and requested additional information on whether or not to list the species under the ESA. At the 30th Stock Assessment Workshop (SAW 30) held in November 1999, the Stock Assessment Research Committee (SARC) reviewed the status of the barndoor skate stock relative to the five listing criteria of the ESA. The SARC provided their report to the NMFS in the SAW 30 document (NEFSC 2000a). NMFS published a decision on the petitions on September 27, 2002 (67FR61055-61061) that the petitioned actions are not warranted at this time. However, NMFS is leaving barndoor skate on the agency’s list of candidate species due to remaining uncertainties regarding the status and population structure of the species.

The barndoor skate occurs from Newfoundland, the Gulf of St. Lawrence, off Nova Scotia, the Gulf of Maine, and the northern sections of the Mid-Atlantic Bight down to North Carolina. It is one of the largest skates in the Northwest Atlantic and is presumed to be a long-lived, slow growing species. Barndoor skates inhabit mud and sand/gravel bottoms along the continental shelf, generally at depths greater than 150 meters. They are believed to feed on benthic invertebrates and fishes (Bigelow and Schroeder 1953).

Roseate Tern and Piping Plover

The roseate tern and piping plover inhabit coastal waters and nest on coastal beaches within the Northeast Region. The terns prey on small schooling fishes, and the plovers prey on shoreline invertebrates and other small fauna. Foraging activity for these species occurs either along the shoreline (plovers) or within the top several meters of the water column (terns).

Blue Whale

Blue whales occur worldwide and are believed to follow a similar migration pattern from northern summering grounds to more southern wintering areas (Perry et al. 1999). Three subspecies have been identified: *Balaenoptera musculus musculus, B.m. intermedia*, and *B.m. brevicauda* (NMFS 1998c). Only *B. musculus* occurs in the northern hemisphere. Blue whales range in the North Atlantic from the subtropics to Baffin Bay and the Greenland Sea. The IWC currently recognizes these whales as one stock (Perry et al. 1999).

Blue whales are only occasional visitors to east coast U.S. waters. They are more commonly found in Canadian waters, particularly the Gulf of St. Lawrence where they are present for most of the year, and in other areas of the North Atlantic. It is assumed that blue whale distribution is governed largely by food requirements (NMFS 1998b). In the Gulf of St. Lawrence, blue whales appear to predominantly feed on several copepod species (NMFS 1998b).

Entanglements in fishing gear such as the sink gillnet gear and ship strikes are believed to be the major sources of anthropogenic mortality and injury of blue whales. However, confirmed deaths or serious injuries are few. In 1987, concurrent with an unusual influx of blue whales into the Gulf of Maine, one report was received from a whale watch boat that spotted a blue whale in the southern Gulf of Maine entangled in gear described as probable lobster pot gear. A second animal found in the Gulf of St. Lawrence apparently died from the effects of an entanglement. In March 1998, a juvenile male blue whale was carried into Rhode Island waters on the bow of a tanker. The cause of death was determined to be due to a ship strike that may have occurred outside the U.S. EEZ (Waring et al. 2001).

Right Whale Critical Habitat

NMFS designated three right whale critical habitat areas on June 3, 1994 (59 FR 28793) to help protect important right whale foraging and calving areas within the U.S. These areas are: Cape Cod Bay; the Great South Channel (both off Massachusetts); and the waters adjacent to the southern Georgia and northern Florida coast. The only way that herring fishing gear could possibly affect pelagic right whale habitat is by reducing the amount of planktonic food available for the whales. Because this is not possible, it is concluded that none of the management measures proposed in this EIS will affect critical right whale habitats in U.S. waters.

4.2.3.2 Protected Species Potentially Affected by this EIS

The potential impacts to protected species that may result from the management measures being considered in this EIS are evaluated in the cumulative impacts section (Section 8) of this document. This section of the EIS focuses on the species that are found in the NE region that may be affected by the Atlantic herring fishery. The primary information presented in the following evaluations is the range of the species – with an emphasis on the NE region of the U.S. (Maine to North Carolina) – its seasonal occurrence in the region, and a summary of reported by-catch information for different types of commercial fishing gear and fisheries – with an emphasis on mid-water trawls and purse seines. Additional background information on the range-wide status of these species can be found in a number of published documents, including sea turtle status reviews (NMFS and USFWS 1995, Marine Turtle Working Group - TEWG, 1998, 2000) and biological reports (USFWS 1997), recovery plans for the humpback whale (NMFS 1991a), right whale (NMFS 1991b), Kemp’s Ridley sea turtle (USFWS and NMFS 1992), Atlantic green sea turtle (NMFS and USFWS 1991a), leatherback sea turtle (NMFS and USFWS 1992) and loggerhead sea turtle (NMFS and USFWS 1991b), and several Marine Mammal Stock Assessment Reports (Waring et al. 1996, 2000, and 2002). Primary reference sources are cited when appropriate.

Northern Right Whale

Right whales were found historically in all the world's oceans within the temperate to sub arctic latitudes. There are three major subdivisions of right whales: North Pacific, North Atlantic, and Southern Hemisphere, with eastern and western subunits found in the North Atlantic (Perry et al. 1999).

Right whales appear to prefer shallow coastal waters, but their distribution is also strongly correlated to zooplankton prey distribution (Winn et al. 1986). In both northern and southern hemispheres, right whales are observed in the lower latitudes and more coastal waters during winter, where calving takes place, and then migrate to higher latitudes during the summer. In the western North Atlantic, they are found west of the Gulf Stream and are most commonly associated with cooler waters (<21º C).

Right whales feed on zooplankton through the water column, and in shallow waters may feed near the bottom. In the Gulf of Maine, they have been observed feeding primarily on copepods, by skimming at or below the water's surface with open mouths (NMFS 1991b; Kenney et al. 1986; Murison and Gaskin 1989; and Mayo and Marx 1990). Research suggests that right whales must locate and exploit extremely dense patches of zooplankton to feed efficiently (Waring et al. 2001). New England waters include important foraging habitat for right whales and at least some portion of the right whale population is present in these waters throughout most months of the year. They are most abundant in Cape Cod Bay between February and April (Hamilton and Mayo 1990; Schevill et al. 1986; Watkins and Schevill 1982) and in the Great South Channel in May and June (Kenney et al. 1986; Payne et al. 1990) where they have been observed feeding predominantly on copepods, largely of the genera *Calanus* and *Pseudocalanus* (Waring et al. 2001). Right whales also frequent Stellwagen Bank and Jeffrey's Ledge, as well as Canadian waters including the Bay of Fundy and Browns and Baccaro Banks, in the spring and summer months. Mid-Atlantic waters are used as a migratory pathway from the spring and summer feeding/nursery areas to the winter calving grounds off the coast of Georgia and Florida.

However, much about right whale movements and habitat use are still unknown. Approximately 85% of the population is unaccounted for during the winter (Waring et al. 2001). Radio and satellite tagging has been used to track right whales, and has shown lengthy and somewhat distant excursions into deep water off the continental shelf (Mate et al. 1997). In addition photographs of identified individuals have documented movements of the western North Atlantic right whales as far north as Newfoundland, the Labrador Basin and southeast of Greenland (Knowlton et al. 1992). Sixteen satellite tags were attached to right whales in the Bay of Fundy, Canada, during summer 2000 in an effort to further elucidate the movements and important habitat for North Atlantic right whales. The movements of these whales varied, with some remaining in the tagging area and others making periodic excursions to other areas before returning to the Bay of Fundy. Several individuals were observed to move along the coastal waters of Maine, while others traveled to the Scotian Shelf off Nova Scotia. One individual was successfully tracked throughout the fall, and was followed on her migration to the Georgia/Florida wintering area.

Right whales may be adversely affected by habitat degradation, habitat exclusion, acoustic trauma, harassment, or reduction in prey resources due to trophic effects resulting from a variety of activities including the operation of commercial fisheries. However, the major known sources of anthropogenic mortality and injury of right whales clearly are ship strikes and entanglement in commercial fishing gear such as sink gillnets and lobster traps. There are no known reports of interactions with herring fishing activities.

Humpback Whale

Humpback whales calve and mate in the West Indies and migrate to feeding areas in the northwestern Atlantic during the summer months. Six separate feeding areas are utilized in northern waters (Waring et al. 2001). Only one of these feeding areas, the Gulf of Maine, lies within U.S. waters contained within the management unit of the FMP (Northeast Region). Most of the humpbacks that forage in the Gulf of Maine visit Stellwagen Bank and the waters of Massachusetts and Cape Cod Bays. Sightings are most frequent from mid-March through November between 41° N and 43° N, from the Great South Channel north along the outside of Cape Cod to Stellwagen Bank and Jeffreys Ledge (CeTAP 1982), and peak in May and August. However, small numbers of individuals may be present in this area year-round. They feed on a number of species of small schooling fishes, particularly sand lance and Atlantic herring, by filtering large amounts of water through their baleen to capture prey (Wynne and Schwartz 1999).

Humpback whales use the mid-Atlantic as a migratory pathway. However, observations of juvenile humpbacks since 1989 in the mid-Atlantic have been increasing during the winter months, peaking January through March (Swingle et al. 1993). Biologists theorize that non-reproductive animals may be establishing a winter-feeding range in the mid-Atlantic since they are not participating in reproductive behavior in the Caribbean. The whales using this mid-Atlantic area were found to be residents of the Gulf of Maine and Atlantic Canada (Gulf of St. Lawrence and Newfoundland) feeding groups, suggesting a mixing of different feeding stocks in the mid-Atlantic region. Strandings and entanglements of humpback whales have increased between New Jersey and Florida during the same period (Wiley et al. 1995).

The major known sources of anthropogenic mortality and injury of humpback whales include entanglement in commercial fishing gear such as sink gillnets and lobster traps, and ship strikes. Based on photographs of the caudal peduncle of humpback whales, Robbins and Mattila (1999) estimated that between 48% and 78% of animals in the Gulf of Maine exhibit scarring caused by entanglement. Several whales have apparently been entangled on more than one occasion. These estimates are based on sightings of free-swimming animals that initially survive the encounter. The most recent data describing the observed entanglements of humpback whales is found in Table 64. Because some whales may drown immediately, the actual number of interactions may be higher. In addition, the actual number of species-gear interactions is contingent on the intensity of observations from aerial and ship surveys.

Humpback whales may also be adversely affected by habitat degradation, habitat exclusion, acoustic trauma, harassment, or reduction in prey resources due to trophic effects resulting from a variety of activities including the operation of commercial fisheries. There are no known reports of interactions with gears used in the directed herring fishery.

Fin Whale

Fin whales inhabit a wide range of latitudes between 20-75° N and 20-75° S (Perry et al. 1999). Fin whales spend the summer feeding in the relatively high latitudes of both hemispheres, particularly along the cold eastern boundary currents in the North Atlantic and North Pacific Oceans and in Antarctic waters (IWC 1992). Most migrate seasonally from relatively high-latitude Arctic and Antarctic feeding areas in the summer to relatively low-latitude breeding and calving areas in the winter (Perry et al. 1999).

Despite our broad knowledge of fin whales, less is known about their life history as compared to right and humpback whales. Based on acoustic recordings from hydrophone arrays, Clark (1995) reported the fin whale as the most acoustically common whale species heard in the North Atlantic and described a general pattern of fin whale movements in the fall from the Labrador/Newfoundland region, south past Bermuda, and into the West Indies. However, evidence regarding where the majority of fin whales winter, calve, and mate is still scarce.

The overall distribution of fin whales may be based on prey availability. This species preys opportunistically on both zooplankton and fish (Watkins et al. 1984). The predominant prey of fin whales varies greatly in different geographical areas depending on what is locally available. In the western North Atlantic fin whales feed on a variety of small schooling fish (i.e., herring, capelin, sand lance) as well as squid and planktonic crustaceans (Wynne and Schwartz 1999). As with humpback whales, fin whales feed by filtering large volumes of water for their prey through their baleen plates. Photo identification studies in western North Atlantic feeding areas, particularly in Massachusetts Bay, have shown a high rate of annual return by fin whales, both within years and between years (Seipt et al. 1990).

The major known sources of anthropogenic mortality and injury of fin whales include ship strikes and entanglement in commercial fishing gear such as sink gillnets and lobster traps. However, many of the reports of mortality cannot be attributed to a particular source. Of 18 fin whale mortality records collected between 1991 and 1995, four were associated with vessel interactions, although the true cause of mortality was not known. Although several fin whales have been observed entangled in fishing gear, with some being disentangled, no mortalities have been attributed to gear entanglement.

In general, known mortalities of fin whales are less than those recorded for right and humpback whales. This may be due in part to the more offshore distribution of fin whales where they are either less likely to encounter entangling gear, or are less likely to be noticed when gear entanglements or vessel strikes do occur. Fin whales may also be adversely affected by habitat degradation, habitat exclusion, acoustic trauma, harassment, or reduction in prey resources due to trophic effects resulting from a variety of activities including the operation of commercial fisheries. There are no known reports of interactions with herring fishing vessels or gear.

Sei Whale

Sei whales are a widespread species in the world’s temperate, subpolar and subtropical and even tropical marine waters. However, they appear to be more restricted to temperate waters than other balaenopterids (Perry et al. 1999). The IWC recognized three stocks in the North Atlantic based on past whaling operations: (1) Nova Scotia; (2) Iceland Denmark Strait; (3) Northeast

Atlantic (Donovan 1991 *in* Perry et al. 1999). Mitchell and Chapman (1977) suggested that the sei whale population in the western North Atlantic consists of two stocks, a Nova Scotian Shelf stock and a Labrador Sea stock. The Nova Scotian Shelf stock includes the continental shelf waters of the Northeast Region, and extends northeastward to south of Newfoundland. The IWC boundaries for this stock are from the U.S. east coast to Cape Breton, Nova Scotia and east to 42°W longitude (Waring et al. 2001). This is the only sei whale stock within the management unit of this FMP.

Sei whales winter in warm temperate or subtropical waters and summer in more northern latitudes. Sei whales occur in deep water throughout their range, typically over the continental slope or in basins situated between banks (NMFS 1998c). In the northwest Atlantic, the whales travel along the eastern Canadian coast in autumn on their way to and from the Gulf of Maine and Georges Bank where they occur in winter and spring. Within the Northeast Region, the sei whale is most common on Georges Bank and into the Gulf of Maine/Bay of Fundy region during spring and summer. Individuals may range as far south as North Carolina. It is important to note that sei whales are known for inhabiting an area for weeks at a time then disappearing for year or even decades. This has been observed all over the world, including in the southwestern Gulf of Maine in 1986, but the basis for this phenomenon is not clear.

Although sei whales may prey upon small schooling fish and squid in the Northeast Region, available information suggests that calanoid zooplankton are the primary prey of this species. There are occasional influxes of sei whales further into Gulf of Maine waters, presumably in conjunction with years of high copepod abundance inshore. Sei whales are occasionally seen feeding in association with right whales in the southern Gulf of Maine and in the Bay of Fundy, although there is no evidence of interspecific competition for food resources. There is very little information on natural mortality factors for sei whales. Possible causes of natural mortality, particularly for young, old or otherwise compromised individuals are shark attacks, killer whale attacks, and endoparasitic helminthes (Perry et al. 1999).

Few instances of injury or mortality of sei whales due to entanglement or vessel strikes have been recorded in U.S. waters. Entanglement is not known to impact this species in the U.S. Atlantic, possibly because sei whales typically inhabit waters further offshore than most commercial fishing operations, or perhaps entanglements do occur but are less likely to be observed. A small number of ship strikes of this species have been recorded, the most recent documented incident occurring in 1994 when a carcass was brought in on the bow of a container ship in Charlestown, Massachusetts. No entanglements in fishing gear have been observed or noted in stranding data. Similar impacts noted above for other baleen whales may also occur. Due to the deep-water distribution of this species, interactions that do occur are less likely to be observed or reported than those involving right, humpback, and fin whales that often frequent areas within the continental shelf. There are no known reports of interactions with the herring fishery.

Sperm Whale

Sperm whales inhabit all ocean basins, from equatorial waters to the polar regions (Perry et al. 1999). In the western North Atlantic they range from Greenland to the Gulf of Mexico and the

Caribbean. The sperm whales that occur in the western North Atlantic are believed to represent only a portion of the total stock.

Sperm whales generally occur in waters greater than 180 meters in depth with a preference for continental margins, seamounts, and areas of upwelling, where food is abundant (Leatherwood and Reeves 1983). Sperm whales in both hemispheres migrate to higher latitudes in the summer for feeding and return to lower latitude waters in the winter where mating and calving occur. Mature males typically range to higher latitudes than mature females and immature animals but return to the lower latitudes in the winter to breed (Perry et al. 1999). Waring et al. (1993) suggest sperm whale distribution is closely correlated with the Gulf Stream edge with a migration to higher latitudes during summer months where they are concentrated east and northeast of Cape Hatteras. Distribution extends further northward to areas north of Georges Bank and the Northeast Channel region in summer and then south of New England in fall, back to the mid-Atlantic Bight (Waring et al. 2001).

Few instances of injury or mortality of sperm whales due to human impacts have been recorded in U.S. waters. Because of their generally more offshore distribution and their benthic feeding habits, sperm whales are less subject to entanglement than are right or humpback whales. Documented takes primarily involve offshore fisheries such as the offshore lobster pot fishery and pelagic driftnet and pelagic longline fisheries. Ships also strike sperm whales. Due to the offshore distribution of this species, interactions (both ship strikes and entanglements) that do occur are less likely to be reported than those involving right, humpback, and fin whales that more often occur in near shore areas. Other impacts noted above for baleen whales may also occur. There are no known reports of interactions with the herring fishery.

Minke Whale

Minke whales have a cosmopolitan distribution in polar, temperate, and tropical waters. The Canadian east coast population is one of four populations recognized in the North Atlantic (Donovan 1991). Minke whales off the eastern coast of the U.S. are considered to be part of this population that extends from Davis Strait off Newfoundland to the Gulf of Mexico (Waring et al. 2002). This species is common and widely distributed within the U.S. Atlantic EEZ (CETAP 1982). They are relatively widespread and common in the spring and summer, when they are also most abundant in New England waters. There are fewer minke whales in New England waters in the fall, and they are largely absent in the winter. Like all baleen whales, the minke whale generally occupies the continental shelf proper, rather than the edge of the shelf (Waring et al. 2002). Recent assessments (1999) for the Georges Bank/Gulf of St. Lawrence area indicated that the minke whale population was about 4,000 (Waring et al. 2002). No population trends are available at this time. This species is protected under the Marine Mammal Protection Act and is not considered endangered or threatened.

Minke whales takes or entanglements have been observed or attributed to purse seines, lobster traps, gillnets, and other unknown fisheries (Waring et al. 2002). Two minkes were caught and released uninjured in Atlantic tuna purse seines in the Gulf of Maine during the 1990s. Read (1994) reported interactions between minke whales and herring weirs in the Bay of Fundy. In almost all cases, the whales were released alive and unharmed. This species has not been observed in Atlantic herring mid-water or purse seine catches.

Long-finned Pilot Whale

There are two species of pilot whale in the Western Atlantic. The long-finned pilot whale generally occurs north of the New Jersey- Cape Hatteras area (Waring et al. 2002). They are distributed principally along the continental shelf edge in the winter and early spring off the northeast U.S. coast (CETAP 1982; Payne and Heinemann 1993). In late spring, pilot whales move onto Georges Bank and into the Gulf of Maine and more northern waters and remain in these areas through late autumn. In general, pilot whales occupy areas of high relief or submerged banks. This species of whale eats herring (Olson and Reilly 2002).

During 1977-1991, observers recorded 436 pilot whales taken in foreign-fishing activities in the U.S. EEZ (Waring et al. 1990; Waring 1995). A total of 391 (90%) were taken in the mackerel fishery and included takes by U.S. vessels participating in joint venture fishing operations. The foreign and JV mackerel fishery primarily utilized mid-water trawls (ref). Due to temporal fishing restrictions, the bycatch occurred during winter and spring (December to May) in continental shelf and continental shelf edge waters (Fairfield et al. 1993; Waring 1995), i.e., at the same time of year when the Atlantic herring mid-water trawl fishery currently operates in the mid-Atlantic and southern New England regions. Four fishery-related mortalities of pilot whales were reported in the U.S. mid-Atlantic mackerel trawl fishery during the 1990s (Waring et al. 2002). Twelve pilot whales were taken in the joint venture mackerel mid-water trawl fishery in the mid-Atlantic during 2001 (data provided to NEFMC for Amendment 1 to the Atlantic Herring FMP). The mackerel, squid, butterfish trawl fishery is a Category II fishery.[1]

Bycatch of pilot whales has also been observed in the pelagic drift gillnet, pelagic longline, pelagic pair trawl, bluefin purse seine, North Atlantic bottom trawl, Atlantic squid, mackerel, butterfish trawl, and mid-Atlantic coastal gillnet fisheries (Waring et al. 2002). Eighteen pilot whale (*Globicephala* sp.) mortalities were reported in the pelagic pair trawl tuna fishery in the mid-Atlantic during 1993-1995. Pilot whales were observed inside purse seine sets made for tuna on Georges Bank in 1996. On one occasion a single whale was encircled and escaped alive. On the other, five whales were released, apparently uninjured (Waring et al. 2002). Pilot whales have also been observed in mid-water trawl catches off the coast of Nova Scotia (Waring et al. 2002).

Long-finned pilot whales inhabit the area utilized by the Atlantic herring fishery at the time of year when the fishery is active (winter in the mid-Atlantic, summer and fall on Georges Bank and in the Gulf of Maine), are relatively small, and feed on herring. Although there have been no observed or reported captures of pilot whales in herring fishing gear, this species has been taken in comparable gear types used in other fisheries and is therefore potentially affected by the Atlantic herring fishery as a result of capture in herring mid-water trawls and purse seines.

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[1] A category II fishery is defined as “a commercial fishery determined by the Assistant Administrator to have occasional incidental mortality and serious injury of marine mammals” (50 CFR 229.2).

Risso's Dolphin

The Risso's dolphin is distributed along the continental shelf edge of North America from Cape Hatteras to Georges Bank during the spring, summer, and autumn (CETAP 1982; Payne et al. 1984). In general, the population occupies the mid-Atlantic and southern New England shelf edge year round, and is rarely seen in the Gulf of Maine (Payne et al. 1984). This species has been observed taken in the pelagic drift gillnet and pelagic longline fisheries (Waring et al. 2002). One mortality was reported in 1992 in the Mid-Atlantic tuna pair trawl fishery. This fishery no longer exists. This species has not been observed in Atlantic herring mid-water or purse seine catches.

Atlantic Spotted Dolphins

This species is distributed in tropical and warm temperate waters of the western North Atlantic (Leatherwood et al. 1976). They occur from southern New England through the Gulf of Mexico and the Caribbean. Off the northeast U.S. coast, spotted dolphins are widely distributed on the continental shelf, along the edge of the shelf, and over the deep ocean south of 40°N (CETAP 1982). They regularly occur in inshore waters south of Chesapeake Bay and near the continental shelf edge and continental slope waters north of this region (Payne et al. 1984). Bycatch has been observed in the drift gillnet and pelagic longline fisheries, but no mortalities or serious injuries were documented in the tuna pair trawl fishery while it was operating during the 1990s (Waring et al. 2000). This species has not been observed in Atlantic herring mid-water or purse seine catches.

Striped Dolphins

This species is distributed worldwide in warm-temperate to tropical seas (Archer and Perrin 1997). In the western North Atlantic, striped dolphins are found from Nova Scotia to the Gulf of Mexico. They appear to prefer continental slope waters offshore to the Gulf Stream (Leatherwood et al. 1976; Perrin et al. 1994; Schmidly 1981). In waters of the northeastern U.S., they are distributed along the edge of the shelf from Cape Hatteras to the southern margin of Georges Bank, and also offshore over the continental slope and rise in the mid-Atlantic region (CETAP 1982). Bycatch has been observed by NMFS observers in the drift gillnet and North Atlantic bottom trawl fisheries, but not in pelagic pair trawls or mid-water trawls.

Bottlenose Dolphins

There are two stocks of bottlenose dolphins in the western North Atlantic, an offshore and a coastal stock (Waring et al. 2002). The offshore stock extends along the entire continental shelf break from Georges Bank to Cape Hatteras during spring and summer (CETAP 1982; Kenney 1990). The coastal stock is distributed along the Atlantic coast south of Long Island and as far south as the Gulf of Mexico. Aerial (CETAP 1982) and shipboard (NMFS,unpublished data) surveys have identified two concentrations, one inshore of 25 m and the other offshore of 25 m. It was suggested that the coastal morphotype is restricted to waters <25 m north of Cape Hatteras (Kenney 1990).

Bottlenose dolphins are occasionally taken in various kinds of nearshore fishing gears, including gillnets, seines, longlines, shrimp trawls, and crab pots (Read 1994; Wang et al. 1994). There are nine Category II commercial fisheries that interact with this species (in 2001), six of which occur in North Carolina waters (Waring et al. 2002). Five fisheries are listed as Category III fisheries:

three inshore gillnet fisheries, the shrimp trawl, and the mid-Atlantic menhaden purse seine fishery. There have been no takes observed by NMFS observers in any of these fisheries (Waring et al. 2002). Menhaden purse seiners reported an annual incidental take of 1 to 5 bottlenose dolphins (NMFS 1991c). This species has not been observed in Atlantic herring mid-water or purse seine catches.

Harbor Porpoise

There are four separate populations of harbor porpoise in the western North Atlantic (Gaskin 1984, 1992). The Gulf of Maine/Bay of Fundy stock are concentrated in the northern Gulf of Maine and southern Bay of Fundy region during the summer (July-September), generally in waters less than 150 m deep (Gaskin 1977; Kraus et al. 1983; Palka 1995a, b), with a few sightings in the uper Bay of Fundy and on the northern edge of Georges Bank (Palka 2000). They are widely dispersed from New Jersey to Maine during the fall (October-December) and spring (April-June), with lower densities north and south. They are most common over the continental shelf, but are seen from the coastline to deep waters. There does not appear to be a temporally coordinated migration or a specific migratory route to and from the Bay of Fundy region (Waring et al. 2002). Recent assessments (1999) for the Gulf of Maine/Bay of Fundy area indicated that the population was about 89,000 (Waring et al. 2002). No population trends are available at this time. This species is protected under the Marine Mammal Protection Act and is not considered endangered or threatened.

Harbor porpoise takes have been documented in the USA Northeast sink gillnet, mid-Atlantic coastal gillnet, and in the Canadian Bay of Fundy groundfish sink gillnet and herring weir fisheries (Waring et al. 2002). They are frequently taken in Canadian herring weirs. There are no reports of harbor porpoises being taken in mid-water trawls or purse seines, but due to their presence and abundance in the Gulf of Maine in nearshore and offshore waters, they are vulnerable to capture in herring mid-water trawls and purse seines.

Atlantic White-Sided Dolphin

White-sided dolphins are found in the temperate and sub-polar waters of the North Atlantic, primarily on the continental shelf waters out to the 100 m depth contour. The species is distributed from central western Greenland to North Carolina, with the Gulf of Maine stock commonly found in continental shelf waters from Hudson Canyon to Georges Bank and into the Gulf of Maine to the lower Bay of Fundy (Waring et al. 2002). Sightings indicate seasonal shifts in distribution (Northridge et al. 1997). During January to April, low numbers are found from Georges Bank to Jeffreys Ledge (off New Hampshire), with even lower numbers south of Georges Bank. From June to September, large numbers are found from Georges Bank to the lower Bay of Fundy. From October to December, white-sided dolphins occur at intermediate densities from southern Georges Bank to the southern Gulf of Maine (Payne and Heinemann 1990). They are observed south of Georges Bank at all times of year, especially around Hudson Canyon, but at low densities (Waring et al. 2002).

Recently, within U.S. waters, white-sided dolphins have been observed caught in the Northeast mid-Atlantic coastal gillnet, pelagic drift gillnet, North Atlantic bottom trawl, and Atlantic squid, mackerel, butterfish trawl fisheries (Waring et al. 2002). In the past, incidental takes have been recorded in the Atlantic foreign mackerel fishery and the pelagic drift gillnet fishery. Forty-two white-sided dolphins were caught in foreign and joint venture mackerel fishing operations between 1977 and 1991. This fishery was a mixed mid-water and bottom trawl fishery and took place in the winter. One was observed taken in the U.S. mackerel fishery in 1997 (Waring et al. 2002) and two in joint venture mackerel fishing operations in 2001 (NMFS observer data). One white-sided dolphin was released alive and unharmed from a herring weir in the Bay of Fundy (Waring et al. 2002).

This species is common in the Gulf of Maine and on Georges Bank at the time of year when the herring fishery is active in those areas. Although the only observed captures of Atlantic white-sided dolphins in mid-water nets have been in the mid-Atlantic region in the winter, this species is clearly vulnerable to capture in herring mid-water trawls and, to a lesser extent, in purse seines used in the spring, summer, and fall in New England.

Common Dolphin

Common dolphins are found world-wide in temperate, tropical, and subtropical seas. In the North Atlantic, this species occurs along the continental slope and in outer continental shelf waters from Cape Hatteras to Georges Bank from mid-January to May (Hain et al. 1981; CETAP 1982; Payne et al. 1984). They move northward onto Georges Bank and the Scotian Shelf from mid-summer to autumn. Seltzer and Payne (1988) reported large aggregations on Georges Bank in autumn. Common dolphins are rarely found in the Gulf of Maine (Seltzer and Payne 1988).

Observers recorded 110 mortalities of common dolphins in foreign mackerel-fishing activities in the mid-Atlantic during 1977-1991 between December and May (Waring et al. 2002). Bycatch has been observed by NMFS sea samplers in pelagic drift gillnets, pair trawls, pelagic longlines, coastal gillnets, bottom trawls, and sink gillnets. During the 1990s, twelve mortalities were observed in the tuna pair trawl fishery in the mid-Atlantic, nine in the mid-Atlantic *Loligo* squid fishery, and one in the Atlantic mackerel fishery. The primary gear used in the squid fishery is a high-rise bottom trawl. Seventeen common dolphins were observed in net transfers of mackerel, squid, and butterfish to foreign processing ships in the mid-Atlantic region in March 1998. There is no information to indicate how many of the common dolphins caught in this fishery were taken in mid-water trawls versus bottom trawls, but this species is clearly vulnerable to capture in herring mid-water trawling operations in the mid-Atlantic region during the winter.

In addition to being vulnerable to capture in mid-water trawls in the mid-Atlantic region during the winter and early spring, before herring migrate north, this species is also vulnerable to capture in the directed herring fishery in the summer and fall on Georges Bank. Because they are rarely found in the Gulf of Maine, captures of common dolphins in mid-water trawls or purse seines in coastal waters of the gulf are unlikely.

White-beaked Dolphin

This species is found from southern New England to western and southern Greenland and Davis Straits in the Barents Sea and south to at least Portugal (Leatherwood et al. 1976; CETAP 1982). Off the northeastern U.S., white-beaked dolphins have been concentrated in the western Gulf of Maine and around Cape Cod (CETAP 1982). The limited distribution of this species in U.S. waters has been attributed to opportunistic feeding (CETAP 1982). There was an apparent shift in distribution of this species in the 1970s from offshore on the continental slope to continental shelf waters, perhaps in response to an increase in sand lance in shelf waters (Katona et al. 1993; Kenney et al. 1996). There is no reported bycatch of this species in commercial fishing gear in U.S. or Canadian waters (Waring et al. 2002).

Harbor seal

The harbor seal is found in all near shore waters of the Atlantic Ocean above about 30 degrees latitude (Waring et al. 2001). In the western North Atlantic they are distributed from the eastern Canadian Artic and Greenland south to southern New England and New York, and occasionally the Carolinas (Boulva and McLaren 1979; Gilbert and Guldager 1998). It is believed that the harbor seals found along the U.S. and Canadian Atlantic coast represent one population (Waring et al. 2001). Harbor seals are year-round inhabitants of the coastal waters of eastern Canada and Maine, and occur seasonally along the southern New England and New York coasts from September through late-May. However, breeding and pupping normally occur only in waters north of the New Hampshire/Maine border. Since passage of the MMPA in 1972, the number of seals found along the New England coast has increased nearly five-fold with the number of pups seen along the Maine coast increasing at an annual rate of 12.9 percent during the 1981-1997 period (Gilbert and Guldager 1998).

Incidental takes of harbor seals have been recorded in groundfish gillnet, herring purse seine, halibut tub trawl, and lobster fisheries (Gilbert and Wynne 1985 and 1987). Observers working on a bycatch study of herring mid-water trawls and purse seines in New England reported that harbor seals and gray seals were frequently observed inside and outside seines, feeding on herring, but in all cases were released unharmed (USDOC 1999). One harbor seal was observed captured in 54 mid-water trawl tows. Harbor seals are also taken in herring weirs in Canada (Read 1994).

Gray seal

The gray seal is found on both sides of the North Atlantic, with the western North Atlantic population occurring from New England to Labrador. There are two breeding concentrations in eastern Canada; one at Sable Island and one that breeds on the pack ice in the Gulf of St Lawrence. There are several small breeding colonies on isolated islands along the coast of Maine and on outer Cape Cod and Nantucket Island in Massachusetts (Waring et al. 2001). The gray seal population in Massachusetts has increased from 2,010 in 1994 to 5,611 in 1999, although it is not clear how much of this increase may be due to animals emigrating from northern areas.

Gray seals have been taken in herring weirs in eastern Canada (Read 1994) and have been seen with harbor seals in herring purse seines off the Maine coast (USDOC 1999). Gray seals are less numerous in the Gulf of Maine than harbor seals, but are vulnerable to capture in herring mid-water trawls and purse seines.

Harp seal

The harp seal occurs throughout much of the North Atlantic and Artic Oceans, and have been increasing off the east coast of the United States from Maine to New Jersey (Waring et al. 2001). Harp seals are at the extreme southern end of the range in U.S. contiental shelf waters and are usually found off there from January to May when the western stock of harp seals is at their most southern point of migration. Harp seals congregate on the edge of the pack ice in February through April when breeding and pupping takes place. The harp seal is highly migratory, moving north and south with the edge of the pack ice. Non-breeding juveniles will migrate the farthest south in the winter, but the entire population moves north toward the Artic in the summer.

Bycatch has been observed by NMFS sea samplers in the Northeast multispecies gillnet fisheries, but no mortalities have been documented in the pelagic pair trawl fishery (Waring et al. 2002).

Hooded Seal

Hooded seals occur throughout much of the North Atlantic and Arctic Oceans (King 1983) preferring deeper water and occurring farther offshore than harp seals (Lavigne and Kovacs 1988). Hooded seals are highly migratory and tend to wander far out of their range, which extends to the Gulf of St. Lawrence (Canada). They are rarely found in the U.S. EEZ, but are occurring with increasing frequency along the U.S. Atlantic coast in the winter and spring (Waring et al. 2002). They have been seen as far south as Puerto Rico. No hooded seals have been taken incidentally in U.S. waters. Given their low numbers and the fact that they stray into southern waters at the time of year when the herring fishery is not very active, it is highly unlikely that they would interact with gears used in the herring fishery.

Leatherback Sea Turtle

In the U.S., leatherback turtles are found throughout the western North Atlantic during the warmer months along the continental shelf, and near the Gulf Stream edge. A 1979 aerial survey of the outer Continental Shelf from Cape Hatteras, North Carolina to Cape Sable, Nova Scotia showed leatherbacks to be present throughout the area with the most numerous sightings made from the Gulf of Maine south to Long Island (CeTAP 1982). Shoop and Kenney (1992) also observed concentrations of leatherbacks during the summer off the south shore of Long Island and New Jersey. Leatherbacks in these waters are thought to be following their preferred jellyfish prey.

Leatherbacks are predominantly a pelagic species and feed on jellyfish and other soft-body prey. Time-depth-recorder data collected by Eckert et al. (1996) indicate that leatherbacks are night feeders and are deep divers, with recorded dives to depths in excess of 1,000 meters. However, leatherbacks may feed in shallow waters if there is an abundance of jellyfish near shore. For example, leatherbacks occur annually in shallow bays such as Cape Cod and Narragansett Bays during the fall.

Estimated to number apprximately 115,000 adult females globally in 1980 (Pritchard 1982) and only 34,500 by 1995 (Spotila et al. 1996), leatherback populations have been decimated worldwide. Anthropogenic impacts to the leatherback population include fishery interactions as well as exploitation of the eggs (Ross 1979). Eckert (1996) and Spotila et al. (1996) record that adult mortality has also increased significantly, particularly as a result of driftnet and longline fisheries. The status of the leatherback population in the Atlantic is difficult to assess since major nesting beaches occur over broad areas within tropical waters outside the U.S. Recent information suggests that western North Atlantic populations declined from 18,800 nesting females in 1996 (Spotila et al. 1996) to 15,000 nesting females by 2000. It appears that the

Western Atlantic portion of the population is being subjected to mortality beyond sustainable levels, resulting in a continued decline in numbers of nesting females.

Numerous fisheries that occur in both U.S. state and federal waters are known to negatively impact juvenile and adult leatherback sea turtles. These include incidental take in several commercial and recreational fisheries. Fisheries known or suspected to incidentally capture leatherbacks include those deploying bottom trawls, off-bottom trawls, purse seines, bottom longlines, hook and line, gill nets, drift nets, traps, haul seines, pound nets, beach seines, and surface longlines (NMFS and USFWS 1992).

Leatherback interactions with the southeast shrimp fishery are well documented. Turtle Excluder Devices (TEDs), typically used in the southeast shrimp fishery to minimize sea turtle/fishery interactions, are less effective for the larger leatherbacks. Therefore, the NMFS established a zone to restrict, when necessary, shrimp trawl activities from off the coast of Cape Canaveral, Florida to the Virginia/North Carolina border. For many years, TEDs that were required for use in the southeast shrimp fishery were less effective for leatherbacks as compared to the smaller, hard-shelled turtles. To address this problem, on February 21, 2003, NOAA Fisheries issued a final rule to amend the TED regulations. Modifications to the design of TEDs are now required in order to exclude leatherbacks as well as large loggerhead and green sea turtles.

Leatherbacks are also susceptible to entanglement in lobster and crab pot gear. The probable reasons may be: attraction to gelatinous organisms and algae that collect on buoys and buoy lines at or near the surface; attraction to the buoys which could appear as prey; or the gear configuration which may be more likely to wrap around flippers. The total number of leatherbacks reported entangled from New York through Maine from all sources for the years 1980 - 2000 is 119. Entanglements are also common in Canadian waters where Goff and Lien (1988) reported that 14 of 20 leatherbacks encountered off the coast of Newfoundland/Labrador were entangled in fishing gear including salmon net, herring net, gillnet, trawl line and crab pot line. Prescott (1988) reviewed stranding data for Cape Cod Bay and concluded that for those turtles where cause of death could be determined (the minority), entanglement in fishing gear is the leading cause of death followed by capture by dragger, cold stunning, or collision with boats.

Due to their distribution and abundance during the summer in the Gulf of Maine and continental shelf of New England, and the fact that they have been taken or are suspected to have been taken in purse seines and “off-bottom trawls” in U.S. waters, leatherbacks are included as one of the endangered species that is vulnerable to capture in herring gear.

Kemp’s Ridley Sea Turtle

The Kemp’s ridley is the most endangered of the world’s sea turtle species. Of the world’s seven extant species of sea turtles, the Kemp's ridley has declined to the lowest population level.

Juvenile Kemp’s ridleys use northeastern and Mid-Atlantic coastal waters of the U.S. Atlantic coastline as primary developmental habitat during summer months, with shallow coastal embayments serving as important foraging grounds. Ridleys found in Mid-Atlantic waters are primarily post-pelagic juveniles averaging 40 centimeters in carapace length, and weighing less than 20 kilograms (Terwilliger and Musick 1995). Next to loggerheads, they are the second most abundant sea turtle in Virginia and Maryland waters, arriving in these areas during May and June (Keinath et al., 1987; Musick and Limpus, 1997). Studies have found that post-pelagic ridleys feed primarily on a variety of species of crabs. Mollusks, shrimp, and fish are consumed less frequently (Bjorndal, 1997).

With the onset of winter and the decline of water temperatures, ridleys migrate to more southerly waters from September to November (Keinath et al., 1987; Musick and Limpus, 1997). Turtles who do not head south soon enough face the risks of cold stunning in northern waters. Cold stunning can be a significant natural cause of mortality for sea turtles in Cape Cod Bay and Long Island Sound. For example, in the winter of 1999/2000, there was a major cold-stunning event where 218 Kemp's ridleys, 54 loggerheads, and 5 green turtles were found on Cape Cod beaches. The severity of cold stun events depends on: the numbers of turtles utilizing Northeast waters in a given year; oceanographic conditions; and the occurrence of storm events in the late fall. Cold-stunned turtles have also been found on beaches in New York and New Jersey. Cold-stunning events can represent a significant cause of natural mortality, in spite of the fact that many cold-stun turtles can survive if found early enough.

Like other turtle species, the severe decline in the Kemp's ridley population appears to have been heavily influenced by a combination of exploitation of eggs and impacts from fishery interactions. Currently, anthropogenic impacts to the Kemp's ridley population are similar to those discussed above for other sea turtle species. Takes of Kemp's ridley turtles have been recorded by sea sampling coverage in the Northeast otter trawl fishery, pelagic longline fishery, and southeast shrimp and summer flounder bottom trawl fisheries.

Kemp's ridleys may also be affected by large-mesh gillnet fisheries. In the spring of 2000, a total of five Kemp's ridley carcasses were recovered from a North Carolina beach where 277 loggerhead carcasses were found. Cause of death for most of the turtles recovered was unknown, but the mass mortality event was suspected to have been from a large-mesh gillnet fishery operating offshore in the preceding weeks. It is possible that strandings of Kemp's ridley turtles in some years have increased at rates higher than the rate of increase in the Kemp's ridley population (TEWG 1998).

This species of turtle would only be vulnerable to capture in the herring mobile gear fishery during the warmer months of the year when it occupies the more northerly waters of the Northeast region. Since they are not common north of Cape Cod and apparently do not occupy offshore waters (e.g., Georges Bank), they are not believed to be vulnerable to capture in gears used in the herring fishery.

Green Sea Turtle

Green turtles are distributed circumglobally. In the western Atlantic they range from Massachusetts to Argentina, including the Gulf of Mexico and Caribbean, but are considered rare north of Cape Hatteras (Wynne and Schwartz, 1999). In the continental United States, green turtle nesting occurs on the Atlantic coast of Florida (Ehrhart 1979).

While nesting activity is obviously important in determining population distributions, the remaining portion of the green turtle's life is spent on the foraging and breeding grounds.

Juvenile green sea turtles occupy pelagic habitats after leaving the nesting beach. Pelagic juveniles are assumed to be omnivorous, but with a strong tendency toward carnivory during early life stages. At approximately 20 to 25 cm carapace length, juveniles leave pelagic habitats and enter benthic foraging areas, shifting to a chiefly herbivorous diet (Bjorndal 1997). Green turtles appear to prefer marine grasses and algae in shallow bays, lagoons and reefs (Rebel 1974) but also consume jellyfish, salps, and sponges.

As is the case for loggerhead and Kemp's ridley sea turtles, green sea turtles use mid-Atlantic and northern areas of the western Atlantic coast as important summer developmental habitat. Green turtles are found in estuarine and coastal waters as far north as Long Island Sound, Chesapeake Bay, and North Carolina sounds (Musick and Limpus 1997). Like loggerheads and Kemp's ridleys, green sea turtles that use northern waters during the summer must return to warmer waters when water temperatures drop, or face the risk of cold stunning. Cold stunning of green turtles may occur in southern areas as well (*i.e*., Indian River, Florida), as these natural mortality events are dependent on water temperatures and not solely geographical location.

Anthropogenic impacts to the green sea turtle population are similar to those discussed above for other sea turtles species. As with the other species, fishery mortality accounts for a large proportion of annual human-caused mortality outside the nesting beaches, while other activities like dredging, pollution, and habitat destruction account for an unknown level of other mortality. Sea sampling coverage in the pelagic driftnet, pelagic longline, scallop dredge, southeast shrimp trawl, and summer flounder bottom trawl fisheries has recorded takes of green turtles.

This species closely resembles the Kemp's Ridley sea turtle in terms of its seasonal occurrence and geographical distribution in the Northeast region and is not believed to be vulnerable to capture in the directed herring fishery.

Loggerhead Sea Turtle

Loggerhead sea turtles occur throughout the temperate and tropical regions of the Atlantic, Pacific, and Indian Oceans in a wide range of habitats. These include open ocean, continental shelves, bays, lagoons, and estuaries (NMFS and USFWS 1995). Loggerhead sea turtles are primarily benthic feeders, opportunistically foraging on crustaceans and mollusks (Wynne and Schwartz 1999). Under certain conditions they may also scavenge fish (NMFS and USFWS 1991b). Horseshoe crabs are known to be a favorite prey item in the Chesapeake Bay area (Lutcavage and Musick 1985).

The threatened loggerhead sea turtle is the most abundant of the sea turtles listed as threatened or endangered in the U.S. waters. However, the status of the northern loggerhead subpopulation is of particular concern.

The activity of the loggerhead is limited by temperature. Loggerheads commonly occur throughout the inner continental shelf from Florida through Cape Cod, Massachusetts. Loggerheads may also occur as far north as Nova Scotia when oceanographic and prey conditions are favorable. Surveys conducted offshore as well as sea turtle stranding data collected during November and December off North Carolina suggest that sea turtles emigrating from northern waters in fall and winter months may concentrate in near shore and southerly areas influenced by warmer Gulf Stream waters (Epperly et al. 1995). This is supported by the collected work of Morreale and Standora (1998) who tracked 12 loggerheads and 3 Kemp's ridleys by satellite. All of the turtles followed similar spatial and temporal corridors, migrating south from Long Island Sound, New York, during October through December. The turtles traveled within a narrow band along the continental shelf and became sedentary for one or two months south of Cape Hatteras.

Loggerhead sea turtles do not usually appear on the most northern summer foraging grounds in the Gulf of Maine until June, but are found in Virginia as early as April. They remain in the mid-Atlantic and northeast areas until as late as November and December in some cases, but the majority leaves the Gulf of Maine by mid-September. Aerial surveys of loggerhead turtles north of Cape Hatteras indicate that they are most common in waters from 22 to 49 meters deep, although they range from the beach to waters beyond the continental shelf (Shoop and Kenney 1992).

Loggerhead sea turtles originating from the western Atlantic nesting aggregations are believed to lead a pelagic existence in the North Atlantic gyre for as long as 7-12 years before settling into benthic environments. Loggerhead sea turtles are impacted by a completely different set of threats from human activity once they migrate to the ocean. During that period, they are exposed to a series of long-line fisheries that include the U.S. Atlantic tuna and swordfish longline fisheries, an Azorean long-line fleet, a Spanish long-line fleet, and various fleets in the Mediterranean Sea (Aguilar et al. 1995, Bolten et al. 1994, Crouse 1999). Observer records indicate that, of the 6,544 loggerheads estimated to be captured by the U.S. Atlantic tuna and swordfish longline fleet between 1992-1998, an estimated 43 were dead (Yeung 1999). For 1998, alone, an estimated 510 loggerheads (225-1250) were captured in the longline fishery. Aguilar et al. (1995) estimated that the Spanish swordfish longline fleet, which is only one of the many fleets operating in the region, captures more than 20,000 juvenile loggerheads annually (killing as many as 10,700).

Once loggerheads enter the benthic environment in waters off the coastal U.S., they are exposed to a suite of fisheries in federal and state waters including trawl, purse seine, hook and line, gillnet, pound net, longline, and trap fisheries. Loggerhead sea turtles are captured in fixed pound net gear in the Long Island Sound, in pound net gear and trawls in summer flounder and other finfish fisheries in the Mid-Atlantic and Chesapeake Bay, in gillnet fisheries in the Mid-Atlantic and elsewhere, and in multispecies, monkfish, spiny dogfish, and northeast sink gillnet fisheries.

Because loggerheads are common as far north as Cape Cod in the summer and fall, but are not common north of Cape Cod where herring fishing takes place at that time of year, they are not very vulnerable to capture in herring mid-waters trawls or purse seines.

Conclusion

Five of the 22 species of protected species that are potentially affected by the management measures that are proposed in this DEIS have been determined to be vulnerable to capture in herring mid-water trawls and purse seines. These five species are therefore the ones that would most likely be affected by any management alternative that affects the amount or location of herring fishing activity in herring management area 1, i.e., within the area affected by management alternatives 3 and 4. These five species are harbor seals, grey seals, harbor porpoise, minke whales, and leatherback turtles.

4.2.4 Essential Fish Habitat

4.2.4.1 Atlantic Herring

Essential Fish Habitat (EFH) for Atlantic herring is described in NEFMC (1998a) as those areas of the coastal and offshore waters (out to the offshore U.S. boundary of the exclusive economic zone) that are designated in Figure 4.17 through Figure 4.20 and in Table 4.10 and meet the following conditions:

Eggs: Bottom habitats with a substrate of gravel, sand, cobble and shell fragments, but also on aquatic macrophytes, in the Gulf of Maine and Georges Bank as depicted in Figure 4.17. Eggs adhere to the bottom, forming extensive egg beds which may be many layers deep. Generally, the following conditions exist where Atlantic herring eggs are found: water temperatures below 15° C, depths from 20 - 80 meters, and a salinity range from 32 - 33‰. Herring eggs are most often found in areas of well-mixed water, with tidal currents between 1.5 and 3.0 knots. Atlantic herring eggs are most often observed during the months from July through November.

Larvae: Pelagic waters in the Gulf of Maine, Georges Bank, and southern New England that comprise 90% of the observed range of Atlantic herring larvae as depicted in Figure 4.18. Generally, the following conditions exist where Atlantic herring larvae are found: sea surface temperatures below 16° C, water depths from 50 - 90 meters, and salinities around 32‰. Atlantic herring larvae are observed between August and April, with peaks from September through November.

Juveniles: Pelagic waters and bottom habitats in the Gulf of Maine, Georges Bank, southern New England and the middle Atlantic south to Cape Hatteras as depicted in Figure 4.19. Generally, the following conditions exist where Atlantic herring juveniles are found: water temperatures below 10° C, water depths from 15 - 135 meters, and a salinity range from 26 - 32‰.

Adults: Pelagic waters and bottom habitats in the Gulf of Maine, Georges Bank, southern New England and the middle Atlantic south to Cape Hatteras as depicted in Figure 4.20. Generally, the following conditions exist where Atlantic herring adults are found: water temperatures below 10° C, water depths from 20 - 130 meters, and salinities above 28‰.

Spawning Adults: Bottom habitats with a substrate of gravel, sand, cobble and shell fragments, but also on aquatic macrophytes, in the Gulf of Maine, Georges Bank, southern New England and the middle Atlantic south to Delaware Bay as depicted in Figure 4.20. Generally, the following conditions exist where spawning Atlantic herring adults are found: water temperatures below 15° C, depths from 20 - 80 meters, and a salinity range from 32 - 33‰. Herring eggs are spawned in areas of well-mixed water, with tidal currents between 1.5 and 3.0 knots. Atlantic herring are most often observed spawning during the months from July through November.

All of the above EFH descriptions include those bays and estuaries listed in Table 4.10, according to life history stage. The Council acknowledges potential seasonal and spatial variability of the conditions generally associated with this species.

4.2.4.2 Other Northeast Region Species

The area where the Atlantic herring fishery takes place has been identified as EFH for species managed under the following federal fishery management plans: Northeast Multispecies; Atlantic Sea Scallop; Atlantic Monkfish; Summer Flounder, Scup and Black Sea Bass; Squid, Atlantic Mackerel and Butterfish; Atlantic Surf Clam and Ocean Quahog; Atlantic Bluefish; Atlantic Billfish; and Atlantic Tuna, Swordfish and Shark. Text descriptions for all benthic (demersal) life stages for federally-managed species in the Northeast region are shown in Table 4.11. Maps showing EFH by species and life stage are included in the 1998 Omnibus EFH Amendment (NEFMC 1998a) and in various fishery management plans developed by the Mid-Atlantic and South Atlantic Fishery Management Councils during the last five years. All the EFH descriptions and maps can be viewed on the NMFS Northeast Regional Office web site.

Table 4.10. Essential fish habitat designation of estuaries and embayments for Atlantic herring.

Estuaries and Embayments	**Eggs**	**Larvae**	**Juveniles**	**Adults**	**Spawning Adults**
Passamaquoddy Bay		m,s	m,s	m,s	
Englishman/Machias Bay	s	m,s	m,s	m,s	s
Narraguagus Bay		m,s	m,s	m,s	
Blue Hill Bay		m,s	m,s	m,s	
Penobscot Bay		m,s	m,s	m,s	
Muscongus Bay		m,s	m,s	m,s	
Damariscotta River		m,s	m,s	m,s	
Sheepscot River		m,s	m,s	m,s	
Kennebec / Androscoggin Rivers		m,s	m,s	m,s	
Casco Bay	s	m,s	m,s	s	
Saco Bay		m,s	m,s	s	
Wells Harbor		m,s	m,s	s	
Great Bay		m,s	m,s	s	
Merrimack River		M	m		
Massachusetts Bay		s	s	s	
Boston Harbor		s	m,s	m,s	
Cape Cod Bay	s	s	m,s	m,s	
Waquoit Bay					
Buzzards Bay			m,s	m,s	
Narragansett Bay		s	m,s	m,s	
Long Island Sound			m,s	m,s	
Connecticut River					
Gardiners Bay			s	s	
Great South Bay			s	s	
Hudson River / Raritan Bay		m,s	m,s	m,s	
Barnegat Bay			m,s	m,s	
Delaware Bay			m,s	s	
Chincoteague Bay					
Chesapeake Bay				s	

S ≡ The EFH designation for this species includes the seawater salinity zone of this bay or estuary (salinity > 25.0‰).

M ≡ The EFH designation for this species includes the mixing water / brackish salinity zone of this bay or estuary (0.5 < salinity < 25.0‰).

F ≡ The EFH designation for this species includes the tidal freshwater salinity zone of this bay or estuary (0.0 < salinity < 0.5‰).

These EFH designations of estuaries and embayments are based on the NOAA Estuarine Living Marine Resources (ELMR) program (Jury *et al.* 1994; Stone *et al.* 1994).

Table 4.11. EFH descriptions for demersal life stages of federally-managed species in the Northeast region.

Demersal Species

Species	Life Stage	Geographic Area of EFH	Depth	Seasonal Occurrence	EFH Description
American plaice	juvenile	GOME and estuaries from Passamaquoddy Bay to Saco Bay, ME and from Mass. Bay to Cape Cod Bay, MA	45 - 150		Bottom habitats with fine grained sediments or a substrate of sand or gravel
American plaice	adult	GOME and estuaries from Passamaquoddy Bay to Saco Bay, ME and from Mass. Bay to Cape Cod Bay, MA	45 - 175		Bottom habitats with fine grained sediments or a substrate of sand or gravel
Atlantic cod	juvenile	GOME, GB, eastern portion of continental shelf off southern NE and following estuaries: Passamaquoddy Bay to Saco Bay; Mass. Bay, Boston Harbor, Cape Cod Bay, Buzzards Bay	25 - 75		Bottom habitats with a substrate of cobble or gravel
Atlantic cod	adult	GOME, GB, eastern portion of continental shelf off southern NE and following estuaries: Passamaquoddy Bay to Saco Bay; Mass. Bay, Boston Harbor, Cape Cod Bay, Buzzards Bay	10 - 150		Bottom habitats with a substrate of rocks, pebbles, or gravel
Atlantic halibut	juvenile	GOME, GB	20 - 60		Bottom habitats with a substrate of sand, gravel, or clay
Atlantic halibut	adult	GOME, GB	100 - 700		Bottom habitats with a substrate of sand, gravel, or clay
Atlantic salmon	juvenile	Rivers from CT to Maine: Connecticut, Pawcatuck, Merrimack, Cocheco, Saco, Androscoggin, Presumpscot, Kennebec, Sheepscot, Ducktrap, Union, Penobscot, Narraguagus, Machias, East Machias, Pleasant, St. Croix, Denny's, Passagassawaukeag, Aroostook, Lamprey, Boyden, Orland Rivers, and the Turk, Hobart and Patten Streams; and the following estuaries for juveniles and adults: Passamaquoddy Bay to Muscongus Bay; Casco Bay to Wells Harbor; Mass. Bay, Long Island Sound, Gardiners Bay to Great South Bay. All aquatic habitats in the watersheds of the above listed rivers, including all tributaries to the extent that they are currently or were historically accessible for salmon migration.	10 - 61		Bottom habitats of shallow gravel/cobble riffles interspersed with deeper riffles and pools in rivers and estuaries, water velocities between 30 - 92 cm/s
Atlantic sea scallop	juvenile	GOME, GB, southern NE and middle Atlantic	18 - 110		Bottom habitats with a substrate

		south to Virginia-North Carolina border and following estuaries: Passamaquoddy Bay to Sheepscot R.; Casco Bay, Great Bay, Mass Bay, and Cape Cod Bay			of cobble, shells, and silt
Atlantic sea scallop	adult	GOME, GB, southern NE and middle Atlantic south to Virginia-North Carolina border and following estuaries: Passamaquoddy Bay to Sheepscot R.; Casco Bay, Great Bay, Mass Bay, and Cape Cod Bay	18 - 110		Bottom habitats with a substrate of cobble, shells, coarse/gravelly sand, and sand
Haddock	juvenile	GB, GOME, middle Atlantic south to Delaware Bay	35 - 100		Bottom habitats with a substrate of pebble and gravel
Haddock	adult	GB and eastern side of Nantucket Shoals, throughout GOME, *additional area of Nantucket Shoals, and Great South Channel	40 - 150		Bottom habitats with a substrate of broken ground, pebbles, smooth hard sand, and smooth areas between rocky patches
Goosefish	juvenile	Outer continental shelf in the middle Atlantic, mid-shelf off southern NE, all areas of GOME	25 - 200		Bottom habitats with substrates of a sandshell mix, algae covered rocks, hard sand, pebbly gravel, or mud
Goosefish	adult	Outer continental shelf in the middle Atlantic, mid-shelf off southern NE, outer perimeter of GB, all areas of GOME	25 - 200		Bottom habitats withsubstrates of a sandshell mix, algae covered rocks, hard sand, pebbly gravel, or mud
Ocean pout	juvenile	GOME, GB, southern NE, middle Atlantic south to Delaware Bay and the following estuaries: Passamaquoddy Bay to Saco Bay; Mass. Bay, and Cape Cod Bay	< 50	Late fall to spring	Bottom habitats in close proximity to hard bottom nesting areas
Ocean pout	adult	GOME, GB, southern NE, middle Atlantic south to Delaware Bay and the following estuaries: Passamaquoddy Bay to Saco Bay; Mass. Bay, Boston Harbor, and Cape Cod Bay	< 80		Bottom habitats, often smooth bottom near rocks or algae
Offshore hake	juvenile	Outer continental shelf of GB and southern NE south to Cape Hatteras, NC	170 - 350		Bottom habitats
Offshore hake	adult	Outer continental shelf of GB and southern NE south to Cape Hatteras, NC	150 - 380		Bottom habitats
Pollock	juvenile	GOME, GB, and the following estuaries: Passamaquoddy Bay to Saco Bay; Great Bay to Waquoit Bay; Long Island Sound, Great South Bay	0 – 250		Bottom habitats with aquatic vegetation or a substrate of sand, mud, or rocks
Pollock	adult	GOME, GB, southern NE, and middle	15 – 365		Hard bottom habitats including

		Atlantic south to New Jersey and the following estuaries: Passamaquoddy Bay, Damariscotta R., Mass Bay, Cape Cod Bay, Long Island Sound			artificial reefs
Red hake	juvenile	GOME, GB, continental shelf off southern NE, and middle Atlantic south to Cape Hatteras and the following estuaries: Passamaquoddy Bay to Saco Bay; Great Bay, Mass. Bay to Cape Cod Bay; Buzzards Bay to Conn. R.; Hudson R./ Raritan Bay, and Chesapeake Bay	< 100		Bottom habitats with substrate of shell fragments, including areas with an abundance of live scallops
Red hake	adult	GOME, GB, continental shelf off southern NE, and middle Atlantic south to Cape Hatteras and the following estuaries: Passamaquoddy Bay to Saco Bay; Great Bay, Mass. Bay to Cape Cod Bay; Buzzards Bay to Conn. R.; Hudson R./ Raritan Bay, Delaware Bay, and Chesapeake Bay	10 - 130		Bottom habitats in depressions with a substrate of sand and mud
Redfish	juvenile	GOME, southern edge of GB	25 - 400		Bottom habitats with a substrate of silt, mud, or hard bottom
Redfish	adult	GOME, southern edge of GB	50 - 350		Bottom habitats with a substrate of silt, mud, or hard bottom
White hake	adult	GOME, southern edge of GB, southern NE to middle Atlantic and the following estuaries: Passamaquoddy Bay to Great Bay; Mass. Bay to Cape Cod Bay	5 - 325		Bottom habitats with substrate of mud or fine grained sand
Silver hake	juvenile	GOME, GB, continental shelf off southern NE, middle Atlantic south to Cape Hatteras and the following estuaries: Passamaquoddy Bay to Casco Bay, Mass. Bay to Cape Cod Bay	20 – 270		Bottom habitats of all substrate types
Silver hake	adult	GOME, GB, continental shelf off southern NE, middle Atlantic south to Cape Hatteras and the following estuaries: Passamaquoddy Bay to Casco Bay, Mass. Bay to Cape Cod Bay	30 – 325		Bottom habitats of all substrate types
Windowpane flounder	juvenile	GOME, GB, southern NE, middle Atlantic south to Cape Hatteras and the following estuaries: Passamaquoddy Bay to Great Bay; Mass. Bay to Chesapeake Bay	1 - 100		Bottom habitats with substrate of mud or fine grained sand
Windowpane flounder	adult	GOME, GB, southern NE, middle Atlantic	1 - 75		Bottom habitats with substrate of

		south to Virginia - NC border and the following estuaries: Passamaquoddy Bay to Great Bay; Mass. Bay to Chesapeake Bay			mud or fine grained sand
Winter flounder	juvenile	GB, inshore areas of GOME, southern NE, middle Atlantic south to Delaware Bay and the following estuaries: Passamaquoddy Bay to Chincoteague Bay	0.1 – 10 (1 - 50, age 1+)		Bottom habitats with a substrate of mud or fine grained sand
Winter flounder	adult	GB, inshore areas of GOME, southern NE, middle Atlantic south to Delaware Bay and the following estuaries: Passamaquoddy Bay to Chincoteague Bay	1 - 100		Bottom habitats including estuaries with substrates of mud, sand, grave
Witch flounder	juvenile	GOME, outer continental shelf from GB south to Cape Hatteras	50 - 450 to 1500		Bottom habitats with fine grained substrate
Witch flounder	adult	GOME, outer continental shelf from GB south to Chesapeake Bay	25 - 300		Bottom habitats with fine grained substrate
Yellowtail flounder	juvenile	GB, GOME, southern NE continental shelf south to Delaware Bay and the following estuaries: Sheepscot R., Casco Bay, Mass. Bay to Cape Cod Bay	20 - 50		Bottom habitats with substrate of sand or sand and mud
Yellowtail flounder	adult	GB, GOME, southern NE continental shelf south to Delaware Bay and the following estuaries: Sheepscot R., Casco Bay, Mass. Bay to Cape Cod Bay	20 - 50		Bottom habitats with substrate of sand or sand and mud
Red crab	juvenile	Southern flank of GB and south the Cape Hatteras, NC	700 - 1800		Bottom habitats of continental slope with a substrate of silts, clays, and all silt-clay-sand composites
Red crab	adult	Southern flank of GB and south the Cape Hatteras, NC	200 - 1300		Bottom habitats of continental slope with a substrate of silts, clays, and all silt-clay-sand composites
Black sea bass	juvenile	Demersal waters over continental shelf from GOME to Cape Hatteras, NC, also includes estuaries from Buzzards Bay to Long Island Sound; Gardiners Bay, Barnegat Bay to Chesapeake Bay; Tangier/ Pocomoke Sound, and James River	1 - 38	Found in coastal areas (April to December, peak June to November) between VA and MA, but winter offshore from NJ and south; estuaries in summer and spring	Rough bottom, shellfish and eelgrass beds, manmade structures in sandy-shelly areas, offshore clam beds, and shell patches may be used during wintering
Black sea bass	adult	Demersal waters over continental shelf from GOME to Cape Hatteras, NC, also includes estuaries: Buzzards Bay, Narragansett Bay, Gardiners Bay, Great South Bay, Barnegat	20 - 50	Wintering adults (November to April) offshore, south of NY to NC; inshore, estuaries from May to October	Structured habitats (natural and manmade), sand and shell substrates preferred

		Bay to Chesapeake Bay; Tangier/ Pocomoke Sound, and James River			
Ocean quahog	juvenile	Eastern edge of GB and GOME throughout the Atlantic EEZ	8 - 245		Throughout substrate to a depth of 3 ft within federal waters, occurs progressively further offshore between Cape Cod and Cape Hatteras
Ocean quahog	adult	Eastern edge of GB and GOME throughout the Atlantic EEZ	8 - 245	Spawn May to December with several peaks	Throughout substrate to a depth of 3 ft within federal waters, occurs progressively further offshore between Cape Cod and Cape Hatteras
Atlantic surfclam	juvenile	Eastern edge of GB and the GOME throughout Atlantic EEZ	0 - 60, low density beyond 38		Throughout substrate to a depth of 3 ft within federal waters, burrow in medium to coarse sand and gravel substrates, also found in silty to fine sand, but not in mud
Atlantic surfclam	adult	Eastern edge of GB and the GOME throughout Atlantic EEZ	0 - 60, low density beyond 38	Spawn summer to fall	Throughout substrate to a depth of 3 ft within federal waters
Scup	juvenile	Continental shelf from GOME to Cape Hatteras, NC includes the following estuaries: Mass. Bay, Cape Cod Bay to Long Island Sound; Gardiners Bay to Delaware Inland Bays; and Chesapeake Bay	(0 - 38)	Spring and summer in estuaries and bays	Demersal waters north of Cape Hatteras and inshore on various sands, mud, mussel, and eelgrass bed type substrates
Scup	adult	Continental shelf from GOME to Cape Hatteras, NC includes the following estuaries: Cape Cod Bay to Long Island Sound; Gardiners Bay to Hudson R./ Raritan Bay; Delaware Bay and Inland Bays; and Chesapeake Bay	(2 -185)	Wintering adults (November to April) are usually offshore, south of NY to NC	Demersal waters north of Cape Hatteras and inshore estuaries (various substrate types)
Spiny dogfish	juvenile	GOME through Cape Hatteras, NC across the continental shelf; continental shelf waters south of Cape Hatteras, NC through Florida; also includes estuaries from Passamaquoddy Bay to Saco Bay; Mass. Bay and Cape Cod Bay	10 - 390		Continental shelf waters and estuaries
Spiny dogfish	adult	GOME through Cape Hatteras, NC across the continental shelf; continental shelf waters south of Cape Hatteras, NC through Florida;	10 - 450		Continental shelf waters and estuaries

		also includes estuaries from Passamaquoddy Bay to Saco Bay; Mass. Bay and Cape Cod Bay			
Summer flounder	juvenile	Over continental shelf from GOME to Cape Hatteras, NC; south of Cape Hatteras to Florida; also includesestuaries from Waquoit Bay to James R.; Albemarle Sound to Indian R.	0.5 – 5 in estuary		Demersal waters, on muddy substrate but prefer mostly sand; found in the lower estuaries in flats, channels, salt marsh creeks, and eelgrass beds
Summer flounder	adult	Over continental shelf from GOME to Cape Hatteras, NC; south of Cape Hatteras to Florida; also includes estuaries from Buzzards Bay, Narragansett Bay, Conn. R. to James R.; Albemarle Sound to Broad R.; St. Johns R., and Indian R.	0 - 25	Shallow coastal and estuarine waters during warmer months, move offshore on outer continental shelf at depths of 150 m in colder months	Demersal waters and estuaries
Tilefish	juvenile	US/Canadian boundary to VA/NC boundary (shelf break, submarine canyon walls, and flanks: GB to Cape Hatteras)	76 - 365	All year, may leave GB in winter	Rough bottom, small burrows, and sheltered areas; substrate rocky, stiff clay, human debris
Tilefish	adult	US/Canadian boundary to VA/NC boundary (shelf break, submarine canyon walls, and flanks: GB to Cape Hatteras)	76 - 365	All year, may leave GB in winter	Rough bottom, small burrows, and sheltered areas; substrate rocky, stiff clay, human debris
Red drum	juvenile	Along the Atlantic coast from Virginia through the Florida Keys	< 50	Found throughout Chesapeake Bay from September to November	Utilize shallow backwaters of estuaries as nursery areas and remain until they move to deeper water portions of the estuary associated with river mouths, oyster bars, and front beaches
Red drum	adult	Along the Atlantic coast from Virginia through the Florida Keys	< 50	Found in Chesapeake in spring and fall and also along eastern shore of VA	Concentrate around inlets, shoals, and capes along the Atlantic coast; shallow bay bottoms or oyster reef substrate preferred, also nearshore artificial reefs
Spanish mackerel, cobia, and king mackerel	juvenile	South Atlantic and Mid-Atlantic Bights			Sandy shoals of capes and offshore bars, high profile rock bottoms and barrier island oceanside waters from surf zone to shelf break, but from the Gulf Stream shoreward
Spanish mackerel, cobia, and king mackerel	adult	South Atlantic and Mid-Atlantic Bights			Sandy shoals of capes and offshore bars, high profile rock bottoms and barrier island oceanside waters from surf zone

					to shelf break, but from the Gulf Stream shoreward
Golden crab	juvenile	Chesapeake Bay to the south through the Florida Straight (and into the Gulf of Mexico)	290 - 570		Continental slope in flat areas of foraminifera ooze, on distinct mounds of dead coral, ripple habitat, dunes, black pebble habitat, low outcrop, and soft bioturbated habitat
Golden crab	adult	Chesapeake Bay to the south through the Florida Straight (and into the Gulf of Mexico)	290 - 570		Continental slope in flat areas of foraminifera ooze, on distinct mounds of dead coral, ripple habitat, dunes, black pebble habitat, low outcrop, and soft bioturbated habitat
Barndoor skate	juvenile	Eastern GOME, GB, Southern NE, Mid-Atlantic Bight to Hudson Canyon	l0 - 750, mosty < 150		Bottom habitats with mud, gravel, and sand substrates
Barndoor skate	adult	Eastern GOME, GB, Southern NE, Mid-Atlantic Bight to Hudson Canyon	l0 - 750, mosty < 150		Bottom habitats with mud, gravel, and sand substrates
Clearnose skate	juvenile	GOME, along shelf to Cape Hatteras, NC; includes the estuaries from Hudson River/Raritan Bay south to the Chesapeake Bay mainstem	0 – 500, mostly < 111		Bottom habitats with substrate of soft bottom along continental shelf and rocky or gravelly bottom
Clearnose skate	adult	GOME, along shelf to Cape Hatteras, NC; includes the estuaries from Hudson River/Raritan Bay south to the Chesapeake Bay mainstem	0 – 500, mostly < 111		Bottom habitats with substrate of soft bottom along continental shelf and rocky or gravelly bottom
Little skate	juvenile	GB through Mid-Atlantic Bight to Cape Hatteras, NC; includes the estuaries from Buzzards Bay south to the Chesapeake Bay mainstem	0 - 137, mostly 73 - 91		Bottom habitats with sandy or gravelly substrate or mud
Little skate	adult	GB through Mid-Atlantic Bight to Cape Hatteras, NC; includes the estuaries from Buzzards Bay south to the Chesapeake Bay mainstem	0 - 137, mostly 73 - 91		Bottom habitats with sandy or gravelly substrate or mud
Rosette skate	juvenile	Nantucket shoals and southern edge of GB to Cape Hatteras, NC	33 - 530, mostly 74 - 274		Bottom habitats with soft substrate, including sand/mud bottoms, mud with echinoid and ophiuroid fragments, and shell and pteropod ooze
Rosette skate	adult	Nantucket shoals and southern edge of GB to Cape Hatteras, NC	33 - 530, mostly 74 -		Bottom habitats with soft substrate, including sand/mud

			274		bottoms, mud with echinoid and ophiuroid fragments, and shell and pteropod ooze
Smooth skate	juvenile	Offshore banks of GOME	31 – 874, mostly 110 - 457		Bottom habitats with a substrate of soft mud (silt and clay), sand, broken shells, gravel and pebbles
Smooth skate	adult	Offshore banks of GOME	31 – 874, mostly 110 - 457		Bottom habitats with a substrate of soft mud (silt and clay), sand, broken shells, gravel and pebbles
Thorny skate	juvenile	GOME and GB	18 - 2000, mostly 111 - 366		Bottom habitats with a substrate of sand, gravel, broken shell, pebbles, and soft mud
Thorny skate	adult	GOME and GB	18 - 2000, mostly 111 - 366		Bottom habitats with a substrate of sand, gravel, broken shell, pebbles, and soft mud
Winter skate	juvenile	Cape Cod Bay, GB, southern NE shelf through Mid-Atlantic Bight to North Carolina; includes the estuaries from Buzzards Bay south to the Chesapeake Bay mainstem	0 - 37, mostly < 111		Bottom habitats with substrate of sand and gravel or mud
Winter skate	adult	Cape Cod Bay, GB southern NE shelf through Mid-Atlantic Bight to North Carolina; includes the estuaries from Buzzards Bay south to the Chesapeake Bay mainstem	0 - 371, mostly < 111		Bottom habitats with substrate of sand and gravel or mud

Mixed or Unknown l Species

Species	**Life Stage**	**Geographic Area of EFH**	**Depth**	**Seasonal Occurrence**	**EFH Description**
White hake	juvenile	GOME, southern edge of GB, southern NE to middle Atlantic and the following estuaries: Passamaquoddy Bay to Great Bay; Mass. Bay to Cape Cod Bay	5 - 225	May to September	Pelagic stage - pelagic waters; demersal stage - bottom habitat with seagrass beds or substrate of mud or fine grained sand

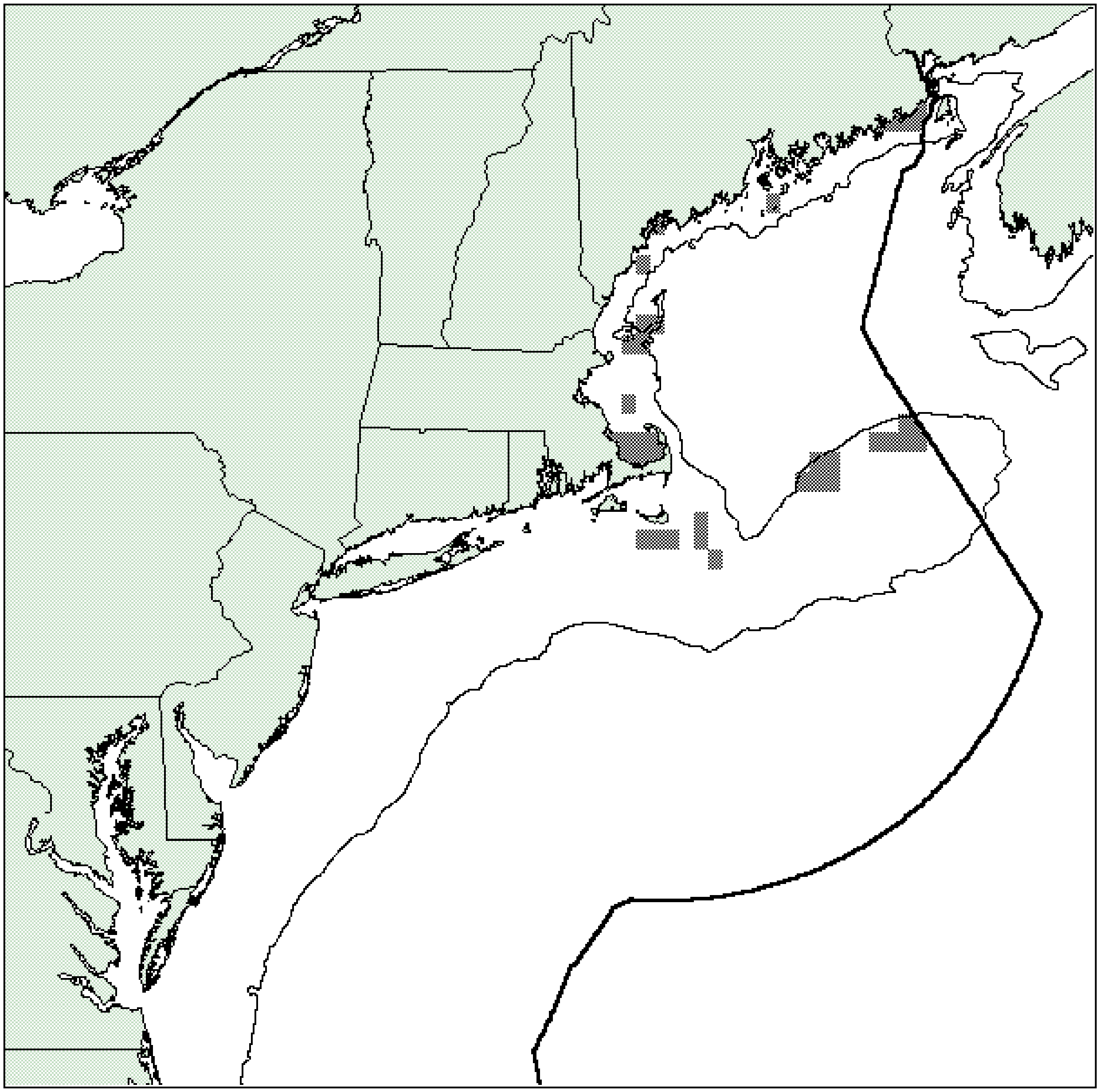

Figure 4.17. The EFH designation for Atlantic herring eggs.

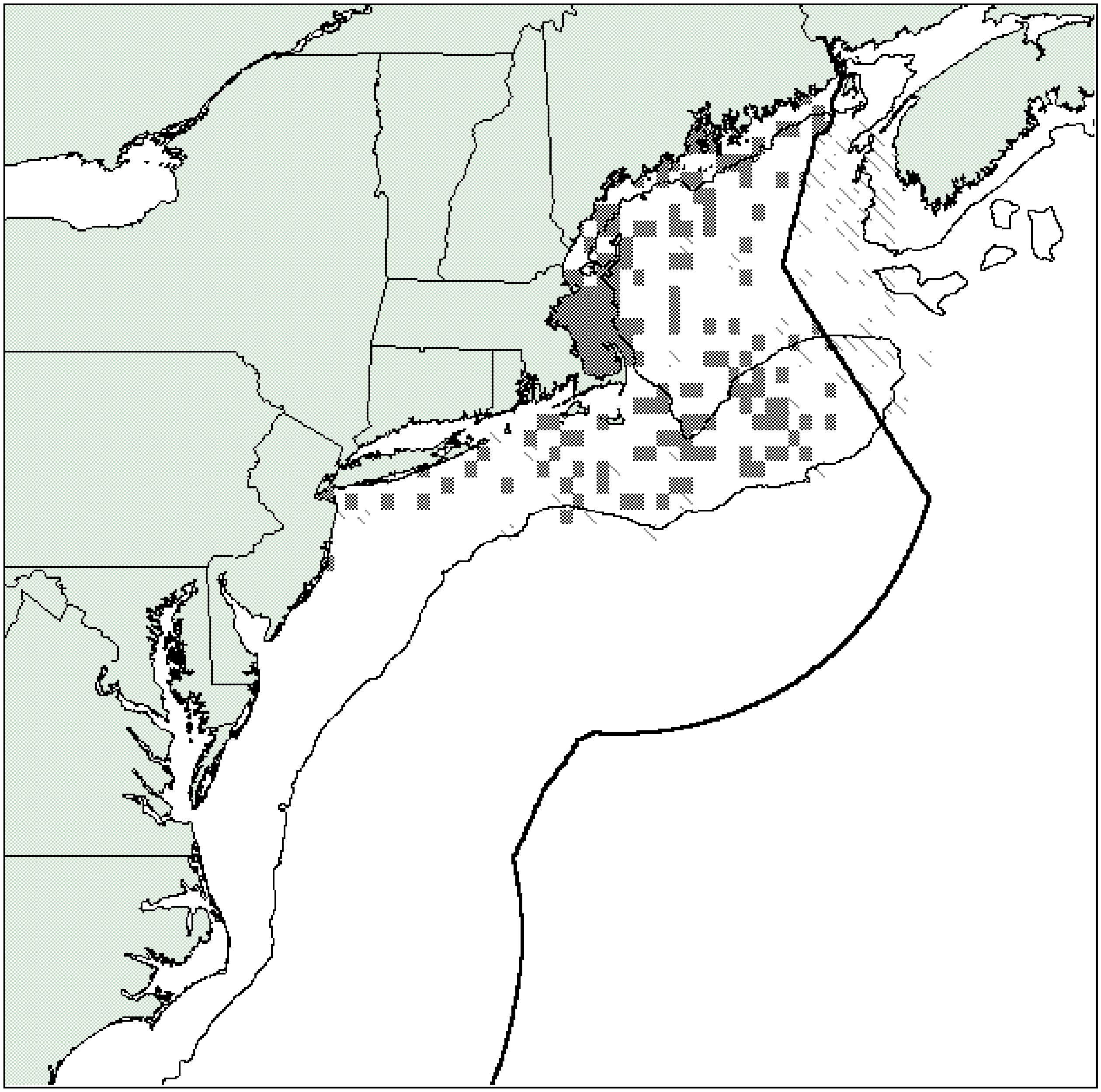

Figure 4.18. The EFH designation for Atlantic herring larvae.

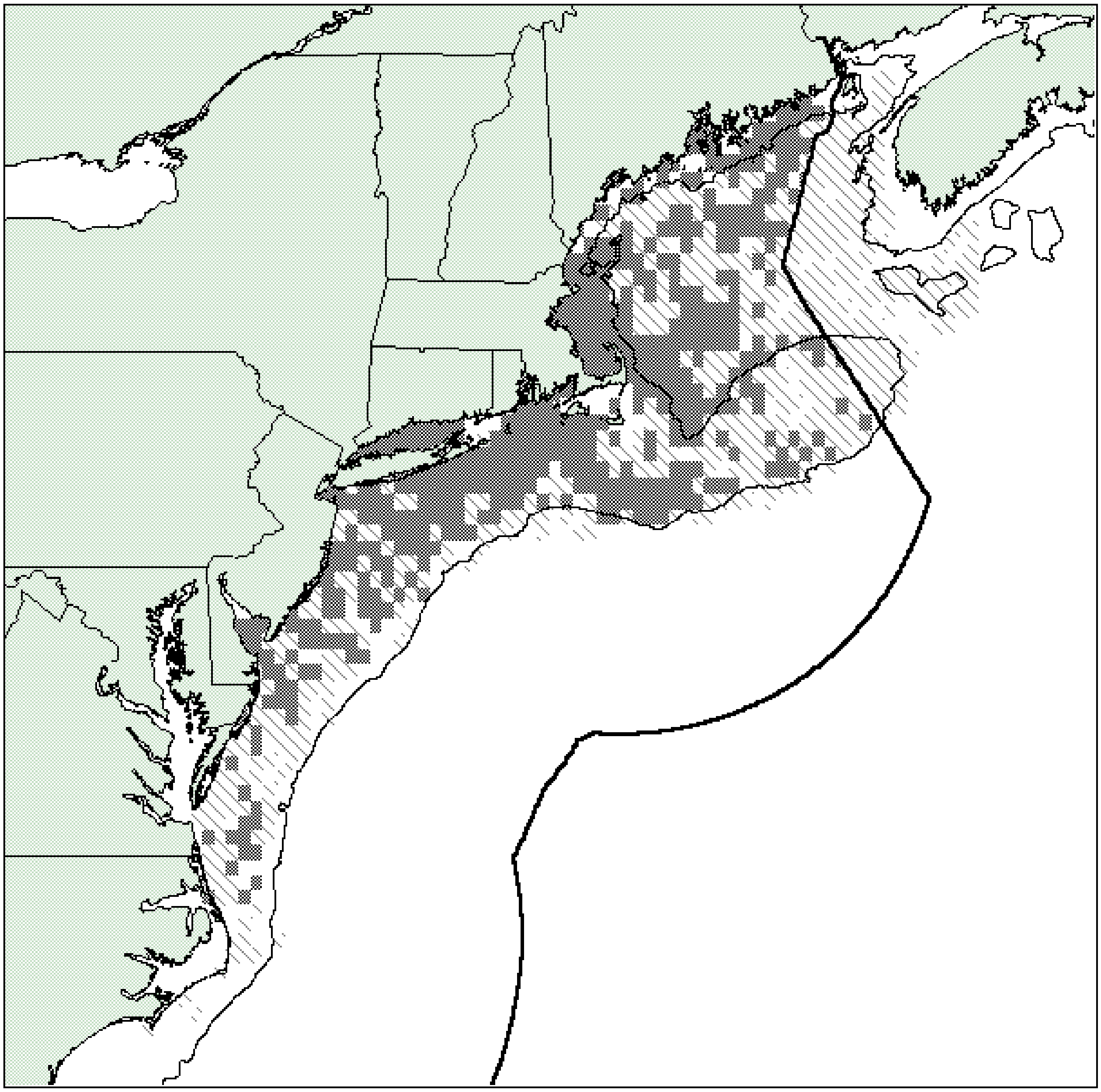

Figure 4.19. The EFH designation for juvenile Atlantic herring.

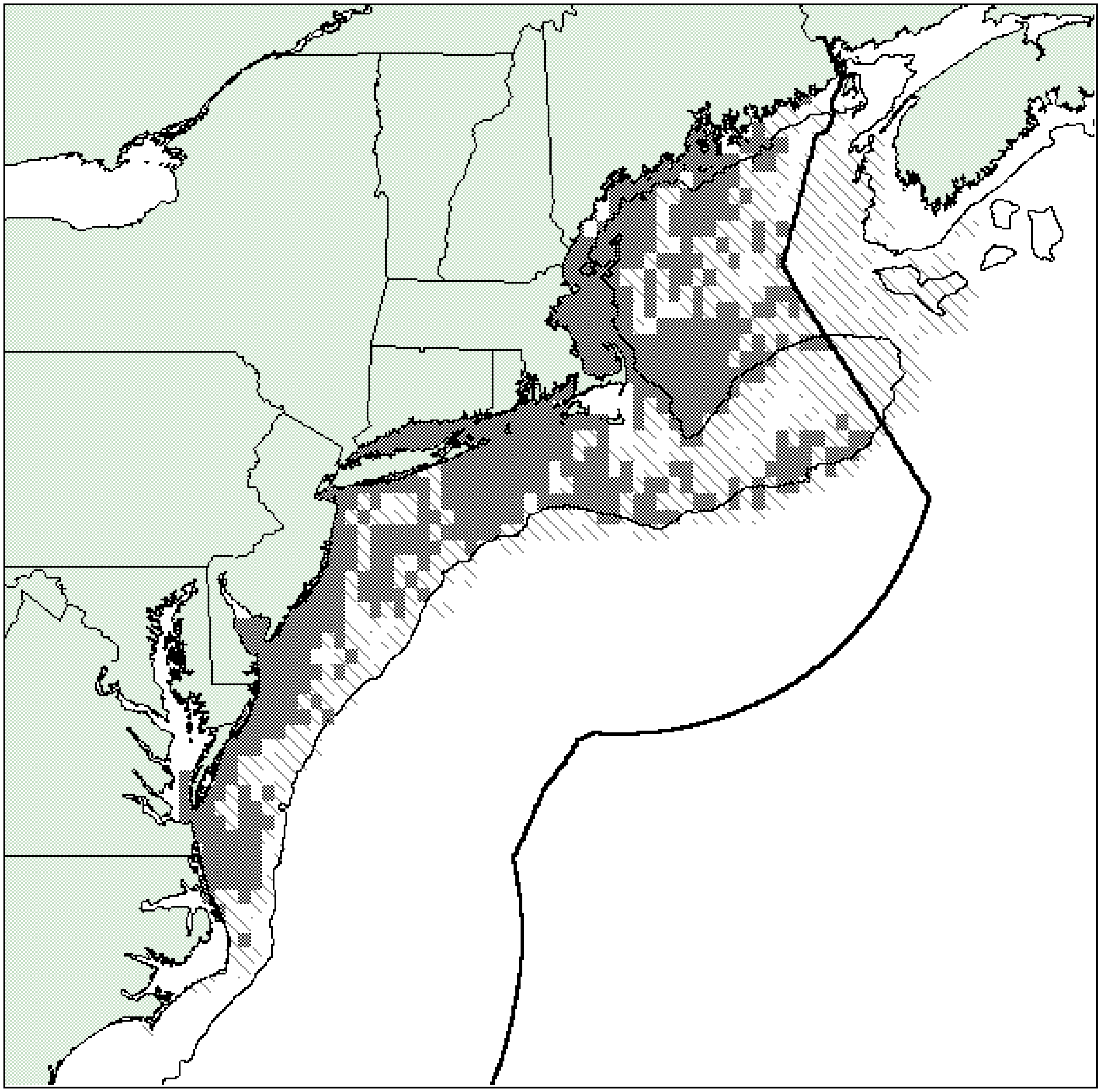

Figure 4.20. The EFH designation for adult Atlantic herring.

4.3 Human Environment

4.3.1 Description of Herring Fishery

Herring fisheries have existed in Europe for over 1,000 years and in the Northwest Atlantic for about 450 years. The herring fishery in Maine developed in the 19th century in conjunction with the “sardine” industry. “Sardines” (juvenile herring) were plentiful along the Maine and New Brunswick coast and supplied a thriving canning industry until the 1960s when the number of canneries in Maine begain to decline (Section 4.3.1.4). In more recent years, herring has been used primarily for lobster bait. Foreign-owned ships were used in state internal waters for a few years in the late 1980s and early 1990s to process herring caught by U.S. fishermen. With the arrival of foreign fishing fleets in the 1960’s, a large adult herring fishery developed on Georges Bank. The widespread use of freezer trawlers contributed to over-exploitation and decline of the stock (Figure 4.21). Since 1982, there have been significant changes in the coastal herring fishery. These include changes in gear types used in the fishery and the end of a directed foreign fishery for herring that existed during the 1970s.

There is a small recreational fishery for Atlantic herring that generally occurs from early spring to late fall, with a large majority of the fishery taking place from party boats (NEFMC 1999). Herring is also caught by tuna boats with small pelagic gillnets for use as live bait in the recreational tuna fisheries.

4.3.1.1 Catch by Area and Gear Type

Following the collapse of the Georges Bank stock and the end of the foreign fishery in herring management area 3 (see Figure 3.2) during the 1970s (caused by the extension of U.S. waters to 200 miles), total catch remained below 50,000 mt for several years and below 100,000 mt until the mid-1990s (Figure 4.21). Catches in area 1 (the Gulf of Maine) have remained between 30,000 and 100,000 mt for the last 40 years. The area 1 catch peaked at 100,000 mt in 1980 and then declined abruptly during the next three years (Figure 4.22). It remained at a very low level until 1985 and then increased during the next 10 years to reach 100,000 mt again in 1996. The U.S. herring fishery became active in area 2 (southern New England and the mid-Atlantic region) in the early 1990s and on Georges Bank in 1997. Area 1A (the inshore portion of the Gulf of Maine) accounted for 64% of the catch in 2003, area 2 for 16%, and area 3 for 20%. The fishery is active in the Gulf of Maine and on Georges Bank in the spring, summer, and fall and in southern New England in the winter. The seasonal pattern of the fishery is determined by the seasonal migrations of the fish (Section 4.2.2.7). In 2003, the states with the highest landings were Maine (47%) and Massachusetts (38%), with less than 10% in Rhode Island and New Hampshire.

There have been several major changes in the use of the five principal gear types used in the U.S. Atlantic herring fishery during the past 25 years (Figure 4.23). All five gears (mid-water trawls, pair trawls, purse seines, stop seines and weirs) have been used during this time period, but fixed gear (stop seines and weirs) were the principal gears used in the U.S. fishery until purse seines were introduced during the 1960s. Fixed gear accounted for 30-70% of the catch during 1977-1982. The inshore fixed gear fishery along the Maine coast – which mostly targeted juveniles for the canning industry – declined dramatically in the 1980s and purse seines made up almost 100% of U.S. landings until single boat mid-water trawls started taking a growing share of the catch during the 1990s. Pair trawls – which were used to some extent in the winter fishery in southern New England during the late 1970s and early 1980s – have been used more and more during the last six years and accounted for 65% of landings in 2003 (Table 4.12). Herring are also caught incidentally to other species by vessels using other gear types. The most important of these is the bottom trawl. Landings of Atlantic herring by bottom trawl vessels accounted for less than 3% of total annual landings in most of the last 25 years (Figure 4.23). The gears used in the directed Atlantic herring fishery are described in Section 4.3.2.

4.3.1.2 Fishing Gears and Practices

Mid-Water Trawls (Single Vessel)

Mid-water trawls are used to capture pelagic species throughout the water column between the surface and the seabed (see Figure 4.24). Mid-water trawls used in the New England Atlantic herring fishery are nylon "rope" trawls with very large meshes in the forward portion of the net that become progressively smaller toward the rear of the net, sometimes called the "brailer" (see www.gma.org, web site of the Gulf of Maine Research Institute). The large opening of the net functions to "herd" schooling fish toward the rear of the net. For nets used on single boats, the net is spread horizontally with two large metal doors positioned in front of the net. As the trawler moves forward, the doors, and therefore the net, are forced outward. Once the net is deployed, changes in its position in the water column (height above the bottom) are made by increasing or decreasing the speed of the vessel or by bringing or letting out trawl wire. An electronic sonar system mounted in the mouth of the net allows the fisherman to continually monitor the size of the net opening and the height of the net above the bottom during each tow.

The footrope of the net is weighted with short lengths of chain in order to keep the mouth of the net open. In most cases, two heavy weights (e.g., "balls"of heavy chain each weighing 1000 to 5000 pounds) are attached forward of the net to cables ("warps") that extend from the net opening to the trawl doors (Figure 4.24). This is done while fishing in deep water to get the net closer to the bottom without using as much trawl wire. There is no ground gear (e.g., "cookies") attached to the footrope. Tows typically last for several hours and catches are large. The fish are usually removed from the net while it remains in the water alongside the vessel by means of a suction pump. In some cases, the fish are removed from the net by repeatedly lifting the cod end aboard the vessel until the entire catch is in the hold.

Herring mid-water trawls are not designed to fish on the bottom and do not normally contact the bottom, although information provided by herring fishermen indicates that the footrope, the belly of the net, and/or the weights do occasionally contact the bottom. Sometimes, when herring are in deep water near the bottom, mid-water trawls are intentionally fished close to or in contact with the bottom. This occurs primarily in southern New England and the Mid-Atlantic during the winter (January-March); it may also occur in certain places on Georges Bank. The use of mid-water trawls near or on the bottom generally only occurs on smooth mud and sand substrate, since bottom contact in more complex, rocky habitats (which are more common in the Gulf of Maine) causes the footrope to "hang up" and causes serious damage to the net. Damaged nets require costly repairs, which provides an incentive to fishermen to avoid bottom contact. The trawl doors do not contact the bottom. Because the herring in the rear of the net remain alive during the tow, even when it is full of herring, the "brailer" normally floats free of the seafloor when fishing near the bottom. (The information in this paragraph was provided in personal communications with David Reingardt, Peter Mullen, and Jerry O'Neill, all of whom have been or are members of the NEFMC Atlantic Herring Industry Advisory Committee, and by Kohl Kanwit of the Maine Department of Marine Resources).

Paired Mid-Water Trawls (Two Vessels)

"Pair trawls" used in the New England Atlantic herring fishery are designed identically as single boat mid-water trawls, but do not have doors, since the net is spread by the two vessels. They are often larger than single-boat mid-water trawls because the combined towing power of two vessels exceeds that of a single vessel.

Purse Seines

The purse seine is a deep nylon mesh net with floats on the top and lead weights on the bottom. Rings are fastened at intervals to the lead line and a purse line runs completely around the net through the rings (see GOMRI web site). One end of the net remains in the vessel and the other end is attached to a power skiff or "bug boat" that is deployed from the stern of the vessel and remains in place while the vessel encircles a school of fish with the net. Then the net is pursed and brought back aboard the vessel through a hydraulic power block. Purse seines vary in size according to the size of the vessel and the depth to be fished. Most purse seines used in the New England herring fishery range from 30 to 50 meters deep (100-165 ft) (Peter Mullen, pers. comm). Purse seining is a year round pursuit in the Gulf of Maine, but is most active in the summer when herring are more abundant in coastal waters. It is done at night, when herring are feeding near the surface. This fishing technique is less successful when fish remain in deeper water and when they do not form "tight" schools.

Because purse seines are so deep, the lead line sometimes contacts the bottom when the nets are first set out, before they are "pursed." At that time, the bottom of the net could be pushed across the seafloor for short distances by tidal currents, disturbing benthic organisms and substrates, particularly in rocky bottom areas. Once the net is pursed, the lead lines lift up off the bottom and there would be no further contact with the bottom. This probably occurs infrequently and causes a minimal amount of disturbance.

Stop Seines and Weirs

Weir and stop seining are traditional fishing techniques associated with the tending of inshore coves in Maine (NEFMC 1999). They are the principal gears used in the inshore herring fishery along the Maine coast. These fishing gear types occur entirely within state waters, and therefore are not regulated under a federal fishery management plan.

Stop Seines

The stop-seine fishing method is used in Maine to harvest schools of juvenile herring (Everhart and Youngs 1981). The stop-seine fishery evolved from the traditional fixed gear weir fishery and involves the setting of nets across a narrow cove after the herring enter, thus blocking their escape. Once the fish are "shut off," the fishermen wait until the fish enter a small "pocket" in the net. Once they enter the pocket, they are removed with a small purse seine and transferred to larger boats called herring "carriers" which bring the catch ashore.

Weirs

The fixed gear weir fishery occurs primarily in eastern Maine and Canada (NE aquarium). A weir is a simple maze that intercepts species that migrate along the shoreline. Brush weirs are used in the Maine herring fishery. These are built of wooden stakes and saplings driven into the bottom in shallow waters. The young herring encounter the lead that they follow to deeper water, finally passing into an enclosure of brush or netting. The concentrated fish are then removed with a small seine (Everhart and Youngs 1981). From here the herring are transferred to larger boats called herring "carriers" which bring the catch ashore.

4.3.1.3 Fleets

This section summarizes the economic aspects of the herring fishery, including vessel, dealer and processor activities, as well as revenues from and utilization of herring.

The total number of vessels landing herring in 2003 was 154 (Table 4.13). However, most of these were vessels that landed small amounts of herring caught incidentally to other species, primarily with bottom trawls. Most herring sold in 2003 was taken from Area 1A (59,451 mt). Area 1B landings were 4,920 mt, Area 2 landings were 16,081 mt, and Area 3 landings were 20,227 metric tons (Table 4.12). Twenty-five vessels used mid-water nets, either singly or working with a second vessel, and there were six purse seine vessels. Some herring fishing vessels use more than one gear, or sometimes fish mid-water trawls in tandem with another vessel or on their own. Each vessel enumerated in Table 4.13 was assigned a principal gear based on the gear that landed the most herring. Landings shown in Table 4.12 are sorted according to the actual gear used, without assignment to a vessel. Table 4.13 also lists number of trips and days at sea by principal gear and management area. For pair trawl gear, trips and days are counted for each participating vessel. For example, if two vessels make a two day pair trawl trip, the total number of trips would equal two and the total number of days at sea would equal four.

Since the dealer data for 2003 is not complete, value information from 2002 is used. Prices for herring ranged from a low of $0.056 per pound in January to a high of $0.078 per pound in May. The average yearly price was $0.065 per pound in 2002. Using the average monthly price of herring sold in 2002, the total value of all herring sold in 2003 was $14.8 million.

Table 4.14 shows the breakdown of quantity and value of landings by state landed and gear used. The state of Maine lands 46,795 mt of herring at a value of $7.1 million. Massachusetts follows next in the ranking with landings of 38,213 mt and a value of $5.5 million. Rhode Island and New Hampshire have significantly less landings of herring. Each of these states has landings in the range of 7,000 to 7,700 mt at a value of $1 to $1.15 million.

Table 4.15 and Table 4.16 provide information on the number of crew members employed in the herring fishery. Table 4.15 reports the average, minimum, and maximum number of crew members (including the captain) per trip as reported on logbooks. Table 4.16 defines fleet sectors by a vessel’s principal gear and the state in which the vessel made the majority of its landings. Then, using the average crew size per vessel, the number of vessels and total number of crew they employ are reported by fleet sector.

Catch and landings for the Atlantic herring fishery are monitored using three separate reporting systems: Vessel Trip Reports (VTR), Interactive Voice Reporting (IVR), and dealer reports. The fishery is dominated by a relatively small group of vessels. Most herring trips are about one day in length, with the exception of a small number of freezer trawlers that average 5-7 days in length.

4.3.1.4 Markets

This information was drawn from previous herring fishery management documents such as the 1999 FMP (NEFMC 1999) and the 2000 SAFE report (NEFSC 2000b). The descriptions of the processing plants and their markets were from summaries of site visits and phone conversations by Herring PDT members. The Herring PDT wishes to thank the processing plant managers and owners for contributing this information.

There are 4 primary markets for herring: 1) the bait market, 2) the canned sardine market, 3) the fresh round market, and 4) the international frozen whole fish market. There are also other markets but these are relatively small markets for the Northeast U.S. fishery. Example of these markets include: smoked herring serviced by companies such as Acme Smoked Fish Corp. of Brooklyn, NY, herring sea pearl essence (from herring scales) produced by Engelhard Corp. of Eastport Maine, and herring fillets processed by Cor - J Seafood Corp of Hampton Bays, NY.

Bait Market

The use of herring as bait is a very important aspect of the fishery, and herring bait has been used for at least 200 years in New England. Present uses of bait are for lobstering (regional) and long-lining (regional-national-international). National use of herring for long-lining is found on the West Coast, in Alaska, and Florida. International use of herring for bait occurs in Costa Rica. In Rhode Island, herring bait is sold as whole salted fish. The fish are sold in 200 lb. barrels and are salted in layers using 35 lb. bags of salt.

Herring are first offloaded in large plastic containers. The containers are forklifted to a height even with a conveyer belt, and then layers of herring conveyed into a barrel, with layers of salt between each layer of herring. The bait keeps best in the winter, but can begin to decay after 2-3 days when it gets warm.

The quantity of herring used as bait is considerable. For the year 1996, when 105,000 mt of herring was landed in the U.S., it has been estimated that on the order of 71,000 tons of herring were utilized as bait (D. Stevenson, personal communication). This includes bait taken as leftover product from herring processing.

It is clear that much of the economy and cultural fabric of coastal New England--especially Maine--depends greatly on herring bait to sustain the lobster enterprise of this region. With a rocky soil and coastline, large distances between urban centers, and no other major industry or significant agricultural centers, coastal Maine has always relied heavily on its marine resources.

As anyone who has traveled the Maine coast can observe, lobster represents the apex of those marine resources.

Small-scale truckers, bait shop owners, and related business all participate in the commercial bait venture. Bait can be delivered dockside from trucks traveling up and down the coast. The trucks pick up the bait from canneries community sites up and down the coast to service smaller bait shops or lobster fishing 'gangs' (Acheson 1987). Island bound and coastal isolated lobster fishermen may also pick up bait directly off vessels, or have it brought out on ferries:

Canned Sardine Market

Connors Bros. Ltd. purchased the remaining sardine canneries in the US from Stinson Seafood in 2000. The canneries are located in Bath ME & Prospect Harbor ME. Connors already owned a plant in Blacks Harbor, Canada, and a seasonal cannery in Seal Cove (Grand Manan, New Brunswick Canada). The Stinson canneries in Bath and Prospect Harbor are the only two remaining canneries in the Northeast United States. Years ago, more than 100 canneries existed (mostly along the coast of Maine) and processed close to the same amount of fish as the remaining two canneries. The demise of most of these canneries has been attributed primarily to increasing technology (and associated costs) and changes in the local and regional economy.

The cannery in Bath is the oldest of the existing plants (in terms of modernization) and has undergone renovations to update cutting equipment and fish storage techniques. The Prospect Harbor Plant is currently undergoing extensive renovations and is the site of numerous major capitalization projects. When finished, the Prospect Harbor cannery is expected to be one of the most modern sardine plants in the world.

Once received at the Bath cannery, the fish are graded by width into four size categories: below 8", 8-9.5", 9.5-11", and larger than 11"and are then stored in refrigerated salt water (RSW) tanks. The heads and tails are cut off the fish (by cutting machines) and are sold for lobster bait. The precut fish are iced in a brine mixture and sent through the cannery to be packed and cooked. The packing line (for one product) at the plant in Bath can accommodate up to 64 packers who will work for an eight-hour shift, with two packers at each table. Each can is packed by hand, and approximately 1,500-2,000 cases (each containing 100 cans) can be packed per day. (All cans and covers for all of the canneries are manufactured in-house at the can plant in Blacks Harbor.) A good packer can produce approximately 80 cases of pre-cut fish or 40 cases of steaks in one shift. In general, two products (sardines & steaks with various sauces) can be processed concurrently at the Bath facility.

At the Prospect Harbor cannery, the fish are transferred directly to RSW tanks, where they are held until they are ready to be processed. At that point, the fish are graded into the same size categories as the Bath cannery. Two different grades can run through the cutting facility at one time. About twenty packers work at the Prospect Harbor facility (versus 120 several years ago when all fish were cut with scissors). On a good day, the Prospect Harbor plant has the ability to process about 150 cases (100 cans each) per packer, or close to 2500 cases of sardines per day (average about 2,200 cases per day). When plant modernization is completed with additional product lines the daily capacity will increase in excess of 3000 cases/day. The Prospect Harbor cannery also sells lobster bait (cuttings - heads and tails) to bait dealers and fishermen, which insures a good working relationship with the community's local lobstermen.

After they are packed into cans, the fish are first pre-cooked in steam boxes for about 20-25 minutes and then drained to eliminate excess water and fish oil. Then, sauces are added, and the cans are covered and sealed, washed, and prepared for the second cooking. The second cooking lasts approximately 50 – 60 minutes in new high tech sterilization equipment (retorts) that can hold about 18,000 cans each.

Mobile freezer containers are located at the facilities to store frozen product for processing during times when fresh product is not available (for example, when bad weather does not allow for fishing). The canneries operate on a year-round basis as fish are available, but April – early May is traditionally a slow period for business. At the Prospect Harbor cannery, vessels (mostly purse seine) offload at the facility from about June – October, and fish are trucked in (mostly from midwater trawlers) during the remainder of the year. Even though Bath has vessel off load facilities, nearly all of the fish are trucked in.

The majority of the products produced by Connors/Stinsons are sold in the US as well as in other countries around the world. Increasing competition from other countries that process sardines for the global market include: Morocco, Korea, Taiwan, and Poland. Norway and Sweden are also large players on the global market. As a result, US production is relatively small from a global perspective, and markets for US product in Europe and Asia are very limited (due in part to a high tariff in force in the EU). The European market for canned sardines is essentially closed to Northeast U.S. canned product because of restrictions placed on the species that can be imported as sardines. Many European countries only allow *Sardinus pilchardus* (European pilchard) to be imported as sardines. The U.S. is lobbying European governments to remove this restriction.

The Bath and Prospect Harbor canneries together employ about 250 benefited employees. The makeup of this workforce includes: management, supervisors, quality control, maintenance, tank room, packing room, sealing room, packaging and shipping.

At the Prospect Harbor cannery, most employees live within one hour of the facility throughout the Downeast Maine region. At the Bath cannery, most employees are local, residing in Bath, Brunswick, and other nearby towns. Some temporary/seasonal employees are hired from Portland ME. Fewer alternative employment opportunities exist around the Prospect Harbor plant as compared to the Bath plant, further supporting the importance of the Prospect Harbor cannery to the local economy and community.

Fresh Round Market

Historically, there has been an extensive trade in herring between the northeastern U. S. and Canada which has benefited both countries. This trade has been used by the industry on both sides of the border to smooth out fluctuations in the supply of herring for both the sardine canneries and the bait market. From 1972 through 1976, for example, imports of Canadian herring provided over 50 percent of the raw material for Maine sardine canneries (NEFMC

1999). The trade occurs both via truck and vessel. In 1996, the Magnuson Act was amended to allow NMFS to issue permits to up to fourteen Canadian vessels to load herring from U. S. vessels and transport it to Canada. U. S. caught herring is also transported to Canada by truck.

International Frozen Market

The market for whole frozen herring is determined by size, grade, and fat content. The major countries consuming this product are in the Middle East, West Africa, Asia (primarily China), and to a lesser extent the Baltic States. Nearly all the product, which is usually frozen in 20 kilogram blocks, is for human consumption where the blocks are thawed and sold in shops.

The market for whole frozen herring is serviced by both domestic freezers (onshore and offshore) and Joint Venture and Internal Waters Processing (JVP/IWP) operations. Joint Venture Processing agreements allow U.S. fishermen to harvest herring and sell them to foreign-owned processing ships in federal waters. Internal Water Processing operations are similar, but the processing ships are anchored in internal state waters. IWP operations are subject to approval by the Atlantic States Marine Fisheries Commission and the governor of any state where the processing vessel is located. Both types of operation are limited by quotas which are determined annually.

JVP/IWP

Prior to the 1990's onboard canning and packing of herring into barrels was done by Soviet processor vessels through JVP/IWP agreements. After the fall of communism, these operations ceased in U.S. waters. Since that time the focus has been on freezing whole herring at sea. Currently there are International Fisheries Agreements, which is a prerequisite for establishing a JVP or IWP, with Russia, Estonia, Lithuania, Latvia, and Poland. There has been no JVP activity since 2001 and the recent IWP operations have focused primarily on mackerel. There are also domestic shore based and at-sea processors competing for the whole frozen market.

Onshore Freezing

Two freezing facilities in Massachusetts have recently begun to supply product to the whole frozen market. Cape Seafoods is a pelagic processing plant based in Gloucester, Massachusetts that began processing operations in June 2001, six months after leasing space for the facility from the Commonwealth of Massachusetts. Allied Cold Storage is located adjacent to Cape Seafoods and currently offers freezer space for about 4,000 tons of product. Allied also invested in capacity upgrades when Cape Seafoods was constructed. The Northern Pelagic Group, LLC (NORPEL) is a new pelagic processing plant based in New Bedford, Massachusetts that opened its doors on December 30, 2002. The adjacent cold storage facility (Maritime International Inc.) is capable of holding nearly 6,000 mt of processed product to help facilitate on-time deliveries according to customer's schedules.

Cape Seafoods

All food-grade product is blast frozen, which takes 20-24 hours. Once the fish are processed and frozen, they are packed into cardboard cartons that are produced in Holland. The plant is working with some US companies to develop a corrugated cardboard carton that is suitable for blast freezing and hopes to purchase this production input from a domestic company in the future. Refrigerated cargo vessels are chartered by Cape Seafoods customers to pick up product at the facility and deliver it overseas. The cargo vessels usually transport about 2,500 – 4,000 tons of product. Any waste from the processing plant is transported to a fish meal plant in Canada.

Atlantic herring processed by Cape Seafoods supplies some established markets in West Africa and the Middle East (frozen herring). The company is working towards developing an export market with China, which currently buys product from the Pacific. In addition, there appears to be an increasing demand from the bait market for fresh herring, and currently, bait fetches a higher price than food-grade herring. The bait shop at Cape Seafoods operates seasonally and supplies fresh bait to local lobster vessels.

In general, the overseas market for pelagic species can be volatile at times. Market limitations and competition necessitate that a reliable and consistent product be supplied by Cape Seafoods to customers around the world. Competition with alternative species (sardinella, horse mackerel, for example) in particular has been challenging. The Norwegians are major competitors in the global market for herring.

There are 10-15 crew members on the two dedicated fishing vessels operated by Western Sea Fishing Company. Cape Seafoods employs 10 full-time individuals on a year-round basis, and contracts for temporary employees through an independent labor company in Massachusetts. The Company is intending to add two or three more full time employees in the near future. The year-round employees are mostly local area residents. Health benefits are provided to the company’s full-time employees. The plant hires about 20-24 temporary employees every day that production is occurring. In addition, Allied Cold Storage employs six individuals at their State Pier, Gloucester facility, and another 15 individuals are employed to load refrigerated cargo vessels for exporting the product. No layoffs or employment reductions are anticipated in the near future. Cape Seafoods and Western Sea use many local area suppliers for such things as electrical maintenance, building modifications, packaging supplies, food and fuel for the vessels, trucking, freezing and cold storage.

NORPEL

In general, NORPEL’s processing operations are composed of about 70% herring and 30% mackerel. Processing herring can be a year-round business, while processing mackerel occurs primarily during the peak season, December – April.

NORPEL processes herring for both the food and bait markets but concentrates the majority of its operations on the food market. While NORPEL is capable of processing herring on a year-round basis, there is some seasonality associated with obtaining a food-grade product. In the spring, when the fish are “feedy,” the product is less desirable. The feed tends to react in the stomachs of the fish, causing the stomach linings to burst when they defrost.

NORPEL estimates that with the influence of seasonality and market conditions, the plant could process fish about 200 of 365 days in a year. The plant is designed to run 24 hours a day so that it can operate in conjunction with the cyclical nature of the fishery. The processing capacity of the plant is about 300 tons per day. NORPEL estimates that it could process about 25,000-30,000 mt of fish during 2003, possibly 40,000 mt depending on fish availability, weather, and market conditions.

Vessels that catch herring for food markets hold the fish in refrigerated sea water (RSW) tanks (30-31°F) until the fish can be graded at the NORPEL facility. RSW tanks are critical to ensure a food-grade product. If the fish are considered to be acceptable for the food market, then NORPEL purchases them, places them in their own specially designed land RSW tanks (30-31° F), grades them to size, packs them into custom poly-coated cartons, and freezes them. NORPEL has six large RSW holding tanks, which are computer-controlled and capable of holding nearly 300 mt.

There are also blast freezers located in an adjacent facility to supplement operations if larger fish (mackerel) are purchased. The adjacent cold storage facility (Maritime International Inc.) is capable of holding nearly 6,000 mt of processed product to help facilitate on-time deliveries according to customer's schedules.

Once frozen in blocks, the fish are packed into cartons (boxes) of 20-25 kg in size on a conveyor system.

NORPEL processes herring and mackerel for food markets worldwide. On a global basis, the U.S. fisheries for pelagic species like herring and mackerel are very small. NORPEL is competing for market share with plants that are supplied by enormous pelagic fisheries (West Africa, for example).

The distance between the processing facility in New Bedford and the customers located throughout the world presents some difficulties for the plant. It can take 2-3 weeks for the customer to receive the product once the plant processes it. However, once NORPEL freezes a food-grade product, it has about a 12-month shelf life.

NORPEL has provided a boost to the economy in the fishing community of New Bedford. It employs 50-60 individuals over the course of a year, the majority of whom live in or near the community. Approximately 30 employees work each shift (two shifts/day) when the plant is operating at capacity, and this number varies based on the amount of product that needs to be processed at any given time. About 90-95% of the employees are of Central American descent (Guatemala, San Salvador). Six individuals work for the processing facility full-time (engineers, managers).

In addition, the two dedicated fishing vessels employ five crew members each and purchase food, fuel, and other supplies from local businesses. The captains and crew members of the two vessels are local residents who participated in fisheries on the West Coast for a period of time and have now come back to their home communities. The plant offers competitive wages to its employees enabling them to support their families.

Offshore Freezing

Sea Freeze

The information presented below was provided by personnel at Sea Freeze, Ltd in North Kingston, RI during a site visit and follow up phone calls carried out by individual members of the NEFMC Herring Plan Development Team. Some additional information was obtained from the company website.

Sea Freeze 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's dedicated trawlers are some of the largest freezer trawlers on the east coast. At sea freezing produces a very high quality product as the product is not damaged during loading and unloading. 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. Fishing operations target illex and loligo squid, mackerel, herring and to a lesser degree, butterfish.

Domestic sales account for approximately 30% of total sales and 70% are international. Internationally, Eastern Europe and Asia are two important regions that purchase from Sea Freeze. In both locations it is used as a bait fish and for human consumption. Zoos and aquariums also purchase their products as feed for other species. Illex squid and mackerel are the mainstay of the business accounting for approximately 80% of revenue. Although herring is the least financially valuable 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 have reached have closed. In this respect, herring, for Sea Freeze, is an important back-up fishery when other fisheries become unavailable.

4.3.1.5 Port/Community Information

Introduction and Background

This section summarizes preliminary social and cultural information about *communities of interest, i.e.* – communities which are most engaged in the herring fishery and may be more proportionately impacted by management measures being considered in this DEIS. It is included here because it is relevant to a description of port and communities that could be affected by the management measures that are evaluated in this DEIS.

Identification of *Communities of Interest*

As part of the general description of the Affected Human Environment, impacts of the proposed measures on all vessels and communities participating in the herring fishery (any measurable level of landings) are considered. The purpose of identifying *communities of interest* is to ensure that more thorough consideration is given to the potential impacts on those communities which are *most* involved in the herring fishery and/or most important to the operation of the herring fishery as a whole. Note that some communities have been grouped together to acknowledge geographic proximity as well as similarities in terms of participation in and dependence on the herring fishery.

Unlike some other fisheries in the region (multispecies, for example), the herring fishery is a smaller, more discrete fishery whose participating vessels and communities are easier to identify. The following *communities of interest* were selected because they meet at least one (and more than one in most cases) of the following five criteria:

1. Atlantic herring landings of at least 10,000,000 pounds (4,536 mt) in each of five years from 1994-2002, or anticipated landings above this level based on interviews and documented fishery-related developments.

This criterion was selected to identify the most active ports currently engaged in the herring fishery. Landings of 10,000,000 pounds (4,536 mt) in a year indicate a relatively substantial degree of participation in the herring fishery, as 10,000,000 pounds equates to 7.5% of the Area 1A and 3 TACs, 45.4% of the Area 1B TAC, and 9% of the Area 2 TAC. Any port with herring landings at or above this level in multiple years can clearly accommodate large vessels that land large quantities of herring.

The provision for anticipated landings above this level is included as part of this criterion to acknowledge that the shoreside aspects of the Atlantic herring fishery are still developing in some areas. Two new shoreside processing plants have opened since 2001(in Gloucester and New Bedford), both of which are capable of receiving and processing large volumes of herring and other pelagic species. The development of these two facilities and the potential to increase landings in the communities where these facilities are located should be recognized even if these communities did not land more than 10,000,000 pounds of herring between 1994 and 2002.

Landings data alone, however, are not adequate to identify all of the communities that are engaged in the herring fishery. Because the fishery is a high-volume fishery, the most active participating vessels are relatively large, and many vessels come into port “loaded down” with herring. When landing large volumes of fish, herring vessels generally require larger, deep-water ports to ensure that they can land safely without running aground. Consequently, large volumes of herring landings tend to be concentrated in a relatively small number of ports.

A transportation network is essential for distributing herring throughout the region from herring vessels to processing facilities, bait facilities, and lobster vessels, all of which are engaged in and dependent on the herring fishery to varying degrees. In some cases, processing facilities and other infrastructure dependent on herring are located in communities with little or no landings of herring, but these facilities employ many individuals and are important social and economic components of the fishery. As a result, it is necessary to consider criteria other than landings to identify the *communities of interest* in this amendment.

2. Infrastructure dependent in part or whole on Atlantic herring.

Infrastructure for the Atlantic herring fishery includes:

- Shoreside processing facilities for food production (sardine canneries, whole frozen);

- Shoreside processing facilities for bait production (salting, etc.);
- Shoreside processing facilities for value-added production (pearl essence);
- At-sea processing facilities (freezer vessels); and
- Trucking and other essential services for distributing fish.

Infrastructure and the opportunity to capitalize on available markets for herring are important elements of the fishery. For the most part, infrastructure in this fishery, whether it be shoreside or at-sea, is dedicated solely to serving the small pelagic fisheries (herring and mackerel, primarily). Very few elements of the infrastructure are engaged in other fisheries like multispecies, monkfish, or scallops. The investments that have been made in the infrastructure for the Atlantic herring fishery reflect a long-term commitment to this fishery.

As previously noted, the number of ports that are capable of accommodating large herring vessels that land large volumes of fish is relatively small. A transportation network is essential to ensuring that herring are distributed as rapidly as possible to processing and other facilities. Trucking and transportation services are therefore a critical element of the infrastructure for this fishery.

Herring are utilized by sardine canneries as well as whole frozen processing facilities to supply product for food markets globally. The sardine canneries rely on herring for 100% of their operations. For the most part, the whole frozen processing facilities rely on a combination of herring and mackerel for 100% of their operations. Joint venture (JV) and internal waters processing (IWP) operations at-sea remain important considerations in the Atlantic herring fishery, although interest in these operations has diminished as additional shoreside processing facilities have developed in recent years.

3. Dependence on herring as lobster and/or tuna bait.

Atlantic herring is an important bait for the lobster and tuna fisheries, as well as other primarily recreational fisheries. The utilization of herring for bait is a very important aspect of the fishery, especially in the State of Maine, which relies heavily on herring to supply the significant lobster fishery in the region. Consideration of a community's dependence on herring for bait purposes is essential, as any changes to the supply of herring bait in some areas could produce negative impacts across other fisheries like the lobster fishery. Management measures in this amendment that may affect the supply of bait could result in multiplier effects throughout the numerous coastal communities that depend largely on herring bait (mostly in Maine).

Another consideration related to dependence on herring bait is the importance of herring as a forage fish for many species and the overall role of herring in the ecosystem. Individuals from communities that are dependent on herring for bait have expressed concern about the supply of herring for forage purposes and the need to maintain an adequate amount of herring in the ocean as prey for other valuable (commercial and recreational) species. Including dependence on herring as bait as a criterion for identifying communities of interest in this amendment provides an opportunity to consider the importance of herring as forage and any social and community impacts related to this issue.

While it is not feasible to identify every community that depends on herring for bait as a *community of interest* in this amendment, several communities have been identified based on an exceptionally high degree of dependence on herring for bait. Assessment of the impacts of the measures proposed in this DEIS on these communities should provide enough context to understand the potential impacts on any community that depends on herring for bait. Parallels can be drawn between the communities that are identified in this section and other similar communities engaged in the lobster, tuna, striped bass, and other recreational fisheries.

4. Geographic isolation in combination with some level of dependence on the Atlantic herring fishery.

Geographic isolation is an important consideration for communities that exhibit dependence on the Atlantic herring fishery. In general, dependence on fishing and opportunities to seek alternatives to fishing decrease as the geographic isolation of a community increases. The isolation of some coastal communities (those in Downeast Maine, for example) has clearly contributed to the dependence of these communities on the marine environment. Communities that are more geographically isolated and dependent on herring in some way may be more proportionately impacted by management measures that decrease the supply of herring or opportunities in the fishery. Since transportation is such an important element of the herring fishery, the lack of major thoroughfare in geographically-isolated communities may exacerbate problems associated with changes in supply and opportunities in the fishery.

5. Utilization of Atlantic herring for value-added production.

Utilizing herring for value-added production includes operations that can herring for sardines and process scales for pearl essence, and may include operations for pickling and/or processing herring for specialty markets in the future. Value-added production suggests that a facility may have invested in niche or specialty markets for the fishery, which may be more sensitive to changes in supply.

Based on the above criteria, the following *communities of interest* are identified for the purposes of analysis in this DEIS:

1. **Portland, Maine**
2. **Rockland, Maine**
3. **Stonington/Deer Isle, Maine**
4. **Vinalhaven, Maine**
5. **Lubec/Eastport, Maine**
6. **Prospect Harbor, Maine**
7. **Bath, Maine**
8. **Sebasco Estates, Maine**
9. **NH Seacoast – Newington, Portsmouth, Hampton/Seabrook**
10. **Gloucester, Massachusetts**
11. **New Bedford, Massachusetts**

12. Southern Rhode Island – Point Judith, Newport, North Kingstown

13. Cape May, New Jersey

Fishing Community Profiles

MARFIN

Hall-Arber et al. (2001) recently completed a report entitled, "*Fishing Communities and Fishing Dependency in the Northeast Region of the United States*" as part of a grant received through the Marine Fisheries Initiative (MARFIN). This report serves to lay the groundwork for regional and community data sharing among managers, fishing industry participants, and fishing communities. One unique feature of the report is that it attempts to characterize and quantify fishing dependence in various coastal communities. Measuring fishing dependence is complicated and requires consideration of fishing history, infrastructure, social institution, gentrification, etc. These and other issues are described in the report. The Hall-Arber report includes profiles of several fishing communities throughout the New England region, including the *communities of interest* identified above.

McCay and Cieri 2000

McCay and Cieri (2000) recently completed general updates to port profiles for the Mid-Atlantic region as work funded by the Mid-Atlantic Fishery Management Council. The authors utilized NMFS landings data, 1990 census information, brief visits to ports and interviews with key informants, and other materials where available, to characterize fishing ports in the Mid-Atlantic region. This information will serve as the most recent information for these ports until additional work is completed.

Aguirre International

In October 1996, Aguirre International completed a report (Aguirre International 1996) entitled, *An Appraisal of the Social and Cultural Aspects of the Multispecies Groundfish Fishery in New England and the Mid-Atlantic Regions*. This report was intended to be the result of the first phase of a comprehensive assessment of the social and cultural characteristics of fishing communities involved in the multispecies fishery. While the focus of this report is the multispecies fishery, it is still useful for general community information and to characterize community dependence on fisheries. The communities profiled in the Aguirre report include:

- Primary Ports: **Portland**, ME; **Gloucester**, MA; Chatham, MA; **New Bedford**, MA; **Point Judith**, RI
- Secondary Ports: **Stonington** and Downeast, ME; **Portsmouth**, NH and southern Maine ports; Provincetown, MA; **Newport**, RI; Montauk, NY; Ocean City, MD; Tidewater, VA; Wanchese, NC.

McCay 1993

McCay et al. (XX) completed a report for the Mid-Atlantic Council detailing aspects of fishing communities in the Mid-Atlantic region in December 1993. This report was intended to serve as a source document for social and economic impact assessments and contains useful information about the fisheries in which vessels in these communities participate. While it does not include much social and community information (demographics, cultural information, etc.), the economic and fisheries information is helpful to characterize communities' involvement in and dependence on various fisheries. The report provides information on communities throughout the Mid-Atlantic area, including ports in New York, New Jersey, and Rhode Island, as well as Stonington, CT, New Bedford and Chatham, MA, Wanchese, NC, Ocean City, MD, and Hampton Roads, VA.

Herring PDT Interviews, Port Visits

The herring fishery is somewhat unique to this region in that it is a relatively small, discrete fishery whose participating vessels and communities are relatively easy to identify. This is because vessels and infrastructure in this fishery are mostly dedicated to this and other small pelagic fisheries (mackerel and some squid); they generally do not participate in other fisheries like groundfish and monkfish, and they have made substantial investments into the small pelagic fisheries (RSW tanks on vessels, infrastructure for processing and transporting herring).

As a result, members of the Herring PDT were able to communicate directly with the vast majority of major participants in this fishery. Some Herring PDT members visited most or all of the herring processing facilities in the region and interviewed individuals at those facilities. PDT members also made several visits to many of the communities engaged in this fishery and interviewed several individuals with extensive historical and contemporary knowledge of the fishery. This information is provided throughout the community profiles and the description of the herring processing facilities in this document (Section 4.2.1.3).

Other Initiatives

Hall-Arber et al. (XX) received funding for a cooperative research project funded by the Saltonstall-Kennedy program and the Northeast Consortium. The project uses "community-based panels" composed of knowledgeable residents to provide socioeconomic information about the situation in which they live. While the results collected from the community panel meetings should be considered non-random data (panel membership varies from meeting to meeting, and participants comprising the panels in each location do not necessarily represent the interests of all stakeholder groups), these panels may ultimately provide new/additional community information, review available information for accuracy and comprehensiveness, and provide insight useful for social impact assessment and resource management decision-making. In its early stages, a pilot program was funded for the communities of Gloucester MA, Downeast Maine (Jonesport), and the South Shore of Massachusetts (Plymouth/Scituate). Additional funding was obtained to establish panels in Chatham MA, New Bedford MA, and Point Judith RI. To the extent possible, relevant social and community information provided by these panels will be incorporated into this amendment document to supplement available data.

4.3.2 Descriptions of Gears Used in Other Fisheries in the Northeast Region

4.3.2.1 Bottom Tending Mobile Gear

Otter Trawls

Trawls are classified by their function, bag construction, or method of maintaining the mouth opening. Function may be defined by the part of the water column where the trawl operates (e.g., bottom) or by the species that it targets (Hayes 1983). There is a wide range of otter trawl types used in the NOAA Fisheries Northeast Region because of the diversity of fisheries prosecuted and bottom types encountered in the region (NREFHSC 2002). The specific gear design used is often a result of the target species (whether they are found on or off the bottom) as well as the composition of the bottom (smooth versus rough and soft versus hard). There are three components of the otter trawl that come in contact with the sea bottom: the doors, the ground cables and bridles which attach the doors to the wings of the net, and the sweep (or foot-rope) which runs along the bottom of the net mouth. Bottom trawls are towed at a variety of speeds, but average about 5.5 km/hr (3 knots or nmi/hr).

The traditional otter board is a flat, rectangular wood structure with steel fittings and a steel “shoe” along the bottom that prevents the bottom of the door from damage and wear as it drags over the bottom. Other types include the V type (steel), polyvalent (steel), oval (wood), and slotted spherical otter board (steel) (Sainsbury 1996). It is the spreading action of the doors resulting from the angle at which they are mounted that creates the hydrodynamic forces needed to push them apart. These forces also push them down towards the sea floor. On fine grained sediments, the doors also function to create a silt cloud that aids in herding fish into the mouth of the net (Carr and Milliken 1998). In shallow waters, lightweight doors are typically used to ensure that the doors and the net spread fully. In these cases, light, foam filled doors can be used (Sainsbury 1996). Vessels fishing large nets in deeper water require very large spreading forces from the doors. In these cases, a 15 m^2 (49 ft^2) V-door weighing 640 kg (1480 lbs) can provide 9 metric tons of spreading force (Sainsbury 1996).

Steel cables are used to attach the doors to the wings of the net. The ground cables run along the bottom from each door to two cables (the “bridle”) that diverge to attach to the top and bottom of the net wing. The bottom portion of the bridle also contacts the bottom. In New England, fixed rubber discs (“cookies”) or rollers are attached to the ground cables and lower bridle. In general, bridles vary in length from 9 - 73 m (30 - 200 ft) while ground cables can be from 0 - 73 m (200 ft) depending upon bottom conditions and towing speed (Sainsbury 1996). The length of these cables can therefore increase the area swept by the trawl by as much as three-fold.

On smooth bottoms, the sweep may be a steel cable weighted with chain, or may be merely rope wrapped with wire. On rougher bottoms, rubber discs (“cookies”) or rollers are attached to the sweep to assist the trawl's passage over the bottom (Sainsbury 1996). There are two main types of sweep used in smooth bottom in New England (Mirarchi 1998). In the traditional chain sweep, loops of chain are suspended from a steel cable, with only 2 - 3 links of the chain touching bottom. Contact of the chain with the bottom reduces the buoyancy of the trawl – which would otherwise be negatively buoyant – to the point where it skims along just a few inches above the bottom to catch species like squid and scup that swim slightly above the bottom. The other type of sweep is heavier and is used on smooth bottom to catch flounder. Instead of a cable, rubber cookies stamped from automobile tires are attached to a heavy chain. This type of sweep is always in contact with the bottom. Cookies vary in diameter from 1.5 - 6.5 cm (4 - 16 in) and do not rotate (Carr and Milliken 1998).

Roller sweeps and rockhoppers are used on irregular bottom (Carr and Milliken 1998). Vertical rubber rollers rotate freely and are as large as 14.5 cm (36 in) in diameter. In New England, the rollers have been largely replaced with "rockhopper" gear that uses larger fixed rollers and are designed to "hop" over rocks as large as 1 m in diameter. Small rubber "spacer" discs are placed in between the larger rubber discs in both types of sweep. Rockhopper gear is no longer used exclusively on hard bottom habitats, but is actually quite versatile and used in a variety of habitat types (NREFHSC 2002). "Street-sweepers" were first used in Massachusetts in 1995, replacing heavier rockhopper gear, and consist of circular brushes up to 12.5 cm (31 in) in diameter. They are lighter than rubber rockhopper gear and can probably fish much rougher bottom than other sweep designs (Carr and Milliken 1998).

Flatfish are primarily targeted with a mid-range mesh flat net that has more ground rigging and is designed to get the fish up off the bottom. A high-rise or fly net with larger mesh is used to catch demersal fish that rise higher off the bottom than flatfish (NREFHSC 2002). Crabs, scallops, and lobsters are also harvested in large mesh bottom trawls.

Small mesh bottom trawls are used to capture northern and southern shrimp, silver hake, butterfish, and squid and usually employ a light chain sweep. Small mesh trawls are designed, rigged, and used differently than large mesh fish trawls. Bottom trawls used to catch northern shrimp in the Gulf of Maine, for example, are smaller than most fish trawls and are towed at slower speeds (< 2 knots versus 4 knots or so for a fish trawl). Footropes range in length from 12 m to over 30 m (40 - 100 ft), but most are 15 to 27 m (50 - 90 ft). Because shrimp inhabit flatter bottom than many fish do, roller gears tend to be smaller in diameter on shrimp nets because they are not towed over rough bottom (Schick, pers. comm.). Because shrimp cannot be herded in the same manner as fish, footropes on shrimp trawls are bare (no cookies) and are limited to 27 m (90 ft) in length (Schick, pers. comm.). Northern shrimp trawls are also equipped with Nordmore grates in the funnel of the net to reduce the bycatch of groundfish. Southern shrimp trawlers that catch brown and white shrimp typically tow two to four small trawls from large booms extended from each side of the vessel (DeAlteris 1998). Northern shrimp trawlers tow a single net astern.

The raised-footrope trawl was designed especially for fishing for silver hake, red hake, and dogfish. It was designed to provide vessels with a means of continuing to fish for small mesh species without catching groundfish. In this type of trawl, 1 m (42 in) long chains connect the sweep to the footrope, which results in the trawl fishing about 0.45 - 0.6 m (1.5 - 2 ft) above the bottom (Carr and Milliken 1998). The raised footrope and net allows complete flatfish escapement, and theoretically travels over codfish and other groundfish (silver hake and red hake tend to swim slightly above the other groundfish). Although the doors of the trawl still ride on the bottom, Carr and Milliken (1998) report that studies have confirmed that the raised footrope sweep has much less contact with the sea floor than does the traditional cookie sweep that it replaces.

An important consideration in understanding the relative effects of different otter trawl configurations is their weight in water relative to their weight in air. Rockhopper gear is not the heaviest type of ground gear used in this region since it loses 80% of its weight in water [i.e., a rockhopper sweep that weighs 1000 pounds on land may only weigh 200 pounds in water; NREFHSC (2002)]. Streetsweeper gear is much heavier in the water due to the use of steel cores in the brush components. Plastic-based gear has the smallest weight in water to weight in air ratio (approximately 5%) (NREFHSC 2002). For the same reasons, steel doors are much heavier in water than wooden doors (Mirarchi 1998).

Hydraulic Clam Dredges

Hydraulic clam dredges have been used in the surfclam (*Spisula solidissima*) fishery for over five decades and in the ocean quahog (*Arctica islandica*) fishery since its inception in the early 1970s. These dredges are highly sophisticated and are designed to: 1) be extremely efficient (80 - 95% capture rate); 2) produce a very low bycatch of other species; and 3) retain very few undersized clams (NREFHSC 2002).

The typical dredge is 3.7 m (12 ft) wide and about 6.7 m (22 ft) long and uses pressurized water jets to wash clams out of the seafloor. Towing speed at the start of the tow is about 4.5 km/hr (2.5 knots or nmi/hr) and declines as the dredge accumulates clams. The dredge is retrieved once the vessel speed drops below about 3 km/hr (1.5 knots), which can be only a few minutes in very dense beds. However, a typical tow lasts about 15 min. The water jets penetrate the sediment in front of the dredge to a depth of about 20 - 25 cm (8 - 10 in), depending on the type of sediment and the water pressure. The water pressure that is required to fluidize the sediment varies from 50 pounds per square inch (psi) in coarse sand to 110 psi in finer sediments. The objective is to use as little water as possible since too much pressure will blow sediment into the clams and reduce product quality. The “knife” (or “cutting bar”) on the leading bottom edge of the dredge opening is 14 cm (5.5 in) deep for surfclams and 8.9 cm (3.5 in) for ocean quahogs. The knife “picks up” clams that have been separated from the sediment and guides them into the body of the dredge (“the cage”). If the knife size is not appropriate, clams can be cut and broken, resulting in significant mortality of clams left on the bottom. The downward pressure created by the runners on the dredge is about 1 psi (NREFHSC 2002).

The high water pressure associated with the hydraulic dredge can cause damage to the flora and fauna associated with bottom habitats. However, water pressure greater than that required for harvesting will reduce the quality of the clams by loading them with sand and increase the rate of clam breakage. Therefore, higher and more damaging water pressures are usually not used.

Before 1990, two types of hydraulic dredges were common in the fishery, stern rig dredges and side rig dredges. A side rig dredge has a chain bag that drags behind the dredge and smoothes out the trench created by the dredge. The chain bag results in significantly more damage to small clams and other bycatch than occurs with the stern rig dredge. Currently, most of the dredges in the fishery are stern rig dredges, which are giant sieves. Small clams and bycatch fall through the bottom of the cage into the trench and damage or injury to benthic organisms is minimal. Improvements in gear efficiency have reduced bottom time and helped to confine the harvest of surfclams to a relatively small area in the Mid-Atlantic Bight (NREFHSC 2002).

Hydraulic clam dredges can be operated in areas of large grain sand, fine sand, sand and small grain gravel, sand and small amounts of mud, and sand and very small amounts of clay. Most tows are made in large grain sand. Dredges are not fished in clay, mud, pebbles, rocks, coral, large gravel greater than one-half inch, or seagrass beds (NREFHSC 2002).

In the softshell clam (*Mya arenaria*) fishery, the dredge manifold and blade are located just forward of an escalator, or conveyor belt, that carries the clams to the deck of the vessel. These vessels are restricted to water depths less than one-half the length of the escalator and are typically operated from 15 m (49 ft) vessels in water depths of 2 - 6 m (6.6 - 20 ft) (DeAlteris 1998). The escalator dredge is not managed under federal fishery management plans. A variation of this type of dredge, the suction dredge, is used in Europe to harvest several bivalve species. Sediment and clams that are dislodged by water pressure are sucked through a hose to the vessel. These dredges are also restricted to shallow water.

Sea Scallop Dredges

The New Bedford scallop dredge is the primary gear used in the Georges Bank and Mid-Atlantic sea scallop (*Placopecten magellanicus*) fishery and is very different than dredges utilized in Europe and the Pacific because it is a toothless dredge.

The forward edge of the New Bedford dredge includes the cutting bar, which rides above the surface of the substrate, creating turbulence that stirs up the substrate and kicks objects (including scallops) up from the surface of the substrate into the bag. Shoes on the cutting bar are in contact with and ride along the substrate surface (NREFHSC 2002). A sweep chain is attached to each shoe and attaches to the bottom of the ring bag (Smolowitz 1998). The bag is made up of metal rings with chafing gear on the bottom and twine mesh on the top, and drags on the substrate when fished. Tickler chains run from side to side between the frame and the ring bag and, in hard bottom scalloping, a series of rock chains run from front to back to prevent large rocks from getting into the bag (Smolowitz 1998). New Bedford dredges are typically 4.3 m (14 ft) wide; two of them are towed by a single vessel at speeds of 4 - 5 knots. New Bedford dredges used along the Maine coast are smaller. Towing times are highly variable, depending on how many marketable sized scallops are on the bottom and the location.

In the northeast region, scallop dredges are used in high- and low-energy sand environments, and high-energy gravel environments. Although gravel exists in low-energy environments of deepwater banks and ridges in the Gulf of Maine, the fishery is not prosecuted there (NREFHSC 2002).

The leading edge of scallop dredges used in Europe, Australia, and New Zealand to catch other species of scallop that “dig” into the bottom have teeth that dig into the substrate. This type of dredge is used by smaller vessels that are not able to tow a non-toothed dredge fast enough (4 - 5 knots) to fish effectively (NREFHSC 2002). Some of the European scallop dredges are spring-loaded so that the cutting bar flexes backward when it contacts a hard object on the bottom, then springs back when the dredge passes over the obstacle. These dredges are approximately 0.75 m (2.5 ft) wide and may be fished in gangs of three to nine dredges on either side of the vessel (Kaiser *et al.* 1996a). A typical tooth bar bears nine teeth, 11 cm (4.3 in) long, spaced about 8 cm (3 in) apart. French dredges, 2 m (6.6 ft) wide, are not spring-loaded and generally are fished on cleaner ground. They are fitted with a diving vane to improve penetration of the bottom. Scallop dredges used in Australia and New Zealand are heavy, rigid, wire mesh “boxes” that do not have a chain bag (McLoughlin *et al.* 1991). A very limited amount of scallop dredging with toothed dredges (e.g., the “Digby” dredge) takes place along the U.S. and Canadian coast of the Gulf of Maine.

Other Non-Hydraulic Dredges

Quahog Dredge

Mahogany quahogs (same species, *Arctica islandica*, as harvested in the Mid-Atlantic) are harvested in eastern Maine coastal waters using a dredge that is essentially a large metal cage on skis with 15 cm (6 in) long teeth projecting at an angle off the leading bottom edge (Thayer, pers. comm.). Maine state regulations limit the length of the cutter bar to 91 cm (36 in). The teeth rake the bottom and lift the quahogs into the cage. This fishery takes place in small areas of sand and sandy mud found among bedrock outcroppings in depths of 9 to > 76 m (30 - 250 ft) in state and federal coastal waters north of $43^{o}20'$ N latitude. These dredges are used on smaller boats, about 9 - 12 m long (30 - 40 ft) and are pulled through the seabed using the boat's engine (NREFHSC 2002). This dredging activity is managed under a federal fishery management plan.

Oyster or Crab Dredge/Scrape/Mussel Dredge

The oyster dredge is a toothed dredge consisting of a steel frame 0.5 - 2.0 m (1.6 - 6.6 ft) in width, a tow chain or wire attached to the frame, and a bag to collect the catch. The bag is constructed of rings and chain-links on the bottom to reduce the abrasive effects of the seabed, and twine or webbing on top. The dredge is towed slowly (< 1 m/sec) in circles, from vessels 7 - 30 m (23 - 98 ft) in length (DeAlteris 1998). Crabs are harvested with dredges similar to oyster dredges. Stern-rig dredge boats [approximately 15 m (49') in length] tow two dredges in tandem from a single chain warp. The dredges are equipped with 10 cm (4 in) long teeth that rake the crabs out of the bottom (DeAlteris 1998). The toothed dredge is also used for harvesting mussels (Hayes 1983). These dredging activities are not managed under federal fishery management plans.

Bay Scallop Dredge

Bay scallops usually reside on the bottom. The bay scallop dredge may be 1 - 1.5 m (3.3 - 4.9 ft) wide and about twice as long. The simplest bay scallop dredge can be just a mesh bag attached to a metal frame that is pulled along the bottom. For bay scallops that are located on sand and pebble bottom, a small set of raking teeth are set on a steel frame, and skids are used to align the teeth and the bag (Sainsbury 1996). This dredging activity is not managed under federal fishery management plans.

Sea Urchin Dredge

Similar to a simple bay scallop dredge, the sea urchin dredge is designed to avoid damaging the catch. It has an up-turned sled-like shape at the front that includes several leaf springs tied together with a steel bar. A tow bail is welded to one of the springs and a chain mat is rigged behind the mouth box frame. The frame is fitted with skids or wheels. The springs act as runners, enabling the sled to move over rocks without hanging up. The chain mat scrapes up the urchins. The bag is fitted with a codend for ease of emptying. This gear is generally only used in waters up to 100 m (330 ft) deep (Sainsbury 1996). This dredging activity is not managed under federal fishery management plans.

4.3.2.2 Bottom Tending Static Gear

Pots

Pots are portable, rigid devices that fish and shellfish enter through small openings, with or without enticement by bait (Everhart and Youngs 1981; Hubert 1983). They are used to capture lobsters, crabs, black sea bass, eels and other bottom dwelling species seeking food or shelter (Everhart and Youngs 1981; Hubert 1983). Pot fishing can be divided into two general classifications: 1) inshore potting in estuaries, lagoons, inlets and bays in depths up to about 75 m (250 ft); and, 2) offshore potting using larger and heavier vessels and gear in depths up to 730 m (2400 ft) or more (Sainsbury 1996).

Lobster Pots

Lobster pots are typically rectangular and are divided into two sections, the chamber and the parlor. The chamber has an entrance on both sides of the pot and is usually baited. Lobsters then move to the parlor via a tunnel (Everhart and Youngs 1981). Escape vents are installed in both areas of the pot to minimize the retention of sub-legal sized lobsters (DeAlteris 1998).

Lobster pots are fished as either a single pot per buoy (although two pots per buoy are used in Cape Cod Bay, and three pots per buoy in Maine waters), or a “trawl” or line with up to one hundred pots. According to NREFHSC (2002), important features of lobster pots and their use are the following:

- About 95% of lobster pots are made of plastic-coated wire.
- Floating mainlines may be up to 7.6 m (25 ft) off bottom.
- Sinklines are sometimes used where marine mammals are a concern; neutrally buoyant lines may soon be required in Cape Cod Bay.
- Soak time depends on season and location - usually 1 - 3 days in inshore waters in warm weather, to weeks in colder waters.
- Offshore pots are larger [more than 1 m (4 ft) long] and heavier (~ 100 lb or 45 kg), with an average of ~ 40 pots/trawl and 44 trawls/vessel. They have a floating mainline and are usually deployed for a week at a time.
- There has been a three-fold increase in lobster pots fished since the 1960s, with more than four million pots now in use.

Although the offshore component of the fishery is regulated under federal rules, American lobster is not managed under a federal fishery management plan.

Fish Pots

Black sea bass pots are similar in design to lobster pots. They are usually fished singly or in trawls of up to twenty-five pots, in shallower waters than the offshore lobster pots or red crab pots. Pots may be set and retrieved 3 - 4 times/day when fishing for scup (NREFHSC 2002). This activity is managed under a federal fishery management plan. Hagfish pots (40 plastic gallon barrels) are fished in deep waters, on mud bottoms. Cylindrical pots are typically used for capturing eels in Chesapeake Bay; however, half-round and rectangular pots are also used and all are fished in a manner similar to that of lobster pots (Everhart and Youngs 1981). Hagfish and eel activities are not managed under a federal fishery management plan.

Crab Pots

Crabs are often fished with pots consisting of wire mesh. A horizontal wire partition divides the pot into an upper and lower chamber. The lower chamber is entered from all four sides through small wire tunnels. The partition bulges upward in a fold about 20 cm (8 in) high for about one third of its width. In the top of the fold are two small openings that give access to the upper chamber (Everhart and Youngs 1981).

Crab pots are always fished as singles and are hauled by hand from small boats, or with a pot hauler in larger vessels. Crab pots are generally fished after an overnight soak, except early and late in the season (DeAlteris 1998). These pots are also effective for eels (Everhart and Youngs 1981). This activity is not managed under a federal fishery management plan.

Deep-sea red crab pots are typically wood and wire traps 1.2 m by 0.75 m (48 by 30 in) with top entry. Pots are baited and soak for about 22 hrs before being hauled. Currently, vessels are using an average of 560 pots in trawls of 75 - 180 pots per trawl along the continental slope at depths from 400 - 800 m (1300 - 2600 ft). These vessels are typically 25 - 41 m (90 - 150 ft) in length. Currently there are about six vessels engaged in this fishery (NEFMC 2002). This activity is managed under a federal fishery management plan.

Traps

A trap is generally a large-scale device that uses the seabed and sea surface as boundaries for the vertical dimension. The gear is installed at a fixed location for a season, and is passive, as the animals voluntarily enter the gear. Traps are made of a leader or fence, that interrupts the coast parallel migratory pattern of the target prey, a heart or parlor that leads fish via a funnel into the bay or trap section that serves to hold the catch for harvest by the fishermen. The non-return device is the funnel linking the heart and bay sections (DeAlteris 1998). This activity is not managed under a federal fishery management plan.

Fish Pound Nets

Pound nets are constructed of netting staked into the seabed by driven piles (Sainsbury 1996). Pound nets have three sections: the leader, the heart, and the pound. The leader (there may be more than one) may be as long as 400 m (1300 ft) and is used to direct fish into the heart(s). One or more hearts are used to further funnel fish into the pound and prevent escapement. The pound may be 15 m (49 ft) square and holds the fish until the net is emptied. These nets are generally fished in waters less than 50 m (160 ft) deep. Pound nets are also used to catch crabs. This activity is not managed under a federal fishery management plan.

Fyke and Hoop Nets

Constructed of wood or metal hoops covered with netting, hoop nets are 2.5 - 5 m (8.2 - 16 ft) long, “Y-shaped” nets, with wings at the entrance and one or more internal funnels to direct fish inside, where they become trapped. Occasionally, a long leader is used to direct fish to the entrance. Fish are removed by lifting the rear end out of the water and loosening a rope securing the closed end. These nets are generally fished to about 50 m (160 ft) deep (Sainsbury 1996).

A common fyke net is a long bag mounted on one or several hoops which keep the net from collapsing as well as provide an attachment for the base of the net funnels to prevent the fish from escaping. This gear is used in shallow water and extensively in river fisheries (Everhart and Youngs 1981). This activity is not managed under a federal fishery management plan.

Shallow Floating Traps

In New England, much of the shoreline and shallow subtidal environment is rocky and stakes cannot be driven into the bottom. Therefore, the webbing of these traps is supported by floats at the sea surface, and held in place with large anchors. These traps are locally referred to as "floating traps." The catch, design elements and scale of these floating traps is similar to pound nets (DeAlteris 1998).

The floating trap is designed to fish from top to bottom, and is built especially to suit its location. The trap is held in position by a series of anchors and buoys. The net is usually somewhat "T-shaped," with the long portion of the net (the leader net) designed to funnel fish into a box of net at the top of the T. The leader net is often made fast to a ring bolt ashore (Sainsbury 1996). This activity is not managed under a federal fishery management plan.

Bottom Gill Nets

Sink Gill Nets

Individual gill nets are typically 91 m (300 feet) long, and are usually fished as a series of 5 - 15 nets attached end-to-end. Gill nets have three components: leadline, webline and floatline. Fishermen are now experimenting with two leadlines. Leadlines used in New England are ~65 lb (30 kg)/net; in the Mid-Atlantic leadlines may be heavier. Weblines are monofilament, with the mesh size depending on the target species. Nets are anchored at each end, using materials such as pieces of railroad track, sash weights, or Danforth anchors, depending on currents. Anchors and leadlines have the most contact with the bottom. Some nets may be tended several times/day (e.g., when fishing for bluefish in the Mid-Atlantic). For New England groundfish, frequency of tending ranges from daily to biweekly (NREFHSC 2002). These activities are managed under federal fishery management plans.

Stake Gill Nets

Generally, a small boat is used inshore so that a gill net is set across a tidal flow and is lifted at slack tide to remove fish. Wooden or metal stakes run from the surface of the water into the sediment and are placed every few meters along the net to hold it in place. When the net is lifted, the stakes remain in place. These nets are generally fished from the surface to about 50 meters deep (Sainsbury 1996). These activities are not managed under federal fishery management plans.

Bottom Longlines

Longlining for bottom species on continental shelf areas and offshore banks is undertaken for a wide range of species including cod, haddock, dogfish, skates, and various flatfishes (Sainsbury 1996). A 9.5 m (31 ft) vessel can fish up to 2500 hooks/day with a crew of one and double that with two crewmembers. Mechanized longlining systems fishing off larger vessels up to 60 m (195 ft) can fish up to 40,000 hooks/day (Sainsbury 1996).

In the northeast region up to six individual longlines are strung together, for a total length of about 460 m (1500 ft), and are deployed with 9 - 11 kg (20 - 24 lb) anchors. The mainline is parachute cord or sometimes stainless steel wire. Gangions (lines from mainline to hooks) are 38 cm (15 in) long and 1 - 2 m (3 - 6 ft) apart. The mainline, hooks, and gangions all contact the bottom. Circle hooks are potentially less damaging to habitat features than other hook shapes. These longlines are usually set for only a few hours at a time (NREFHSC 2002). Longlines used for tilefish are deployed in deepwater, may be up to 40 km (25 mi) long, are stainless steel or galvanized wire, and are set in a zigzag fashion (NREFHSC 2002). These activities are managed under federal fishery management plans.

4.3.2.3 Pelagic Gear

Drift Gill Nets

Gillnets operate principally by wedging and gilling fish, and secondarily by entangling (DeAlteris 1998). The nets are a single wall of webbing, with float and lead lines. Drift gillnets are designed to float from the sea surface and extend downward into the water column and are used to catch pelagic fish. In this case, the buoyancy of the floatline exceeds the weight of the leadline. Drift gillnets may be anchored at one end or set out to drift, usually with the fishing vessel attached at one end (DeAlteris 1998). This activity is managed under federal fishery management plans. This gear is not expected to have contact with or impacts upon bottom habitats.

Pelagic Longline Gear

The pelagic or subsurface longline is a technique directed mostly towards tunas, swordfish, sailfish, dolphin (dorado), and sharks. The gear is typically set at depths from the surface to around 330 m (1100 ft). The gear can also be set with a main line hanging in arcs below the buoy droplines to fish a band of depths (Sainsbury 1996). The gear is set across an area of known fish concentration or movement, and may be fished by day or night depending upon the species being sought (Sainsbury 1996). The length of the mainline can vary up to108 km (67 mi) depending on the size of the vessel. If the mainline is set level at a fixed depth, then the leader or gangion lengths vary from 2 - 40 m (6.6 - 130 ft), so as to ensure the hooks are distributed over a range of depths (DeAlteris 1998). If a line-shooter is used to set the mainline in a catenary shape with regard to depth, then the gangions are usually a single minimal length, but are still distributed by depth (DeAlteris 1998). Each gangion typically contains a baited hook and chemical night stick to attract the fish. Traditional or circle hooks may be used. Swordfish vessels typically fish 20 to 30 hooks per 1.6 km (1 mi) of mainline between 5 - 54 km (3 - 34 mi) in length (Sainsbury 1996). This activity is managed under federal fishery management plans. This gear is not expected to have contact with or impacts upon bottom habitats.

Troll Lines

Trolling involves the use of a baited hook or lure maintained at a desired speed and depth in the water (Sainsbury 1996). Usually, two to four or more lines are spread to varying widths by the use of outrigger poles connected to the deck by hinged plates. Line retrieval is often accomplished by means of a mechanized spool. Each line is weighted to reach the desired depth and may have any number of leaders attached, each with a hook and bait or appropriate lure. This gear is generally fished from the surface to about 20 m (Sainsbury 1996). This activity is managed under federal fishery management plans. This gear is not expected to have contact with or impacts upon bottom habitats.

4.3.2.4 Seines

Haul Seines

Haul seining is a general term describing operations where a net is set out between the surface and seabed to encircle fish. It may be undertaken from the shore (beach seining), or away from shore in the shallows of rivers, estuaries or lakes (Sainsbury 1996). Seines typically contact the sea bottom along the lead line. Additionally the net itself may scrape along the bottom as it is dragged to shore or the recovery vessel. This activity is not managed under federal fishery management plans.

Beach Haul Seines

The beach seine resembles a wall of netting of sufficient depth to fish from the sea surface to the seabed, with mesh small enough that the fish do not become gilled. A floatline runs along the top to provide floatation and a leadline with a large number of weights attached ensures that the net maintains good contact with the bottom. Tow lines are fitted to both ends. The use of a beach seine generally starts with the net on the beach. One end is pulled away from the beach, usually with a small skiff or dory, and is taken out and around and finally back to shore. Each end of the net is then pulled in towards the beach, concentrating the fish in the middle of the net. This is eventually brought onshore as well and the fish removed. This gear is generally used in relatively shallow inshore areas (Sainsbury 1996). This activity is not managed under federal fishery management plans.

Long Haul Seines

The long haul seine is set and hauled in shallow estuarine and coastal areas from a boat typically 15 m (49 ft) long. The net is a single wall of small mesh webbing less than 5 cm (2 in), and is usually greater than 400 m (1440 ft) in length and about 3 m (9.8 ft) in depth. The end of the net is attached to a pole driven into the bottom, and the net is set in a circle to surround fish feeding on the tidal flat. After closing the circle, the net is hauled into the boat, reducing the size of the circle, and concentrating the fish. Finally, the live fish are brailed or dip-netted out of the net (DeAlteris 1998). This activity is not managed under federal fishery management plans.

Danish and Scottish Seines

Danish seining or anchor dragging was developed in the 1850s prior to the advent of otter trawling. The Danish seine is a bag net with long wings that includes long warps set out on the seabed enclosing a defined area. As the warps are retrieved, the enclosed area (a triangle) reduces in size. The warps dragging along the bottom herd the fish into a smaller area, and eventually into the net mouth. The gear is deployed by setting out one warp, the net, then the other warp. On retrieval of the gear, the vessel is anchored. This technique of fishing is aimed at specific schools of fish located on smooth bottom. In contrast to Danish seining, if the vessel tows ahead while retrieving the gear, then this is referred to as Scottish seining or fly-dragging. This method of fishing is considered more appropriate for working small areas of smooth bottom, surrounded by rough bottom. Scottish and Danish seines have been used experimentally in U.S. demersal fisheries. Space conflicts with other mobile and fixed gears, have precluded the further development of this gear in the U.S., as compared to northern Europe (DeAlteris 1998). This activity is managed under federal fishery management plans.

4.3.2.5 Other Gears

Rakes

A bull rake is manually operated to harvest hard clams and consists of a long shaft with a rake and basket attached. The length of the shaft can be variable but usually does not exceed three times the water depth. The length and spacing of the teeth as well as the openings of the basket are regulated to protect juvenile clams from harvest (DeAlteris 1998). Rakes are typically fished off the side of a small boat. This activity is not managed under federal fishery management plans.

Tongs

A more efficient device than rakes for harvesting shellfish is tongs. Shaft-tongs are a scissor-like device with a rake and basket at the end of each shaft. The fisherman stands on the edge of the boat and progressively opens and closes the baskets on the bottom gathering the shellfish into a mound. The tongs are closed a final time, brought to the surface, and the catch emptied on the culling board for sorting. The length of the shaft must be adjusted for water depth. Oysters are traditionally harvested with shaft tongs in water depths up to 6 m (21 ft), with shaft tongs 8 m (29 ft) in length (DeAlteris 1998). Patent tongs harvest clams and oysters and are opened and closed with a drop latch or with a hydraulic ram and require a mechanized vessel with a mast or boom and a winch (DeAlteris 1998). Patent tongs are regulated by weight, length of teeth, and bar spacing in the basket. This activity is not managed under federal fishery management plans.

Line Fishing

Hand Lines

The simplest form of hook and line fishing is the hand line. It consists of a line, sinker, leader and at least one hook. The line is usually stored on a small spool and rack and can vary in length. The line varies in material from a natural fiber to synthetic nylon. The sinkers vary from stones to cast lead. The hooks are single to multiple arrangements in umbrella rigs. An attraction device must be incorporated into the hook, usually a natural bait and artificial lure (DeAlteris 1998). Although not typically associated with bottom impacts, this gear can be fished in such as manner as to hit bottom and bounce or be carried by currents until retrieved. This activity is managed under federal fishery management plans.

Mechanized Line Fishing

Mechanized line hauling systems have been developed to allow more lines to be worked by smaller crews and use electrical or hydraulic power to work the lines on the spools or jigging machines (Sainsbury 1996). These reels, often termed bandits, are mounted on the vessel bulwarks and have a spool around which the mainline is wound (Sainsbury 1996). Each line may have a number of branches and baited hooks, and the line is taken from the spool over a block at the end of a flexible arm. This gear is used to target several species of groundfish, especially cod and pollock and it has the advantage of being effective in areas where other gears cannot be used. Jigging machine lines are generally fished in waters up to 600 m (2000 ft) deep (Sainsbury 1996). This gear may also have the ability to contact the bottom depending upon the method selected to fish. This activity is managed under federal fishery management plans.

Hand Hoes

Intertidal flats are frequently harvested for clams and baitworms using handheld hoes. These are short handled, rake-like devices that are often modified gardening tools (Creaser *et al*. 1983).

Baitworm hoes have 5 to 7 tines, 21 - 22 cm (8.3 - 8.7 ft) in length for bloodworms and 34 - 39 cm (13 - 15 in) for sandworms. Clam hoes in Maine typically have 4 to 5 tines, 15 cm (6 in) long. This activity is not managed under federal fishery management plans.

Diving

By either free diving or using SCUBA, divers collect crustaceans, mollusks and some reef fish in shallow water. Often a support vessel is used to transport the diver(s) to the fishing site and carry the landings to port. In deeper waters, helmet diving systems are used and the diver is tethered to the vessel and supplied with air pumped from the surface. This method is most often used by sea urchin divers and some lobster divers. Divers normally use small rakes or hoes to scrape creatures off rocks or dig them out of the seabed. Generally, the catch is placed in bags that are either towed to the surface by the boat or floated to the surface using an air source and a lift bag. Divers rarely work deeper than about 20 m (66 ft) (Sainsbury 1996). This activity is not managed under federal fishery management plans.

Spears

Spears came into use when it was found that a pole or shaft with a point on it could be used by a fisherman operating from shore, floating raft, or boat to capture animals previously out-of-reach (DeAlteris 1998). However, the single prong spear required an accurate aim, and fish easily escaped. With the addition of a barb, fish retention was improved; and spears with multi-prong heads increased the likelihood of hitting the target. Spears were initially thrust without leaving the hand, then thrown, and then finally placed in launching devices including crossbows, spear guns for divers, etc. Spears with long shafts (gigs) are used by fishermen in small boats at night in the Carolina sounds for flounder, through the ice for eels in New England bays, and by divers for fish in coastal waters (DeAlteris 1998). This activity is not managed under federal fishery management plans.

4.3.3 Distribution of Fishing Activity by Gear Type

This section of the DEIS describes the spatial distribution of fishing activity by gear type for federally-permitted fishing vessels operating in the Northeast region of the U.S. (Maine to North Carolina) during two time periods, 1995-2001 and 1997-2002. Fishing activity is depicted using geographical information systems (GIS) software (ArcView 3.2, developed by the Environmental Systems Research Institute, Inc.) by ten minute “squares” of latitude and longitude for fifteen gear types. Each “square” measures approximately ten nautical miles high by 7.5 nmi wide.

The data used to create these plots were extracted from NOAA Fisheries vessel trip report (VTR) and clam logbook databases. Data included in the analysis are provided by vessels operating with federal permits and participating in the following fisheries: northeast multispecies, sea scallops, surf clams and ocean quahogs, goosefish, summer flounder, scup, black sea bass, squid, Atlantic mackerel, butterfish, spiny dogfish, bluefish, Atlantic herring, and tilefish. Vessels that operate strictly within state waters (0 - 3 mi from shore) are not required to have a federal permit and therefore do not submit trip reports. For this reason, fishing trips in nearshore ten minute squares (TMS) that include a significant proportion of state waters are under-represented. Data for bottom-tending fixed and mobile gear types were compiled for the years 1995-2001 (1995-

2000 for fish traps). Data for mid-water gears used in the herring fishery were compiled for the years 1997-2002 and only included trips for which 50% or more of the landed catch was Atlantic herring.

Permit holders are required to fill out a VTR form or make a logbook entry for each trip made by the vessel; i.e., each time the vessel leaves and returns to port. Fishermen report the location where they spend most of their time fishing during a trip and the date and time that the vessel left and returned to port. They are given the choice of reporting the location of a trip as a point (latitude and longitude) or simply assign it to a statistical area (these areas are quite large and include many TMSs). Only trips that were reported as a point location and therefore could be assigned to a TMS were included in this analysis. Most trips are reported this way. Logbook entries in the clam dredge fishery include time that was actually spent fishing. Data for gears used mostly in state waters and/or that are not well represented in the VTR database (e.g., mussel and sea urchin dredges, Danish seines, shrimp pots) were not displayed. Data reported south of Cape Hatteras, North Carolina (35° N) and north of 45° N latitude in the Gulf of Maine were excluded from analysis.

Mobile gear (mid-water trawls, purse seines, scallop dredges and three types of bottom otter trawls) fishing activity was calculated as the total number of days absent from port. Fixed gear (bottom longlines, sink gill nets, and five types of pots) activity was calculated as the total number of trips. Days absent for each trip were calculated based on the date and time of departure from, and return to, port in hours and converted to fractions of 24 hr days. Trips made to more than one statistical area (for which two locations are noted) were excluded from the analysis. Logbook data for hydraulic clam dredges were also converted to 24 hr days. The clam dredge data excluded trips made by “dry” quahog dredge vessels in Maine that are included in the logbook database.

Days absent calculations for trawl and scallop dredge vessels are clearly preferable to simply summing the number of trips, but overestimate actual fishing time since they include travel time and any other non-fishing related activity while vessels are away from port. Thus, the GIS plots do not represent fishing effort. They indicate the relative, not the absolute, distribution of fishing activity within the Northeast region.

In order to emphasize the relative nature of the fishing activity plots, all GIS input data were compiled and sorted into categories. For bottom-tending gears, these categories corresponded to cumulative percentages of 50, 75, and 90% of the total number of trips, days at sea, or days spent fishing. For pelagic gears used in the herring fishery, fishing activity data were sorted into four categories (25, 50, 75, and 90%). Fishing activity is most intense (high density) in TMSs which account for 25 or 50% of the total number of trips (or days) and much less intense (low density) as additional TMS with fewer and fewer trips (or days) are included in the analysis. Table 4.11 provides an example showing how TMS were assigned to categories.

The depth contours shown in the GIS plots (Figure 4.25 to Figure 4.40) are 50 and 100 fathoms (approximately 100 and 200 m). The U.S./Canada border and the outer boundary of the U.S. Exclusive Economic Zone (EEZ) are also shown in each figure. Three areas on Georges Bank were closed in December 1994 to all gears that catch groundfish and remained closed during

1995-2001. These closures affected the patterns of gear use for bottom otter trawls used to catch fish, for bottom longlines and gill nets, and for scallop dredges, and are therefore shown in the maps for those gear types that have been affected by the closures. Scallop dredging was prohibited in these areas during 1995-1998 and again in 2001, but portions of the groundfish closed areas were opened temporarily to scallop dredging in 1999 and 2000.

4.3.3.1 Gears Used in the Herring Fishery

Mid-Water Trawls

This gear was used primarily in three areas during 1997-2002: southern New England, the northern edge of Georges Bank, and the southwestern Gulf of Maine (Figure 4.25). Mid-water trawling activity in the Gulf of Maine was exclusively south of 44 degrees North latitude and was concentrated in TMS east of Casco Bay, on Jeffreys Ledge, near Cape Ann, east of Cape Cod, and offshore, near Cashes Ledge. Mid-water trawling on Georges Bank was distributed along the northern edge of the bank from the Canadian border west to 69°W and appeared to be located primarily between 50 and 100 fathoms, with some fishing up on the bank in shallower water. Mid-water trawling activity in southern New England was dispersed over a large area and was most intense in the vicinity of Block Island, Rhode Island. Mid-water trawling in southern New England occurs in the winter in inner and mid-shelf waters less than 50 fathoms deep.

Mid-Water Pair Trawls

The amount and distribution of fishing activity by mid-water pair trawlers during 1997-2002 (Figure 4.26) was very similar to that reported for single boat mid-water trawlers. A small amount of pair trawling took place in the Gulf of Maine north of 44°N.

Purse Seines

Purse seining was almost completely limited to the Gulf of Maine during 1997-2002 (Figure 4.27). This gear was used over a large area of the gulf south of Penobscot Bay in depths less than and greater than 50 fathoms, extending west to the mainland and northeast to include the area around Mt. Desert Rock. There was some overlap between areas fished with mid-water trawls and purse seines in the southwestern portion of the gulf, e.g., on the northern end of Jeffreys Ledge.

4.3.3.2 Bottom-Tending Mobile Gear

Bottom Otter Trawls – Fish

Most of the reported otter trawl activity (Figure 4.28) is directed at the capture of fish (rather than shrimp or scallops). More than any other gear, bottom otter trawling for fish during 1995-2001 was widespread in coastal and offshore waters throughout most of the northeast region. Areas of highest activity were located in southwestern and central portions of the Gulf of Maine, along the western side of the Great South Channel, north of Closed Area I and on the northern part of Georges Bank west of Closed Area II, in coastal waters of Rhode Island and Long Island, in the mid-shelf region of southern New England, and along the shelf break, especially north and south of 40ºN between 70º and 73º W longitude and in the Hudson Canyon area. Bottom trawling was not actively conducted in the three groundfish closed areas on Georges Bank, nor in a large area of the continental shelf off southern New Jersey, Maryland, and Virginia.

Bottom Otter Trawls – Shrimp

Shrimp trawling was localized in two areas: the coastal waters of the Gulf of Maine, primarily between Cape Ann and Penobscot Bay, and in nearshore waters of North Carolina, particularly inside the barrier islands (Figure 4.29). The shrimp fishery in the Gulf of Maine targets pandalid (or northern) shrimp while the fishery in North Carolina is on penaeid shrimp.

Bottom Otter Trawls – Scallops

The scallop trawl fishery is conducted on the outer Mid-Atlantic shelf, primarily between 40º and 37ºN in depths less than 50 fathoms (Figure 4.30).

Hydraulic Clam Dredges

The largest area of hydraulic clam dredging activity was located in a small area off the central New Jersey coast, with smaller areas extending north and east to southern New England and south to the Delmarva Peninsula (Figure 4.31). Hydraulic clam dredges are not used to harvest clams on Georges Bank because of the presence of red tide-causing microorganisms in ocean quahogs, nor are they used in the Gulf of Maine due to the prevalence of gravel and rocky bottom where hydraulic dredges cannot operate. There is a localized fishery for ocean quahogs in eastern Maine, but the dredges used there are not hydraulically operated.

Non-Hydraulic Clam Dredges

Non-hydraulic clam dredges were used to harvest ocean quahogs primarily in eastern Maine coastal waters and to some extent in central Maine coastal waters during 1995-2000 (Figure 4.32). This fishery does not take place anywhere else in the Northeast region.

Scallop Dredges

Scallop dredges were used primarily in a broad area of the Mid-Atlantic shelf from Long Island to Virginia, in Massachusetts Bay (north of Cape Cod) and the Great South Channel, in localized areas of Georges Bank northeast of Closed Area I and west of the northern portion of Closed Area II, and in a larger area on the southeast flank of the Bank that included the southern portion of Closed Area II that was opened to limited scallop dredging in 1999 (Figure 4.33). Some scallop dredging was also reported from eastern Maine coastal waters. No active scallop dredging was reported in shallow open areas on Georges Bank, in southern New England, nor in inner shelf waters of the Mid-Atlantic Bight.

4.3.3.3 Bottom-Tending Static Gear

Lobster Pots

Lobster pot trips during 1995-2001 were reported primarily in coastal waters of the Gulf of Maine from the Canadian border to Cape Cod, in nearshore Rhode Island waters, and in the New York Bight (Figure 4.34). Fewer trips were made to more offshore locations in southern New England and along the shelf break in depths greater than 100 fathoms.

Conch and Whelk Pots

Most fishing activity was reported in Nantucket Sound and inshore waters of southern Massachusetts, in a single TMS south of Rhode Island, and in coastal waters of southern New Jersey and the Delmarva Peninsula, extending south to North Carolina (Figure 4.35).

Fish Pots

Most fish pot trips were reported on the south shore of Massachusetts and Rhode Island, Long Island, and off southern New Jersey, Delaware, and Maryland (Figure 4.36). Other areas where fewer trips were reported were located on Jeffreys Ledge in the western Gulf of Maine, east of Long Island and south of Nantucket and Martha's Vineyard, along the outer edge of the continental shelf in the southern Mid-Atlantic Bight, and off the entrance to Chesapeake Bay.

Crab Pots

Crab pot trips were reported in a number of TMSs in deepwater along the shelf break from eastern Georges Bank all the way to Cape Hatteras, in a single TMS south of Nantucket, in several nearshore locations in the Gulf of Maine, Nantucket Sound, Cape May (New Jersey), and in inshore waters behind the North Carolina barrier islands (Figure 4.37).

Hagfish Pots

Hagfish pots were used exclusively in the southwestern Gulf of Maine, particularly east of cape Ann and between Cape Ann and Cape Cod (Figure 4.38).

Bottom Gill Nets

Bottom gill net trips were made in the western Gulf of Maine and along the western side of the Great South Channel, extending north of Cape Ann and on Jeffreys Ledge, and in a few TMSs in the outer gulf (Figure 4.39). Gill nets were also used in Rhode Island coastal waters, along the outer shore of Long Island, off northern New Jersey, the Delmarva Peninsula, and in North Carolina. Gill net fishing activity was highest in the western Gulf of Maine and the Great South Channel in areas that were also actively fished with longlines, bottom trawls, and scallop dredges.

Bottom Longlines

Longline trips during 1995-2001 were reported primarily in TMSs in the western Gulf of Maine (Massachusetts Bay) and along the western side of the Great South Channel (Figure 4.40). There were a few trips reported in deepwater along the shelf break, in Rhode Island and central Maine coastal waters, and in offshore locations of the Gulf of Maine.

Table 4.12. Metric tons of herring sold by gear and management area in 2003.

	1A	**1B**	**2**	**3**	**Total**
Midwater Pair Trawl	33,765	3,784	10,967	17,385	65,901
Midwater Trawl	7,846	1,001	4,238	2,756	15,841
Purse Seine	17,738	132	0	0	17,870
Bottom Trawl	88	1	862	86	1037
Weir	0	0	1	0	1
Other	14	1	13	0	28
Total	59,452	4,920	16,081	20,227	100,680

Table 4.13. Number of vessels, herring trips and days, and herring sold (mt) by management area and principal herring gear for 2003.

		1A	**1B**	**2**	**3**	**Total**
Midwater Pair Trawl 16 vessels	**Number of trips**	396	37	105	131	669
	Days at Sea	907	98	343	561	1909
	Landings (mt)	32,804	3,784	11,286	17,576	65,450
Midwater Trawl 9 vessels	**Number of trips**	179	11	55	10	255
	Days at Sea	313	25	152	49	539
	Landings (mt)	7,352	980	3,001	2,565	13,898
Purse Seine 6 vessels	**Number of trips**	324	5	12	0	341
	Days at Sea	625	10	14	0	649
	Landings (mt)	19,193	153	810	0	20,156
Bottom Trawl 63 vessels	**Number of trips**	273	8	152	39	472
	Days at Sea	279	12	287	238	816
	Landings (mt)	88	1	970	86	1145
Weir	**Landings (mt)**	0	0	1	0	1
Other Gear 60 vessels	**Number of trips**	120	4	406	0	530
	Days at Sea	125	4	418	0	547
	Landings (mt)	14	1	12	0	27
Total 154 vessels	**Number of trips**	1292	65	730	180	2267
	Days at Sea	2249	149	1214	848	4460
	Landings (mt)	59,451	4,919	16,080	20,227	100,677

Table 4.14. Atlantic herring landings and value by gear used and state.

		MA	**ME**	**NH**	**RI**	**Other Mid-Atlantic**	**Other New England**	**Total**
Midwater Pair Trawl	**MT**	35,375	20,764	5,883	3,228	407	242	65,899
	Value	5,989,225	3,200,748	1,048,157	774,929	63,553	40,898	11,117,510
Midwater Trawl	**MT**	2,353	9,784	558	3,021	0	126	15,842
	Value	455,850	1,528,183	91,985	625,165	0	21,277	2,722,460
Purse Seine	**MT**	456	16,232	1,183	0	0	0	17,871
	Value	59,824	2,706,408	177,515	0	0	0	2,943,747
Bottom Trawl	**MT**	18	9	62	819	23	105	1036
	Value	3,576	1,759	8,162	239,264	3,606	20,148	276,515
Weir	**MT**	1	0	0	0	0	0	1
	Value	71	0	0	0	0	0	71
Other	**MT**	10	6	0	0	12	0	28
	Value	1,686	1,005	0	0	2,416	0	5,107
Total	**MT**	38,213	46,795	7,686	7,068	442	473	100,677
	Value	6,510,232	7,438,103	1,325,819	1,639,358	69,575	82,323	17,065,410

Table 4.15. Average crew size (including captain) by gear used.

	Average	**Minimum**	**Maximum**
Midwater Pair Trawl	4.6	1	7
Midwater Trawl	3.7	1	12
Purse Seine	5.4	1	6
Bottom Trawl	3.3	1	13

Table 4.16. Total number of vessels and crew (including captain) employed per fleet sector.

		MA	ME	NH	RI	Total
Midwater Pair Trawl	Number of Vessels	9	4	2	1	16
	Total # of Crew	44	18	8	3	73
Midwater Trawl	Number of Vessels		6		3	9
	Total # of Crew		15		20	35
Purse Seine	Number of Vessels		6			6
	Total # of Crew		31			31
Total	Number of Vessels	9	16	2	4	31
	Total # of Crew	44	64	8	23	139

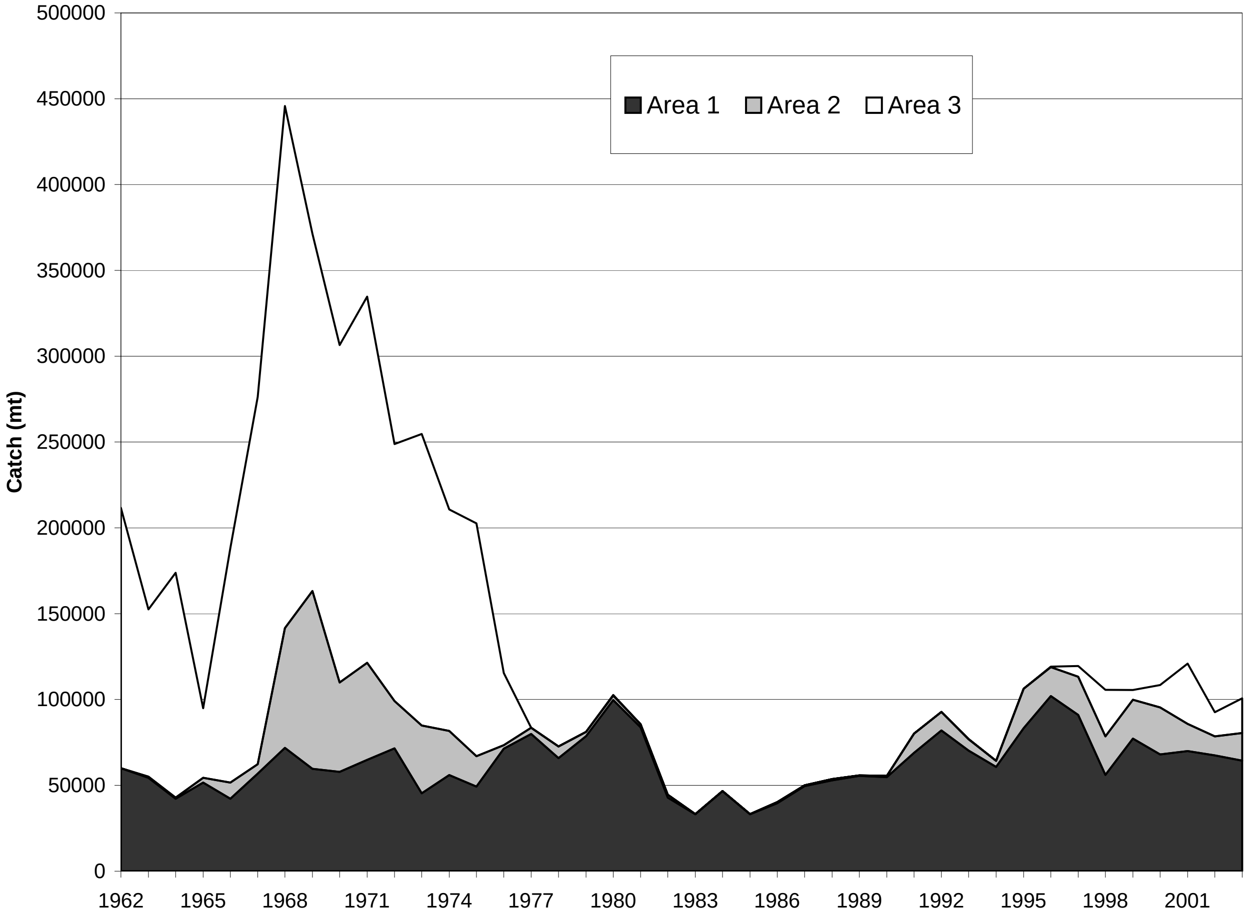

Figure 4.21. Atlantic herring catch by management area (U.S. and foreign)

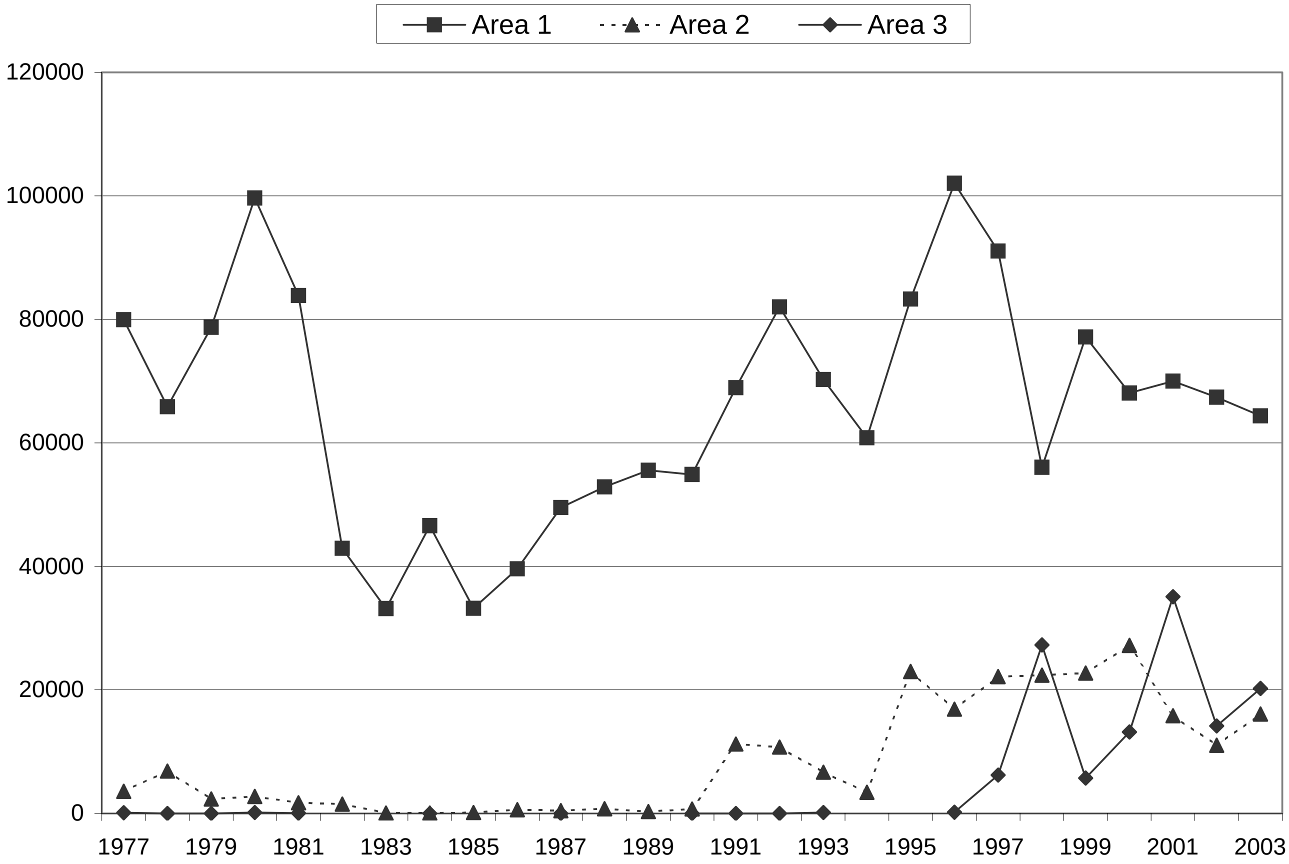

Figure 4.22. U.S. Atlantic herring catch (metric tons) by management area, 1977-2003.

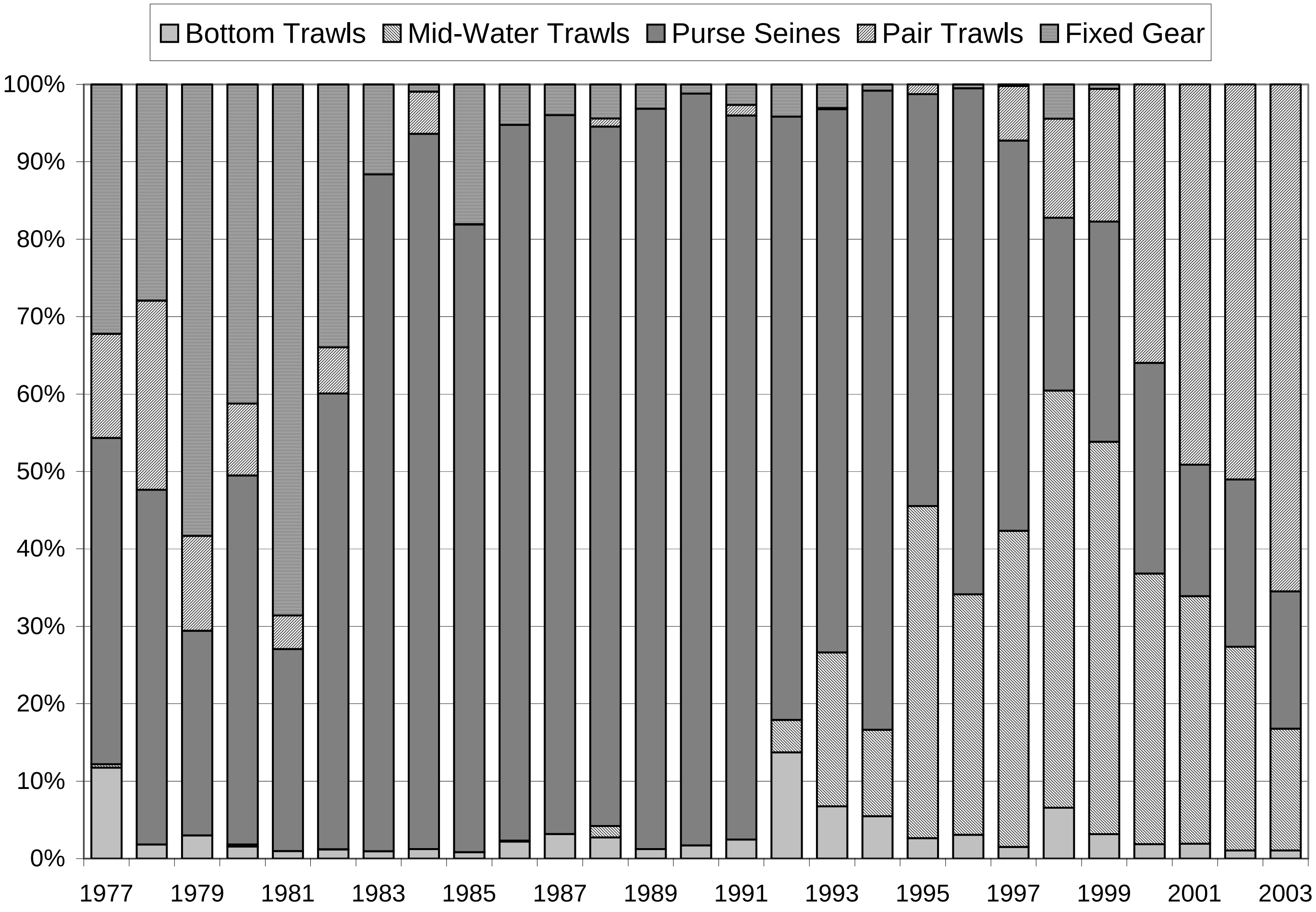

Figure 4.23. Percent U.S. Atlantic herring catch by gear type, 1977-2003.

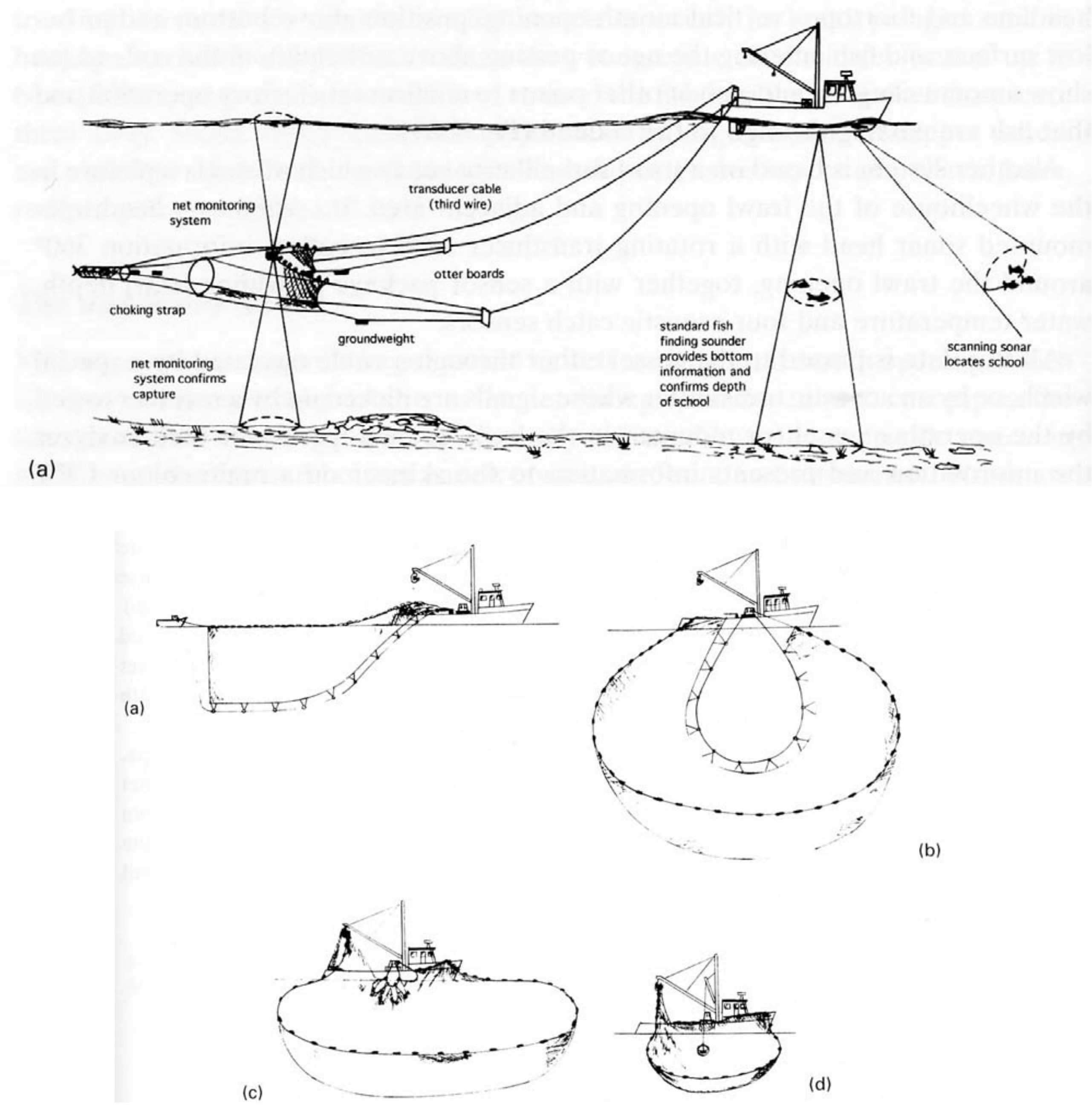

Figure 4.24. Schematic drawings of single boat midwater trawling (top) and purse seining (bottom) operations. Source: Sainsbury 1996.

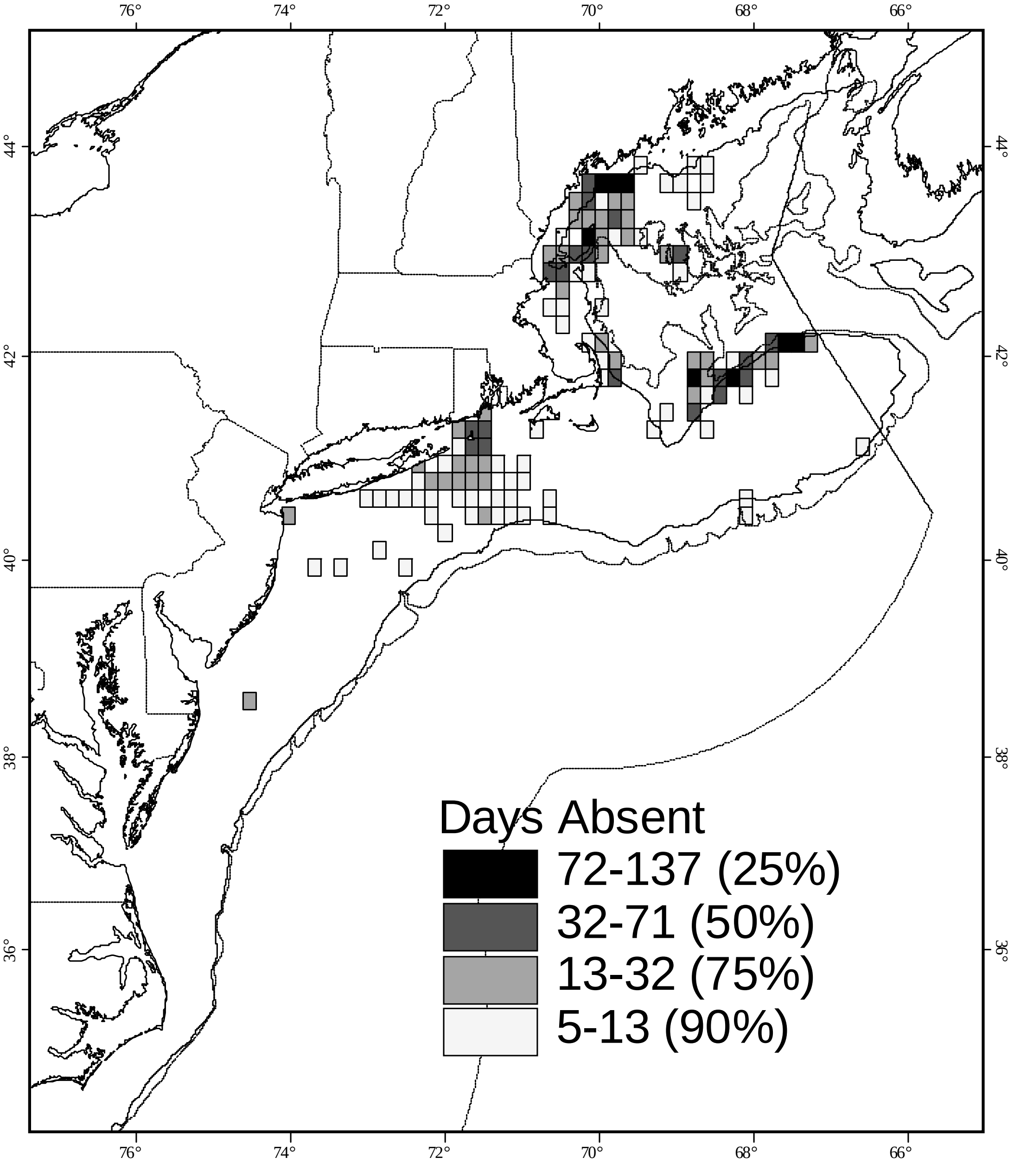

Figure 4.25. Spatial distribution of ten minute squares that accounted for various levels of fishing activity by herring mid-water trawls in the U.S. Northeast region during 1997-2002.

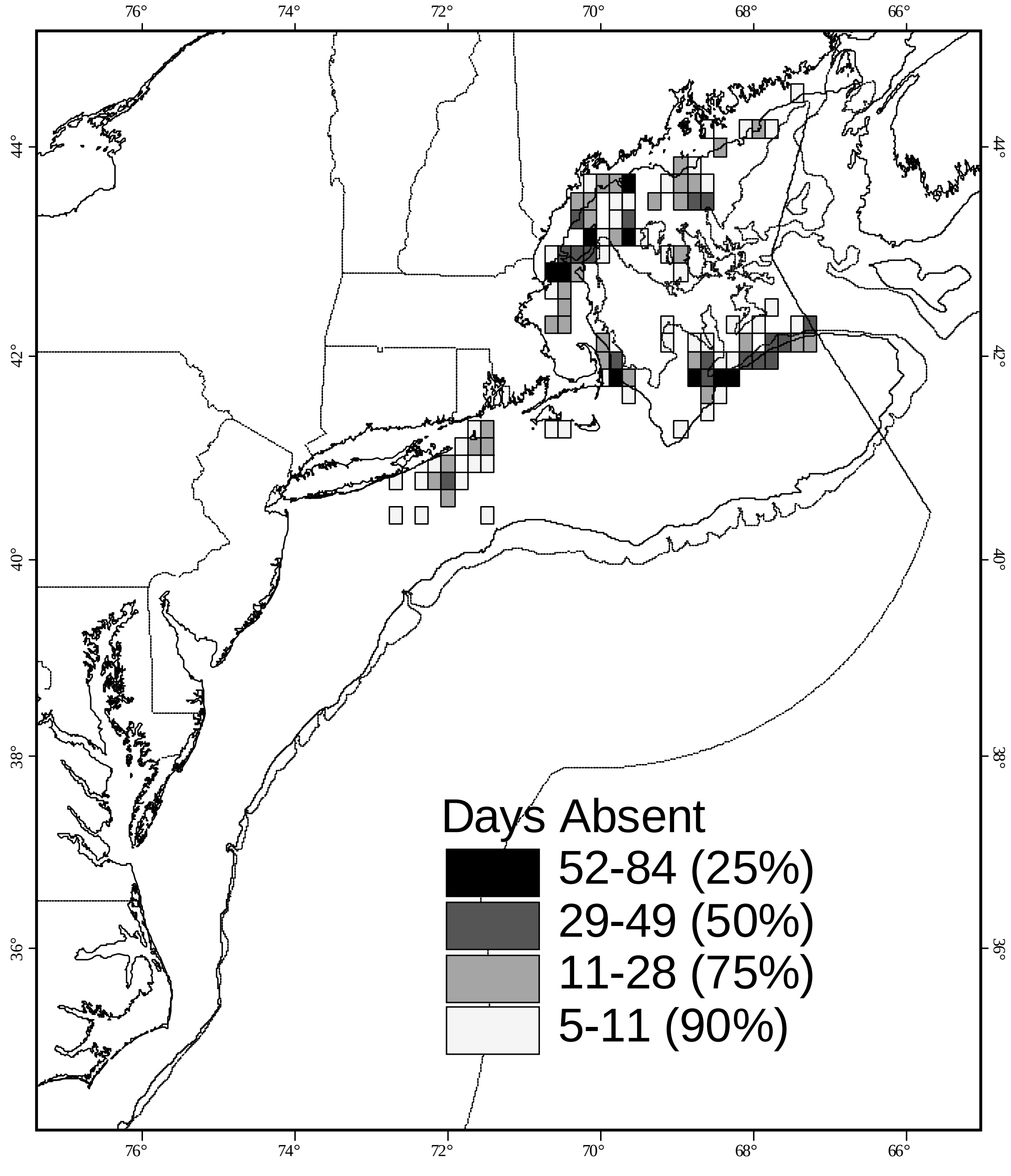

Figure 4.26. Spatial distribution of ten minute squares that accounted for various levels of fishing activity by herring pair trawls in the U.S. Northeast region during 1997-2002

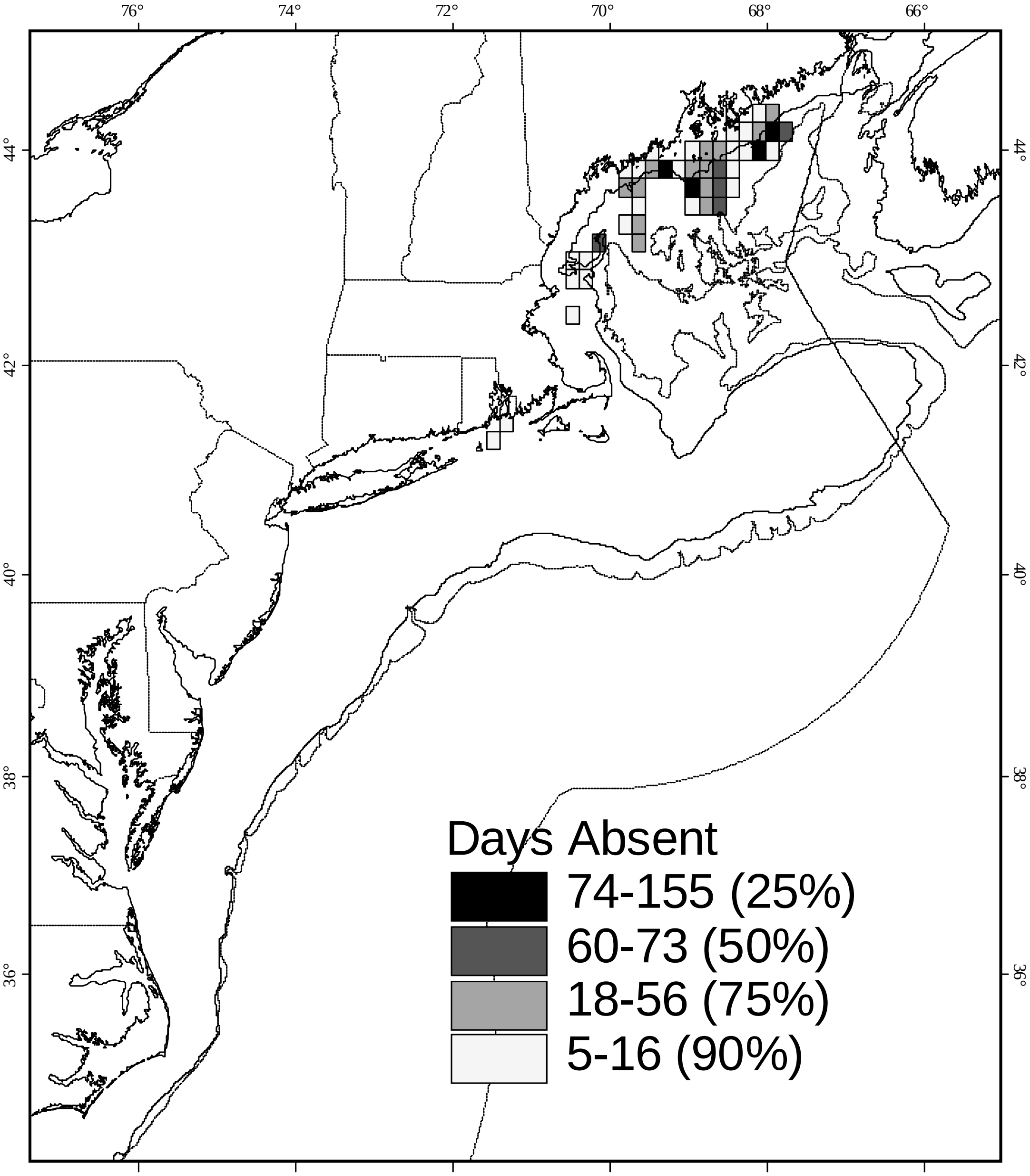

Figure 4.27. Spatial distribution of ten minute squares that accounted for various levels of fishing activity by herring purse seines in the U.S. Northeast region during 1997-2002.

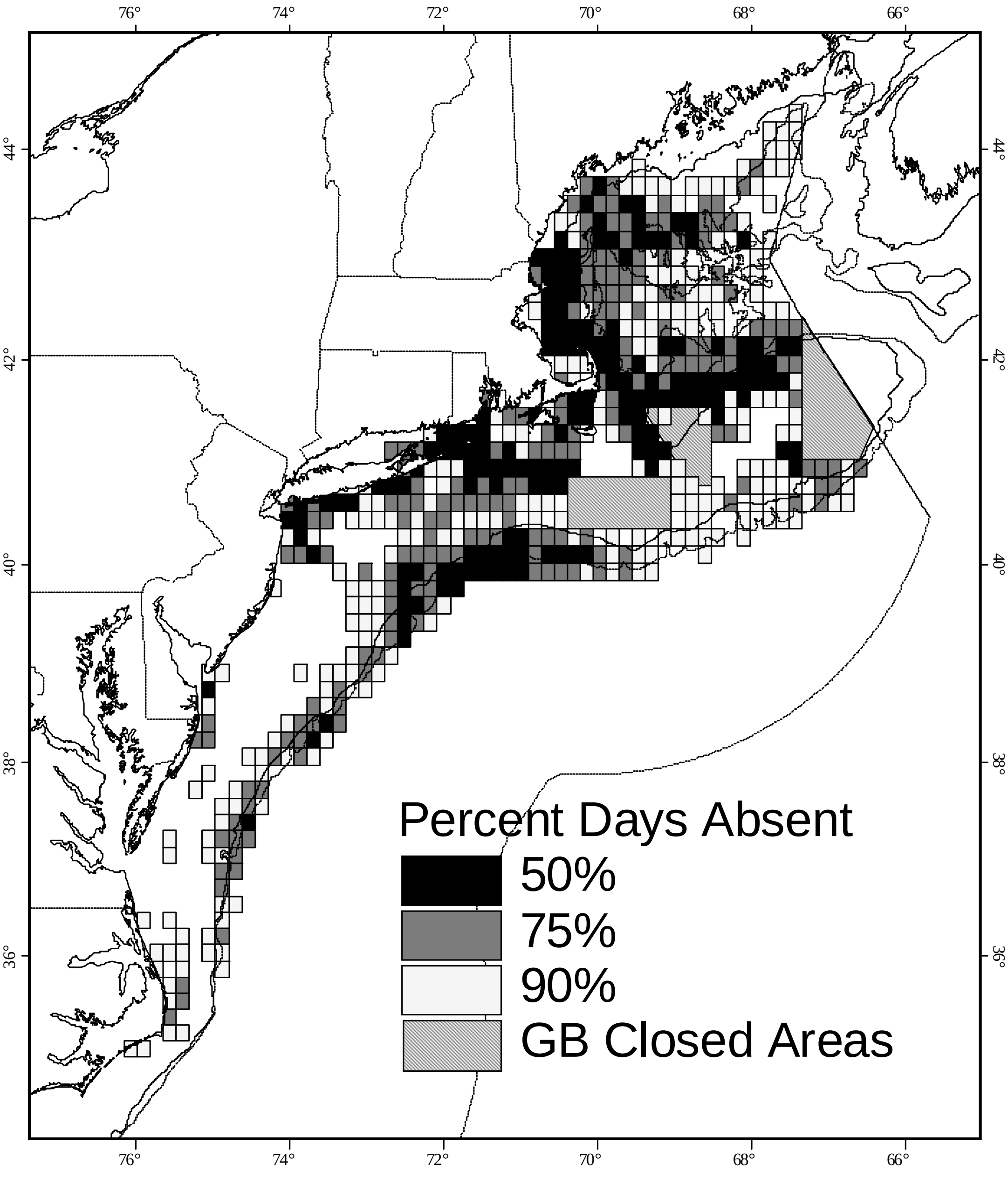

Figure 4.28. Spatial distribution of ten minute squares (TMS) that accounted for high (50%), medium (75%), and low (90%) levels of fishing activity by fish otter trawls in the U.S. Northeast region during 1995-2001

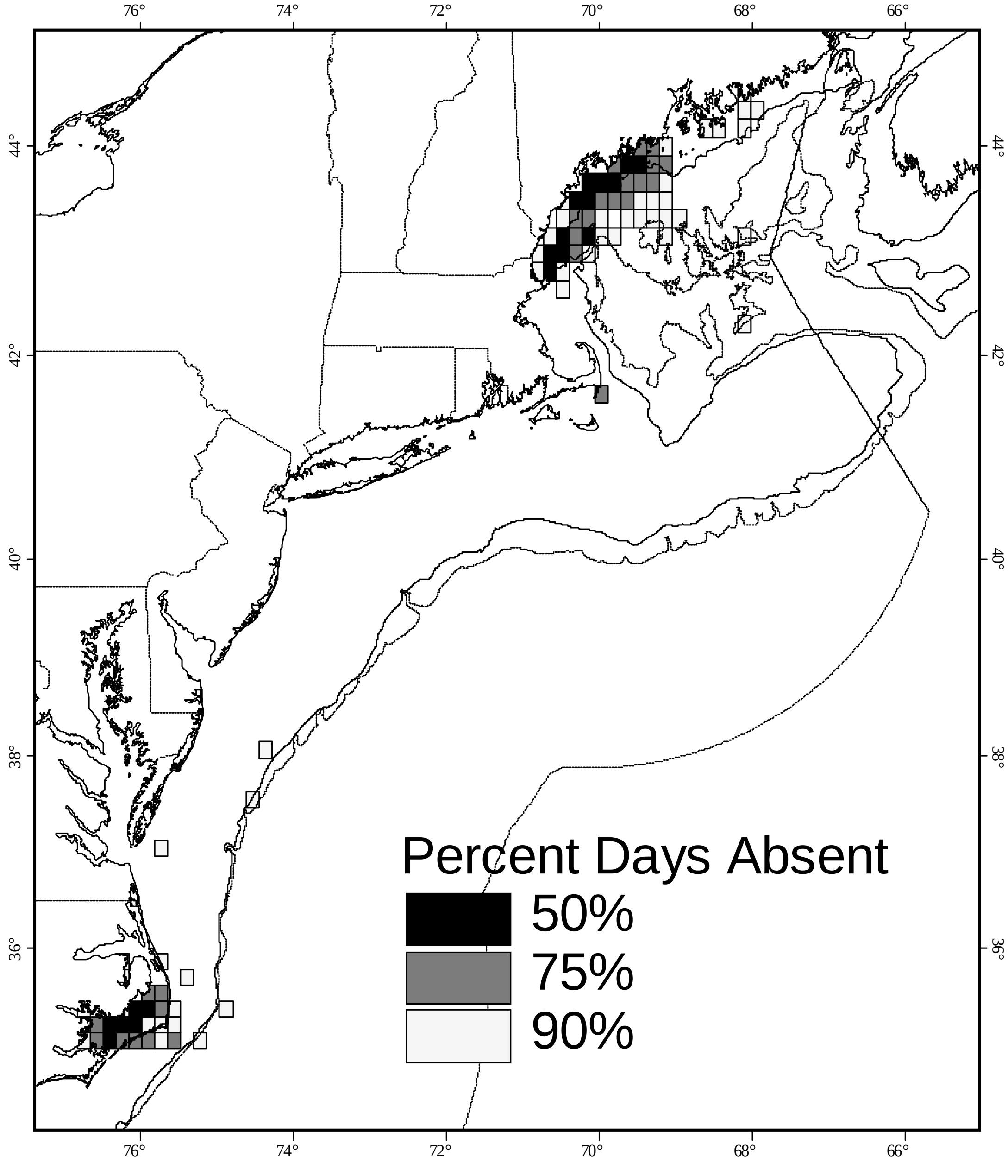

Figure 4.29. Spatial distribution of ten minute squares (TMS) that accounted for high (50%), medium (75%), and low (90%) levels of fishing activity by shrimp otter trawls in the U.S. Northeast region during 1995-2001.

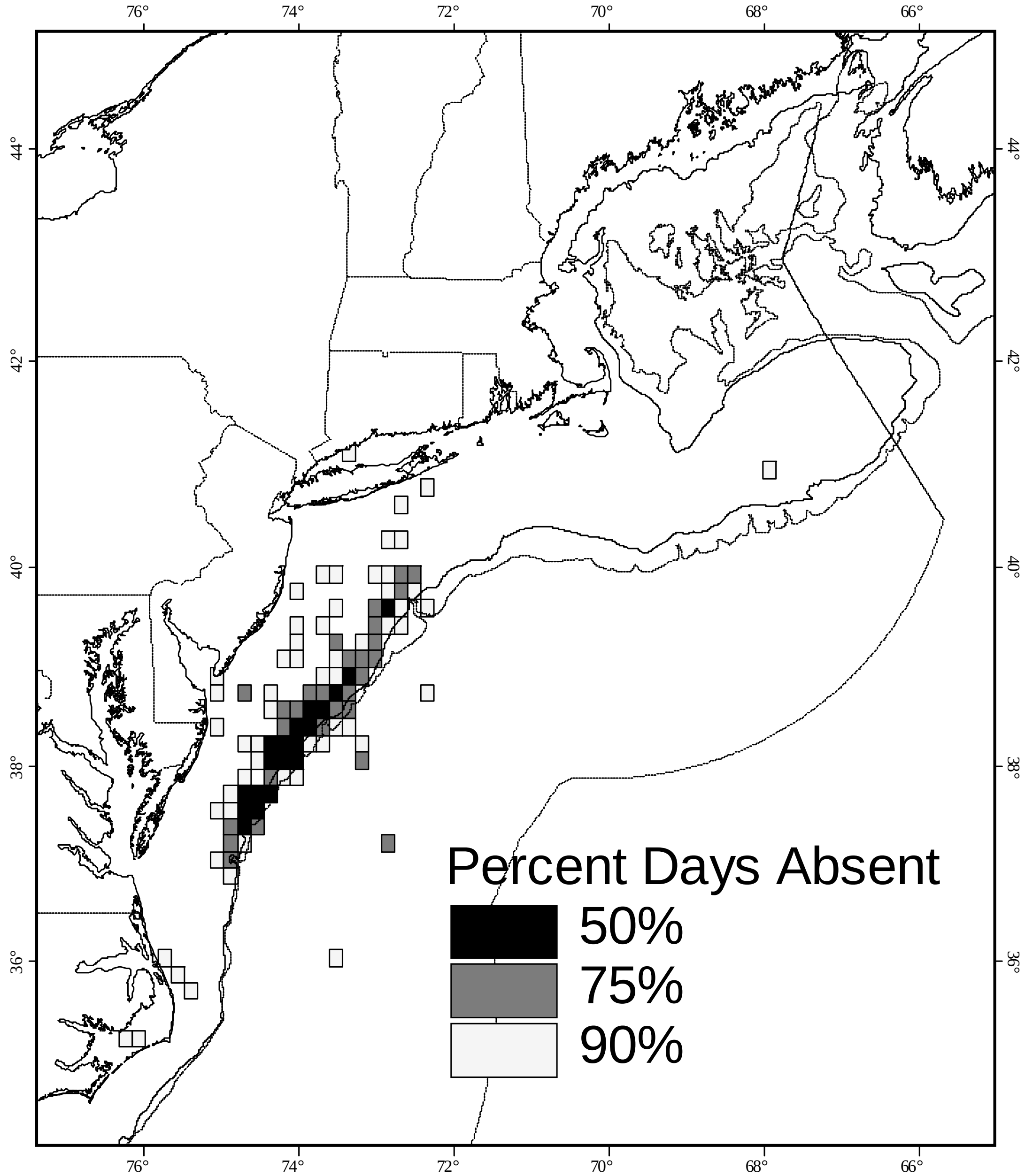

Figure 4.30. Spatial distribution of ten minute squares (TMS) that accounted for high (50%), medium (75%), and low (90%) levels of fishing activity by scallop otter trawls in the U.S. Northeast region during 1995-2001.

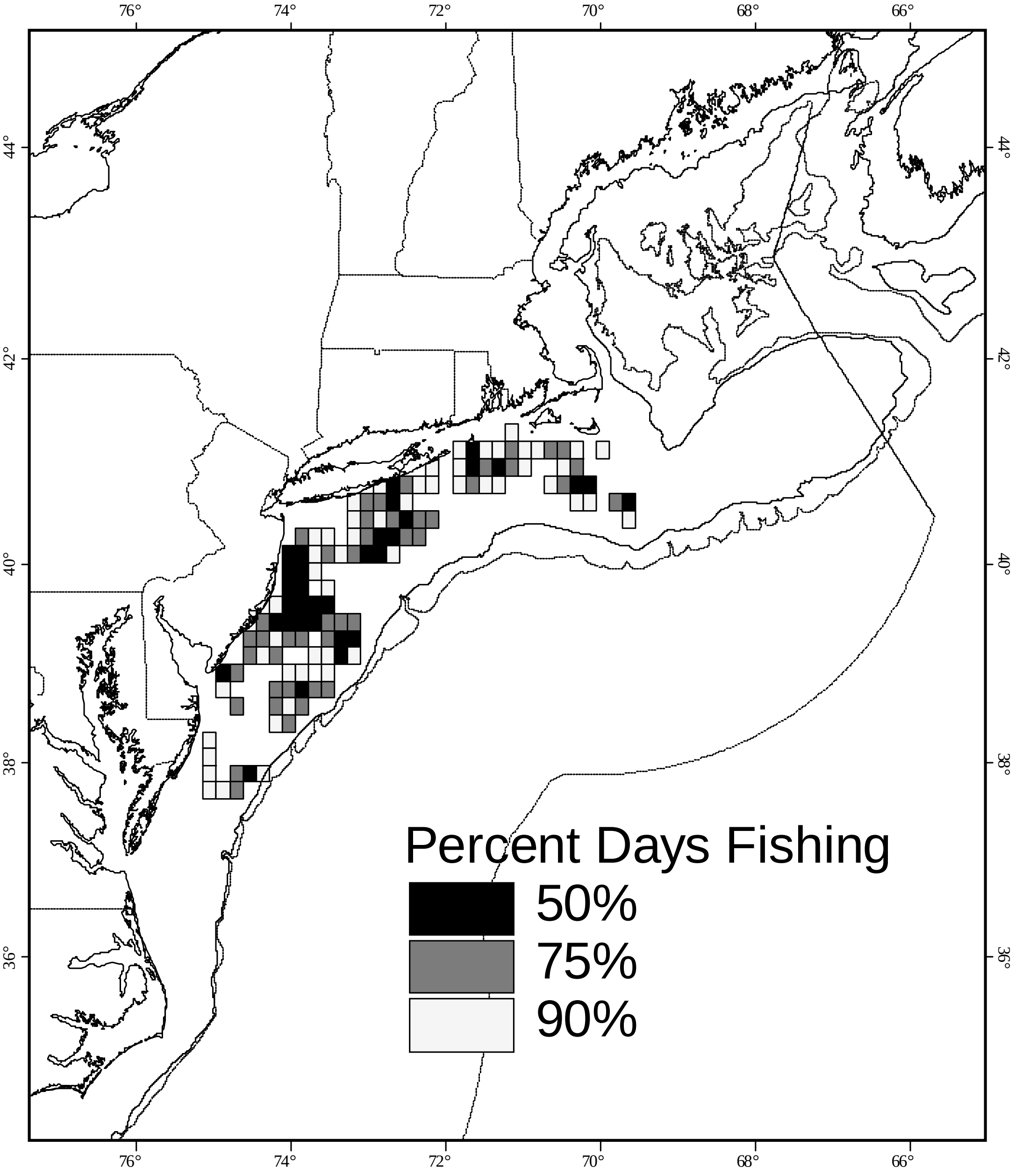

Figure 4.31. Spatial distribution of ten minute squares (TMS) that accounted for high (50%), medium (75%), and low (90%) levels of fishing activity by hydraulic clam dredges in the U.S. Northeast region during 1995-2001.

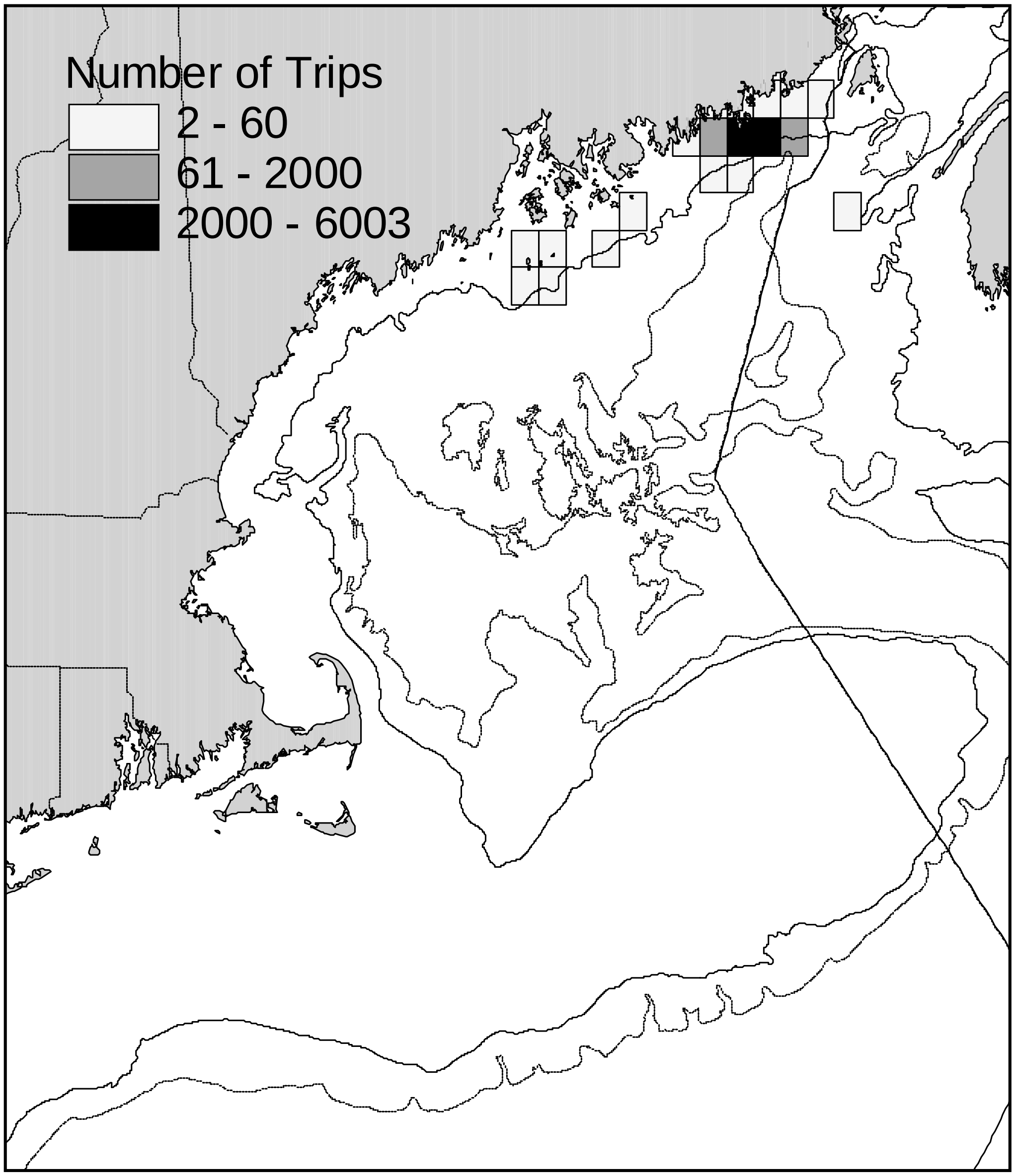

Figure 4.32. Reported number of trips made by vessels using non-hydraulic clam dredges within ten minute squares of latitude and longitude in the U.S. Northeast region during 1995-2000.

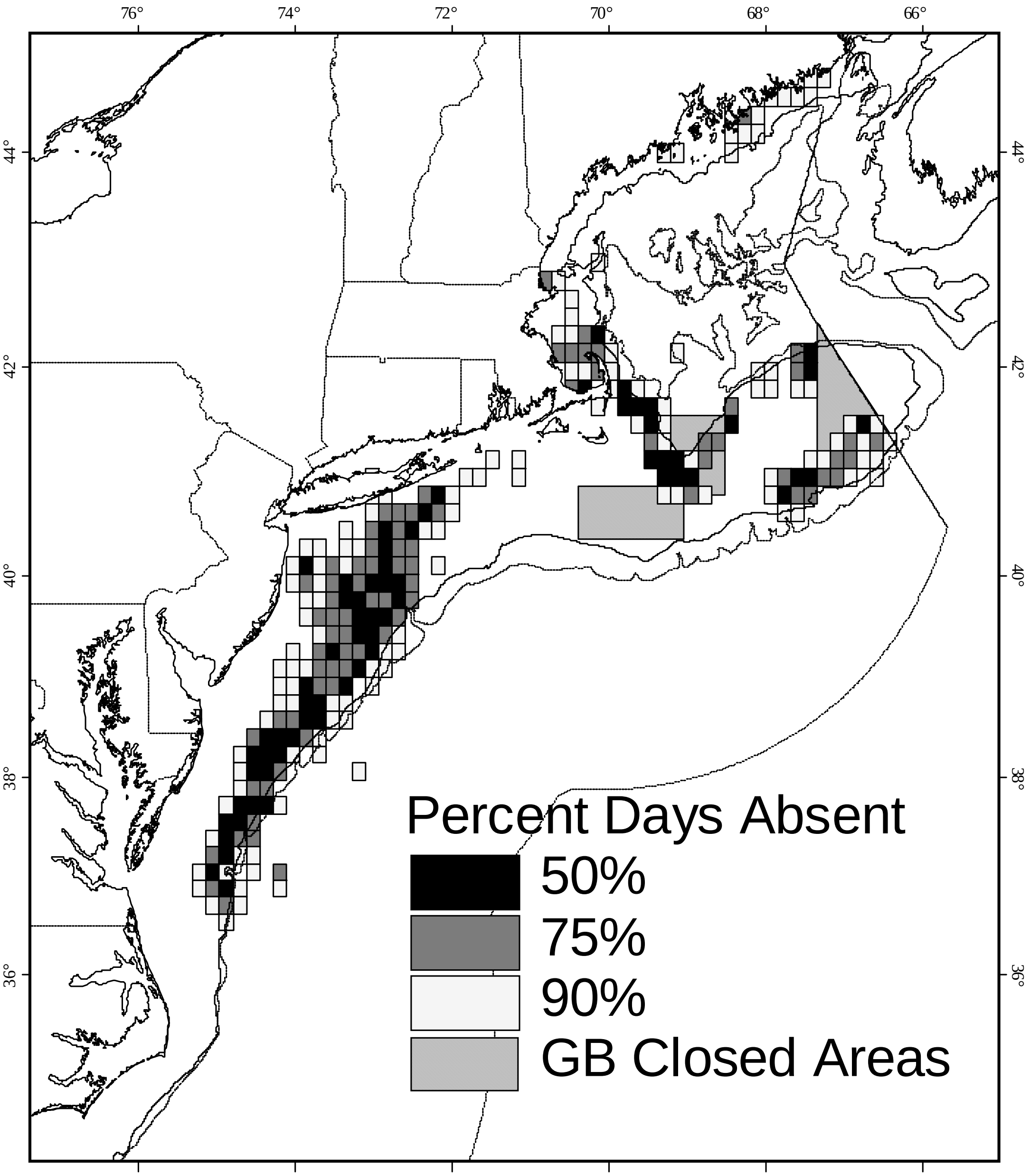

Figure 4.33. Spatial distribution of ten minute squares (TMS) that accounted for high (50%), medium (75%), and low (90%) levels of fishing activity by scallop dredges in the U.S. Northeast region during 1995-2001.

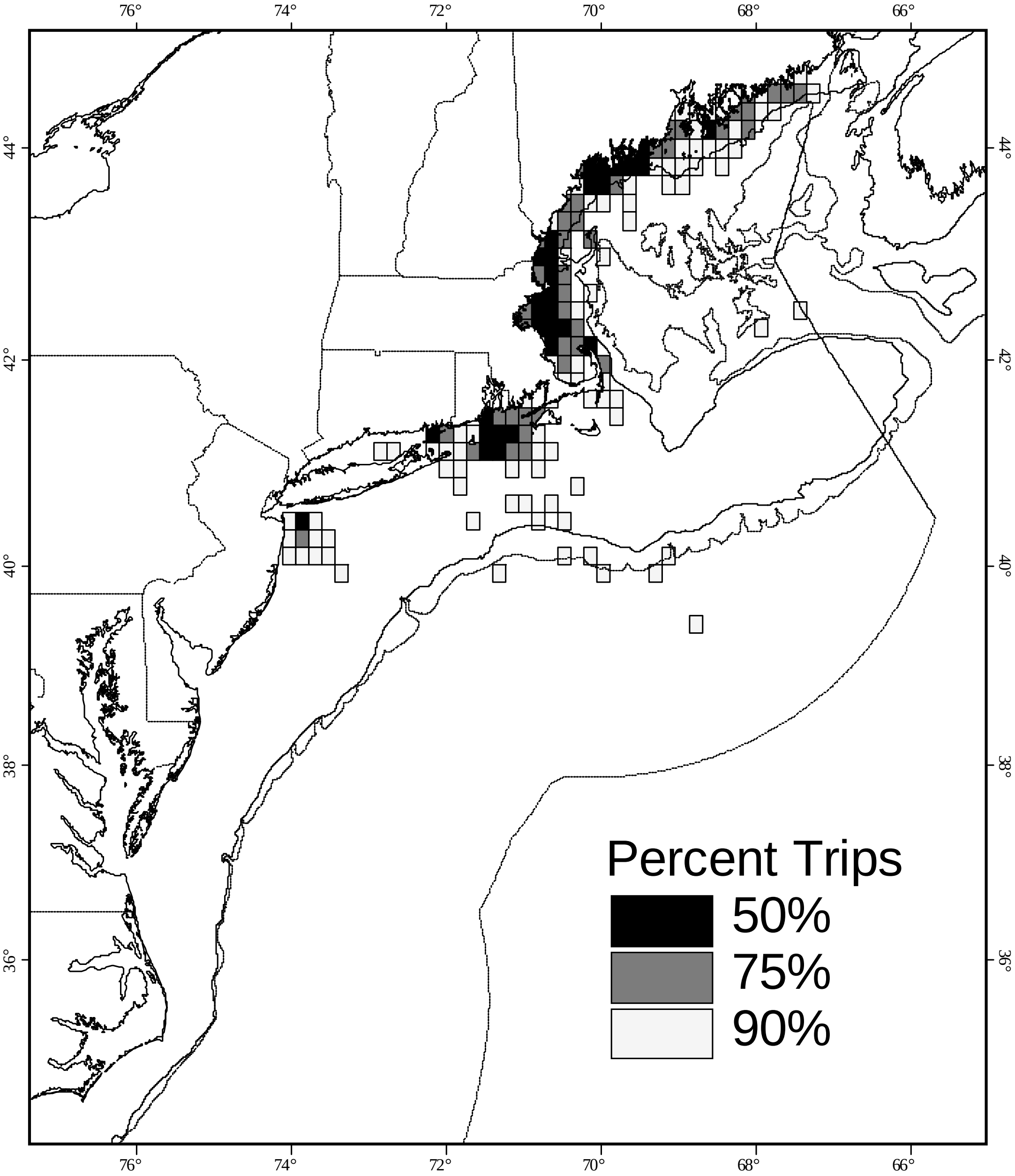

Figure 4.34. Spatial distribution of ten minute squares (TMS) that accounted for high (50%), medium (75%), and low (90%) levels of fishing activity by lobster pots in the U.S. Northeast region during 1995-2001.

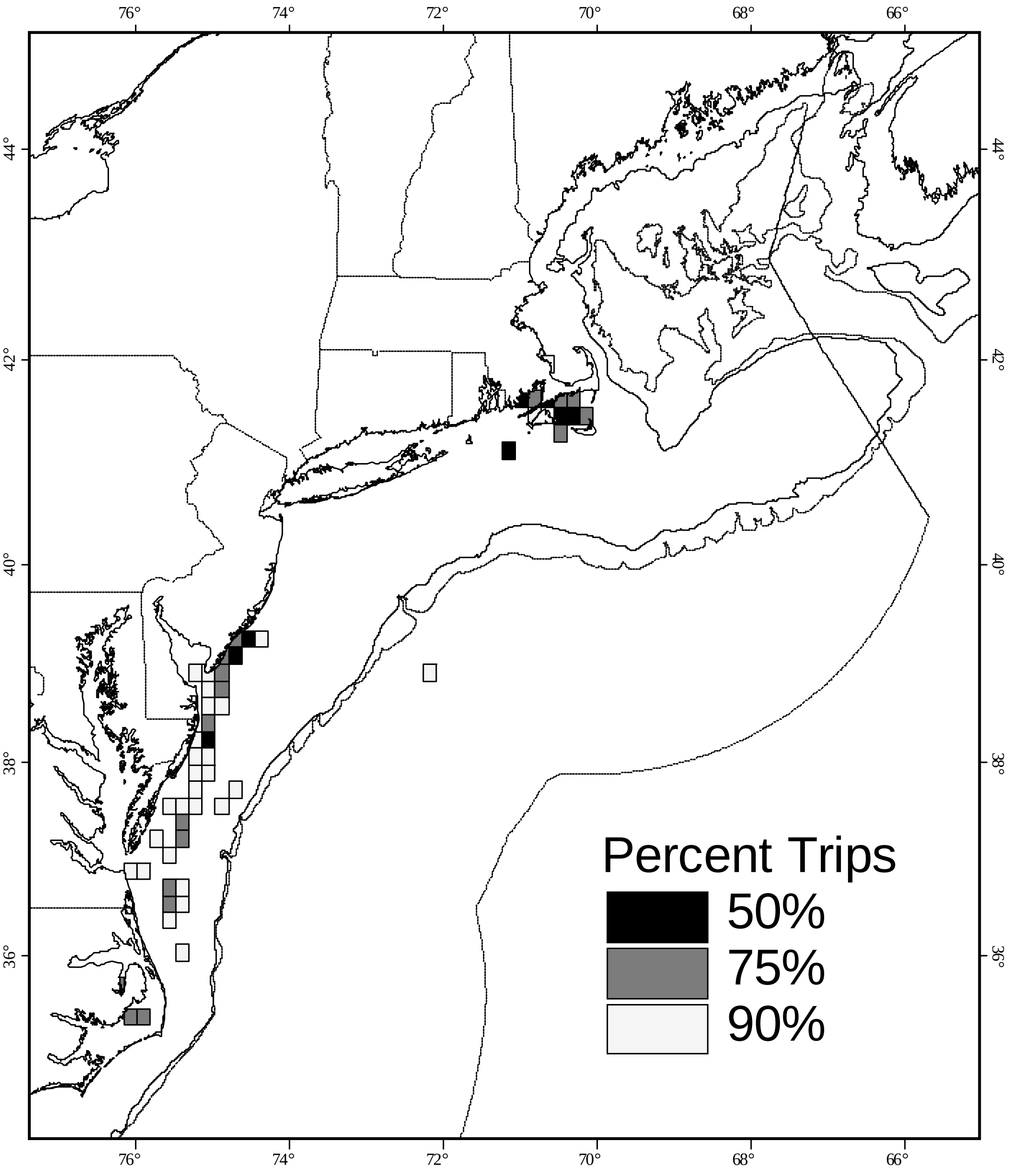

Figure 4.35. Spatial distribution of ten minute squares (TMS) that accounted for high (50%), medium (75%), and low (90%) levels of fishing activity by conch and whelk pots in the U.S. Northeast region during 1995-2001.

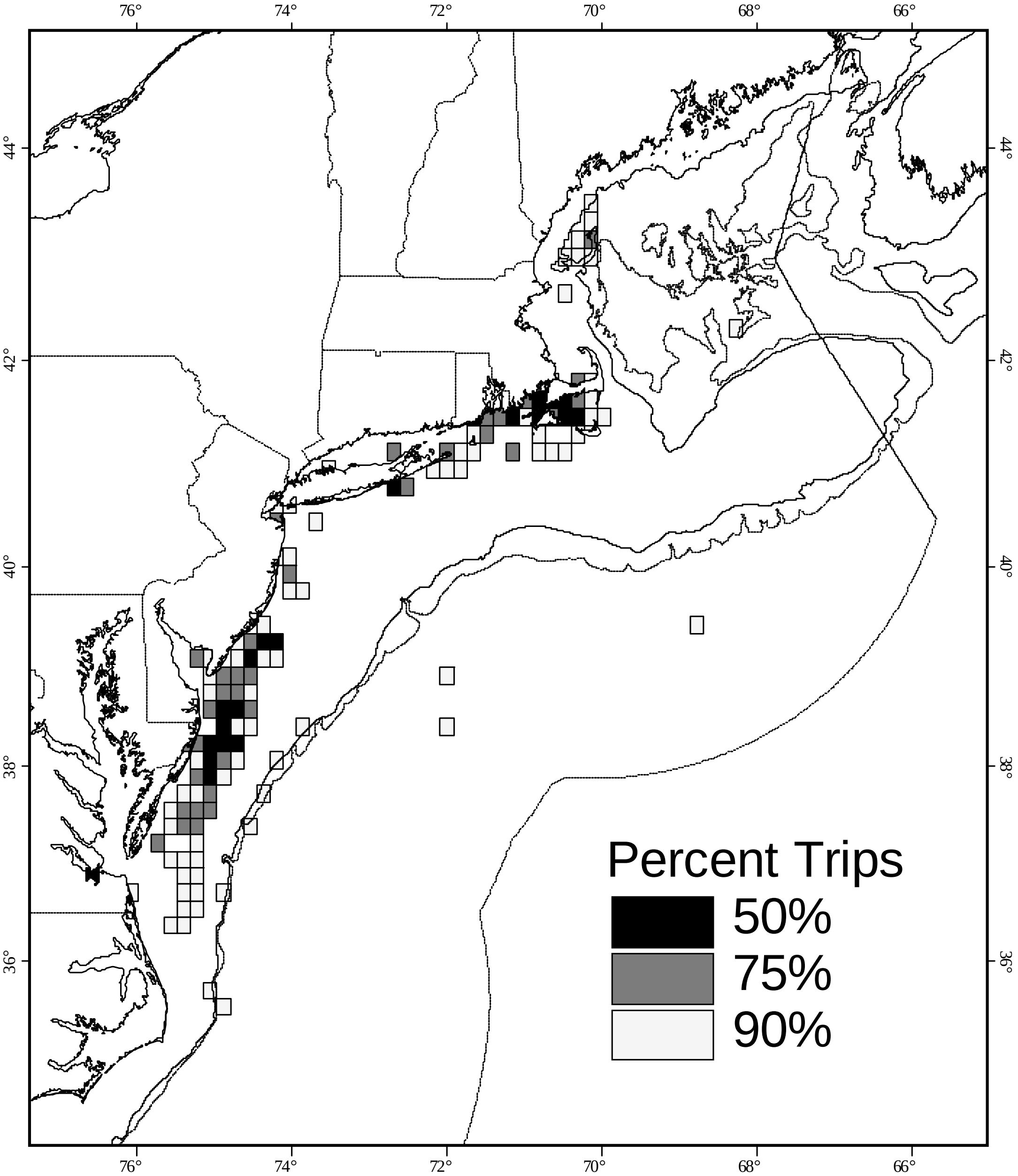

Figure 4.36. Spatial distribution of ten minute squares (TMS) that accounted for high (50%), medium (75%), and low (90%) levels of fishing activity by fish (black sea bass) pots in the U.S. Northeast region during 1995-2001.

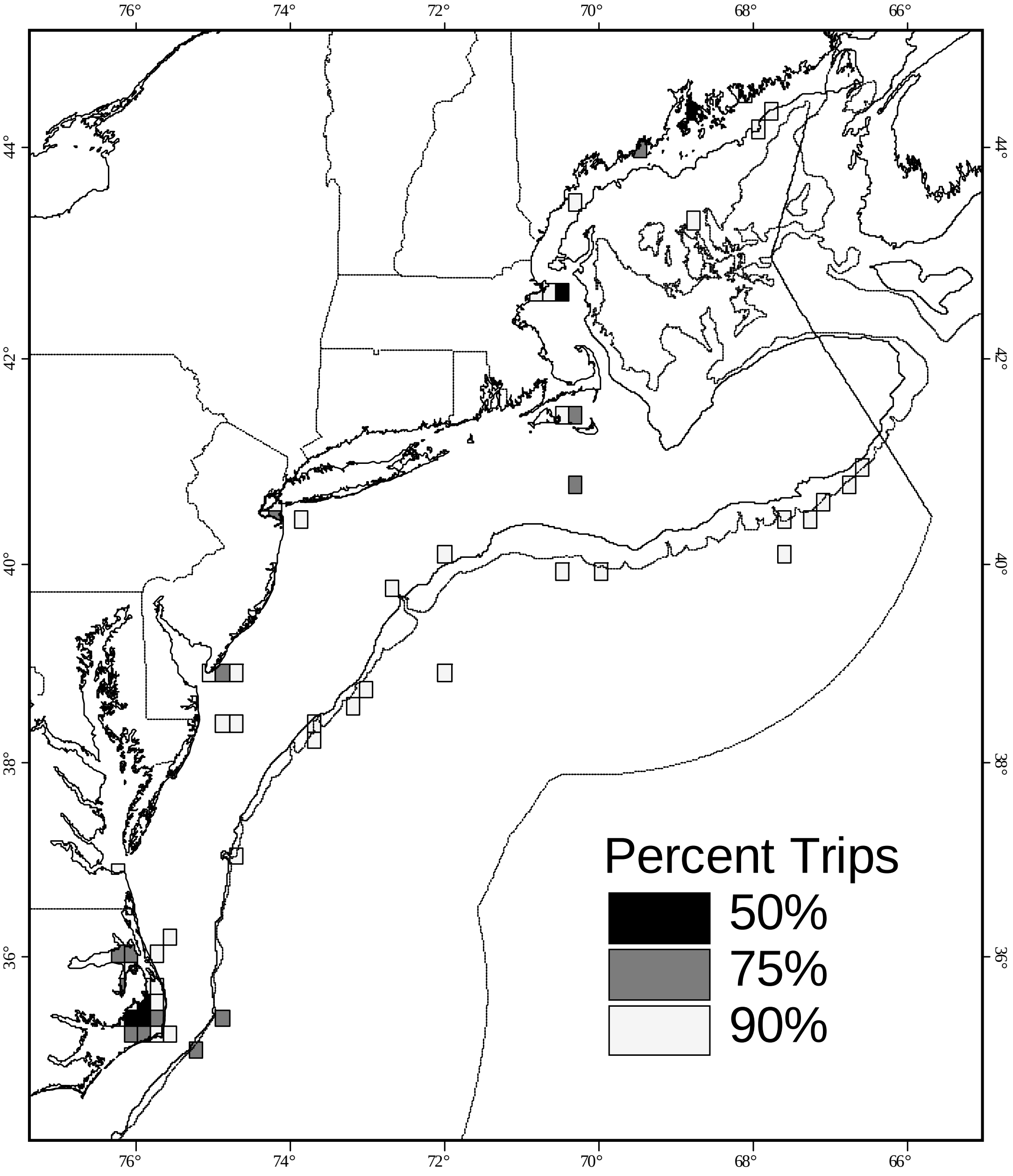

Figure 4.37. Spatial distribution of ten minute squares (TMS) that accounted for high (50%), medium (75%), and low (90%) levels of fishing activity by crab pots in the U.S. Northeast region during 1995-2001.

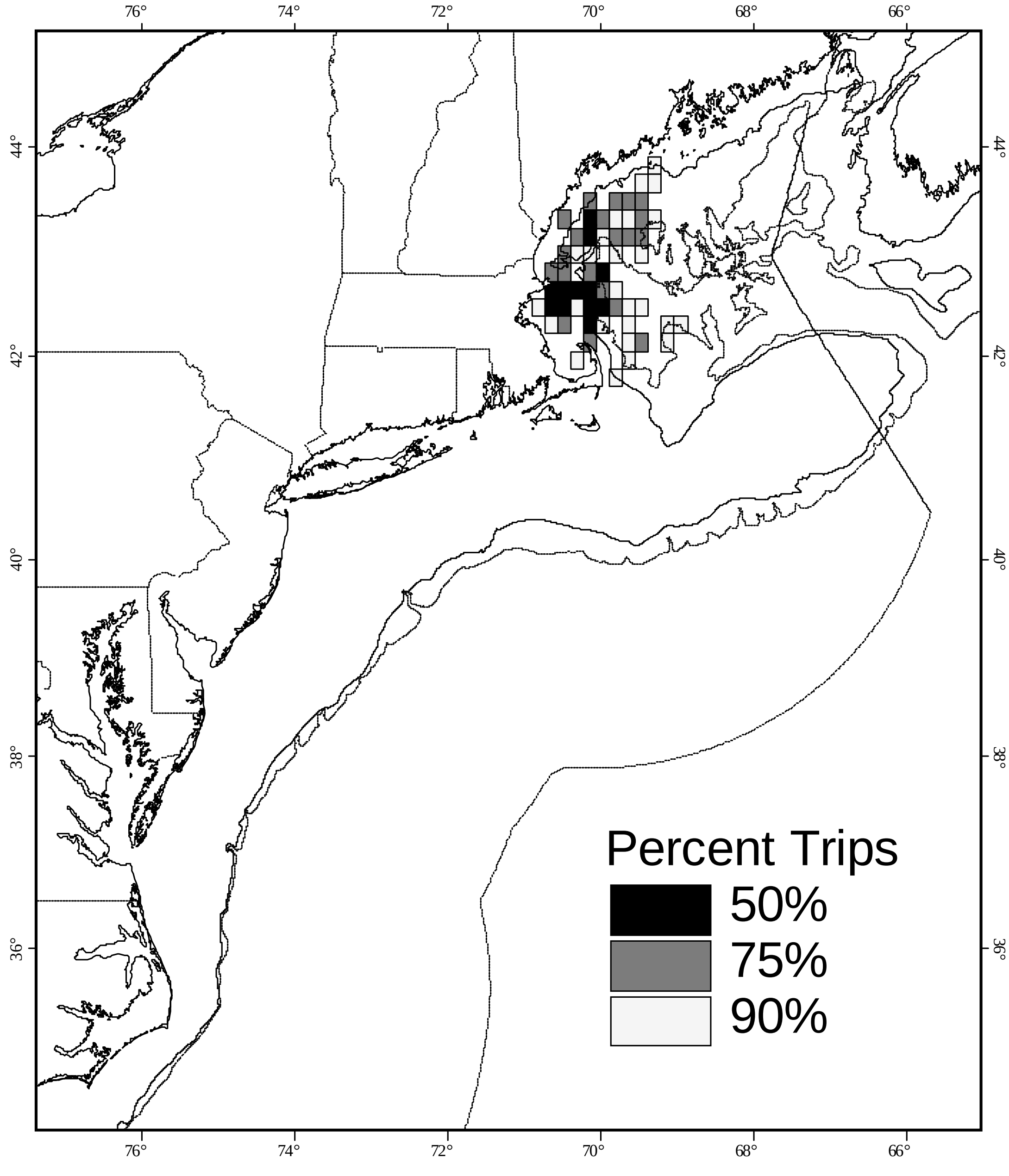

Figure 4.38. Spatial distribution of ten minute squares (TMS) that accounted for high (50%), medium (75%), and low (90%) levels of fishing activity by hagfish pots in the U.S. Northeast region during 1995-2001.

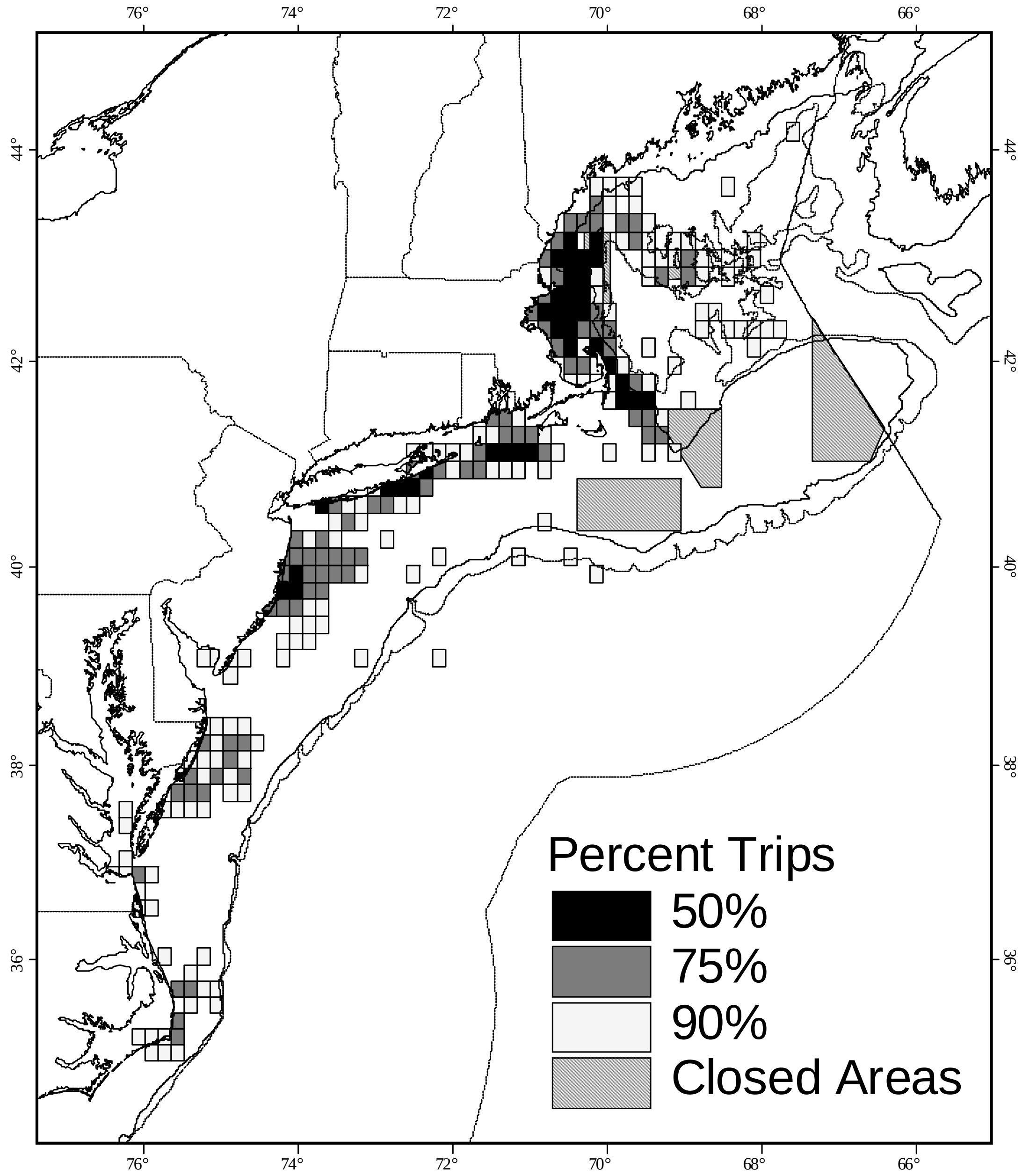

Figure 4.39. Spatial distribution of ten minute squares (TMS) that accounted for high (50%), medium (75%), and low (90%) levels of fishing activity by bottom gill nets in the U.S. Northeast region during 1995-2001.

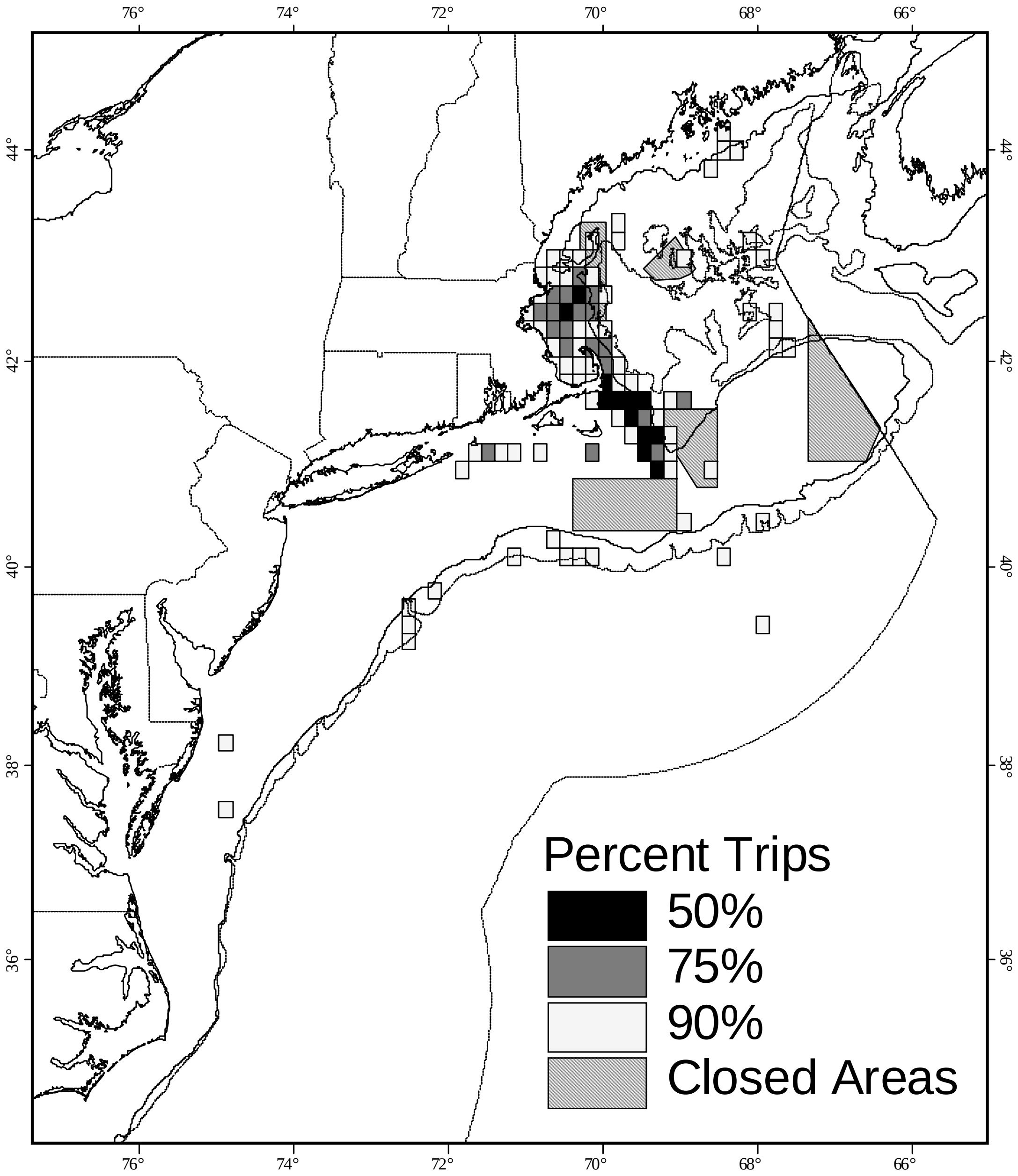

Figure 4.40. Spatial distribution of ten minute squares (TMS) that accounted for high (50%), medium (75%), and low (90%) levels of fishing activity by bottom longlines in the U.S. Northeast region during 1995-2001.

5.0 HABITAT IMPACTS OF FISHING

5.1 Herring Fishery Impacts on EFH

5.1.1 Impacts on Atlantic Herring EFH

This section will evaluate the impacts of gear used in the directed herring fishery on herring EFH. Atlantic herring are pelagic fish and the gear operates in the water column. However, impacts to herring EFH are possible.

Larval, juvenile, and adult herring are pelagic (Section 4.2.2), even though EFH for juveniles and adults is described as “pelagic waters and bottom habitats.” Herring eggs are demersal and are deposited on “bottom habitats with a substrate of gravel, sand, cobble, shell fragments, and aquatic macrophytes.” (Atlantic herring EFH is described for five life stages in Table 5.17). Adult herring travel in schools and migrate to discrete spawning grounds (Section 4.2.2.7) prior to spawning. Mature adult herring do not feed and remain near the bottom until they spawn. Ten minute squares of latitude and longitude that are designated as EFH for each life stage are shown in Figure 4.17 - Figure 4.20.

The two primary gear types used in the Atlantic herring fishery are mid-water trawls and purse seines (Section 4.3.1.2). Mid-water trawls are towed either by a single boat or by two boats that operate in “pairs” (thus the term “pair trawls”). These are the only gears used to directly harvest herring in federal waters of the Northeast region. Bottom trawls only accounted for about 2% of total landings during 2000-2002 (see Figure 4.23). Herring catches in bottom trawls are incidental in other fisheries such as the whiting, northern shrimp, and mackerel fisheries. Some of the herring taken as bycatch in these fisheries is landed and sold, primarily as lobster bait. A very small amount of herring is harvested with “fixed gear” (stop seines and weirs) in state waters on the eastern Maine coast (see descriptions in Section 4.3.1.2).

Herring are extremely sensitive to noise and schools are known to disperse when approached by vessels or when disturbed by mid-water nets or purse seines (see Table 5.18). This disturbance could be interpreted as a potential impact on the pelagic spawning habitat of juvenile or adult herring. The effect, however, is known to be temporary: schools of herring that are dispersed by vessels or mid-water trawls re-form quickly after passage of the boat or the net, within a matter of minutes (Table 5.18). This may adversely affect the pelagic habitat for juvenile and adult herring, but the effects are minimal and temporary in nature and do not need to be minimized.

The other potential impact of mid-water trawls and purse seines on Atlantic herring EFH is on the habitat for herring eggs. In order for herring egg EFH to be more than minimally impacted by these gears, the gears would have to 1) contact bottom habitats that are used by herring for spawning, and 2) disturb the bottom in a way that reduces its functional value as an egg habitat. According to information obtained from fishermen, bottom contact occasionally occurs on smooth sand or mud bottom when herring are very close to the bottom and can not be caught unless the net is towed just above the bottom (Section 4.3.1.2). This happens primarily during the winter fishery in southern New England, may occur in certain locations on Georges Bank, but not in the Gulf of Maine because the gear is not designed to withstand contact with rocky substrates. When contact occurs, it is by chains attached to the footrope and by two heavy weights attached to the wings of the net. The trawl doors do not contact the bottom.

Because any bottom contact by mid-water trawls used in the Northeast U.S. Atlantic herring fishery is expected to be limited to flat mud and sand substrates, and because herring do not deposit eggs on mud (Section 4.2.2.3), the only habitats utilized as herring egg EFH that are likely to be vulnerable to impacts from mid-water trawls or purse seines are in sandy bottom areas. However, herring fishing gears only contact the bottom occasionally and many sand bottom habitats where herring spawn (e.g., on Georges Bank) are located in fairly shallow depths that are subject to scouring action by strong bottom currents. Therefore, if there are any adverse impacts of mid-water trawls in sandy bottom habitats, they are not more than minimal or temporary in nature and therefore do not need to be minimized.

Bottom contact by mid-water trawls may occasionally occur in certain gravel or sand substrate spawning locations on Georges Bank that are free of rocks. However, any kind of infrequent disturbance of bottom sediments that provide a substrate for herring eggs would not reduce the functional value of the habitat as EFH for the eggs. The only exception to this would be benthic macrophytes or emergent epifauna – attached algae, bryozoans, etc. – that herring eggs also stick to and which are easily damaged or removed from the bottom by bottom-tending fishing gear. This type of egg substrate is not very common, however. (See more detailed discussion in Section 5.3). There is no evidence to indicate that herring are less likely to deposit their eggs on bottom habitats composed of gravel, sand, cobble, and shell fragments that have been disturbed by fishing gear than on un-disturbed substrate, or that eggs deposited on disturbed substrates would have a reduced survival rate.

Purse seines are used almost exclusively in the Gulf of Maine in coastal and offshore waters. Because they are so deep (up to 50 meters), they sometimes contact the bottom when they are first set out, before they are "pursed." Before the net is pursed, the bottom lead lines can be pushed across the bottom for short distances by tidal currents, causing disturbance to benthic organisms and substrates. If there are impacts to benthic habitats, they would be more pronounced in complex, rocky bottom areas which are more vulnerable to disturbance (Auster and Langton 1999, NEREFHSC 2002). Although purse seines may occasionally contact gravel and coarse sand benthic habitats that serve as substrate for herring eggs in the Gulf of Maine, the potential adverse impacts of this gear are also minimal and temporary in nature because there is no evidence to suggest that disturbance of bottom substrates reduced the quality of herring egg EFH. Noise produced by herring fishing vessels and gear may adversely affect pelagic EFH for juvenile and adult herring, but these effects are also minimal and temporary (Table 5.18).

Bycatch Data

Additional information supporting the conclusion that mid-water trawls and purse seines do not contact the bottom to any significant degree is provided by bycatch data available from observers place aboard commercial herring fishing vessels. For this analysis, bycatch data were sorted into three categories: pelagic species that occupy the water column, "semi-demersal" species that live near the bottom, but do not normally rest on the bottom), and demersal species that are in direct contact with the bottom most of the time. Catches of any significant number (or pounds) of fully demersal species would provide the best evidence that a mid-water trawl (or purse seine) was in contact with the bottom during one or more of the hauls or sets that were sampled during a fishing trip. However, it is important to note that even fully demersal species such as flounder do come off the bottom at various times. Consequently, bycatch information must be used with caution. Catches of "semi-demersal" species would be less convincing since species like cod or haddock could be caught if the net was being fished near the bottom, but not on it. Observed species were grouped by category according to their life history characteristics (Table 5.19). For this analysis, the terms "bycatch" (discards of target or non-target species) and "incidental" catch (non-target species that are not discarded) were not used. Any finfish or shellfish species that was caught with Atlantic herring was included in the analysis as bycatch. Catches of marine mammals or seabirds were not included.

Four sources of information were available for this analysis:

1. National Marine Fisheries Service (NMFS) sea sampling (observer) database, 1994-2003;
2. Observer reports from foreign processing pessels engaged in Joint Venture (JV) operations in 2001 (JV processing vessels purchased herring caught by U.S. fishermen);
3. Maine DMR observer data (1997/1998), collected in cooperation with Manomet Center for Conservation Sciences (USDOC 1999); and
4. Results from a herring bycatch survey conducted by ME DMR in 2003/2004.

Data were obtained from 110 mid-water (single boat and pair trawlers) and 31 purse seine trips, representing catches of 41 million lbs (18,660 metric tons) and 5 million lbs (2,317 mt) of Atlantic herring, respectively. The results indicate that 1.8% of the mid-water trawl catch and 1.5% of the purse seine catch was composed to species other than herring (Table 5.20 and Table 5.21). Almost all of the bycatch taken by purse seines was composed of pelagic species (spiny dogfish). Bycatch in mid-water trawls was almost equally divided between pelagic and semi-demersal species: demersal species accounted for three hundred-thousandths of a percent (140 lbs during 110 trips that produced over 41 million lbs of herring). Most of the semi-demersal catch was composed of silver hake, a species that leaves the bottom at night in pursuit of prey (Klein-MacPhee 2002). The primary non-target pelagic species caught in herring mid-water trawls are Atlantic mackerel, spiny dogfish, alewives, and blueback herring. These results support the conclusion that any contact of the bottom by herring mid-water trawls or purse seines is negligible.

Conclusions:

There are indications that mid-water trawls and purse seines do occasionally contact the seafloor and may impact benthic habitats utilized by a number of federally-managed species, including EFH for Atlantic herring eggs. Howver, after reviewing all the available information, the NMFS concludes that if the quality of EFH is reduced as a result of this contact, the impacts are minimal and/or temporary and, pursuant to MSA, do not need to be minimized (Table 5.24). The following information supports this conclusion.

- Bottom contact by mid-water trawls is limited to occasional contact by "tickler" chains that hang down in short loops from the footrope, or the footrope itself, the belly of the net, or the two weights that are attached to the wire trawl warps that extend from the bottom of the net to the doors – the doors and the codend do not touch bottom.

- The lead lines of purse seines may occasionally contact the bottom when the net is first set, but not once the net is "pursed."

- Mid-water trawls are not designed to fish in contact with the bottom and are easily damaged if they hit an obstacle (rocks) or if the nylon netting in the belly drags over any kind of bottom substrate. Repairs are costly.

- Bottom contact, when it occurs, is much more likely to occur on flat sand or mud bottom, not on structurally complex and more sensitive hard bottom. Bottom contact is most likely to occur in southern New England during the winter, and to a lesser extent on sandy bottom areas on Georges Bank.

- Bycatch of fully demersal fish species in 110 trips made by mid-water trawlers and 31 trips made by purse seiners was insignificant, accounting for .0003% of the mid-water trawl catch and .0001% of the purse seine catch.

- Use of bottom trawls and dredges in southern New England and on the northern edge of Georges Bank is much more intensive (compare Figure 4.25 and Figure 4.26 with Figures Figure 4.28 and Figure 4.33). Overall, throughout the entire NE region, herring mid-water trawls only accounted for 1.1% of all days absent from port by mobile gear vessels during 1997-2002 (Table 5.22).

5.1.2 Impacts on EFH for Other Species

It is possible that occasional bottom contact by mid-water herring trawls could potentially affect EFH for benthic life stages of species in the Northeast region, especially those that occupy sand and mud habitats that may be disturbed from time to time by mid-water trawls. Purse seines could have similar effects in a variety of benthic habitat types. A list of federally-managed species and life stages in the Northeast region that have been determined to have EFH that is vulnerable to the effects of bottom trawling and dredging is shown in Table 5.23. The EFH vulnerability rankings in this table were based on published scientific information on the life histories and habitat requirements of each species and life stage, using a numerical evaluation procedure (see notes at the bottom of the table). Most of these species and life stages inhabit sand or mud bottom. EFH for these species and life stages could possibly be vulnerable to any bottom disturbance caused by mid-water trawls or purse seines as well. Because any bottom contact by herring mid-water trawls is limited primarily to sand and mud bottoms, no adverse impacts are expected on rocky or gravel substrates. If the quality of benthic EFH for other species in the NE region is reduced as a result of bottom contact by herring fishing gear, the effects are no more than minimal or temporary in nature. These conclusions are summarized in Table 5.24.

Table 5.17. Atlantic herring EFH - vulnerability to effects of bottom-tending fishing gears.

Life Stage	**Geographic Area of EFH**	**Depth (m)**	**Seasonal Occurrence**	**EFH Description**	**EFH Vulnerability***				
					OT	**SD**	**CD**	**PT**	**NL**
Eggs	GOME, GB and following estuaries: Englishman/Machias Bay, Casco Bay, and Cape Cod Bay	20 - 80	July through November	Bottom habitats with a substrate of gravel, sand, cobble, shell fragments, and aquatic macrophytes, tidal currents 1.5 - 3 knots	L	L	0	L	L
Larvae	GOME, GB, Southern NE and following estuaries: Passamaquoddy Bay to Cape Cod Bay, Narragansett Bay, and Hudson R./ Raritan Bay	50 - 90	Between August and April, peaks from September to November	Pelagic waters	NA	NA	NA	NA	NA
Juveniles	GOME, GB, Southern NE and Middle Atlantic south to Cape Hatteras and following estuaries: Passamaquoddy Bay to Cape Cod Bay; Buzzards Bay to Long Island Sound; Gardiners Bay to Delaware Bay	15 - 135		Pelagic waters and bottom habitats	NA	NA	NA	NA	NA
Adults	GOME, GB, southern NE and middle Atlantic south to Cape Hatteras and following estuaries: Passamaquoddy Bay to Great Bay; Mass. Bay to Cape Cod Bay; Buzzards Bay to Long Island Sound; Gardiners Bay to Delaware Bay; and Chesapeake Bay	20 - 130		Pelagic waters and bottom habitats	NA	NA	NA	NA	NA
Spawning Adults	GOME, GB, southern NE and middle Atlantic south to Delaware Bay and Englishman/Machias Bay Estuary	20 - 80	July through November	Bottom habitats with a substrate of gravel, sand, cobble, and shell fragments, also on aquatic macrophytes	L	L	0	L	L

Rationale: Atlantic herring (*Clupea harengus*) is a coastal pelagic species ranging from Labrador to Cape Hatteras in the western Atlantic (Reid *et al.* 1999; Munroe 2002). For most pelagic life stages (larvae, juveniles, adults) EFH vulnerability to bottom-tending fishing gear s is not applicable. Atlantic herring eggs are laid in high-energy, benthic habitats on rocky, pebbly, gravelly or shell substrates or macrophytes (Reid *et al.* 1999; Munroe 2002). These habitats are less susceptible to fishing gear impacts since they have evolved under a high-energy disturbance regime (strong bottom currents). Vulnerability of herring egg EFH to scallop dredges and otter trawls is considered low. Although these gears may directly affect the eggs, only the effect of the gear on the functional value of the habitat was considered for this evaluation. EFH vulnerability from clam dredges was considered to be none since this gear does not operate in areas of herring egg EFH. Spawning adults are closely associated with the bottom. Effects on the functional value of habitat from mobile gears are unknown and were rated as low since spawning occurs on the bottom. EFH vulnerability from clam dredges was rated as none for the reasons described above. Spawning could be disrupted by noise associated with these gears, but this issue was not addressed as a habitat related issue.

Definitions: GOME - Gulf of Maine; GB - Georges Bank; NE - New England; HAPC - Habitat Area of Particular Concern; YOY - Young-of-Year; OT - Otter Trawls; SD - New Bedford Scallop Dredge; CD - Hydraulic Clam Dredge; PT- Pots and Traps; NL - Gill Nets and Longlines. NA - not applicable; 0 - No vulnerability; L - Low vulnerability; M - Moderate vulnerability; H - High vulnerability; EFH - essential fish habitat; * derived from matrix analysis – see **Error! Reference source not found.**.

Table 5.18. Published observations of the behavioral responses of Atlantic herring to noise created by vessels and fishing gear.

Authors	Title	Citation	Year	Summary
Mohr, H.	Observations on the Atlanto-Scandian herring with respect to schooling and reactions to fishing gear.	in Vol. 3, p. 4507-577, of Proceedings of the Conference on Fish Behavior in relation to Fishing Techniques and Tactics, FAO Fisheries Report No. 62, Vol. 1-3; ed. A. Ben-Tuvea, W. Dickson.	1968	This paper reports observations on Atlanto-Scandian herring. (1) Herring east of Iceland were not active or reactive to stimuli. Ships passing through concentrations did not cause a reaction. Fish did not take flight before the net. Dense masses of fish present 20 m below the net. (2) Migrating herring in Arctic water similar to that east of Iceland. **Once in warmer waters, travel at much greater speed and showed sensitive reaction to ship and gear. Frequent changes of direction in front of ship, sometimes divided into two or more schools. At 30 to 40 m from net, fish moved quickly to sides or downwards, found 20m to 50m below net.** Trawling not successful, gear could not reach fish before they reformed an escaping school. Tow speed 3.8 to 4 kn. (3) **In coastal waters, schools dispersed some at night but still sensitive to ship and gear. Catches usually poor because fish disappeared downwards; seiners, on the other hand, successful.** Some fish at deeper levels could be caught successfully as they appeared not to react. One additional observation noted that when net was lowered quickly, school did not disperse.
Okonski, S.	Echo sounding observations of fish behavior in the proximity of the trawl.	*in* Proceedings of the Conference on Fish Behavior in relation to Fishing Techniques and Tactics, FAO Fisheries Report No. 62, Vol. 1-3; ed. A. Ben-Tuvea, W. Dickson.	1968	Reaction of fish schools dependent on how net "attacked" school. Schools went up when net attacked lower part of school. Observations made on 2 boat pair trawl in the Skagerrak, 16-20 m net opening, 3.5 knot tow speed. **Scattered herring returned to a more compact form 450 m or 5 minutes after net passed.**
Misund, Ole Arve	Sonar observations of schooling herring: school dimensions, swimming behavior, and avoidance of vessel and purse seine	Rapp. P.-v. Cons. int. Explor. Mer. 189:135-146.	1990	Norwegian spring spawning herring (winter fishery) and North Sea herring (summer fishery). **Avoidance behavior most apparent with spawning, migrating schools. Schools escaped capture 36% of the sets in summer daylight. North Sea herring observed to escape under the sinking net, under the vessel, and in four instances school divided.** Some bycatches of preying cod and saithe. Norwegian herring did not show avoidance behavior at night; North Sea herring did during the day.
Misund, Ole A. and Asgeir Aglen	Swimming behavior of fish	ICES J. Mar. Sci. 49:325-334	1992	Herring may react to trawl by expelling gas from swim bladder to dive more quickly. **Observed diving and vertical compression of schools after the**

	schools in the North Sea during acoustic surveying and pelagic trawl sampling.			**vessel passed, but before the trawl arrived**.
Suuronen, Petri, Esa Lehtonen, John Wallace	Herring avoidance and escape during midwater trawling.	Misund PhD. Thesis	1995	Baltic herring, SE coast of Finland. 15-35 m daytime depth, 2-20 m night. Tow speed 2.2-3.3 knots. Mouth opening of 15-22m, 25m to 35 m between wingtips. Paired MWT. Avoidance reactions, usually strong downward. **Parts of school escaped on 170 of 493 observations. Returned to earlier swimming depth as soon as trawl passed. Avoidance reaction varied significantly with time of day, CPUE and water temp. Reactions stronger during daytime, reaction distance short (probably reacting within visible range). More avoidance reactions when large quantities of herring in the water.**
Pitcher, Tony J., O.A. Misund, Anders Ferno, Bjorn Totland, Vebjorn Melle.	Adaptive behavior of herring schools in the Norwegian Sea as revealed by high resolution sonar.	ICES J. Mar. Sci. 53:449-452	1996	Wide range of and frequent responses by schools to various stimuli. At approach of a saithe school, herring dove rapidly to 150m. Similar response noticed at approach of research vessel. **Schools are very dynamic regime. Some change in status every 5.5. minutes.**

Table 5.19. Species observed during Atlantic herring mid-water trawl and purse seine trips, sorted by category.

Pelagic Species	Semi-demersal species	Demersal species
Alewife	Atlantic cod	Monkfish
Bluefish	Haddock	Ocean pout
Spiny dogfish	Red hake	Sculpin
Blueback herring	Silver hake	Sea raven
Shad	White hake	Sea robin
Atlantic mackerel	Northern shrimp	Skates
Squid	Lumpfish	American plaice
Other sharks	Scup	Winter flounder
Striped bass	Pollock	Witch flounder
Tuna		
Butterfish		
Atlantic menhaden		
Rays		

Table 5.20. Catch (lbs and percent of total catch) of pelagic, semi-demersal, demersal species, and Atlantic herring in 110 single mid-water trawl and pair trawl trips sampled during 1994-2004.

	NMFS, 1994-2002	NMFS, 2003	JV, 2001	ME DMR, 1997-1998	ME DMR, 2003-2004	TOTAL	PERCENT
Number of trips	18	27	23	27	15	110	
Pelagic species	202,103	73,764	0	117,494	11,702	405,063	0.967
Semi-Demersal species	487	3,627	332,734	48	429	337,325	0.805
Demersal species	43	22	0	70	5	140	.0003
Atlantic herring	3,653,048	6,956,552	23,632,970	4,489,898	2,414,475	41,146,943	98.23
Total	3,855,681	7,033,965	23,965,704	4,607,510	2,426,611	41,889,471	

Table 5.21. Catch (lbs and percent of total catch) of pelagic, semi-demersal, demersal species, and Atlantic herring in 31 herring purse seine trips sampled during 1994-2004.

	NMFS, 1994-2002	NMFS, 2003	ME DMR, 1997-1998	ME DMR, 2003-2004	TOTAL	PERCENT
Number of trips	3	2	23	3	31	
Pelagic species	700	24	77,366	719	78,809	1.519
Semi-Demersal species	0	0	10	1	11	0.0002
Demersal species	0	0	4	0	4	0.0001
Atlantic herring	550,000	115,000	4,003,400	441,000	5,109,400	98.4801
Total	550,703	115,026	4,080,803	441,723	5,188,255	

Table 5.22. Estimated percentages of total fishing activity (days absent from port) in the Northeast region of the U.S. for six types of mobile fishing gears, based on NMFS vessel trip reports and clam dredge logbook data collected during 1995-2002.

Gear	**Years**	**Reported Days**	**Percent Trips Reported**	**"Missing" Days**	**“New” Days**	**Annual Average**	**Percent Total**
All bottom trawls	1995-2001	395,013	0.785	84,928	479,941	68,563	67.81
Scallop dredges	1995-2001	157,513	0.72	44,104	201,617	28,802	28.49
Clam dredges	1995-2001	15,951	0.992	128	16,079	2,297	2.27
Mid-water trawls	1997-2002	3,135	0.765	737	3,872	645	0.64
Pair trawls	1997-2002	2,366	0.765	556	2,922	487	0.48
Purse seines	1997-2002	1,538	0.765	361	1,899	317	0.31

Note: “Reported” days at sea were only for trips that were assigned a latitude and longitude. “Missing” days (for trips reported by statistical area) were estimated according to the percentage of “unreported” trips for each gear type and added to “reported” days to get “new” days. Percent trips reported for mid-water trawls, pair trawls, and purse seines were not available for individual gears. A “day absent from port” equals 24 hrs from the date and time a vessel left port to when it returned and does not represent actual time spent fishing.

Table 5.23. EFH vulnerability matrix for benthic life stages of federally managed fish and shellfish species in the Northeast region of the U.S.

Species	**Habitat Criteria**				**Habitat Rank**	**Gear Criteria**			**Gear Ranks**			**EFH Vulnerability**		
	Shelter	**Food**	**Repro**	**Habitat Sensitivity**		**OT Dist.**	**SD Dist.**	**CD Dist.**	**OT Rank**	**SD Rank**	**CD Rank**	**OT Vuln.**	**SD Vuln.**	**CD Vuln.**
American Plaice (A)	1	2	1	1	5	2	2	0	10	10	0	High	High	None
American Plaice (J)	1	2	0	1	4	2	2	0	8	8	0	Mod	Mod	None
Atlantic Cod (A)	1	1	0	2	4	2	2	1	8	8	4	Mod	Mod	Low
Atlantic Cod (J)	2	1	0	2	5	2	2	0	10	10	0	High	High	None
Atlantic Halibut (A)	1	1	1	1	4	2	2	0	8	8	0	Mod	Mod	None
Atlantic Halibut (J)	1	2	0	1	4	2	2	0	8	8	0	Mod	Mod	None
Atlantic Herring (E)	0	0	1	1	2	2	2	0	4	4	0	Low	Low	None
Atlantic Herring (SA)	0	0	1	1	2	2	2	0	4	4	0	Low	Low	None
Atlantic Sea Scallops (A)	1	0	1	1	3	2	2	2	6	6	6	Low	Low	Low
Atlantic Sea Scallops (J)	1	0	0	1	2	2	2	2	8	8	8	Low	Low	Low
Barndoor Skate (A)	1	1	1	1	4	2	2	1	8	8	4	Mod	Mod	Low
Barndoor Skate (J)	1	2	0	1	4	2	2	1	8	8	4	Mod	Mod	Low
Black Sea Bass (A)	2	1	0	2	5	2	2	2	10	10	10	High	High	High
Black Sea Bass (J)	2	1	0	2	5	2	2	2	10	10	10	High	High	High
Clearnose Skate (A)	1	1	1	1	4	2	2	2	8	8	8	Mod	Mod	Mod
Clearnose Skate (J)	1	2	0	1	4	2	2	2	8	8	8	Mod	Mod	Mod
Golden Crab (J,A)	1	1	1	2	5	1	0	0	5	0	0	Low	None	None
Haddock (A)	1	2	0	2	5	2	2	1	10	10	5	High	High	Low
Haddock (J)	2	2	0	2	6	2	2	1	12	12	6	High	High	Low
Little Skate (A)	1	1	1	1	4	2	2	2	8	8	8	Mod	Mod	Mod
Little Skate (E)	0	0	1	1	2	2	2	2	4	4	4	Low	Low	Low
Little Skate (J)	1	2	0	1	4	2	2	2	8	8	8	Mod	Mod	Mod
Goosefish (A)	1	1	0	1	3	2	2	2	6	6	6	Low	Low	Low
Goosefish (J)	1	1	0	1	3	2	2	2	6	6	6	Low	Low	Low
Ocean Pout (A)	2	2	1	2	7	2	2	2	14	14	14	High	High	High
Ocean Pout (E)	2	0	1	2	5	2	2	2	10	10	10	High	High	High
Ocean Pout (J)	2	2	0	2	6	2	2	2	12	12	12	High	High	High
Ocean Quahog (A)	1	0	1	1	3	2	2	2	6	6	6	Low	Low	Low
Ocean Quahog (J)	1	0	0	1	2	2	2	2	4	4	4	Low	Low	Low
Offshore Hake (A)	1	1	0	1	3	2	1	0	6	3	0	Low	Low	None
Offshore Hake (J)	1	1	0	1	3	2	1	0	6	3	0	Low	Low	None
Pollock (A)	1	1	1	1	4	2	2	1	8	8	4	Mod	Mod	Low
Pollock (J)	1	1	0	1	3	2	2	1	6	6	3	Low	Low	Low
Red Crab (A)	1	1	1	2	5	1	0	0	5	0	0	Low	None	None
Red Crab (J)	1	1	0	2	4	1	0	0	4	0	0	Low	None	None
Red Drum (A)	1	1	0	1	3	2	2	2	6	6	6	Low	Low	Low
Red Drum (J)	2	1	0	2	5	1	0	0	5	0	0	Low	None	None
Red Hake (A)	1	2	0	1	4	2	2	1	8	8	4	Mod	Mod	Low
Red Hake (J)	2	2	0	2	6	2	2	2	12	12	12	High	High	High
Redfish (A)	1	1	0	2	4	2	2	0	8	8	0	Mod	Mod	None
Redfish (J)	2	1	0	2	5	2	2	0	10	10	0	High	High	None
Rosette Skate (A)	1	1	1	1	4	2	2	2	8	8	8	Mod	Mod	Mod
Rosette Skate (J)	1	2	0	1	4	2	2	2	8	8	8	Mod	Mod	Mod
Scup (A)	1	1	0	1	3	2	2	2	6	6	6	Low	Low	Low
Scup (J)	1	2	0	1	4	2	2	2	8	8	8	Mod	Mod	Mod
Silver Hake (A)	1	1	0	1	3	2	2	2	6	6	6	Low	Low	Low
Silver Hake (J)	1	1	0	2	4	2	2	2	8	8	8	Mod	Mod	Mod
Smooth Skate (A)	1	2	1	1	5	2	2	0	10	10	0	High	High	None
Smooth Skate (J)	1	2	0	1	4	2	2	0	8	8	0	Mod	Mod	None
Spiny Dogfish (A)	1	1	0	1	3	2	2	2	6	6	6	Low	Low	Low
Spiny Dogfish (J)	1	1	0	1	3	2	2	2	6	6	6	Low	Low	Low
Summer Flounder (A)	1	1	0	1	3	2	2	2	6	6	6	Low	Low	Low
Summer Flounder (J)	1	1	0	1	3	2	2	2	6	6	6	Low	Low	Low
(Atlantic) Surfclam (A)	1	0	1	1	3	2	2	2	6	6	6	Low	Low	Low
(Atlantic) Surfclam (J)	1	0	0	1	2	2	2	2	4	4	4	Low	Low	Low

Species	Habitat Criteria				Habitat Rank	Gear Criteria			Gear Ranks			EFH Vulnerability		
	Shelter	Food	Repro	Habitat Sensitivity		OT Dist.	SD Dist.	CD Dist.	OT Rank	SD Rank	CD Rank	OT Vuln.	SD Vuln.	CD Vuln.
Thorny Skate (A)	1	1	1	1	4	2	2	0	8	8	0	Mod	Mod	None
Thorny Skate (J)	1	2	0	1	4	2	2	0	8	8	0	Mod	Mod	None
Tilefish (A)	2	2	0	1	5	2	1	0	10	5	0	High	Low	None
Tilefish (J)	2	2	0	1	5	2	1	0	10	5	0	High	Low	None
White Hake (A)	1	1	0	1	3	2	2	0	6	6	0	Low	Low	None
White Hake (J)	1	2	0	1	4	2	2	0	8	8	0	Mod	Mod	None
Windowpane Flounder (A)	1	0	0	1	2	2	2	2	4	4	4	Low	Low	Low
Windowpane Flounder (J)	1	1	0	1	3	2	2	2	6	6	6	Low	Low	Low
Winter Flounder (A)	1	1	1	1	4	2	2	2	8	8	8	Mod	Mod	Mod
Winter Flounder (E)	0	0	1	1	2	2	2	2	4	4	4	Low	Low	Low
Winter Flounder (J)	1	1	0	1	3	2	2	2	6	6	6	Low	Low	Low
Winter Skate (J)	1	2	0	1	4	2	2	2	8	8	8	Mod	Mod	Mod
Winter Skate (A)	1	1	1	1	4	2	2	2	8	8	8	Mod	Mod	Mod
Witch Flounder (A)	1	2	0	1	4	2	1	1	8	4	4	Mod	Low	Low
Witch Flounder (J)	1	2	0	1	4	2	1	0	8	4	0	Mod	Low	None
Yellowtail Flounder (A)	1	2	0	1	4	2	2	2	8	8	8	Mod	Mod	Mod
Yellowtail Flounder (J)	1	2	0	1	4	2	2	2	8	8	8	Mod	Mod	Mod

KEY:

(J) = juvenile, (A) = adult, (E) = egg, and (SA) = spawning adult

OT = Otter Trawl; SD = New Bedford Scallop Dredge; CD = Hydraulic Clam Dredge

Shelter: 0 = no dependence; 1 = lower dependence, not reliant on complex structure; 2 = strong dependence, reliant on complex structure

Food: 0 = no dependence on benthic prey; 1 = includes benthic prey; 2 = relies exclusively on benthic prey

Reproduction: 0 = no dependence, e.g., spawns in water column, or life stage not reproductive; 1 = dependence, e.g., spawns on or over bottom

Habitat Sensitivity: 0 = not sensitive; 1 = low sensitivity, i.e., no habitat structural/complexity issues, rapid recovery rates, e.g., high energy sand habitats; 2 = highly sensitive, e.g., habitat structural/complexity issues, slow recovery rates, deepwater/low energy habitats.

Habitat Rank: = Sum of Shelter + Food + Reproduction + Habitat Sensitivity

Gear Distribution: 0 = gear not utilized in this habitat; 1 = gear operates in a small portion of this habitat; 2 = gear operates in much of this habitat

Gear Rank (overall impact on EFH of a particular gear) = Habitat Rank x Gear Distribution. This is the vulnerability of EFH to the gear type.

EFH vulnerabilities were assigned from Gear Ranks as follows: 0 = none, 1 - 6 = low vulnerability, 7 - 9 = moderate vulnerability, 10 - 14 = high vulnerability.

Table 5.24. Summary of EFH impacts attributed to fishing gears used in the Atlantic herring fishery, other MSA fisheries, and non-MSA fisheries.

Gear	Herring egg EFH	Juvenile and adult herring EFH	Benthic EFH for other species
Herring fishery			
Mid-water trawls	Bottom contact - no adverse impact (gravel and rocky substrate); potential adverse impacts that are not more than minimal or temporary in nature (sand)	Noise - potential adverse impacts that are not more than minimal or temporary in nature	Bottom contact - No adverse impact (gravel/rocky substrate) to potential adverse impacts that are not more than minimal or temporary in nature (sand)
Purse seines	Bottom contact - potential adverse impacts that are not more than minimal or temporary in nature	Noise - potential adverse impacts that are not more than minimal or temporary in nature	Bottom contact - minimal and temporary adverse impact
Other MSA fisheries			
Bottom trawls	Bottom contact - potential adverse impacts that are not more than minimal or temporary in nature	Noise - potential adverse impacts that are not more than minimal or temporary in nature	N/A
Scallop dredges	Bottom contact - potential adverse impacts that are not more than minimal or temporary in nature	Noise - potential adverse impacts that are not more than minimal or temporary in nature	N/A
Clam dredges	Bottom contact - potential adverse impacts that are not more than minimal or temporary in nature	Noise - potential adverse impacts that are not more than minimal or temporary in nature	N/A
Fixed gear	Bottom contact - potential adverse impacts that are not more than minimal or temporary in nature	Noise - potential adverse impacts that are not more than minimal or temporary in nature	N/A
Non-MSA fisheries			
Mussel dredges	Potential impacts	Not evaluated	N/A
Sea urchin dredges	Potential impacts	Not evaluated	N/A
Lobster pots	Potential impacts	Not evaluated	N/A

5.2 Impacts of Other MSA Fisheries on Atlantic Herring EFH

Comparison of ten minute squares of latitude and longitude that have been designated as EFH for Atlantic herring eggs (Figure 4.17) with maps showing the distribution of fishing activity by gear type in the NE region (Figure 4.28 - Figure 4.40) reveals that the following bottom-tending fishing gears could potentially affect herring egg EFH: bottom otter trawls that catch fish and northern shrimp, scallop dredges, lobster pots, fish and hagfish pots, bottom gill nets, and bottom longlines. However, EFH for Atlantic herring eggs and spawning adults in the Northeast region was ranked low in terms of its vulnerability to the effects of bottom otter trawls, scallop dredges, pots and traps, and bottom gill nets and longlines (Table 5.23). Essential fish habitats that were given a low vulnerability rank were not considered to be adversely impacted to a degree that is more than minimal or temporary in nature.

As explained in the rationale section at the bottom of Table 5.17, herring egg habitats are “less susceptible to fishing gear impacts since they have evolved under a high-energy disturbance regime (strong bottom currents). Although [scallop dredges and bottom trawls] may directly affect the eggs, only the effect of the gear on the functional value of the habitat was considered for this evaluation.” Bottom trawling and scallop dredging have been shown to re-suspend and disperse fine bottom sediments in the path of the gear (Stevenson et al. in press), so that, if anything, use of these gears on herring egg substrates might increase the amount of hard surface area available for spawning and improve the quality of herring egg EFH. For spawning adult EFH, “spawning could be disrupted by noise associated with these gears, but this issue was not addressed as a habitat-related issue.” Research has shown, however, that any disturbance to EFH for spawning adult herring caused by noise associated with fishing is temporary, since schools of herring that are dispersed by the passage of a vessel or a net quickly re-form (Table 5.18).

One type of substrate for herring eggs that is included in the EFH description is “aquatic macrophytes.” Because benthic macroalgae are attached to hard substrates and extend up into the water column for some distance, they are very susceptible to damage or removal by bottom-tending gear, particularly bottom trawls and dredges (NREFHSC 2002). If bottom vegetation or emergent epifauna (e.g., bryozoans, hydroids, sponges) were preferred substrates for herring eggs, or if egg survival rates were appreciably higher on this kind of substrate, then herring egg EFH would be much more vulnerable to the effects of mobile, bottom-tending gear. Such is not the case. Underwater observations of herring egg “beds” have shown that the eggs are laid in carpets up to 5 inches thick over anything that is on the bottom in the location that the fish have selected as a spawning site (Table 5.25). Although there are some observations of herring eggs deposited in benthic algae (McKenzie 1964, Cooper et al. 1975) in the Gulf of Maine, observations of eggs on shell fragments, and gravel, sandy, or rocky substrates are much more common. Underwater observations also have demonstrated that hatching rates of herring eggs laid in layers an inch thick in areas with strong bottom currents are very high (Stevenson and Knowles 1988), indicating that utilization of emergent vegetation or epifauna would not have improved egg survival rates. Bottom currents of 1.5 – 3 knots are listed as part of the EFH description for Atlantic herring eggs.

As noted in Section 5.1, disturbance of abiotic (non-living) egg substrate by any kind of bottom-tending gear is not likely to cause a reduction in the functional value of the habitat. There is no evidence to indicate that herring are less likely to deposit their eggs on bottom habitats composed of gravel, sand, cobble, and shell fragments that have been disturbed by any kind of mobile, bottom-tending fishing gear than on un-disturbed substrate, or that eggs deposited on disturbed substrates would have a reduced survival rate.

In conclusion, bottom-tending mobile gears used in other MSA fisheries may have adverse effects on benthic EFH for herring eggs or pelagic EFH for juvenile and adult herring, but they are not more than minimal or temporary in nature (Table 5.24).

Table 5.25. Underwater observations of Atlantic herring eggs from the Gulf of Maine and Georges Bank.

Authors	Observation/ Sampling Method	Location	Lat/Long	Date	Depth (m)	Size (km2)	Thickness (cm)	Current (knots)	Substrate
McKenzie 1964	Biological dredge	Trinity Ledge, SW Nova Scotia	44°01′N/66 12′W	Sept ′61	11-13	.067	Trace to 3.25	1.5-2	Flat, sandy bottom with few small stones, no vegetation**
Caddy & Iles 1973	Submersible	Northern portion of eastern Georges Bank	41°54′N/67 15′W	Sept/Oct 1970	50	1.1*	1-2	0.5-1	Level gravel, on rounded pebbles 2-10 mm in diameter and on epifaunal growth
			41°52′N/67 15′W			0.53*			
			41 59′N/67 33′W			0.3*			
Cooper et al. 1975	SCUBA divers, grab samples	East of Cape Ann, MA and Jeffreys Ledge	42°40′N/70 25′W	Oct ′74	35-50	0.78	Max 4-5		Bedrock, boulder, rock, gravel and shell with 0-80% red alga (*Ptiloda serrata*) cover
			42°47′N/70 15′W		40-55	1.39			
Stevenson & Knowles 1988	ROV, grab samples & SCUBA	Eastern Maine	44°46′N/67 02′W	Sept ′85	30				Flat bottom, primarily large shell fragments and gravel
			44°34′N/67 20′W	Sept ′86	40-50				Primarily shell fragments
			44°38′N/67 13′W	Sept ′86	20-35	0.8	1-3		Egg cover thickest on gravel and shell fragments
Valentine, pers. comm.	Underwater video, grab sample	Stellwagen Bank	42°23'N/70 19'W	Oct '96	34				Coarse sand

*Egg bed sizes given in Pankratov and Sigajev 1973

**Eggs were observed “completely permeating” an alga (*Desmarestia aculeata*) on a nearby spawning site that was not surveyed

5.3 Impacts of Non-MSA Fisheries on Atlantic Herring EFH

The following section describes the potential adverse impacts of non-MSA (Magnuson-Stevens Act) fishing activities on EFH for Atlantic herring eggs. The other life stages of this species are pelagic and are not vulnerable to the effects of fishing (Sections 5.1 and 5.2). Non-MSA activities include those fishing activities that occur within bays, estuaries, and state waters (0-3 miles), or are not regulated under a federal fishery management plan. The general parameters that have been utilized to determine potential adverse effects on Atlantic herring eggs include depth, substrate, and salinity. As identified earlier in this document, Atlantic herring generally spawn at depths ranging from 20-80 meters. In addition, they spawn in marine waters, rather than estuarine or brackish water, and on coarse bottom substrates, as opposed to softer sediments such as sand and mud. In order to determine which non-MSA fishing activities may have adverse impacts on Atlantic herring egg EFH, the following section relies on the information in Table 5.26 and Table 5.27. Table 5.26 identifies which fishing gear types are used in estuary/bay or coastal waters (0-3 miles offshore), those that contact the bottom, and those that are not federally regulated. Any gear type that meets these parameters has been included in this analysis because its use may overlap with Atlantic herring spawning habitat. Those gear types that do not contact the bottom, are use exclusively offshore (3-200 miles), and are federally regulated were not included in this analysis. Most of the gear types included in this analysis are described in Section 4.3.2 of this document. Table 5.27 identifies gear types that accounted for 1% or more of total landings in each state in 1999.

Conch/Whelk dredges

The primary species harvested by this gear is the channeled whelk. This species inhabits lower intertidal to subtidal waters to a depth of about 18 meters, along bay and ocean beaches (Gosner 1978). It is uncommon north of Cape Cod. Since Atlantic herring spawn in deeper water (20-80 meters), this gear is therefore not expected to have adverse impacts on Atlantic herring EFH.

Crab dredges

Crab dredges are used to harvest blue crabs within coastal and estuarine areas in the mid-Atlantic region where Atlantic herring do not spawn. Most of the reported landings for this gear type in 1999 were in Delaware (Table 5.27). Therefore, this fishing activity is not expected to have adverse impacts on Atlantic herring EFH.

Mussel dredges

Mussel dredges are used in estuaries, bays, and coastal waters. Mussel dredges are used in the Gulf of Maine along the coast of Maine and Massachusetts, and on the south shore of Cape Cod and Rhode Island (Figure 5.41) in substrates and depths similar to those utilized by Atlantic herring for spawning. Therefore, this fishing activity may have adverse effects on Atlantic herring EFH.

Oyster dredges

Oysters are harvested primarily in sounds and estuaries at salinities between 5-30 ppt (Gosner 1978). Oysters are intolerant of prolonged exposure to marine or freshwater salinities (Gosner 1978). Thus, they are not generally associated with salinities utilized by Atlantic herring for spawning. Therefore, it is highly unlikely that this fishing activity is having any adverse impact on Atlantic herring EFH.

Bay scallop dredges

Bay scallops are generally found within nearshore estuary or bay waters. Bay scallops are generally found in shallow waters out to 15 meters (Gosner 1978), while Atlantic herring spawning generally occurs at depths ranging from 20-80 meters. Bay scallops reside on the substrate and are located primarily on sandy or muddy bottoms, or associated with eelgrass beds (http://www.csc.noaa.gov/benthic/resources/species/species4.htm). Atlantic herring prefer hard substrates for spawning and are not expected to be located in association with bay scallops. Therefore, this fishing activity is not expected to adversely affect Atlantic herring EFH.

Sea urchin dredges

Sea urchin dredges are utilized primarily in coastal waters along the western Gulf of Maine coast in areas where herring spawn (see Figure 5.42 and Table 5.27). Sea urchins are generally associated with substrates ranging from sand to cobble (Gosner 1978), including substrates utilized by herring for spawning. When used on coarse bottom substrates, this type of dredge may adversely impact EFH for Atlantic herring eggs.

Fyke and hoop nets

Fyke and hoop nets are utilized primarily in estuary, bay, and coastal waters (Section 4.3.2). They are used in shallow water and extensively in river fisheries, whereas Atlantic herring spawning occurs in deeper marine waters. The only state that reported any significant landings for this gear type in 1999 was Maryland (Table 5.27). Therefore, this fishing activity does not have any adverse impacts on Atlantic herring EFH.

Beach haul seines

Beach haul seines are generally utilized in the littoral and surf zones of estuaries, bays and coastal waters (Section 4.3.2) where Atlantic herring do not spawn. This gear is also used primarily in the mid-Atlantic region (Table 5.27), not in the Gulf of Maine. Therefore, this fishing activity does not have any adverse impacts on Atlantic herring EFH.

Long haul seines

Long haul seines are also utilized in estuaries, bays and coastal waters in the mid-Atlantic region (Section 4.3.2, Table 5.27) in shallower inshore areas as opposed to deeper waters associated with Atlantic herring spawning. Therefore, this fishing activity does not have any adverse impacts on Atlantic herring EFH.

Hand hoes

This gear is utilized to harvest clams and worms in intertidal flats in coastal areas utilized as spawning habitat by herring. However, since Atlantic herring do not spawn within the intertidal zone, this fishing activity does not have any adverse effect on Atlantic herring EFH.

Crab bottom otter trawl

This fishing activity occurs within estuary, bay and coastal waters. Atlantic herring do not spawn in estuaries and coastal waters where this gear is used (e.g., in North Carolina – see Table

5.27). The primary species harvested with this gear is the blue crab, which is generally found south of Massachusetts (Table 5.27) and therefore not in areas associated with Atlantic herring spawning areas. Therefore, this fishing activity is not expected to have adverse impacts on Atlantic herring EFH.

Crab pots
Blue crab pots are used within estuary, bay and coastal waters in the mid-Atlantic states (Table 5.27). Other species of crab are harvested with pots in deeper continental shelf water in southern New England (Figure 4.37). Atlantic herring do not spawn in this location (Figure 4.17). Therefore, this gear type is not expected to adversely affect EFH for Atlantic herring eggs.

Fish pots
Hagfish pots are fished in deep waters in marine environments associated with Atlantic herring spawning (Figure 4.38). However, hagfish pots are generally fished in association with mud bottoms (Section 4.3.2) rather than the gravelly bottoms preferred by spawning Atlantic herring. Cylindrical pots are typically used for capturing eels in Chesapeake Bay where Atlantic herring do not spawn. Pots used to catch finfish such as scup and black sea bass are used primarily south of Cape Cod (Figure 4.36). Fish pots are not generally used in areas utilized as spawning substrate by herring and are not expected to affect EFH for herring eggs.

Lobster pots
Lobster pots are used extensively in estuaries, bays and within coastal and offshore waters of the Gulf of Maine and southern New England (Figure 4.34). Lobster fishing occurs at similar depths and on the same substrates that are utilized by Atlantic herring for spawning and impacts to egg EFH could result from the combined effect of repeatedly setting and hauling large numbers of pots throughout the year. Lobster pots placed within Atlantic herring spawning areas may have adverse impacts on EFH for Atlantic herring eggs.

Pound nets
Pound nets are utilized to harvest crab and fish in estuaries, bays, and coastal waters, generally in depths less than 50 meters (Section 4.3.2). This gear is utilized primarily in mid-Atlantic waters (Table 5.30), and is not associated with Atlantic herring spawning areas in the Gulf of Maine. Therefore, this fishing activity is not expected to have adverse effects on Atlantic herring EFH.

Rakes
Rakes are utilized to harvest hard clams and are used primarily within estuaries or shallow bays. This fishing activity generally occurs in shallower areas, as opposed to deeper waters utilized for Atlantic herring spawning. Furthermore, this fishing activity is associated with harvest of clams that prefer softer substrates, rather than gravelly substrates utilized by herring for spawning. Therefore, this fishing activity is not expected to have adverse effects on Atlantic herring EFH.

Tongs
Tongs are utilized to harvest clams and oysters within estuarine and bay waters. The teeth of the tongs could have adverse impacts on bottom habitats. However, oysters and clams prefer sandy and mud substrates as opposed to the deeper gravelly substrates utilized for Atlantic herring

spawning. Therefore, this fishing activity is not expected to have adverse impacts on Atlantic Herring EFH.

Conclusions

This section has analyzed non-MSA fishing activities for potential adverse effects on EFH for Atlantic herring eggs. Based on this analysis, the non-MSA fishing activities that may have adverse effects on Atlantic herring EFH include mussel dredges, sea urchin dredges, and lobster pots. Of these three gears, dredges have the greatest potential to adversely impact bottom habitats that are utilized as spawning grounds by Atlantic herring due to their function as bottom tending mobile gears. However, because lobster pots are so numerous, are hauled so often, and are so heavily fished in coastal waters of the Gulf of Maine where Atlantic herring spawn, their potential impact on EFH for Atlantic herring eggs could easily exceed that of mussel and sea urchin dredges which are used sparingly and can not be towed over very rough bottom without being damaged.

Table 5.26. Fishing gears used in estuaries and bays, coastal waters, and offshore waters of the EEZ, from Maine to North Carolina.

GEAR	Estuary or Bay	Coastal 0-3 Miles	Offshore 3-200 Miles	Contacts Bottom	Federally Regulated
Bag Nets	X	X	X		X
Beam Trawls	X	X	X	X	X
By Hand	X	X			X
Cast Nets	X	X	X		
Clam Kicking	X			X	
Diving Outfits	X	X	X		
Dredge Clam	X	X	X	X	X
Dredge Conch	X			X	
Dredge Crab	X	X		X	
Dredge Mussel	X	X		X	
Dredge Oyster, Common	X			X	
Dredge Scallop, Bay	X			X	
Dredge Scallop, Sea		X	X	X	X
Dredge Urchin, Sea		X	X	X	
Floating Traps (Shallow)	X	X		X	X
Fyke And Hoop Nets, Fish	X	X		X	
Gill Nets, Drift, Other			X		X
Gill Nets, Drift, Runaround			X		X
Gill Nets, Sink/Anchor, Other	X	X	X	X	X
Gill Nets, Stake	X	X	X	X	X
Haul Seines, Beach	X	X		X	
Haul Seines, Long	X	X		X	
Haul Seines, Long(Danish)		X	X	X	X
Hoes	X			X	
Lines Hand, Other	X	X	X		X
Lines Long Set With Hooks		X	X	X	X
Lines Long, Reef Fish		X	X	X	X
Lines Long, Shark		X	X		X
Lines Troll, Other		X	X		X
Lines Trot With Baits		X	X		X
Otter Trawl Bottom, Crab	X	X	X	X	
Otter Trawl Bottom, Fish	X	X	X	X	X
Otter Trawl Bottom, Scallop		X	X	X	X
Otter Trawl Bottom, Shrimp	X	X	X	X	X
Otter Trawl Midwater		X	X		X
Pots And Traps, Conch	X	X		X	
Pots and Traps, Crab, Blue Peeler	X	X		X	
Pots And Traps, Crab, Blue	X	X		X	
Pots And Traps, Crab, Other	X	X	X	X	X
Pots And Traps, Eel	X	X		X	
Pots and Traps, Lobster Inshore	X	X		X	
Pots and Traps, Lobster Offshore			X	X	X
Pots and Traps, Fish	X	X	X	X	X
Pound Nets, Crab	X	X		X	
Pound Nets, Fish	X	X		X	
Purse Seines, Herring		X	X		X
Purse Seines, Menhaden		X	X		
Purse Seines, Tuna		X	X		X
Rakes	X			X	
Reel, Electric or Hydraulic		X	X		X
Rod and Reel	X	X	X		X
Scottish Seine		X	X	X	X
Scrapes	X			X	
Spears	X	X	X		
Stop Seines	X			X	
Tongs and Grabs, Oyster	X			X	
Tongs Patent, Clam Other	X			X	
Tongs Patent, Oyster	X			X	
Trawl Midwater, Paired		X	X		X
Weirs	X			X	

Includes all gears that accounted for 1% or more of any state's total landings and all gears that harvested any amount of any federally managed species, based upon 1999 NMFS landings data and ASMFC Gear Report (ASMFC 2000). Shaded rows represent gears that are federally managed and contact the bottom.

Table 5.27. Principal fishing gears used in each state in the Northeast Region in 1999.

Gear	Percent of Landings (1% or more) for All Species by State											
	CT	DE	MA	MD	ME	NC	NH	NJ	NY	RI	VA	All States Combined
By Hand, Other		18										
Diving Outfits, Other					5							1
Dredge Clam			9	10				39	1	1		6
Dredge Crab		11									1	
Dredge Mussel					1							
Dredge Other					3							
Dredge Scallop, Sea	7		10		1		1	2			1	2
Dredge Urchin, Sea					1							
Floating Traps (Shallow)										1		
Fyke And Hoop Nets, Fish				2								
Gill Nets, Drift, Other		4		3				2				1
Gill Nets, Drift, Runaround						1						
Gill Nets, Other						14						1
Gill Nets, Sink/Anchor,			12	5	1		42	5	5	4	3	4
Gill Nets, Stake		7										
Haul Seines, Beach				2							1	
Haul Seines, Long						1						
Hoes					1							
Lines Hand, Other		1	2	1		1	1		1			1
Lines Long Set With Hooks			4			1		1	4			1
Lines Long, Shark						1						
Lines Troll, Other						1						
Lines Trot With Baits				17								1
Otter Trawl Bottom, Shrimp					1	6	3					1
Otter Trawl Midwater			11		21		8			18		6
Pots And Traps, Conch		2										
Pots And Traps, Crab, Blue		51		36		36		3			6	8
Pots And Traps, Crab, Other			2							1		
Pots And Traps, Eel		2		1								
Pots And Traps, Fish		1		3								
Pots And Traps, Lobster Inshore	13		5		25		9			4		5
Pots And Traps, Lobster Offshore	2		4				9	1		2		1
Pots And Traps, Other			1		1							
Pound Nets, Crab				1								
Otter Trawl Bottom, Crab						1						
Otter Trawl Bottom, Fish	61		38	3	9	7	26	26	58	56	2	18
Pound Nets, Fish				14		1			1		4	2
Purse Seines, Herring			1		23							4
Purse Seines, Menhaden						27		18			74	28
Purse Seines, Other											7	2

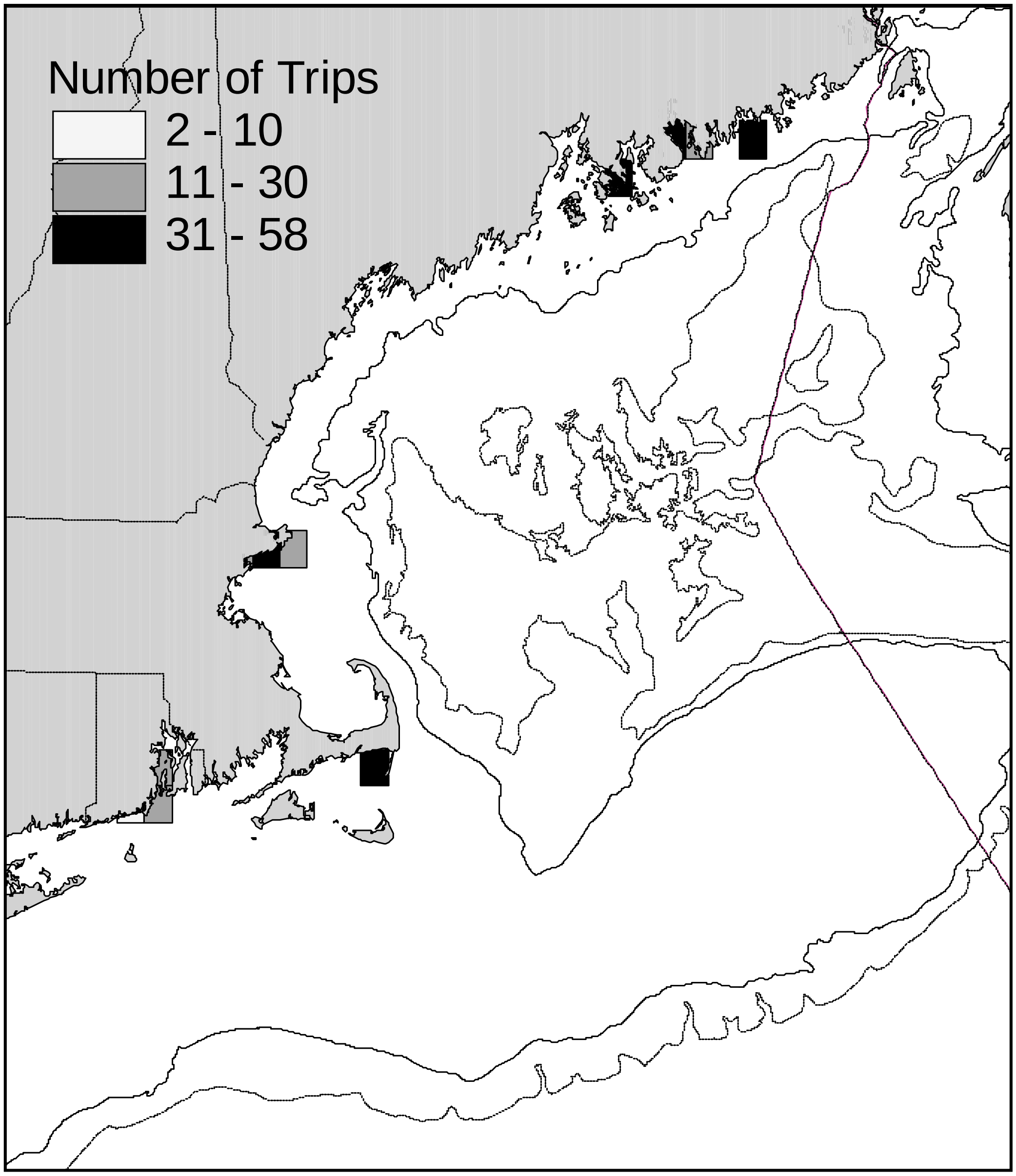

Figure 5.41. Reported number of trips made by federally-permitted mussel dredge vessels within ten minute squares of latitude and longitude in the U.S. Northeast region during 1995-2000.

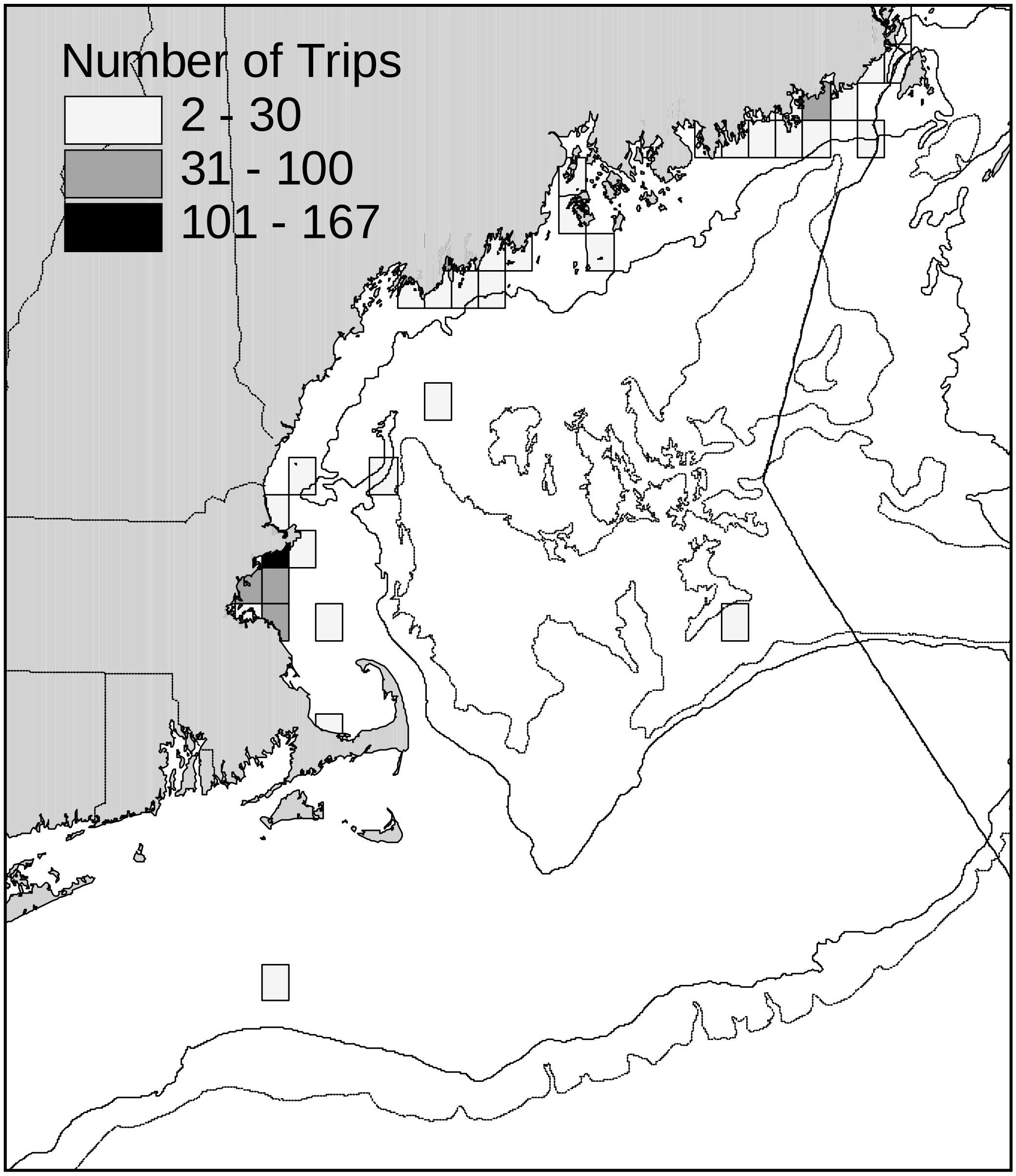

Figure 5.42. Reported number of trips made by federally-permitted sea urchin dredge vessels within ten minute squares of latitude and longitude in the U.S. Northeast region during 1995-2000.

6.0 IMPACTS OF NON-FISHING ACTIVITIES ON HERRING EFH

A variety of non-fishing activities could impact essential fish habitat (EFH) for Atlantic herring. The diversity, widespread distribution, and ecological linkages with other aquatic and terrestrial environments make the water and substrates that comprise herring EFH susceptible to a wide array of human activities unrelated to fishing. This section reviews human, non-fishing activities that are generally known or expected to have adverse affects on living marine resources. Due to the complex nature of these effects, the interactive relationships of the various factors, and a lack of full understanding of these effects, a comprehensive and cumulative assessment of non-fishing impacts related to Atlantic herring and Atlantic herring EFH was not attempted in this section of the document.

During the compilation of this section, we borrowed heavily from the document, *Non-fishing impacts to Essential Fish Habitat and recommended conservation measures* (NOAA Fisheries 2003). Although this review of non-fishing impacts was developed by the Alaska, Northwest, and Southwest Regional offices of the NOAA Fisheries, much of the information has relevance to the Northeast Region.

Vessel Operations and Marine Transportation

The demand by port districts to increase infrastructure capacity to accommodate additional vessel operations for cargo handling activities and marine transportation is predicted to continue. In addition, increases in human population growth along the coast results in increased demand for providing new and expanded water transit services. Finally, providing additional recreational opportunities by constructing and enlarging recreational marinas is also foreseen.

The expansion of port facilities, vessel/ferry operations, and recreational marinas can bring additional impacts to EFH. Additional land needed to improve shipping efficiency can only be accommodated by changing land-use operations or adding new land by filling aquatic habitats. These activities typically lead to new channel deepening and maintenance dredging and disposal of dredged material (Section 5.7.1.3). Additional impacts include vessel groundings, modification of water circulation (breakwaters, channels, and fill), vessel wake generation, pier lighting, anchor scour and prop scour, and the discharge of contaminants and debris, including ballast water discharges. The latter also has been documented to be a source of introductions of exotic species (Section 5.7.1.13).

Vessel discharges, engine operations, bottom paint sloughing, boat washdowns, painting and other vessel maintenance activities can deliver debris, nutrients and contaminants to waterways and may degrade water quality and contaminate sediments. Fuel and oil spills can affect animals directly or indirectly through the food chain. Fuel, oil, and some hydraulic fluids contain polyaromatic hydrocarbons (PAH's) which can cause acute toxicity to species and their prey at high levels of exposure and can also cause chronic lethal as well as acute and chronic sublethal toxicity (Neff 1985, Warrington 1999). Incidental fuel spills involving small vessels are probably common events, but these spills typically involve small amounts of material and are unlikely to adversely affect fishery resources. Larger spills may have significant adverse affects, although these events are relatively rare and usually involve small geographic areas. Any type of spill has the potential to cause impacts to the water column, bottom habitat and benthic resources, and shoreline habitats, but it is unknown as to what extent these effects are individually or cumulatively significant.

An increase in the number and size of vessels can generate more wave and surge effects on shorelines. Vessel-wake/wash events can affect shorelines depending on the wake wave energy, the water depth, and the type of shoreline. Vessel wakes can cause a significant increase in shoreline erosion, impact wetland habitat, and increase water turbidity (Kennish 2002). Contact between the vessel and the bottom and prop wash can also damage aquatic vegetation and disturb sediments, which may increase turbidity and suspend contaminants (Burdick and Short 1999, Klein 1997) and affect faunal spatial distributions and abundance patterns (Uhrin and Holmquist 2003).

Impacts can also occur from anchor scour. Mooring buoys, when anchored in shallow nearshore waters, can drag the anchor chain across the bottom, destroying submerged vegetation and creating a circular scour hole (Walker et al. 1989, cited in Shafer 2002). A study by Hastings et al. (1995 cited in Shafer 2002) in Australia found that up to 18 percent of total seagrass cover was lost to mooring buoy scour. Atlantic herring eggs are known to be laid on coarse sand, gravel, shell hash, small cobble, and attached vegetation, such as the macroalgae species *Ptiloda serrata*; eggs are easily dislodged from these substrates as a result of turbulence or mechanical disturbance (ASMFC 1999)

Information is available that suggests some of the activities described in this section could have adverse effects on habitats utilized by Atlantic herring or their prey species. For example, construction and maintenance of ports and marinas (e.g. disposal of dredge material) could impact the survival and growth of herring eggs by siltation or burial if located near spawning grounds (Section 5.7.1.3 below). Likewise, discharge of pollutants (e.g. fuel/oil, paint, and detergents) from vessels and ports/marinas could affect water quality and interfere with the metabolism and survival of Atlantic herring, particularly early life history stages (i.e. eggs, larvae, and juveniles). This could be particularly critical in nearshore and estuarine larval and juvenile herring habitats, where marine transportation facilities are located. For example, copper, used as a biocide treatment on boat hulls, has been identified in sediments associated with marina operations. Laboratory experiments have shown high mortality of herring eggs and larvae at copper concentrations of 30 micrograms/L and 1,000 micrograms/L, respectively, and vertical migration of larvae was impaired at copper concentrations of greater than 300 micrograms/L (Blaxter 1977, cited in ASMFC 1999). Various levels of toxicity also have been observed in eggs and larvae exposed to crude oil in concentrations of 1 to 20 ml/L (Blaxter and Hunter 1982, cited in ASMFC 1999). However, there appears to be little in-situ experimental evidence demonstrating the activities of vessel operations and marine transportation are affecting Atlantic herring EFH or their prey species.

Dredge and Fill Activities

Dredging navigable waters is a continuous impact affecting benthic and water-column habitats in the course of constructing and operating marinas, harbors, and ports. Routine dredging, that is, the excavation of soft bottom substrates, is used to create deepwater navigable channels or to maintain existing channels that periodically fill with sediments. In addition, port expansion has become an almost continuous process due to economic growth, competition between ports, and significant increases in vessel size (Section 5.7.1.2). Elimination or degradation of aquatic and upland habitats is commonplace since port expansion almost always affects open water, submerged bottoms, and, possibly, riparian zones.

The environmental effects of dredging on EFH can include 1) direct removal/burial of aquatic vegetation; 2) turbidity/siltation effects, including light attenuation from turbidity; 3) contaminant release and uptake, including nutrients, metals, and organics; 4) release of oxygen consuming substances; 5) entrainment; 6) noise disturbances; and 6) alteration to hydrodynamic regimes and physical habitat.

Dredging may adversely affect Atlantic herring EFH by siltation or burial of eggs. Messieh et al. (1981, cited in ASMFC 1999) found 100 percent mortality in herring eggs covered by 1 cm of sediment and 85 percent mortality in eyed-eggs covered with only a thin film of sediment. Resuspension of bottom sediments, particularly within port facilities or near industrial outfalls, can release pollutants such as toxic metals, hydrocarbons, pesticides, organic compounds, and nutrients. Similarly, the dredging activity may also cause spawning fish to leave the area for more suitable spawning conditions. The use of certain types of dredging equipment can result in greatly elevated levels of fine-grained mineral particles or suspended sediment concentration (SSC), usually smaller than silt, and organic particles in the water column. The associated turbidity plumes of suspended particulates may reduce light penetration and lower the rate of photosynthesis for subaquatic vegetation (Dennison 1987, Mills and Fonseca 2003) and the primary productivity of an aquatic area if suspended for extended periods of times (Cloern 1987). If suspended sediment loads remain high, fish may suffer reduced feeding ability (Benfield and Minello 1996) and be prone to fish gill injury (Nightingale and Simenstad 2001a). Messieh et al. (1981, cited in ASMFC 1999) reported that juvenile Atlantic herring avoided suspended sediment concentrations between 9.5 and 12 mg/L, and some juveniles avoided concentrations as low as 2.5 mg/L.

Dredging, as well as the equipment used in the process such as pipelines, may damage or destroy spawning, nursery, and other sensitive habitats such as emergent marshes and subaquatic vegetation, including eelgrass beds (Mills and Fonseca 2003), macroalgae and kelp beds. Aquatic macrophytes have been identified as EFH for Atlantic herring eggs and spawning adults. Aquatic macrophytes are important sources of primary production in estuarine and coastal ecosystems. This primary production, combined with other nutrients, provide high rates of secondary production in the form of fish (Herke and Rogers 1993, Sogard and Able 1991). Dredging may also modify current patterns and water circulation of the habitat by changing the direction or velocity of water flow, water circulation, or dimensions of the water body traditionally used by fish for food, shelter, or reproductive purposes.

The contents of the suspended material may react with the dissolved oxygen in the water and result in short-term oxygen depletion to aquatic resources (Nightingale and Simenstad 2001a). Dredging can also disturb aquatic habitats by resuspending bottom sediments and, thereby, recirculate toxic metals (e.g., lead, zinc, mercury, cadmium, copper etc.), hydrocarbons (e.g., polyaromatics), hydrophobic organics (e.g., dioxins), pesticides, pathogens, and nutrients into the water column (EPA 2000). Toxic metals and organics, pathogens, and viruses, absorbed or adsorbed to fine-grained particulates in the material, may become biologically available to organisms either in the water column or through food chain processes.

Direct uptake of fish species by hydraulic dredging is also an issue. Definitive information in the literature shows that elicit avoidance responses to the suction dredge entrainment occurs for both benthic and water column oriented species (Larson and Moehl 1990, McGraw and Armstrong 1990).

Beach nourishment, the process of mechanically or hydraulically placing sand directly on an eroding shore to restore or form an adequate protective or desired recreational beach, has been steadily increasing in occurrences along the eastern U.S. coastline since the 1960's (ASMFC 2002). Placement of sand to "nourish" beach shorelines can result in adverse impacts to fish and invertebrates, including displacing species during and after nourishment, potential for gill clogging, temporary removal of benthic prey, burial of structures that serve as foraging and shelter sites, potential burial of demersal fish, and mortality of vulnerable life stages, such as eggs, larvae, and juveniles (ASMFC 2002). Likewise, offshore mining of sand can result in entrainment, sedimentation and turbidity impacts to fish and invertebrates in and around the borrow site.

The placement of fill material within estuarine and marine habitats has a number of purposes, primarily driven by increased human populations and the subsequent development. Fill material is used for a variety of needs, such as offsetting shoreline erosion and protecting property from flood and storm damage (Section 5.7.1.10), expanding or creating new port facilities and recreational marinas (Section 5.7.1.2), constructing residential and commercial development in wetland habitat (Section 5.7.1.8), and installing utility services, such as oil/gas pipelines and electrical/communication lines (Section 5.7.1.11).

Adverse impacts known to affect EFH from the placement of fill material includes many of the same affects discussed above for dredging, including burial of prey or aquatic vegetation, turbidity/siltation effects, contaminant release and uptake, release of oxygen consuming substances and changes in hydrologic patterns. In addition, placement of fill material may involve the complete loss of the habitat structure or function. Aquatic habitats sustain remarkably high levels of productivity and support various life stages of fish species and their prey. Many times these habitats are used for multiple purposes including habitat necessary for spawning, breeding, feeding, or growth to maturity. The introduction of fill material eliminates those functions and permanently removes the habitat from production.

Disposing dredged materials result in varying degrees of change in the physical, chemical, and biological characteristics of the substrate. Discharges may adversely affect infaunal and bottom-dwelling organisms at the site by smothering immobile organisms (e.g., prey invertebrate species) or forcing mobile animals (e.g., benthic-oriented fish species) to migrate from the area. Infaunal invertebrate plants and animals present prior to a discharge are unlikely to recolonize if the composition of the discharged material is drastically different.

The discharge of dredged material can result in greatly elevated levels of fine-grained mineral particles, usually smaller than silt, and organic particles in the water column (i.e., turbidity plumes). These suspended particulates may reduce light penetration and lower the rate of photosynthesis and the primary productivity of an aquatic area if suspended for lengthy intervals. Managed fish species may suffer reduced feeding ability, leading to limited growth and lowered resistance to disease if high levels of suspended particulates persist. The contents of the suspended material may react with the dissolved oxygen in the water and result in oxygen depletion. Toxic metals and organics, pathogens, and viruses absorbed or adhered to fine-grained particulates in the material may become biologically available to organisms either in the water column or through food chain processes.

The discharge of dredged or fill material can modify current patterns and water circulation by obstructing flow, changing the direction or velocity of water flow and circulation, or otherwise changing the dimensions of a water body. 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 (NMFS 1998d).

Dredge and fill activities, including dredge material disposal, could have potentially adverse affects on Alantic herring EFH by disturbing the benthic environment and introducing excessive suspended sediments into the water column. Siltation of spawning and egg development habitat could result in adverse effects on herring EFH. Since eggs are demersal and are deposited on coarse substrates or aquatic macrophytes year after year in the same general location, their habitat is vulnerable to disturbances to the substrate type or quality and sediment load in the water column (ASMFC 1999). However, these activities typically occur close to the coastline and may individually impact a relatively small area. For example, there are a total of ten dredged material offshore disposal sites utilized by the Army Corps of Engineers (ACOE) New England District and are on average 1.15 square nautical miles in size (ACOE's New England District website: www.nae.usace.army.mil). Atlantic herring spawning takes place in areas of fairly strong bottom currents and herring egg survival require well oxygenated water (Sindermann 1979, cited in ASMFC 1999). Most dredging activities are located along the shoreline or nearshore waters, which, by in large, may not be optimal Atlantic herring spawning or egg habitat. In areas of herring spawning and egg habitats, turbidity and sedimentation may have only temporary and localized affects due to the typically strong currents in these areas.

Pollution/Water Quality

Humans attempt to control and alter natural processes of aquatic and marine environments for an array of reasons, including industrial uses, coastal development, port and harbor development, erosion control, water diversion, agriculture, and silviculture. 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.

Nonpoint source pollution generally results from land runoff, precipitation, atmospheric deposition, seepage, or hydrologic modification. Technically, the term ‘nonpoint source’ means 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.

While the effects of contaminants on Atlantic herring EFH is relatively unclear, pollution may make these resources more susceptible to disease or impair reproductive success. Nonpoint source pollution is usually lower in intensity than an acute point source event, but may be more damaging to fish habitat in the long term. Nonpoint source pollution is often difficult to detect. It may affect sensitive life stages and processes, and the impacts may go unnoticed for a long time. When severe population impacts are finally noticed, they may not be tied to any one event and hence may be difficult to correct, clean up, or mediate. The development of coastal regions to accommodate more people leads to an increase in impervious surfaces, including but not limited to roads and parking lots. Impervious surfaces cause greater volumes of run-off and associated contaminants into aquatic and marine waters (Section 5.7.1.9). Golf courses and marinas are two examples of coastal projects and activities that represent sources of contaminated run-off that may potentially impact fishery resources.

There are many potential impacts from point-source discharge, but it is important to note that point-source discharges and resulting altered water quality in aquatic environments does not necessarily result in adverse impacts to either marine resources or EFH. Because most point-source discharges are regulated by the state or EPA through the National Pollutant Discharge Elimination System (NPDES) permit program, effects to receiving waters are generally considered in those cases. Point-source discharges can adversely affect EFH by 1) reducing habitat functions necessary for growth to maturity, 2) modifying community structure.

Point-source discharges from municipal sewage treatment facilities or storm water discharges are controlled through the NPDES permit program or by state water regulations. The primary concerns associated with municipal point-source discharges involve treatment levels needed to attain acceptable nutrient inputs and overloading of treatment systems due to rapid development of the coastal zone. Storm drains are contaminated from communities with settling and storage ponds, street runoff, and harbor activities. Annually, wastewater facilities through sewage outfall lines introduce large volumes of untreated excrement and chlorine as well as treated freshwater into the nation’s waters.

At certain concentrations, point-source discharges can alter the diversity, nutrient and energy transfer, productivity, biomass, density, stability, connectivity, and species richness and evenness of ecosystems and associated communities. Pollution effects may be related to changes in water flow, pH, hardness, dissolved oxygen, and other parameters that affect individuals, populations, and communities. Sewage, fertilizers, and de-icing chemicals (e.g., glycols, urea) are examples of common urban pollutants that decompose with high biological or chemical oxygen demand (NPFMC 1999). Point-source discharges, at certain concentrations, can modify by altering the following characteristics of finfish, shellfish, and related organisms: growth, visual acuity, swimming speed, equilibrium, feeding rate, response time to stimuli, predation rate, photosynthetic rate, spawning seasons, migration routes, and resistance to disease and parasites.

Available data suggest that early life stages of fish are more susceptible to environmental and pollutant stress than older life stages (Rosenthal and Alderdice 1976).

Estuarine and coastal waters of the northeastern U.S. adjacent to highly urbanized and high-intensity agriculture areas have experienced significant increases in inputs of nitrogen, phosphorus, and other plan nutrients (O'Reilly1994). There is evidence that nutrient overenrichment has led to undesirable eutrophication effects in estuarine and coastal areas, including increased incidence, extent, and persistence of blooms and noxious or toxic species of phytoplankton; increased frequency, severity, areal 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). In the northeastern U.S., extensive hypoxia has been more chronic in river-estuarine systems in the Northeast-Narragansett Bay to Chesapeake Bay, Boston Harbor/Charles River, and the freshwater portion of the Merrimack River (O'Reilly 1994). The only two areas on the open U.S continental shelf that have been reported to be affected by recurring hypoxia are coastal waters of the New York Bight and the inshore Gulf of Mexico off Louisiana (Whitledge 1985 in O'Reilly 1994).

Elevated salinity levels from desalination plants may be potential sources of impacts to Atlantic herring EFH. While studies have shown that they may not produce toxic effects (Bay and Greenstein 1994), peripheral effects of pollution may include forcing rearing fish into areas of high predation. Conversely, influx of treated freshwater from municipal wastewater plants may force rearing fish into habitat with less than optimal salinity for growth (NPFMC 1999). Laboratory studies with Atlantic herring indicate that fertilization, egg development, and hatching can succeed in salinities between 5.9 and 52.5 parts per thousand (Holliday and Blaxter 1960, cited in ASFMC 1999). In another laboratory experiment, Blaxter and Hunter (1982, cited in ASFMC 1999), found larvae tolerated salinities of 1.4 to 60 ppt for 7-days.

Atlantic herring are known to be sensitive to changes in water alkalinity. Mining and metal production operations have been known to be responsible for acid releases to the environment. Oulasvirta (1990 in Stewart and Arnold 1994) reported periodic massive mortalities of 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 in Stewart and Arnold 1994). Point source pollution from industrial sources are currently regulated by the state or the EPA through the NPDES permit program, which does not allow discharges of low pH water into U.S. estuaries and coastal waters.

Point-discharges may affect the growth, survival and condition of managed species and prey species if high levels of contaminants (e.g., chlorinated hydrocarbons; trace metals, PAHs, pesticides, and herbicides) are discharged. If contaminants are present, they may be absorbed across the gills or concentrated through bioaccumulation as contaminated prey is consumed (Raco-Rands 1996). Many heavy metals and persistent organic compounds such as pesticides and polychlorinated biphenyls tend to adhere to solid particles discharged from outfalls. As the particles are deposited, these compounds or their degradation products (which may be equally or more toxic than the parent compounds) can enter the foodchain by bioaccumulating in benthic organisms at much higher concentrations than in the surrounding waters (Stein et al. 1995). Due to burrowing, diffusion, and other upward transport mechanisms that move buried contaminants to the surface layers and eventually to the water column, pelagic and nektonic biota may also be exposed to contaminated sediments through mobilization into the water column.

Discharge sites may also modify habitat by creating adverse impacts to sensitive areas such as freshwater shorelines and wetlands, emergent marshes, sea grasses, and kelp beds if located improperly. Extreme discharge velocities of effluent may also cause scouring at the discharge point as well as entrain particulates and thereby create turbidity plumes. These turbidity plumes of suspended particulates can reduce light penetration and lower the rate of photosynthesis and the primary productivity of an aquatic area while elevated turbidity persists. The contents of the suspended material can react with the dissolved oxygen in the water and result in oxygen depletion, or smother submerged aquatic. Accumulation of outfall sediments may also alter the composition and abundance of infaunal or epibenthic invertebrate communities (Ferraro 1991). Pollutants, either suspended in the water column (e.g., nitrogen, contaminants, fine sediments) or settled on the bottom, can affect habitat. Many benthic organisms are quite sensitive to grain size, and accumulation of sediments can also bury food organisms (Section 5.7.1.3).

Elevated levels of environmental pollutants in several other fish species are associated with reproductive impairment (Cameron et al. 1992, Longwell et al. 1992), reduced egg viability (Von Westernhagen et al. 1981, Hansen 1985; Mac and Edsall 1991), and reduced survival of larval fish (Berlin et al. 1981, Giesy et al. 1986). Although accumulation of some organic contaminants are known to have measurable impacts at higher levels, the specific effects on herring populations have not been detected (Stewart and Arnold 1994) and studies assessing the impacts of contaminants on herring habitats are scarce. Because herring exhibit preferences for coarse substrates, it is possible that oil-contaminated substrates may influence selection of spawning sites (Stewart and Arnold 1994). In laboratory experiments, herring eggs and larvae exposed to crude oil concentrations between 1 and 20 ml/L experienced toxicities that varied with the origin of the oil (Blaxter and Hunter 1982 in ASFMC 1999). Pacific herring (*Clupea herengus pallasi*) that were exposed to high concentrations of dispersed oil could be fertilized and hatched to produce normal larvae; however, eggs that were exposed to undispersed oil developed deformed larvae (Pearson et al. 1985 in Stewart and Arnold 1994). Herring larvae exposed to high concentrations of petroleum were found to have brief increases in activity, followed by reduced activity, sporadic twitching, loss of responsiveness, and ultimately death (Linden 1975, Struhsaker et al 1974 in Stewart and Arnold 1994).

In a Baltic Sea study, polychlorinated biphenyls (PCBs) in herring ovaries were linked to reduced hatching success at concentrations of 120 ng/g (Hansen et al 1985, cited in Stewart and Arnold 1994). Heavy metals, such as lead and mercury, can occur in organic forms, which are soluble in lipids. Since Atlantic herring contain a relatively high lipid content, the species may be particularly susceptible to metal accumulation. Laboratory experiments have shown high mortality of herring eggs and larvae at copper concentrations of 30 micrograms/L and 1,000 micrograms/L, respectively, and vertical migration of larvae was impaired at copper concentrations of greater than 300 micrograms/L (Blaxter 1977, cited in ASMFC 1999). A typical range of methyl mercury concentration of herring from the Bay of Fundy was reported to be 0.005 to 0.015 parts per million (ppm) (Braune 1987). In a 1978 report, NMFS reported mean methyl mercury concentrations in herring at .04 ppm (NMFS 1978 in Food and Drug

Administration website http://www.cfsan.fda.gov/~frf/sea-mehg.html). The Food and Drug Administration has reported certain species to have typically “high” methyl mercury concentrations (i.e. shark, swordfish, king mackerel, and tilefish) and these species typically have levels near 1 ppm (http://www.cfsan.fda.gov/~dms/admehg3.html).

Although adverse effects of coastal pollution on EFH for some managed species have been identified, they may not represent a serious, widespread threat to Atlantic herring. Spawning grounds for herring are generally areas with strong bottom currents, are in relatively deep (20 to 50 meters depth) and well-mixed water. Considering the relatively short incubation period for Atlantic herring eggs (10 to 15 days) and the relative distance from coastal pollution sources, the threats to spawning and egg habitats may not be great. However, herring larvae are potentially more susceptible to coastal pollution than the eggs since they have a relatively long life cycle (about six months) and primarily inhabit inshore waters where contamination is more likely to be a problem (MDEP 1998). Likewise, juvenile Atlantic herring may also be prone to coastal pollution due to their occurrence in inshore waters.

Agricultural and Silviculture/Timber Harvest Runoff

Substantial portions of croplands and commercial nursery operations are connected to inland and coastal waters where nonpoint pollution can have a direct adverse effect on aquatic habitats. Tillage aerates the upper soil, but compacts 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. Agricultural lands are also characterized by poorly maintained dirt roads and ditches that, along with drains, route sediments, nutrients, and pesticides directly into surface waters. Natural channels filter and process pollutants. 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).

Rangeland soils can also become compacted by livestock (Platts 1991, Heady and Child 1994) with similar effects on runoff. Compaction of rangelands generally increases with grazing intensity, although site-specific soil and vegetative conditions are important (Kauffman and Krueger 1984, Heady and Child 1994). Johnson (1992) reviewed studies related to grazing and hydrologic processes and concluded that heavy grazing nearly always decreases infiltration, reduces vegetative biomass, and increases bare soil. Primary runoff pollutants are nutrients, pesticides, sediment, salts, and animal wastes. Because the primary routes of pesticide transport to EFH include not only surface runoff events, but also direct application, aerial drift, and groundwater systems, pesticide contamination is addressed separately in Section 5.7.1.6 below.

The harvest and cultivation of timber and other forestry products are major activities that can have both short- and long-term impacts throughout many coastal watersheds and estuaries. Timber harvest removes the dominant vegetation, converts mature and old-growth upland and riparian forests to tree stands or forests of early seral stage, reduces permeability of soils and increases the area of impervious surfaces, increases sedimentation from surface runoff and mass wasting processes, results in altered hydrologic regimes, and impairs fish passage through inadequate design, construction, and/or maintenance of stream crossings.

Deforestation associated with timber harvest can alter or impair instream habitat structure and watershed function. Timber harvest may result in inadequate or excessive surface and stream flows, increased stream bank and stream bed erosion, loss of complex instream habitats, sedimentation of riparian habitat, and increased surface runoff with associated contaminants (e.g., herbicides, fertilizers, fine sediments). Hydrologic characteristics, (e.g., water temperature, annual hydrograph) change, and greater variation in stream discharge is associated with timber harvest. Alterations in the supply of large woody debris and sediment can have negative effects on the formation and persistence of instream habitat features. Excess debris in the form of small wood and silt can smother benthic habitat and reduce dissolved oxygen levels.

Impacts associated with agriculture and silviculture to Atlantic herring EFH or their prey species are not well understood. Although land-use modifications (e.g. forested wetlands to agriculture), increased surface runoff and associated contaminants, and hydrological changes are known to affect coastal and estuarine habitats, there is a paucity of information regarding the specific effects to Atlantic herring habitats.

Pesticide Application

More than 800 different pesticides are currently registered for use in the United States. Legal mandates covering pesticides are the Clean Water Act (CWA) and the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). Water quality criteria for the protection of aquatic life have only been developed for a few of the currently used chemicals (EPA, Office of Pesticide Programs). Collectively, these substances are designed to repel, kill, or regulate the growth of undesirable biological organisms. This diverse group includes fungicides, herbicides, insecticides, nematicides, molluscicides, rodenticides, fumigants, disinfectants, repellents, wood preservatives, and antifoulants. The most common pesticides are insecticides, herbicides, and fungicides. These are used for pest control on forested lands, agricultural crops, tree farms and nurseries, highways and utility rights of way, parks and golf courses, and residences. Pesticides can enter the aquatic environment as single chemicals or complex mixtures. Direct applications, surface runoff, spray drift, agricultural return flows, and groundwater intrusions are all examples of transport processes that deliver pesticides to aquatic ecosystems.

Pesticides are frequently detected in freshwater and estuarine systems that provide EFH. Nationwide, the most comprehensive environmental monitoring efforts have been conducted by the United StatesGeological Society as part of the National Water Quality Assessment (NAWQA) Program. A variety of human activities such as fire suppression on forested lands, forest site preparation, noxious weed control, right-of-way maintenance (roads, railroads, power lines, etc.), algae control in lakes and irrigation canals, various agricultural practices, riparian habitat restoration, and urban and residential pest control results in contamination from these substances. It is important to note that the term “pesticide” is a collective description of hundreds of chemicals with different sources, different fates in the aquatic environment, and different toxic effects on fish and other aquatic organisms. Despite these variations, all current use pesticides are 1) specifically designed to kill, repel, or regulate the growth of biological organisms and 2) intentionally released into the environment.

Habitat alteration from pesticides is different from more conventional water quality parameters such as temperature, suspended solids, or dissolved oxygen because, unlike temperature or dissolved oxygen, the presence of pesticides can be difficult to detect due to limitation in proven methodologies. This monitoring may also be expensive. However, as analytical methodologies have improved in recent years, the number of pesticides documented in fish and their habitats has increased. DDE, the only DDT metabolite surveyed in fish tissue in the EPA National Study of Chemical Residues in Fish, was detected at more sites than any single pollutant (99 percent of the 362 sites sampled) (U.S. EPA, 1992c and 1992d at U.S. EPA website: http://www.epa.gov/waterscience/fishadvice/volume1/index.html). Various pesticides, including DDT and toxaphene have been detected in Atlantic herring tissues from the St. Lawrence estuary and Gulf of St. Lawrence in Canada, and Halifax, Nova Scotia (Musial and Uthe 1983, cited in Stewart and Arnold 1994). It is believed that herring spawning beds in Mirimichi Bay, Canada, were exposed to DDT derivatives from forest spraying in the 1950's and 1960's (Messieh and El-Sabh 1988, Messieh 1979 in Stewart and Arnold 1994). Hansen et al. (1985 in Stewart and Arnold 1994) found reduced hatching success in Baltic Sea herring with ovarian tissue concentrations DDE (DDT derivative) above 0.018 ppm. In a sampling study conducted between 1971 and 1981, mean DDT concentrations in Atlantic herring were 0.016 ppm (Jeff Kaelin, personal communication, Maine Sardine Council, in MDEP 1998). Impacts associated with pesticide residues on Atlantic herring EFH or their prey species are not well understood. Although a number of pesticides have been detected in various fish species, including herring, the effects of this contaminant on Atlantic herring EFH are unknown at this time.

Water Intake Structures/Discharge Plumes

The withdrawal of estuarine and marine waters by water intake structures is a common aquatic activity. Water may be withdrawn to cool coastal power generating stations, used as a source of water for agricultural purposes, and more recently, as a source of potable water for desalinization plant operations. In the case of power plants and desalinization plants, the subsequent discharge of heated and/or chemically-treated discharge water can also occur. 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 to surface waters. In most cases, the NPDES permit program is administered by authorized states.

Adverse impacts to EFH from water intake structures and effluent discharges can interfere or disrupt EFH functions in the source or receiving waters by 1) entrainment, 2) impingement, 3) discharge, 4) operation and maintenance, and 5) construction-related impacts.

Entrainment is the withdrawal of aquatic organisms along with the cooling water into the cooling system. These organisms are usually the egg and larval stages of managed species and their prey. 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. Long-term water withdrawal may adversely affect fish and shellfish populations by adding another source of mortality to the early life-stage, which often determines recruitment and year-class strength (Travnichek et al. 1993).

Impingement occurs to organisms that are too large to pass through in-plant screening devices and 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 (Grimes 1975, Hanson et al. 1977, Helvey and Dorn 1987, Helvey 1985, Langford et al. 1978, Moazzam and Rizvi 1980). The organisms cannot escape due to the water flow that either pushes them against the screen or prevents them from exiting the intake tunnel. Similar to entrainment, the withdrawal of water can entrapped particular species especially when visual acuity is reduced (Helvey 1985). This condition reduces the suitability of the source waters to provide normal EFH functions necessary for subadult and adult life stages of managed living marine resources and their prey.

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). Barker (1981, cited in ASMFC 1999) tested thermal tolerances of herring under conditions associated with passage through condenser cooling systems of electrical generating stations. He found larvae acclimated to 8 °C survived temperature changes of 17 °C for up to 60 minutes, and higher temperatures (27 to 29.1 °C for less than 30 minutes. At water temperatures of 19.5 to 21.2 °C, juvenile herring experienced a 50 percent mortality rate after 48-hour exposure (Brawn 1960b, cited in ASMFC 1999).

Used as a treatment to reduce fouling organisms, chlorine is added as hypochlorite or chlorine gas to cooling waters of power plants. It is also used as a disinfectant in sewage treatment facilities. Herring post-larvae exposed to concentrations of chlorine-produced oxidants above 0.25 ppm for 1 day caused significant mortality, and concentrations of 0.7 ppm resulted in 100 percent mortality of after exposure of only 30 minutes (Dempsey 1986 in Stewart and Arnold 1994). Generally, the NPDES average daily limit for free available chlorine for power plant discharge is 0.20 ppm (40 CFR, Ch. I, Subch. N, Part 423).

Impacts associated with water intake structures and discharge plumes on Atlantic herring EFH or their prey species are not well understood. Although some larval and juvenile Atlantic herring are lost through entrainment and impingement to water intake structures, these do not directly effect the water quality or benthic habitats of herring. Discharge plumes may effect temperature, water quality and benthic habitats in a restricted area surrounding discharge point, but are controlled and regulated under EPA’s NPDES permit program. Because discharges are generally located inshore of Atlantic herring egg habitats, the effects on water quality and habitat may be more pronounced for larval, juvenile and adult Atlantic herring. However, the effects of water intake structures and discharge plumes on Atlantic herring EFH are not well understood at this time.

Loss of Coastal Wetland

The information in this section is adapted from NOAA Fisheries’ Draft Document - Non-fishing threats and water quality: A reference for EFH consultation (1998). 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. 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. This runoff from impervious surfaces and storm sewers is the most widespread source of pollution into the Nation’s waterways (EPA 1995).

Development activities within watersheds and in coastal marine areas often impact the EFH of managed species on both long-term and short-term scales. Many of the impacts listed here are discussed in greater detail in other sections of this document. However, primary impacts include 1) the loss of shoreline habitat and vegetation and 2) runoff. An increase in impervious surfaces, such as the addition of new roads (Section 5.7.1.9), roofs, bridges, and parking facilities, results in a decreased infiltration to groundwater and increased runoff volumes. This also has the potential to adversely affect water quality and water quantity/timing in downstream water bodies (i.e. estuaries and coastal waters) (Section 5.7.1.4).

Due to the intermittent nature of rainfall and runoff, the large variety of pollutant source types, and the variable nature of source loadings, urban runoff is difficult to control (Safavi 1996). The National Water Quality Inventory (EPA 2002) reports that runoff from urban areas is the leading source of impairment to surveyed estuaries and the third largest source of impairment to surveyed lakes. These include construction sediments, oil from autos, bacteria from failing septic systems, road salts, and heavy metals. Urban areas have an insidious pollution potential that one-time events such as oil spills do not. Waterborne PAH levels have been found to be significantly higher in an urbanized watershed when compared to a non-urbanized watershed (Fulton et al. 1993). Pollutant increases gradually result in gradual declines in habitat quality (Section 5.7.1.4).

Failing septic systems are eventual consequences of urban development. EPA estimates that 10 to 25 percent of all individual septic systems are failing at any one time, introducing excrement, detergents, endocrine disruptors, and chlorine into the environment. Sewage discharge is a major source of coastal pollution, contributing 41 percent, 16 percent, 41 percent, and 6 percent of the total pollutant load for nutrients, bacteria, oils and toxic metals, respectively (Kennish 1998). Nutrients such as phosphorus concentrations, in particular, are indicative of urban stormwater runoff (Holler 1990). Sewage wastes may also contain significant amounts of organic matter that exert a biochemical oxygen demand (Kennish 1998). Sewage sludge has various effects on eggs and larval herring, depending on concentration, and includes hastening hatching but reducing hatching success, causing early larval mortality, trapping of larvae by particle flocs, and fin damage (Costello and Gamble 1992, Urho 1989 in Stewart and Arnold 1994). Organic contamination contained within urban runoff can also cause immuno suppression (Arkoosh et al. 2000) (NOAA Fisheries Draft 1998).

Estuarine habitats are an important component of herring EFH (Section 4.2.1.1.3). The loss of these wetlands due to human population growth and associated coastal development may influence the availability of overwintering sites, prey availability, and other factors necessary for larval and juvenile herring survival. Other factors, such as pollution, turbidity and nutrient loading (described in the above Section 5.7.1.4), could compromise the health of estuarine ecosystems, and reduce the quality of essential pelagic and benthic habitats utilized by larval and juvenile Atlantic herring.

Road Building and Maintenance

The building and maintenance of roads can affect aquatic habitats by increasing rates of natural processes such as debris slides or landslides and sedimentation, introducing exotic species, and degrading water quality and chemical contamination (e.g., petroleum-based contaminants; Section 5.7.1.4). Paved and dirt roads introduce an impervious or semi-pervious surface into the landscape. This surface intercepts rain and creates runoff carrying soil, sand and other sediments, and oil-based materials quickly downslope. If roads are built near streams, wetlands, or other sensitive areas, these may be affected by the increased sedimentation that occurs both from maintenance and use and during storm and snowmelt events. Even carefully designed and constructed roads can become sources of sediment and pollutants if they are not properly maintained.

The effects of roads on aquatic habitat can be profound and include 1) increased deposition of fine sediments, 2) changes in water temperature, 3) elimination or introduction of migration barriers such as culverts, 4) changes in streamflow, 5) introduction of non-native plant species, and 6) changes in channel configuration.

Poorly surfaced roads can substantially increase surface erosion, and the rate of erosion is primarily a function of storm intensity, surfacing material, road slope, and traffic levels. This surface erosion results in an increase in fine sediment deposition (Bilby et al. 1989, MacDonald et al. 2001, Ziegler et al. 2001). An increase of fine-sediment deposition in stream gravels has been linked to decreased fry emergence, decreased juvenile densities, loss of winter carrying capacity, and increased predation of fishes (Koski 1981). 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. Beschta et al. (1987) and Hicks et al. (1991) document some of the negative effects of road construction on fish habitat, including elevation of stream temperatures beyond the range of preferred rearing, inhibition of upstream migrations, increased disease susceptibility, reduced metabolic efficiency, and shifts in species assemblages. Roads can also degrade aquatic habitat through improperly placed culverts at road-stream crossings that reduce or eliminate fish passage (Belford and Gould 1989, Clancy and Reichmuth 1990, Evans and Johnston 1980, Furniss et al. 1991).

Roads may be the first point of entry into a virgin landscape for non-native grass species that are seeded along road cuts or introduced from seeds transported by tires and shoes. Roads can serve as corridors for such species allowing plants to move further into the landscape (Greenberg et al. 1997, Lonsdale and Lane 1994). Some non-native plants may be able to move away from the roadside and into aquatic sites of suitable habitat, where they may out-compete native species and have significant biological and ecological effects on the structure and function of the ecosystem.

Roads have three primary effects on hydrologic processes. First, they intercept rainfall directly on the road surface, in road cutbanks, and as subsurface water moving down the hillslope. Second, they concentrate flow, either on the road surfaces or in adjacent ditches or channels. Last, they divert or reroute water from flowpaths that would otherwise be taken if the road were not present (Furniss et al. 1991). These hydrological changes may lead to increased erosion and sedimentation impacts in adjacent streams.

Impacts associated with road construction and maintenance on Atlantic herring EFH or their prey species are not well understood. Although some impacts to riverine and estuarine water quality and habitat have been identified, the direct effects on Atlantic herring EFH are unknown at this time.

Flood Control/Shoreline Stabilization

The protection of riverine and estuarine communities from flooding events can result in varying degrees of change in the physical, chemical, and biological characteristics of existing shoreline and riparian habitat. The use of dikes and berms can also have long-term adverse effects in tidal marsh and estuarine habitats. Structures placed for coastal shoreline protection include, but are not limited to, 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); vegetative plantings; and sandbags.

Dikes, levees, ditches, or other water controls at the upper end of a tidal marsh can cut off all tributaries feeding the marsh, preventing freshwater flushing and annual flushing, annual renewal of sediments and nutrients, and the formation of new marshes. In deeper channels where reducing conditions prevail, large quantities of hydrogen sulfide are produced that are toxic to marsh grasses and other aquatic life. Acid conditions of these channels can also result in release of heavy metals from the sediments.

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 a myriad of species (Chapman 2003, Williams and Thom 2001). Hydraulic effects to the shoreline include increased energy seaward of the armoring, reflected wave energy, dry beach narrowing, substrate coarsening, beach steepening, changes in sediment storage capacity, loss of organic debris, and downdrift sediment starvation (Williams and Thom 2001). As with armoring, breakwaters and jetties modify hydrology and nearshore sediment transport as well as movement of larval forms of many species (Williams and Thom 2001).

Impacts associated with flood control and shoreline stabilization on Atlantic herring EFH or their prey species are not well understood. Although some of the impacts to water quality and habitat in marine and estuarine ecosystems are known, the direct effects on Atlantic herring EFH are unknown at this time.

Utility Line/Cables/Pipeline Installation

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 water, sewage, etc. 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.

Adverse effects to EFH from the installation of pipelines, utility lines, and cables can occur through 1) destruction of organisms and habitat, 2) turbidity impacts, 3) resuspension of contaminants, and 4) changes in hydrology.

Destruction of organisms and habitats can occur in the right-of-way of pipeline or cable. This destruction can lead to long-term or permanent damage depending on the degree and type of habitat disturbance and the mitigation measures employed. 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).

Increased water turbidity from higher than normal sediment loading can result in decreased primary production. Depending on the time of year of the construction, adverse impacts can occur, such as during highly productive spring phytoplankton blooms or times when organisms are already under stressed conditions. Changes in turbidity can temporarily alter phytoplankton communities. Depending upon the severity of the turbidity, these changes in water clarity can affect the EFH habitat functions of species higher in the food chain.

Another impact is resuspension of contaminants such as heavy metals and pesticides from the sediment, which can have lethal effects (Gowen 1978). Spills of petroleum products, solvents, and other construction-related material can also adversely affect habitat.

Pipeline canals 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 father inland during periods of high tides (Chabreck 1972). Saltwater intrusion into freshwater marsh often causes loss of salt-intolerant emergent and submerged aquatic plants (Chabreck 1972, Pezeshki et al. 1987), erosion, and net loss of soil organic matter (Craig et al. 1979).

Impacts associated with utility lines, cables, and pipeline installation on Atlantic herring EFH or their prey species are not well understood. Although some of the impacts to water quality and habitat in marine and estuarine ecosystems are known, the direct effects on Atlantic herring EFH are unknown at this time.

Oil and Gas Exploration/Development/Production

Although petroleum exploration, development, and production does not currently occur within the range of Atlantic herring in U.S. waters, the transportation of oil and gas (e.g. pipelines and tankers) and its complementary, shore-based infrastructure is widespread along the eastern U.S. coast. This section discusses the adverse impacts associated with oil and gas exploration, development, and production, as well as potential impacts of hydrocarbon spills associated with the transportation, loading and offloading of oil and gas products.

Petroleum exploration, development, and production occurs in varying water depths and usually over soft-bottom substrates, although hard-bottom habitats may be present in the general vicinity. These areas are subject to an assortment of physical, chemical, and biological disturbances. These disturbances include: 1) noise from seismic surveys, vessel traffic, and construction of drilling platforms or islands, traffic from vessels; 2) physical alterations to habitat 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; 3) waste discharges including well drilling fluids, produced waters, surface runoff and deck drainage, domestic waste waters generated from the offshore facility, solid-waste from wells (drilling muds and cuttings) and other trash and debris from human activities associated with the facility; 4) oil spills; and 5) platform storage, and pipeline decommissioning (NPFMC 1999, Helvey 2002).

Noise sources may generate sound pressure that can disrupt or damage marine life. Oil and gas activities may generate noise from drilling activities, construction, production facility operations, seismic exploration and supply vessel and barge. The impacts of oil exploration-related seismic energy releases may interrupt and cause fish to disperse from the acoustic pulse with possible disruption to their feeding patterns. 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 (movement, feeding), interfere with echolocation and communication, or may result in injury to hearing organs (Richardson et al. 1995).

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 (Section 5.7.1.8). Disturbances to the associated epifaunal communities, which may provide feeding or predator escape habitat, can also result. 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 muds and cuttings can result in varying degrees of change on the sea floor and affect feeding, nursery, and shelter habitat for various life stages of managed species. Drilling muds and cuttings may adversely affect bottom-dwelling organisms at the site by burial of immobile forms or forcing mobile forms to migrate. Exploratory and construction activities may also result in resuspension of fine-grained mineral particles, usually smaller than silt, in the water column. These suspended particulates can reduce light penetration and lower the rate of photosynthesis and the primary productivity of the aquatic area especially if suspended for lengthy intervals. Groundfish and other fish species can suffer reduced feeding ability leading to limited growth if high levels of suspended particulates persist. The contents of the suspended material can react with the dissolved oxygen in the water and result in oxygen depletion. In addition, the discharge of oil drilling muds can change the chemical and physical characteristics of benthic sediments at the disposal site by introducing toxic chemical constituents. Changes in the clarity and the addition of contaminants can reduce or eliminate the suitability of water bodies as habitat for fish species and their prey (NMFS 1998d).

Oil spills are a serious potential source of contamination to the marine environment from oil and gas development. Offshore oil and gas development will inevitably result in some oil entering the environment. Most spills are expected to be of small size, although there is a potential for large spills to occur. Many factors determine the degree of damage from a spill, including the type of oil, size and duration of the spill, geographic location of the spill, and the season. 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).

In whatever quantities, lost oil can affect habitats and living marine resources. Accidental discharge of oil can occur during almost any stage of exploration, development, or production on the outer continental shelf (OCS) or in nearshore coastal areas. Oil spills can occur from many possible sources including equipment malfunction, ship collisions, pipeline breaks, other human error, or severe storms. Oil spills can also be attributed to support activities associated with product recovery and transportation. In addition to crude oil spills, chemical, diesel, and other contaminant spills can occur with OCS activities (NPFMC 1999).

Chronic small oil spills are a potential problem because residual oil can build up in sediments and affect living marine resources. Low levels of petroleum components (PAH) from such chronic pollution can accumulate in fish tissues and cause lethal and sublethal effects, particularly at the embryo stage (Section 5.7.1.4).

The potential disturbances and associated adverse impacts on the marine environment has been reduced through the operating procedures required by regulatory agencies and in many cases self imposed by facilities operators. Most of the activities associated with oil and gas operations are conducted under permits and regulations that require companies to minimize impacts or avoid construction in sensitive marine habitats. New technological advancements result in improved operating practices reducing the potential for impacts. For example, the discharge of muds and cuttings is being phased out of modern oil and gas production programs; generally such byproducts of exploration or development are ground into finer materials and injected into wells that penetrate subsea reservoir strata and do not enter the marine environment.

Atlantic herring may be susceptible to hydrocarbon spills because they spawn in localized areas over preferred substrate types (coarse sediment and/or marine macrophytes); and because some herring stocks are maintained by physical processes in retention areas, which presumably would retain hydrocarbons as well (Stewart and Arnold 1994). Various impacts on herring populations have been observed after a major oil spill in the northern Baltic Sea. One year following a bunker oil spill, catches of larvae were small and the frequency of abnormal larvae was high and coincided with the location of the oil spill (Urho and Hudd 1989 in Stewart and Arnold 1994). The *Exxon Valdez* spill in Prince William Sound, Alaska, did not appear to impact Pacific herring catches for the following year (Baker et al. 1992 in Stewart and Arnold 1994). However, egg survival was lower in areas of heavy oiling than in control areas, there was an earlier mean age at hatch, and various abnormalities and deformities of larvae occurred for heavily oiled herring eggs (McGurk et al. 1993 in Stewart and Arnold 1994). Although hydrocarbon spills, at any scale, are known to adversely effect estuarine and coastal habitats, large-scale spills are relatively rare and usually involve small geographic areas.

Introduction of Exotic Species

The introductions of exotic species into estuarine and marine habitats has been well documented (Rosecchi et al. 1993, Kohler and Courtenay 1986, Spence et al. 1996) and can be intentional (e.g., for the purpose of stock or pest control) or unintentional (e.g., fouling organisms). Exotic fish, shellfish, pathogens, and plants can enter the environment from industrial shipping (e.g., as ballast), recreational boating, aquaculture (Section 5.7.1.14), biotechnology, and aquariums. The transportation of nonindigenous organisms to new environments can have many severe impacts on habitat (Omori et al. 1994).

Long-term impacts of the introduction of nonindigenous and reared species can 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. Overall, exotic species introductions create five types of negative impacts: 1) habitat alteration, 2) trophic alteration, 3) gene pool alteration, 4) spatial alteration, and 5) introduction of diseases. Habitat alteration includes the excessive colonization of exotic species (e.g., common reed, *Phragmites australis*) which preclude the growth of endemic organisms (e.g., *Spartina* grasses). The introduction of exotic species may alter community structure by predation on native species or by population explosions of the introduced species. Spatial alteration occurs when territorial introduced species compete with and displace native species. Although hybridization is rare, it may occur between native and introduced species and can result in gene pool deterioration. The introduction of bacteria, viruses, and parasites is another severe threat to EFH as it may reduce habitat quality. New pathogens or higher concentrations of disease can be spread throughout the environment resulting in deleterious habitat conditions. Although impacts from the introduction of exotic species in marine and estuarine ecosystems have been documented, the direct effects on Atlantic herring EFH or their prey species are unknown at this time.

Aquaculture Operation

Productive embayments are often used for commercial culturing and harvesting operations. These locations provide a source of warmer water temperatures and protected waters, thereby providing excellent growout sites for oyster and mussel culturing. These operations may occur in areas of productive eelgrass beds. Finfish aquaculture operations, such as salmon farms, have become increasingly common and profitable along the Maine coastline (Maine Dept. of Marine Resources, draft 2002).

Adverse impacts to EFH by operations that directly or indirectly utilize habitat include 1) discharge of organic waste/contaminants, 2) impacts to the seafloor bed, 3) risk if introducing undesirable species, 4) impacts on estuarine food webs.

The culture of estuarine and marine species in estuarine areas can reduce or degrade habitats used by native species, depending on the location and operation of these facilities. A major concern of culture operations is the discharge of organic waste. The introduction of antibiotics and other drugs in medicated feeds is also a concern. Wastes are composed primarily of feces and excess feed. The buildup of waste products into the receiving waters will depend upon water depths and circulation patterns. The release of these wastes can introduce nutrients and/or organic materials into the surrounding water body and cause a high biological oxygen demand leading to lower dissolved oxygen levels, thereby potentially affecting the survival of many aquatic organisms in the area. Nutrient overloads at the discharge site can also induce changes in community composition and structure, potentially favoring one group of organisms to the detriment of other.

In the case of cage mariculture operations for grow-out operations, impacts to the seafloor below the cages or pens can occur. The build-up of organic materials on the sea floor can impact the composition and diversity of the bottom-dwelling community (e.g., prey organisms for EFH species). The growth of submerged aquatic vegetation, which provides shelter and nursery habitat for a number of fish species and their prey, can be inhibited by shading effects.

The rearing of non-native, ecologically undesirable species may pose a risk of escape or accidental release into areas adversely affecting the ecological balance. Escape or other release into the environment can result in competition with native, wild fish for food, mates, spawning sites, which, if followed by successful interbreeding with wild stocks, can result in genetic dilution. Escapees can also pose a risk of transmission of disease to wild stocks.

Concern has also been expressed about extensive shellfish culture in estuaries and their impacts on estuarine food webs. Oysters are efficient filter feeders and can change the trophic structure by removal of the microalgae and zooplankton that are also the food source for salmon prey species. However, the extent of this effect, if any, is unknown, especially in light of the fact that native oysters were once present in large quantities co-existing with other species. Some effects might also be offset by the structure that oyster shells create, which creates shelter for a diverse biota.

Impacts associated with aquaculture operations on Atlantic herring EFH or their prey species are not well understood. Although some of the impacts to habitat in marine and estuarine ecosystems are known, the direct effects on Atlantic herring EFH are unknown at this time.

Marine Mining

Offshore mining as well the mining of gravel from beaches, can increase turbidity of water and, thus, the resuspension of organic materials could affect less motile organisms (i.e., eggs and recently hatched larvae) in the area. Benthic habitats could be damaged or destroyed by these actions. Mining of large quantities of beach gravel can significantly affect the removal, transport, and deposition of sand and gravel along the shore, both at the mining site and down current (NPFMC 1999). Neither the future extent of this activity nor the effects of such mortality on the abundance of marine species is known.

Mining is usually conducted with hydraulic dredges by surficial scrapping or point excavation of materials (Pearce 1994). Mining practices that can impact EFH include physical impacts from intertidal dredging and chemical impacts from the use of additives such as flocculates (NPFMC 1999). Impacts include the removal of substrates that serve as habitat for fish and invertebrates; creation (or conversion) of areas to less productive or uninhabitable sites such as anoxic holes or silt bottom; burial of productive habitats, such as in near shore disposal sites (as in beach nourishment); release of harmful or toxic materials either in association with actual mining, or in connection with machinery and materials used for mining; creation of harmful turbidity levels; and adverse modification of hydrologic conditions so as to cause erosion of desirable habitats. Submarine disposal of mine tailings can also alter the behavior of marine organisms. Reductions in herring catches near the Finnish sand and gravel mining operation were suggested to be due to disturbance to the herring movement patterns by noise and activity associated with the operation (Kiorboe et al. 1981 in Stewart and Arnold). Submarine mine tailings may not provide suitable habitat for some benthic organisms. In laboratory experiments, benthic dwelling flatfishes (Johnson et al. 1998b) and crabs (Johnson et al. 1998a) strongly avoided mine tailings.

During beach gravel mining, water turbidity increases and the resuspension of organic materials can affect less motile organisms (i.e., eggs and recently hatched larvae) in the area. Benthic habitats can be damaged or destroyed by these actions. Changes in bathymetry and bottom type may also cause alteration in population and migrations patterns (Hurme and Pullen 1988).

Sparse information is available regarding the impacts of offshore mining operations on Atlantic herring EFH. The principal concern noted by the ICES Working Group on the Effects of Extraction of Marine Sediments on Fisheries was dredging in spawning areas of commercial fish species (International Council for the Exploration of the Sea 1992a in Pearce 1994). Two species of concern recognized in this report were those with demersal eggs, Atlantic herring and sand lance. The report noted that when aggregates are removed, herring eggs are taken with them. In the case of Atlantic herring, impacts to eggs could be avoided if the mining operations are conducted outside the spawning season and egg development period (July through November).

Other Potential Sources

Although the magnitude and severity is unknown at this time, foreseeable future non-fishing threats to herring EFH could include global warming and the effects that this may have on water temperature. The impacts to the fish stocks from global climate change are not certain and therefore could not be incorporated into this assessment. The possibility of wind energy-generating structures in marine waters for the purposes of harnessing alternative sources of energy could also have an impact on herring EFH, especially as it relates to the disruption of habitat. This is the subject of a forthcoming EIS being prepared by the Army Corps of Engineers; the impacts of this project to fisheries and EFH are yet to be determined.

Summary of Non-fishing Impacts

Table 6.28 below describes 8 types of potential chemical threats, 19 categories of potential physical threats and 4 types of potential biological threats to the five life history stages of herring EFH, which are categorized as low, moderate or high threats (L, M and H, respectively) based on their geographic location (inshore and offshore). Some types and categories of potential chemical, physical and biological threats were unable to be characterized for this document and were assigned “U” (unknown). The categories were modified from a table in Amendment 13 to the Northeast Multispecies FMP developed by the New England Fishery Management Council (NEFMC 2003a). In general, the closer the proximity to the coast, i.e., close to pollution sources and habitat alterations, the greater the potential for impact. In addition, because inshore and coastal areas support essential larval and juvenile herring habitats (Section 4.2.1), it is likely that the potential impacts to inshore and coastal habitats are of greater importance to the species than effects to offshore habitats. An exception to this general characterization is Atlantic herring spawning and egg development habitats, which are located primarily in deeper, offshore areas of the Gulf of Maine and Georges Bank. Some relatively shallow, inshore areas of Maine have also been identified as spawning and egg development habitat. Atlantic herring deposit demersal eggs on bottom substrates (boulders, rocks, gravel, sand, and shell fragments) and macrophytes. The potential impacts to these habitats may be high or medium if particular activities (e.g. dredge material disposal, marine mining) were to occur in these areas during periods of spawning and egg development.

Table 6.28. Summary of potential inshore and offshore impacts of various non-fishing activities to Atlantic herring EFH by lifestage.

	EFH BY LIFE HISTORY STAGE/ GEOGRAPHIC LOCATION									
	EGGS		LARVAE		JUVENILE		ADULT		ADULT SPAWNING	
POTENTIAL THREATS	Inshore	Offshore	Inshore	Offshore	Inshore	Offshore	Inshore	Offshore	Inshore	Offshore
Chemical										
PAH	M	M	M	L	M	L	M	L	M	M
PCB	M	L	M	L	M	L	M	L	M	L
Heavy Metals	M	L	M	L	M	L	M	L	M	L
Nutrients	M	L	M	L	M	L	M	L	M	L
Pesticides/Herbicides	U	U	U	U	U	U	U	U	U	U
Acid	M	L	M	L	M	L	L	L	M	L
Chlorine	M	L	M	L	M	L	M	L	M	L
Greenhouse Gases	U	U	U	U	U	U	U	U	U	U
Physical										
Channel Dredging	M	L	M	L	M	L	M	L	M	L
Dredge and Fill	M	L	M	L	M	L	M	L	M	L
Dredge Material Disposal	H	H	M	M	M	L	M	L	H	H
Marina/Docks	M	L	M	L	M	L	L	L	L	L
Vessel Operation	M	L	L	L	L	L	L	L	L	L
Utility Lines/Pipelines	U	U	U	U	U	U	U	U	U	U
Oil/Gas Operations	M	M	M	L	M	L	M	L	M	M
Erosion/Flood Control Structures	U	U	U	U	U	U	U	U	U	U
Road Building/Maintenance	U	U	U	U	U	U	U	U	U	U
Dam Construction/Operation	U	U	U	U	U	U	U	U	U	U
Agriculture/Silviculture	U	U	U	U	U	U	U	U	U	U
Water Intake	M	L	M	L	L	L	L	L	L	L
Water Discharge	L	L	M	L	M	L	M	L	L	L
Sewage/Septic Discharge	M	L	M	L	M	L	M	L	M	L
Marine Mining	M	M	L	L	L	L	L	L	M	M
Salinity	L	L	L	L	L	L	L	L	L	L
Suspended Particles	M	M	M	M	M	M	L	L	M	M
Thermal	M	L	M	L	M	L	L	L	L	L
Dissolved Oxygen	M	L	M	L	M	L	M	L	M	L
Biological										
Exotic Species	U	U	U	U	U	U	U	U	U	U
Pathogens	U	U	U	U	U	U	U	U	U	U
Aquaculture Operations	U	U	U	U	U	U	U	U	U	U
Plankton Blooms	U	U	U	U	U	U	U	U	U	U

Key: H = high, M = moderate, L = low, and U = unknown.

7.0 ANALYSIS OF ALTERNATIVES

7.1 Alternative 1 – No Action (Preferred Alternative)

The baseline against which any potential impacts of management measures that are proposed in this DEIS are evaluated is the status quo condition of each of the valued environmental components that exists as of July 2004, when the DEIS is made available for public comment. Under the no action alternative, no additional measures would be implemented to minimize the adverse effects of the Atlantic herring fishery on EFH and the existing conditions of any affected environmental components would not change. Therefore, this alternative assumes no additional or incremental impacts on any of the components of the affected environment identified in Section 4.0 of the DEIS other than would have occurred without any proposed action by this agency.

Existing environmental conditions within the geographic range of the Atlantic herring fishery (nearshore and continental shelf waters from Maine to New Jersey) support healthy Atlantic herring stock production. Section 5.1 concludes that the only potential effect of the herring fishery on pelagic EFH for these life stages is the noise and disturbance of the water column produced by fishing vessels and the setting and towing of fishing gear (purse seines and mid-water trawls). This effect is minimal and temporary in nature because schools of herring quickly re-form after being dispersed. It is further concluded that herring fishing activities have little or no impact on benthic EFH for herring eggs because the gear contacts the bottom so infrequently, and does so primarily in areas with bottom substrates which do not function as substrates for herring eggs (Sections 4.2.2.2 and 4.3.1.2). Furthermore, the functional value of the habitat as a substrate for herring eggs is not reduced when it is disturbed. Therefore, even if herring egg EFH is adversely impacted by mid-water trawls or purse seines, the effects are no more than minimal or temporary in nature (Sections 5.1 and 5.2).

Benthic habitats of other species in the Northeast region of the U.S. have been adversely impacted by mobile, bottom-tending gear. However, recent amendments to the Northeast Multispecies and Sea Scallop Fishery Management Plans (NEFMC 2003 a and b) include habitat closed area provisions that prohibit the use of mobile, bottom-tending gears in 2,811 nm^2 of ocean bottom on Georges Bank and the Gulf of Maine (see Figure 3.1) and therefore mitigate these effects. Areas closed to groundfish fishing (which includes most types of mobile, bottom-tending gears) on Georges Bank and in the Gulf of Maine have been in place for the past 5-9 years. Although the groundfish closed areas are temporary and could be eliminated or modified as groundfish stocks recover, the habitat closed areas will remain in place indefinitely. Both types of closures protect benthic habitats for a variety of species, including Atlantic herring, inside the closed areas. Both recent amendments to NEFMC FMPs also include reductions in fishing effort, which will provide additional protection to benthic EFH for Atlantic herring eggs and demersal finfish species in the NE region. As a result, if none of the proposed management measures in this DEIS are implemented, it is likely that EFH for Atlantic herring and other federally-managed species will continue to be protected from the effects of fishing by these measures without any further action by this agency.

7.2 Alternative 2 – Modifications to the Regulatory Definition of Mid-Water Trawls

The purpose of the existing regulatory definition (Section 3.2) is to prevent any bottom contact of mid-water trawls. Because there is some bottom contact by mid-water trawls (Section 4.3.1.1), the proposed modifications to the definition are intended to increase the enforceability of the regulation by stipulating what can not be added to the footrope of the net, thus making the prohibition on bottom contact more effective. One of the proposed options includes a number of other details concerning how the nets are rigged and constructed and another includes a prohibition on the use of chafing gear. While the proposed changes to the definition will make it easier to detect nets that are not in compliance with the regulation, it is not clear that any of them will actually succeed in eliminating bottom contact. For the purposes of this analysis, however, it is assumed that a modified definition will reduce the amount of bottom contact to some unknown degree. Rather than speculate about whether any of the proposed modifications to the definition would be more effective at reducing bottom contact, the three options are evaluated together.

Atlantic herring

There would be no direct or indirect effects of a modified definition on the Atlantic herring resource. Proposed changes in the definition will improve its enforceability and are expected to reduced the incidence of bottom contact by mid-water trawls, but should not significantly affect the amount of herring removed from the resource by fishing (direct effect) or stock size (indirect effect). There may be less fishing for herring in deep water over mud and sand bottom areas, particularly during the winter fishery in southern New England, but it is likely that any “lost” near-bottom catches would be made up by increased mid-water fishing. It is therefore unlikely that any reduction in the catch of the magnitude caused by effectively stopping mid-water trawling near or on the bottom would have any negative effect on stock size. Stock size is affected not only by catch levels, but is also subject to a variety of natural factors that affect recruitment and natural mortality.

Protected Species

There is no expected direct or indirect effect of the modified mid-water trawl definition on protected species because there is no indication that any of the endangered species or protected marine mammal species that are vulnerable to mid-water trawl gear are more likely to be affected by the fishery in deeper water near the bottom (Section 4.2.3.2).

Essential Fish Habitat (EFH) for Atlantic Herring

EFH for larval Atlantic herring is strictly pelagic and for eggs and spawning adults is strictly benthic (Table 5.17). EFH for juveniles and non-spawning adults is described as including “pelagic waters and bottom habitats.” However, because juvenile and adult herring are pelagic, plankton-feeding fish that do not utilize benthic habitats except for spawning (Section 4.2.2), they are treated here as only utilizing the pelagic habitat. Mid-water trawling does not affect larval herring EFH. It is assumed that any modification to the existing mid-water trawl definition would reduce the incidence of bottom contact by mid-water herring trawls, especially in mud and sand bottom habitats where bottom contact is more likely to occur at present (Section 4.3.1.1).

Mid-water trawls were used during 1997-2002 within a few ten minute squares that have been designated as EFH for Atlantic herring eggs (Figure 7.45). However, because there is so little bottom contact by mid-water trawls and because the occasional bottom disturbance caused by mid-water trawling does not reduce the functional value of herring egg EFH (Section 5.1.1), it is highly unlikely that a reduction in bottom contact by mid-water trawls would have a positive effect on herring egg EFH. Furthermore, herring eggs are not laid on mud and mid-water trawls seldom come in contact with gravel and rocky bottom substrates that are the preferred habitats for herring eggs (Sections 4.2.2.2 and 5.1.1).

The noise and disturbance caused by fishing vessels and mid-water nets constitute a temporary impact to the pelagic EFH for juvenile and adult Atlantic herring, causing schools of herring to dive or disperse (see Table 5.18). A reduction in the use of mid-water trawls near or on the bottom could conceivably lead to their increased use higher in the water column, but there would be no measurable change in the amount of disturbance compared to the status quo condition.

EFH for Other Species

It was concluded in the gear effects evaluation that fishing with mid-water trawls could potentially reduce the quality of benthic EFH for a number of federally-managed species and life stages in the NE region, especially those that inhabit mud and sand bottom habitats, but that the adverse effects of mid-water trawls on benthic habitats are minimal compared to the effects of bottom trawls and dredges (Section 5.2). If the regulatory definition of mid-water trawls is modified so that their use on or near the bottom is reduced, there could be a very small positive impact on benthic EFH for some of the other federally-managed species in the region (see Table 4.11 for a list of benthic species and life stages that inhabit sandy bottom areas). However, because benthic habitats in most areas where mid-water trawls are used have been greatly impacted by bottom trawls and dredges, any habitat benefits resulting from a change in the regulatory definition of mid-water trawls would be limited to the areas that have been closed to scallop dredges and most types of bottom trawls since they were established in December 1994. There are no open access areas used by the mid-water herring fleet that are not impacted by bottom trawls and scallop dredges (compare Figure 4.25 and Figure 4.26 with Figure 4.28 and Figure 4.29).

Direct benefits that could be expected inside undisturbed closed areas include reduced smoothing of seafloor features caused by chains on the footrope or by the belly of the net or furrows caused by the two “down weights” that are placed forward of the net. Indirect benefits could include increased shelter for demersal fish (e.g., in the shelter of sand waves) and improved survival of benthic invertebrates that are preyed upon by demersal fish. However, even in the closed areas, physical and biological features of relatively shallow, sandy bottom habitats would be much more susceptible to natural disturbance caused by bottom currents and storms than the occasional disturbance caused by a mid-water trawl that comes in contact with the bottom. It seems likely that even inside the closed areas, there would be no measurable change in the quality of benthic EFH utilized by other species.

Human Communities

There could be a negative economic impact of a modified mid-water trawl definition on the winter fishery in southern New England and the mid-Atlantic if herring occupy near-bottom waters at this time of year to the extent that a reduction in the use mid-water trawls near or on the bottom would reduce the efficiency of fishing operations and the income earned by vessel owners and crew. There is, however, no information available to indicate that this would happen.

7.3 Alternative 3 - Prohibit the Use of Mid-Water Trawls in Habitat Closed Areas

This alternative would prohibit the use of mid-water trawls in 2,811 nm^2 within seven separate areas in the Gulf of Maine, on Georges Bank, and in southern New England (Section 3.3). Since these areas are closed to all mobile, bottom-tending gears which adversely impact benthic habitats to a much greater extent than mid-water trawls (Section 5.1), any bottom contact by mid-water herring trawls inside these areas is more likely to reduce the quality of benthic EFH than it is outside them. The HCAs are open to certain types of bottom-tending fixed gears (e.g., lobster pots) which minimally affect benthic habitats (Table 5.23).

A GIS analysis was performed to determine the amount of mid-water trawling activity that was reported during 1997-2002 within ten minute squares of latitude and longitude that overlap entirely or partially with habitat closed areas. The results are summarized in

Table 7.29 and displayed in Figure 7.43 and Figure 7.44. Twelve percent of the 5501 days at sea reported by latitude and longitude in the NE region during this six year period were estimated to fall within the habitat closed areas. Most mid-water trawling (65%) was reported from the western Gulf of Maine (WGOM) closed area, with much smaller percentages in the cod HAPC on eastern Georges Bank, in the northern part of closed area 1 (CA1) in the Great South Channel, and in the closed areas on Cashes Ledge and Jeffreys Bank. No mid-water trawling was reported from the southern part of CA1 or within the Nantucket Lightship closed area (NLSCA). Most of the mid-water trawling in the WGOM closed area was in the northern part of the area, in the vicinity of Jeffreys Ledge. Only about 3% of the total herring catch in 2003 was taken from the WGOM closed area (Table 7.32).

Atlantic Herring

There would be no expected effects, direct or indirect, of this alternative on the Atlantic herring resource. Most, if not all, of the catch that is currently being taken from inside the habitat closed areas would probably be taken elsewhere, or by purse seiners that will continue to operate inside the closed areas. Even if some proportion of the mid-water trawl catch that is currently taken inside these areas could not be made up by purse seiners, or by mid-water trawl fishing outside them, it is highly unlikely that the size of the resource would be affected since the effects of natural processes such as recruitment and natural mortality would be much greater.

Protected Species

The prohibition of mid-water trawling inside the habitat closed areas would have a positive effect on protected species within those areas, but not outside them. There would not likely be any overall effects of this alternative on protected species that occupy the range of the Atlantic herring fishery since mid-water trawling activity would increase in open access areas that are also inhabited by protected species. Species that would benefit directly from this alternative inside the closed areas are those which are susceptible to capture in mid-water trawls and which occupy the closed areas during the spring, summer, and fall when the herring mid-water fishery in them is active. These include pilot whales, minke whales, harbor seals, harbor porpoises, and leatherback turtles. Jeffreys Ledge, where most of the mid-water trawling activity that would be affected by this alternative occurred during 1997-2002 (Figure 7.44), is a primary feeding ground for several species of whales and dolphins. Direct benefits of this alternative inside the closed areas could include a reduced probability of marine mammal captures, and possible injury or mortality.

Atlantic Herring EFH

Larval Atlantic herring EFH is strictly pelagic and for eggs and spawning adults is strictly benthic (see Table 5.17). EFH for juveniles and non-spawning adults is considered to be pelagic (Section 7.2). Mid-water trawling does not affect pelagic EFH for Atlantic herring larvae, juveniles, and non-spawning adults.

Mid-water trawls were used during 1997-2002 within five ten minute squares that have been designated as EFH for Atlantic herring eggs that fall within the existing habitat closed areas (Figure 7.45). Three of these TMS are in the WGOM closed area and two are in CA2 (the cod HAPC) on eastern Georges Bank. Most mid-water trawling that was reported within herring egg EFH during 1997-2002 that would be displaced to open areas took place within one entire TMS and two half TMS in the WGOM closed area and one entire TMS in CA2. Together these three TMS represent about 10% of the total herring egg EFH area in the NE region (three out of 32 TMS). No mid-water trawling was reported in the two additional TMS that are EFH for Atlantic herring eggs, one in the northern portion of the NLS closed area and one in CA2. However, because there is so little bottom contact by mid-water trawls and because the occasional bottom disturbance caused by mid-water trawls does not reduce the functional value of herring egg EFH (Section 5.1.1), this alternative is not expected to produce any measurable change in the quality of EFH for Atlantic herring eggs relative to the status quo (Alternative 1). Furthermore, bottom contact by mid-water trawls is much more likely to occur in sand and mud bottoms, not on gravel substrates which make up a portion of the WGOM and CA2 areas (Table 7.30 and Figure 7.46) and which are the preferred substrate for herring eggs (Section 4.2.1.2).

EFH for Other Species

A prohibition on the use of herring mid-water trawls in habitat closed areas would eliminate any effects of mid-water trawls on benthic EFH for other federally-managed species and life stages in these areas, particularly those that utilize sand and mud substrates (see Table 4.11) since these are the bottom types that are most likely to be contacted by mid-water trawl gear. However, the elimination of mid-water trawlers from the closed areas would likely lead to an increased use of fixed gear such as lobster pots since there would no longer be any mobile gear types to interfere with the use of fixed gear. Even though individual pots do not significantly affect the quality of benthic marine habitats, the collective effect of setting and hauling large numbers of pots could easily exceed the effects of mid-water trawls. Overall, therefore, this alternative could have a negative impact on EFH for other species inside the habitat closed areas. It would certainly not benefit EFH for other species.

Some mid-water trawling during 1997-2002 took place in the northern part of the WGOM closed area, in the Cashes Ledge and Jeffreys Bank closed areas in the outer Gulf of Maine, and in one TMS in CA1 and another in CA2 (Figure 7.44). Because the closed areas on Georges Bank have a more constant bottom topography and contain a much higher percentage of sand than the more diverse closed areas in the Gulf of Maine (Table 7.30, Figure 7.46), any benefits to EFH for species other than Atlantic herring are more likely to occur in the small portions of closed areas CA1 and CA2 where mid-water trawls operate (Figure 7.44) and where there is little or no fixed gear fishing (Figures 4.32-4.38). However, these two areas are relatively shallow, with sand and gravel habitat and strong bottom currents (Section 4.1.1), so that any adverse effects of mid-water trawling are probably insignificant compared to the effects of natural disturbances.

Human Communities

There are two primary ways in which this alternative may economically impact vessels which use mid-water trawl gear (single or pair). The first is increased vessel operating costs (primarily increased fuel costs), related to longer steam times if a vessel's optimal fishing location is in a closed area and the vessel must choose a second best location that is beyond a closed area. The second is the cost of decreased net revenues (revenues less the cost of items that vary directly with the quantity of fish caught such as pumping, refrigeration, and packaging costs) from choosing a second best fishing location. These two impacts are related in that the choice of fishing location depends on the cost of reaching a location and the expected abundance and quality of fish at that location. These choice factors, and others including business relationships with buyers (choice of market); the vessel's homeport; and the status of the TAC in a management area, determine the selection of fishing locations.

If these closures are implemented and the best fishing location happens to be in one of the closed areas, then the captain is faced with balancing the additional costs of choosing a more distant location with the expected catch from the alternative area. It may be that due to the seasonal migration of herring at a particular time, the only choice is to transit a closed area in order to find fish. Given that the second best choice involves increased operating costs, the total impacts would include the increased vessel operating costs and the decreased net revenue.

Circumstances may dictate that the second best fishing location choice may be a location which is closer to port and results in a cost savings. The net impact in this situation is the loss of net revenue as offset by the decreased steaming costs. Presumably, the loss of net revenue is greater than the cost savings in this case or the fishing captain would have chosen the alternative location in the first place.

The discussion above assumes that a single fishing location is chosen. In many cases, the trip may include several different fishing locations. Each location choice then depends on the success of the previous choice and the interplay of the decision points described for the single location would occur as the trip unfolds.

With the provision that gear must be stowed while transiting a closed area, additional vessel operating costs may be incurred if a vessel captain decides to go around a closed area rather than stow the gear.

Another assumption of this analysis is that closed areas of this size, number, and location in this fishery will not reduce the amount of fish that are available to be caught. This assumption is based on the fact that herring seasonally migrate through these areas unlike a highly localized resource like scallops where a closed area essentially fences off a portion of the resource.

With this alternative there would be increased enforcement costs. Enforcement of the area TACs is currently accomplished through VMS monitoring and Coast Guard observations. Applying habitat closed areas to the herring fishery would increase the number of vessels the Coast Guard would have to watch for which increases monitoring costs.

Another strategy vessel owners could consider if this alternative is selected is they could change gear type. This strategy would involve incurring significant costs (see analysis of Alternative 4 for a full discussion of gear changes). Based on the analysis presented below, it does not appear that the number of trips impacted by the habitat area closures are likely to induce gear changes.

Crews who work on purse seine vessels may benefit due to their inceased opportunities to fish in the closed areas, especially in the WGOM closed area, which is located close to shore. This might benefit ports that are located nearby such as Gloucester, Newington, and Portland.

Magnitude of Single and Pair Mid-water Trawl Trips Impacted by Alternative 3

To evaluate the potential magnitude of the number of trips that are likely to be impacted, 2003 landings data are used to first describe the level of landings, number of trips, and ports of landing of vessels which use mid-water trawl gear. This descriptive information and the assumption that the fishing location choices seen in 2003 are optimal, given the bounds of the status quo, provide the background upon which a qualitative determination can be made as to whether or not a particular closed area will have an impact on a significant number of trips.

There are 16 vessels which used mid-water pair trawls as their primary gear in 2003 and averaged more than 2,000 pounds of herring per trip. Using the same criteria, 7 vessels used single mid-water trawls. See Table 4.13 in the Affected Human Environment section for information about landings, trips, and days at sea by management area for these vessels.

To evaluate the impact of the habitat area closures, the number of trips to these areas and the associated landings are compared to the total activity of vessels which principally used either single or paired mid-water trawl gear and averaged more than 2,000 pounds of herring per trip (the current FMP's definition of a directed trip). Table 7.31 describes the 2003 landings of the 16 single mid-water trawl and 7 pair trawl vessels in order to make comparisons with trips and landings in the areas that vessels would be precluded from if this alternative is selected. This table reports trips and landings by port where the number of trips was greater than three (for data confidentiality reasons). It is assumed that the trip originated in the port of landing which may not be the case for all trips.

Western Gulf of Maine Closed Area

In 2003, single vessel mid-water trawls made eight trips to the Western Gulf of Maine (WGOM) closed area and landed 614 metric tons (mt) (Table 7.32). Most of these trips terminated in Portland, ME. The eight trips to this area represented 3.4% of the total trips made by this sector and 4.4% of the landings. Mid-water pair trawl vessels took a total of 20 trips to the Western Gulf of Maine (WGOM) closed area and landed 2,288 mt. These trips terminated in ME, NH, and MA ports. The 20 trips to this area represented 3% of all the trips made by this sector in 2003 and 3.5% of the landings. For all mid-water trawling activity, 2,902 mt were landed during 28 trips. This represented 3% of all trips and 3.6% of total landings reported by mid-water trawlers in 2003.

Using 1997 through 2002 data and the number of 24 hour days at sea as a measure of effort in a closed area, the single vessel mid-water trawl fleet spent an average of 8.1% of their days in the WGOM closed area. The pair trawl fleet spent an average of 5.6% of their days in the WGOM closed area.

The proposed WGOM habitat closed area, while not the largest of the seven habitat closures, contains the largest percentage of catch and effort. This, with its size, shape, (it is a 60 by 10 nautical mile rectangle with the longer dimension running north to south) and location indicates that this closure is the one most likely to result in economic impacts to the herring mid-water trawl fleet. This area is located in the middle of management Area 1A which is the one area where the TAC is fully harvested and, in some years, is taken before the end of the fishing seasons (the season is split in two). If the TAC is nearly exhausted and fish are concentrated in the closed area, as can happen on Jeffreys Ledge late in the season, mid-water trawl vessels could be precluded from obtaining adequate supplies.

Cashes Closed Area

There were no trips in 2003 by mid-water trawl vessels to the Cashes Ledge closed area so no impact is expected from implementing the closure.

Using 1997 through 2002 data and the number of 24 hour days at sea as a measure of effort in a closed area, the single vessel mid-water trawl fleet spent an average of 1.1% of their days in the Cashes closed area. The pair trawl fleet spent an average of 0.6% of their days in the Cashes closed area.

Jeffreys Bank Closed Area

In 2003, single vessel mid-water trawls made two trips to the Jeffreys Bank closed area and landed 132 mt. These trips terminated in Portland, ME. The two trips to this area are 0.9% of the total trips taken by this sector and 0.9% of the landings. Mid-water pair trawl vessels made eight trips to the Jeffreys Bank closed area and landed 569 mt. These trips terminated in Rockland and Vinalhaven, ME and Newington, NH. The eight trips to this area represented 1.2% of the total trips made by this sector and 0.9% of the landings. Table 7.33 lists these trips by port of landing.

Using 1997 through 2002 data and the number of 24 hour days at sea as a measure of effort in a closed area, the single vessel mid-water trawl fleet spent an average of 0.35% of their days in the Jeffreys Bank closed area. The pair trawl fleet spent an average of 1.4% of their days at sea in the Jeffreys Bank closed area.

Nantucket Lightship Closed Area

In 2003, mid-water pair trawl vessels made two trips to the Nantucket Lightship closed area and landed 494.33 metric tons (Table 7.34). These trips terminated in Gloucester, MA. The two trips to this area represented 0.3% of the total trips made by this sector and 0.8% of the landings.

During 1997 through 2002, there were no recorded trips to the Nantucket Lightship Closed Area by single or paired mid-water trawl vessels.

Closed Area I - North

In 2003, mid-water pair trawl vessels made a total of four trips to the Closed Area I - North closed area and landed 309 mt (Table 7.35). These trips terminated in Portland, ME and Gloucester, MA. The four trips to this area represented 0.6% of the total trips made by this sector and 0.5% of the landings.

Using 1997 through 2002 data and the number of 24 hour days at sea as a measure of effort in a closed area, the single vessel mid-water trawl fleet spent an average of 1.8% of their days in the Closed Area I - North closed area (Table 7.35). The pair trawl fleet spent an average of 0.5% of their days at sea in the Closed Area - North closed area.

Closed Area I - South

There were no trips in 2003 by mid-water trawl vessels to the Closed Area I - South area so no impact is expected from implementing the closure. Also, during 1997 through 2002, there were no recorded trips to the Closed Area I - South closed area by single or paired mid-water trawl vessels.

Closed Area II

In 2003, single vessel mid-water trawls made one trip to the Closed Area II closed area and landed 265 mt. This trip terminated in Portland, ME and represented 0.4% of the total trips made by this sector of the fishery and 2% of the landings. Mid-water pair trawl vessels made two trips to Closed Area II and landed 324 metric tons. These trips terminated in Rockland, ME and New Bedford, MA. The two trips to this area represented 0.3% of the total trips taken by this sector and 0.5% of the landings. Table 7.36 lists these trips by port of landing.

Using 1997 through 2002 data and the number of 24 hour days at sea as a measure of effort in a closed area, the single vessel mid-water trawl fleet spent an average of 1% of their days in the Closed Area II closed area. The pair trawl fleet spent an average of 0.8% of their days in the Closed Area II closed area.

Summary

A total of 11 trips were made by single mid-water trawl vessels in the habitat closed areas in 2003 (Table 7.37). Total landings on those trips were 1,011 mt. As a percent of this sector's total activity, 4.7% of the trips and 7.3% of the landings were from these areas. Mid-water pair trawl vessels made 36 trips in the habitat closed areas in 2003. Total landings on those trips were 3,986 mt. As a percent of this sector's total activity, 5.4% of the trips and 6.1% of the landings were from these areas. For both gear types combined, 47 trips were reported from the habitat closed areas in 2003 with total landings of 4,996 mt, or 6.1% of total landings and 10% of the fishing trips made by this sector of the fishery.

Using 1997 through 2002 data and the number of 24 hour days at sea as a measure of effort in a closed area, the single vessel mid-water trawl fleet spent an average of 12.4% of their days in all the closed areas. The pair trawl fleet spent an average of 11.7% of their days in all the closed areas. For both gear types combined, 12.1% of the mid-water trawl fishing activity was spent in the habitat closed areas during 1997-2002.

Given the fairly low percentage of activity in the closed areas, it appears that this alternative would have low impacts on the herring mid-water trawl fleet. The larger areas in the southern region (Nantucket Lightship and Closed Area I) historically have little herring fishing activity. With the exception of the WGOM habitat closed area, the other areas are small enough to allow herring vessels to work around without significant steaming cost or losses in net revenue. As discussed above, the WGOM habitat closure may result in some impacts but with effort only reaching 7.8% of the total effort, the impacts should be minimal, particularly since mid-water trawl vessels will be able to re-locate to fishing grounds located outside of the closed areas.

7.4 Alternative 4 - Prohibit the Use of Mid-Water Trawls in the Gulf of Maine

This alternative would prohibit the use of the herring mid-water trawls in the Gulf of Maine (Area 1) on a year-round basis. Figure 3.2 shows the area that would be affected by this alternative.

Atlantic Herring

Area 1 is the most important of the three management areas: 64% of the total catch in 2003 came from this area (see Table 4.12 in Section 4.3). This area is where the inshore component of the Atlantic herring resource resides during the spring, summer, and fall. Seventy percent of the herring that were caught in this area in 2003 were caught by mid-water trawlers and 30% by purse seiners. It is expected that this alternative would have a small positive impact on the inshore stock since some of the catch that is currently taken by mid-water trawlers in area 1 (41,600 metric tons in 2003) would probably not be available to be harvested by purse seines and would instead contribute to stock production. Mid-water trawls are more efficient at harvesting herring when they are dispersed in the water column and are not available to capture by purse seines (Section 4.3.1.1).

Protected Species

The prohibition of mid-water trawling in Area 1 would have a direct, positive impact on species of marine mammals that occupy the Gulf of Maine during the spring, summer, and fall and that are vulnerable to capture in this gear. This would include minke whales, pilot whales, leatherback turtles, grey seals, harbor porpoises, and harbor seals. Indirect benefits would result from a reduction in the harvest of herring which are a food source for piscivorous whales, toothed whales, and pinnipeds. The benefits of this alternative for protected species are significantly greater than the benefits of Alternative 3, which would only prohibit mid-water trawling in habitat closed areas.

Atlantic Herring EFH

Larval Atlantic herring EFH is strictly pelagic and for eggs and spawning adults is strictly benthic (Table 5.17). EFH for juveniles and non-spawning adults is considered to be pelagic (Section 6.2). Mid-water trawling does not affect pelagic EFH for Atlantic herring larvae, juveniles, and non-spawning adults.

EFH for Atlantic herring eggs is designated within ten minute squares of latitude and longitude in all three management areas (Figure 7.47). Approximately 14 TMS in Area 1A are designated as herring egg EFH. This alternative would guarantee that no bottom contact by mid-water trawlers would occur in areas designated as EFH for Atlantic herring eggs in Area 1. However, herring utilize primarily gravel, coarse sand, and shell fragment substrates for spawning (Section 4.2.1.2) and bottom contact by mid-water trawlers is more likely to occur on smooth bottom composed of finer sediments (Section 4.3.1.1), so the probability that there is any significant effect of mid-water trawling on herring egg EFH in the Gulf of Maine is low. In addition, areas designated as EFH for herring eggs that lie outside the existing habitat or groundfish closed areas (i.e., in Cape Cod Bay, northwest of Cape Cod, and along the Maine coast) could also be impacted by bottom trawls and scallop dredges, which are used on substrates where herring eggs are laid and which have much greater negative impacts to benthic habitats. For this reason, any positive effect of this alternative on EFH for herring eggs would be limited to the habitat closed areas.

This alternative would reduce the amount of noise and disturbance in the pelagic environment utilized by juvenile and adult herring in the Gulf of Maine. This could have a positive effect on the quality of pelagic EFH for these two life stages, although the dispersal of herring schools by vessels and nets has been shown to be temporary (see Table 5.18 in Section 5.1.1).

EFH for Other Species

This alternative would eliminate any effects of mid-water trawls on benthic EFH for other federally-managed species and life stages in the Gulf of Maine. Potentially, this could improve the quality of benthic EFH for species and life stages of fish and shellfish that inhabit this area. However, except for bottom areas inside the WGOM and Cashes Ledge groundfish closed areas (see Figure 7.46), benthic habitats that are vulnerable to disturbance by mid-water trawl gear have been adversely affected by bottom trawls and dredges for a long time (Section 5.1). This alternative would therefore not improve the quality of benthic EFH for other species in the Gulf of Maine.

Human Communities

Atlantic Herring Fishery

This alternative, if implemented, would have significant impacts on the single and pair mid-water trawl sectors of the herring fleet. In 2003, 46.1% (46,396 mt) of the total catch was harvested using mid-water trawl gear. Single mid-water trawl gear harvested 8,847 mt (8.8%) and pair trawl gear harvested 37,549 mt (37.3%) of the 100,680 mt total landings. See Table 4.13 in the Affected Human Environment section for a detailed breakdown of the landings by gear used and management area.

Of the vessels which averaged more than 2,000 lbs of herring per trip in Area 1A, 12 vessels used mid-water pair trawl as their principal gear and 5 vessels used single mid-water trawl gear. These vessels caught 44,605 mt from Area 1 or 44.3% of the total catch. See Table 4.13 in the Affected Human Environment section for a detailed breakdown of the landings by principal gear and management area.

Table 7.38 and Table 7.39 are provided to show the regional dependence of mid-water trawl gear on Area 1. Table 7.38 shows the landings, trips, and days at sea in all management areas by port for both single and pair mid-water trawl vessels which averaged greater than 2,000 pounds per trip in Area 1. Table 7.39, then, shows the same information but only for the landings in Area 1. With Table 7.39 being a subset of Table 7.38, the dependence of mid-water trawl vessels on Area 1 for each of the ports can be determined. For instance, the single mid-water trawl vessels landing in Gloucester, MA harvest 92.8% of their herring from Area 1 and the Portland, ME vessels harvest 73% from Area 1. For pair trawl vessels, those landing in the Maine ports of

Portland, Rockland, and Vinalhaven all show greater than 83% of landings from Area 1. Landings in Gloucester, MA and Newington, NH are less dependent at 60.8% and 68.1%, respectively. The notable exception is landings to New Bedford, MA which shows a low dependence of 22.9%.

There are three primary ways in which this alternative will impact vessels which use mid-water trawl gear (single or pair). The first is increased vessel operating costs (primarily increased fuel costs), related to longer steam times when a vessel must move beyond Area 1 to fish for herring. The second is the cost of decreased net revenues (revenues less the cost of items that vary directly with the quantity of fish caught such as pumping, refrigeration, and packaging costs) from being precluded from access to nearly half of the resource and not being able to fully make it up from fishing in other areas. The third is costs incurred to convert a mid-water trawl vessel to a purse seine vessel since it is likely that vessels would need to convert to purse seine gear in order to get access to fish in Area 1.

The degree of economic impacts from this alternative will depend on whether or not the historical dependence of mid-water trawlers on Area 1 is due to availability of fish (i.e., they fish there because that is where the fish are located) or because fish are available in other locations but those locations are further away and more costly to reach. If mid-water trawlers are precluded from Area 1 and fish are not available in other locations at the time the market is calling for fish, then the impacts will be most significant because net revenue will be lost, operating costs will increase (because they will be steaming longer distances to look for fish), and vessels will likely convert to purse seine gear. Impacts will be less significant if the reason for fishing Area 1 has been because it is a low cost area. Under this scenario, fish can presumably be obtained in sufficient quantities (and so no revenue loss) in other areas but at a higher cost. Conversions to purse seine gear are less likely in this case.

To the degree that the mid-water trawl fleet is servicing the bait market, increased costs to the mid-water trawl fleet will likely induce increased costs of bait, particularly if supply shortages occur.

The cost of converting a mid-water trawl vessel to a purse seine vessel would be significant. The cost will depend on the size and characteristics of the vessel. At a minimum, a new purse seine net for a 150 to 200 metric ton capacity vessel costs on the order of $200,000. Nets for smaller inshore vessels cost about $50,000 to $100,000. However, in order to use purse seine nets other equipment changes are required, depending on the current configuration of the vessel. These include changes/additions to/of: hydraulic rollers, power blocks, and the mast. Also, certain vessels may have to remove their gallows frame if they have one. Depending on whether the vessel has thrusters, they may need to purchase a 20to 25 ft aluminum “bug boat.” Estimates of total conversion costs could be on the order of $300,000 to $500,000.

There would be some benefits from this alternative to the purse seine fleet. As shown in Table 7.39 of the Affected Human Environment section, the six purse seine vessels harvest 96% of their herring from Area 1. These vessels are smaller, on average, than the mid-water trawl vessels and are unable to fish offshore. Since the Area TAC is typically reached before the end of the fishing season, purse seine vessels would not have to compete with mid-water trawlers for the Area 1 TAC. To the extent that mid-water trawling disperses fish, there may be some additional benefits gained by the purse seine fleet in that harvest costs may be lower.

Fishing Communities

This alternative would have some negative social impact on fishing communities and families in the region. Herring mid-water trawlers, which account for most of the fishing activity in Area 1 (A+B), would have to fish on Georges Bank and might use certain ports in the western Gulf of Maine to a lesser extent. There could be an indirect effect caused by vessels landing more herring in ports that are located further away from lobster fishing communities in the Gulf of Maine. This could cause shortages and increased prices in the lobster bait market (this has happened before when herring were scarce in the Gulf of Maine and fishing shifted to Georges Bank). In addition to its direct economic effects, this would have negative social impacts in fishing communities that are dependant on the lobster fishery, especially in Maine. Other possible direct effects include the impact of longer fishing trips (to Georges Bank) on crew satisfaction and family life and increased safety concerns. Some of the negative impacts on mid-water trawl crew members could be offset by the added income and satisfaction of purse seine fishermen who will have more opportunities to fish in Area 1 and added income. If the supply of herring provided by mid-water trawlers who are forced to fish full-time on Georges Bank is reduced, processing plants that rely on herring from these vessels will be impacted economically, possibly causing a loss of jobs and income to plant workers and associated social impacts on families and communities.

7.5 Selection of the Preferred Alternative and Practicability Analysis

The analyses in this document show that none of the proposed management measures have any measurable benefit to EFH (Table 7.40). There are no socio-economic costs associated with Alternative 2, neutral to low negative costs associated with Alternative 3, and high negative costs associated with Alternative 4. While Alternative 1 and Alternative 2 appear to be practicable to implement based solely upon the cost/benefit analysis, Alternative 2 is not necessary because there are no adverse effects to EFH from herring fishing gear that need to be minimized as part of an Atlantic herring FMP. Alternative 3 is not practicable because it would not benefit EFH and has some associated economic costs. Alternative 4 is not practicable because it would not benefit EFH and would have high socioeconomic costs. In addition, Alternatives 1 and 2 would have no effects on protected species, while Alternatives 3 and 4 would have only low positive effects.

The no action alternative has been selected as the preferred alternative for two reasons. First, this analysis has determined that the Atlantic herring fishery on EFH for Atlantic herring has little or no adverse effect on herring EFH and none of the alternatives would provide any measurable benefit to EFH for Atlantic herring or any other federally-managed species in the Northeast region. Second, the continuation of status quo conditions within the range of the Atlantic herring fishery already benefit EFH for Atlantic herring and other species that might be affected by gears used in the herring fishery.

The EFH provisions in the MSA state that each FMP shall "minimize to the extent practicable adverse effects on [EFH] such habitat caused by fishing…" The EFH Final Rule at 50 CFR 600.815(a)(2)(iii) provides guidance on evaluating the practicability of management measures:

> "In evaluating the practicability of the identified management measures, Councils should consider the nature and extent of the adverse effect on EFH and the long- and short-term costs and benefits of the potential management measures to EFH, associated fisheries and the nation consistent with national standard 7. In determining whether management measures are practicable, Councils are not required to perform a formal cost/benefit analysis."

A practicability analysis of EFH measures in a fisheries management plan is supposed to weigh the economic and social costs and benefits against the benefits to habitat of EFH protections. However, the ecological costs and benefits are substantially harder to evaluate. In essence, the benefits of specific actions to protect or restore habitat are not all readily quantifiable in the same units as the costs (dollars). It is therefore very difficult to make direct quantitative comparisons and hence give specific quantified answers to the questions of practicability. This is in part due to the uncertainty in the direct effects of fishing gears on habitat function and lack of information on the relationships between habitat function and the productivity of the managed and non-managed species. This uncertainty and lack of information is both a consequence of and exacerbated by the complexities of the ecological relationships and processes involved.

In addition to the practicability analysis the EFH Final Rule (50 CFR 600.815(a)(2)(ii)) states that "…FMPs…should adopt any new measures that are necessary and practicable." The preamble to the EFH Final Rule recognizes that new measures may not be necessary in all cases.

Table 7.40 compares the costs and benefits of the various EFH alternatives and provides the basis for evaluating the practicability of implementing each one. In addition the table specifies whether the implementation of each alternative is necessary to fulfill the MSA requirement to minimize adverse effects to EFH that are more than minimal and temporary in nature. The practicability analysis uses the conclusions from the alternative impact analyses that were described in sections 7.1 – 7.4 for the Atlantic herring resource, EFH, and the human environment. Because the purpose and need of this DEIS is to minimize impacts of the herring fishery on EFH, not on protected species, the practicability analysis does not include impacts to protected species.

This alternative would have some negative social impact on fishing communities and families in the region. Herring mid-water trawlers, which account for most of the fishing activity in Area 1 (A+B), would have to fish on Georges Bank and might use certain ports in the western Gulf of Maine to a lesser extent. There could be an indirect effect caused by vessels landing more herring in ports that are located further away from lobster fishing communities in the Gulf of Maine. This could cause shortages and increased prices in the lobster bait market (this has happened before when herring were scarce in the Gulf of Maine and fishing shifted to Georges Bank). In addition to its direct economic effects, this would have negative social impacts in fishing communities that are dependant on the lobster fishery, especially in Maine. Other possible direct effects include the impact of longer fishing trips (to Georges Bank) on crew satisfaction and family life and increased safety concerns. Some of the negative impacts on mid-water trawl crew members could be offset by the added income and satisfaction of purse seine fishermen who will have more opportunities to fish in Area 1 and added income. If the supply of herring provided by mid-water trawlers who are forced to fish full-time on Georges Bank is reduced, processing plants that rely on herring from these vessels will be impacted economically, possibly causing a loss of jobs and income to plant workers and associated social impacts on families and communities.

Table 7.29. Number of days at sea (DAS) reported by herring mid-water trawl vessels inside habitat closed areas (HCA) during 1997-2002.

	Mid-Water (one boat)		Pair Trawl (two boats)		Total	
Closed Areas	DAS	Percent	DAS	Percent	DAS	Percent
Closed Area 2 (HAPC)	30	7.7	24.5	8.8	54.5	8.2
Closed Area 1 (north)	57	14.7	13.5	4.9	70.5	10.6
Western GOM	254.5	65.7	177.25	63.9	431.8	65.0
Cashes Ledge	2	0.5	18	6.5	20	7.9
Jeffreys Bank	11	2.8	44	15.9	55	8.3
All habitat closed areas	387.2		277.2		664.4	
Entire NE region	3135		2366		5501	
Percent DAS in HCA		12.4		11.7		12.1

Note: Days at sea calculated from NMFS vessel trip reports as duration of individual trips on a 24-hr basis and assigned to ten minute squares (TMS) of latitude and longitude that overlap completely or partially with HCA (see Figure 7.43). DAS shown in table were estimated according to the proportion of each TMS that falls inside each HCA.

Table 7.30. Percent substrate composition of habitat closed areas.

Closed Area	Bedrock	Gravel and Rock	Gravelly Sand	Sand	Muddy Sand	Mud
CA1			34.5	65.5		
CA2			33.0	67.0		
WGOM		10.7	15.7	20.6	16.0	37.0
NLS			4.1	91.7	4.1	
CL	8.7	7.3				84.0
JB		17.3				82.7

Note: Estimates derived from digitized U.S.G.S. sediment maps (Poppe et al. 1989;1994). See Figure 7.47.

Table 7.31. 2003 landings and trips by port of landing and principal gear for mid-water trawl vessels averaging greater than 2,000 pounds per trip.

State of Landing	Port of Landing		Principal Gear Mid-water Trawl	 Pair Trawl	Total
CT	New London	Metric Tons	not reported	not reported	
		Number of Trips	< 3 trips	< 3 trips	
MA	Gloucester	Metric Tons	1,041	18,432	19,474
		Number of Trips	12	170	182
	New Bedford	Metric Tons		17,592	17,592
		Number of Trips		141	141
ME	New Harbor	Metric Tons	11		11
		Number of Trips	6		6
	Portland	Metric Tons	9,243	9,808	19,051
		Number of Trips	157	111	268
	Rockland	Metric Tons		6,074	6,074
		Number of Trips		95	95
	Vinalhaven	Metric Tons		4,445	4,445
		Number of Trips		66	66
NH	Newington (1 pair trip landed in Portsmouth)	Metric Tons	558	5,883	6,441
		Number of Trips	3	55	58
NJ	Cape May	Metric Tons		407	407
		Number of Trips		5	5
RI	North Kingstown	Metric Tons	481		481
		Number of Trips	7		7
	Point Judith	Metric Tons	2,273	not reported	2,273
		Number of Trips	44	< 3 trips	47
	Other	Metric Tons	not reported	2,360	2,360
		Number of Trips	< 3 trips	22	25
Totals		Metric Tons	13,883	65,450	79,333
		Number of Trips	232	669	901

Table 7.32. 2003 mid-water trawl landings and trips in the western Gulf of Maine habitat closure.

State of Landing	Port of Landing		Principal Gear		
			Mid-water Trawl	Pair Trawl	Total
MA	Gloucester	Metric Tons		718	718
		Number of Trips		6	6
	New Bedford	Metric Tons		181	181
		Number of Trips		2	2
ME	Portland	Metric Tons	239	470	709
		Number of Trips	7	6	13
	Rockland	Metric Tons		316	316
		Number of Trips		3	3
	Vinalhaven	Metric Tons		175	175
		Number of Trips		1	1
NH	Newington	Metric Tons	375	428	803
		Number of Trips	1	2	3
Totals		Metric Tons	614	2,288	2,902
		Number of Trips	8	20	28

Table 7.33. 2003 mid-water trawl landings and trips in the Jeffreys Bank habitat closure.

State of Landing	Port of Landing		Principal Gear		
			Mid-water Trawl	Pair Trawl	Total
ME	Portland	Metric Tons	132		132
		Number of Trips	2		2
	Rockland	Metric Tons		345	345
		Number of Trips		5	5
	Vinalhaven	Metric Tons		175	175
		Number of Trips		2	2
NH	Newington	Metric Tons		50	50
		Number of Trips		1	1
Totals		Metric Tons	132	569	701
		Number of Trips	2	8	10

Table 7.34. 2003 mid-water trawl landings and trips in the Nantucket Lightship habitat closure.

State of Landing	Port of Landing		Principal Gear
			Pair Trawl
MA	Gloucester	Metric Tons	494
		Number of Trips	2

Table 7.35. 2003 mid-water trawl landings and trips in Closed Area 1- North closure.

State of Landing	Port of Landing		Principal Gear
			Pair Trawl
MA	Gloucester	Metric Tons	252
		Number of Trips	3
ME	Portland	Metric Tons	58
		Number of Trips	1
Totals		Metric Tons	309
		Number of Trips	4

Table 7.36. 2003 mid-water trawl landings and trips in Closed Area 2.

State of Landing	Port of Landing		Principal Gear		
			Mid-water Trawl	Pair Trawl	Total
MA	New Bedford	Metric Tons		150	150
		Number of Trips		1	1
ME	Portland	Metric Tons	265		265
		Number of Trips	1		1
	Rockland	Metric Tons		175	175
		Number of Trips		1	1
Totals		Metric Tons	265	324	589
		Number of Trips	1	2	3

Table 7.37. 2003 mid-water trawl trips and landings in all habitat closed areas in 2003.

Closed Area		Mid-water Trawl	Pair Trawl	Total
WGOM	Metric Tons	614	2,288	2,902
	Number of Trips	8	20	28
JB	Metric Tons	132	569	701
	Number of Trips	2	8	10
NLS	Metric Tons	0	494	494
	Number of Trips	0	2	2
CA1	Metric Tons	0	309	309
	Number of Trips	0	4	4
CA2	Metric Tons	265	324	589
	Number of Trips	1	2	3
Total	Metric Tons	1,011	3,984	4,995
	Number of Trips	11	36	47

Table 7.38. 2003 landings, trips, and days at sea (in all areas) by port of landing and principal gear for vessels averaging greater than 2,000 pounds per trip in Area 1.

			Principal Gear		
State of Landing	Port of Landing		Mid-water Trawl	Pair Trawl	Total
CT	New London	Metric Tons	126	145	271
		Number of Trips	1	1	2
		Days at Sea	5	3	8
MA	Gloucester	Metric Tons	1041	18311	19352
		Number of Trips	12	168	180
		Days at Sea	26	451	477
	New Bedford	Metric Tons		15396	15396
		Number of Trips		127	127
		Days at Sea		487	487
ME	New Harbor	Metric Tons	11		11
		Number of Trips	6		6
		Days at Sea	6		6
	Portland	Metric Tons	9243	9808	19051
		Number of Trips	157	111	268
		Days at Sea	320	272	592
	Rockland	Metric Tons		6074	6074
		Number of Trips		95	95
		Days at Sea		215	215
	Vinalhaven	Metric Tons		4445	4445
		Number of Trips		66	66
		Days at Sea		159	159
NH	Newington	Metric Tons	558	5753	6311
		Number of Trips	3	54	57
		Days at Sea	5	169	174
	Portsmouth	Metric Tons		131	131
		Number of Trips		1	1
		Days at Sea		2	2
NJ	Cape May	Metric Tons		111	111
		Number of Trips		1	1
		Days at Sea		4	4
RI	Newport	Metric Tons		9	9
		Number of Trips		1	1
		Days at Sea		3	3
	Point Judith	Metric Tons	2273	97	2370
		Number of Trips	44	1	45
		Days at Sea	91	4	95
	Providence	Metric Tons	33	2351	2384
		Number of Trips	1	21	22
		Days at Sea	3	52	55

Table 7.39. 2003 landings, trips, and days at sea (in Area 1) by port of landing and principal gear for vessels averaging greater than 2,000 pounds per trip in Area 1.

State of Landing	Port of Landing		Principal Gear		
			Mid-water Trawl	Pair Trawl	Total
MA	Gloucester	Metric Tons	966	11132	12098
		Number of Trips	11	114	125
		Days at Sea	23	246	269
	New Bedford	Metric Tons		3522	3522
		Number of Trips		26	26
		Days at Sea		81	81
ME	New Harbor	Metric Tons	11		11
		Number of Trips	6		6
		Days at Sea	6		6
	Portland	Metric Tons	6782	8132	14915
		Number of Trips	147	96	243
		Days at Sea	281	215	496
	Rockland	Metric Tons		5517	5517
		Number of Trips		90	90
		Days at Sea		195	195
	Vinalhaven	Metric Tons		3938	3938
		Number of Trips		61	61
		Days at Sea		139	139
NH	Newington	Metric Tons	558	3918	4475
		Number of Trips	3	42	45
		Days at Sea	5	117	122
	Portsmouth	Metric Tons		131	131
		Number of Trips		1	1
		Days at Sea		2	2

Table 7.40. Summary of costs and benefits associated with each alternative and valued ecosystem component and the practicability of each alternative.

	Cost/benefit of Alternative on VEC				Practicability [1]	Necessary to Implement per MSA
	Herring	EFH	Protected Species	Human Environment		
Alt 1	Neutral	Neutral	Neutral	Neutral	Practicable	Implementation not required
Alt 2	Neutral	Neutral	Neutral	Neutral	Practicable	No – impacts do not need to be minimized
Alt 3	Neutral	Neutral	Neutral	Low Negative	Not Practicable	No – impacts do not need to be minimized
Alt 4	Low Positive	Neutral	Low Positive	High Negative	Not Practicable	No – impacts do not need to be minimized

[1] Practicability evaluation does not include impacts to protected species

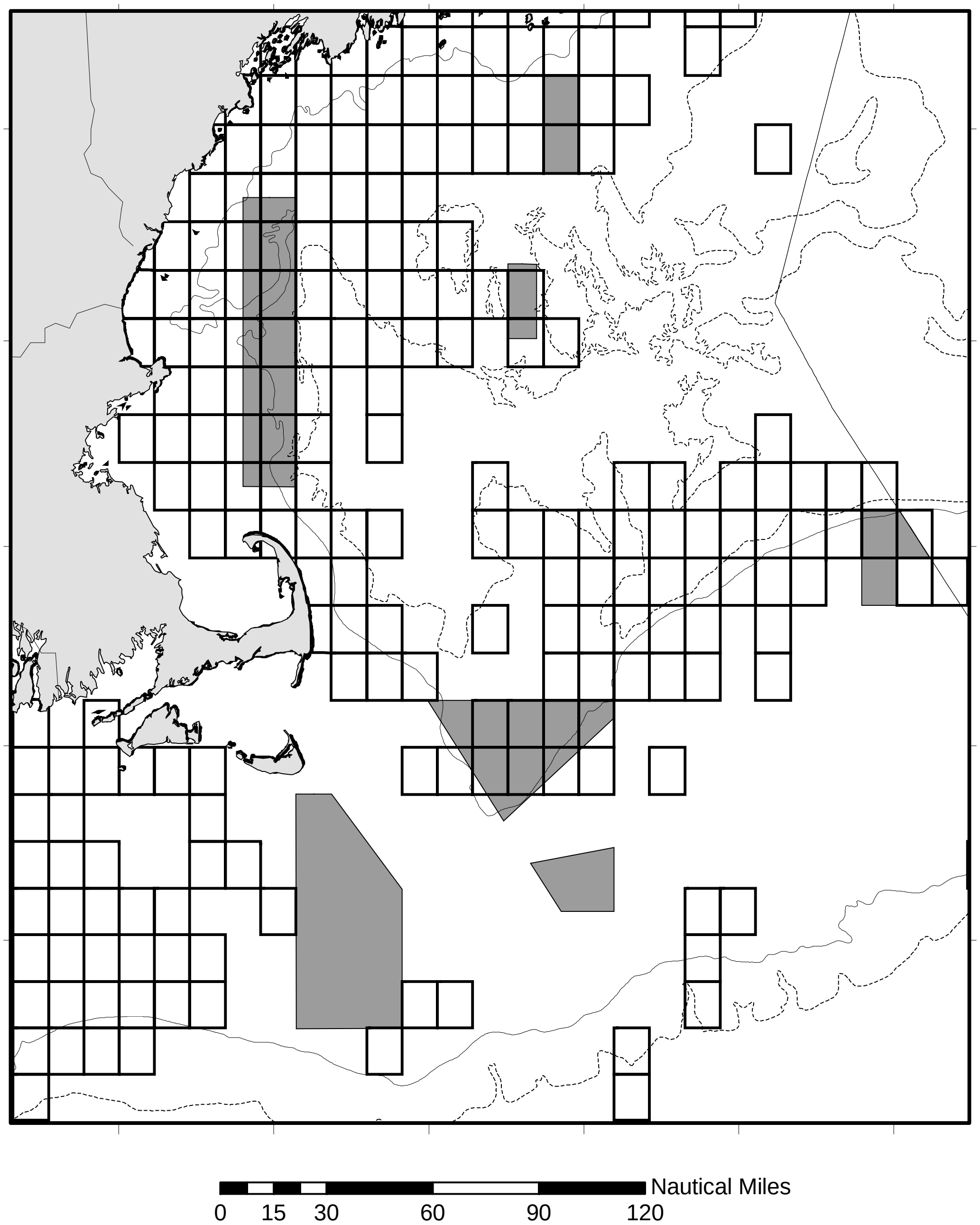

Figure 7.43. Map of habitat closed areas and ten minute squares of latitude and longitude where mid-water trawls were used during 1997-2002.

Figure 7.44. Maps of habitat closed areas showing numbers of days at sea for mid-water trawlers reported by ten minute squares during 1997-2002.

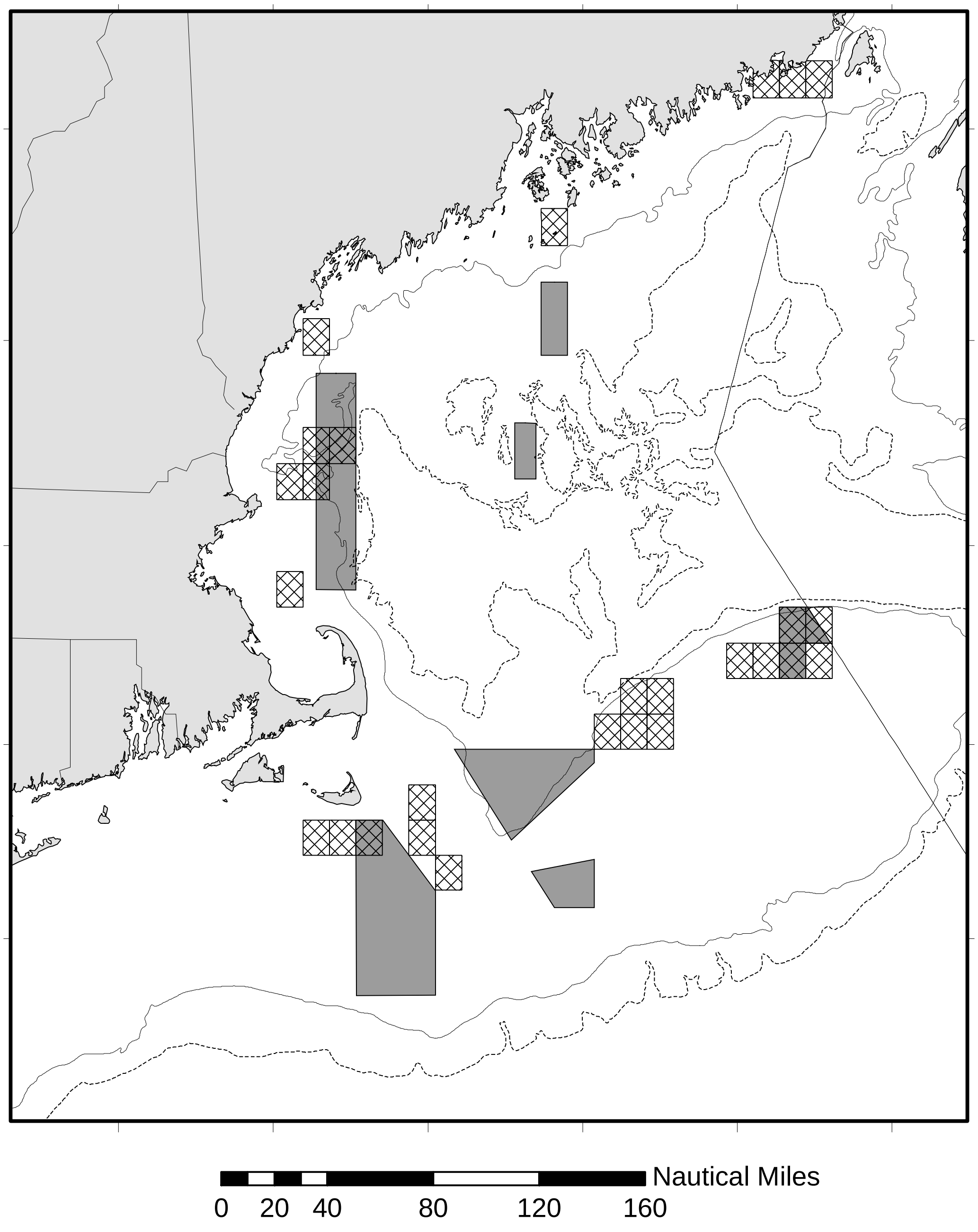

Figure 7.45. Map showing ten minute squares that are designated as EFH for Atlantic herring eggs (TMS in Cape Cod Bay not shown – see Figure 4.17) overlaid on habitat closed areas.

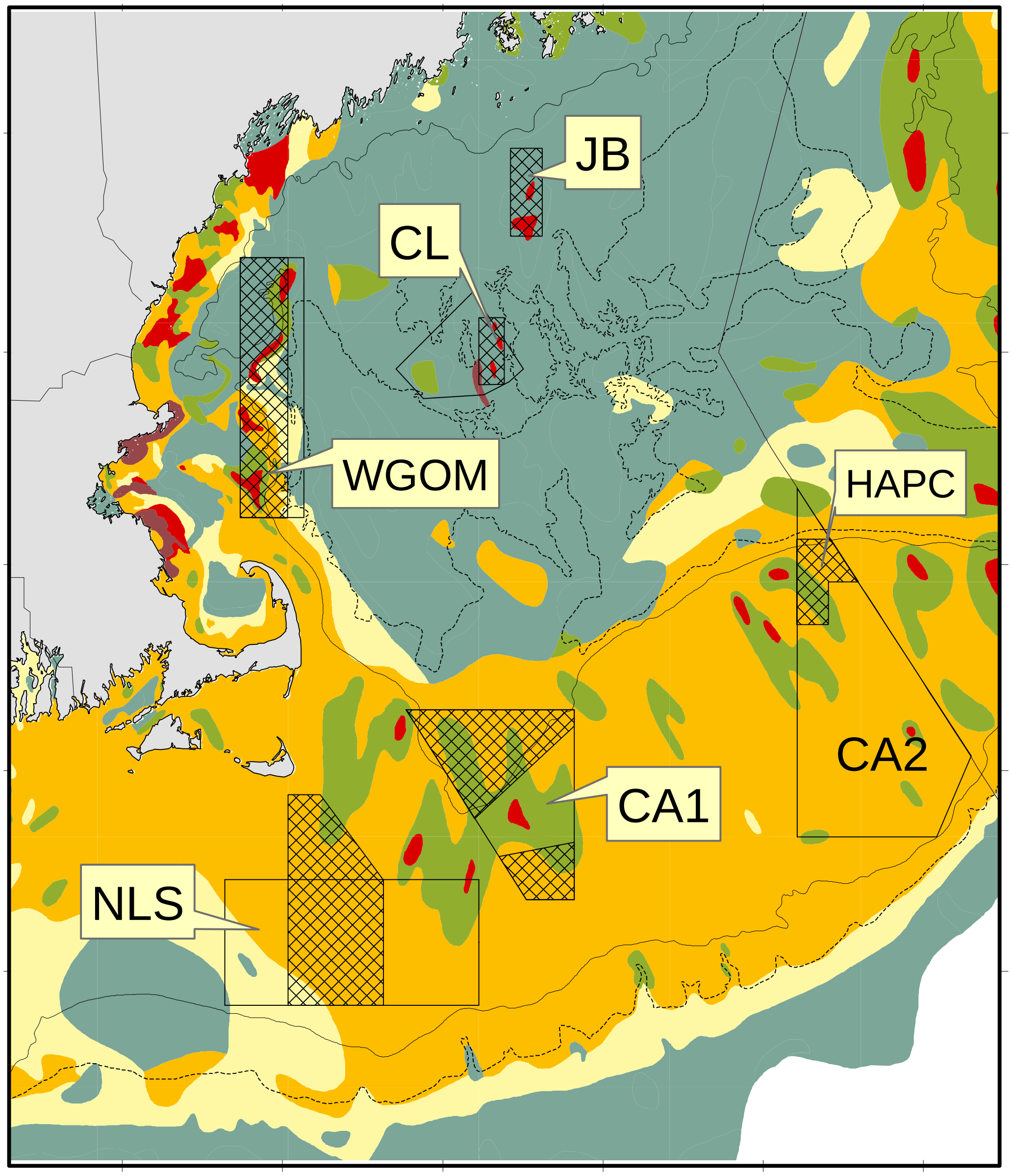

Figure 7.46. Map showing habitat closed areas (hatched) and groundfish closed areas (open) overlaid of substrate types. Key: mud is blue, muddy sand is yellow, orange is sand, green is gravelly sand, red is gravel/rock, and maroon is bedrock.

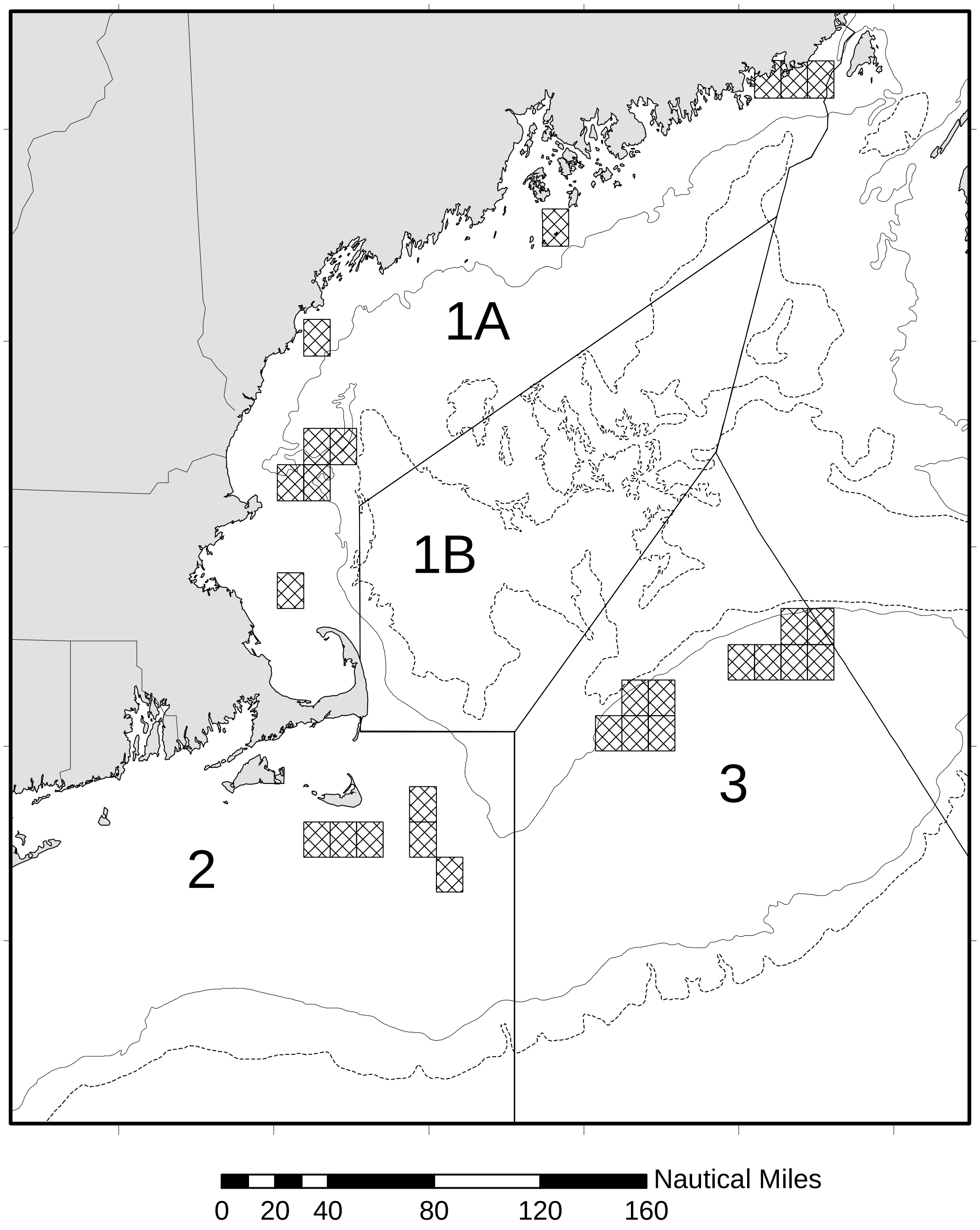

Figure 7.47. Map showing ten minute squares designated as EFH for Atlantic herring eggs (excluding Cape Cod Bay) and herring management areas.

8.0 CUMULATIVE EFFECTS

8.1 Introduction to Cumulative Effects

The term “cumulative effects” is defined in the Council of Environmental Quality’s (CEQ) regulations in 40 CFR Part 1508.7 as:

“The impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions.”

Cumulative effects are linked to incremental actions or policy changes that individually may have small outcomes, but that, in the aggregate and combined with other factors, can result in greater environmental effects on the affected environment. At the same time, the CEQ guidelines recognize that it is not practical to analyze the cumulative effects of an action on the universe. Analyses should focus on those effects that are truly meaningful.

The following analysis will identify and characterize the impact on the environment by the alternatives proposed in this document when analyzed in the context of other past, present, and reasonably foreseeable future actions.

The analysis is generally qualitative in nature because of the limitations of the effects data associated with specific gear over the large geographic areas under consideration. However, NMFS believes that the assessments provided below are reasonable and utilize the best available information.

8.1.1 Valued Ecosystem Components (VECs)

The Valued Ecosystem Components (VECs) are defined in the Affected Environment section of this document (Section 4.0). They are:

The Atlantic Herring Resource
Protected Species
Essential Fish Habitat for:
    Atlantic Herring
    Other Species
The Human Environment
    Fishing Communities
    The Herring Fishery

The baseline conditions against which the cumulative impact analysis is conducted for each identified VEC is defined herein as the current status or condition of each (Section 4.0).

8.2 Spatial and Temporal Boundaries

The geographic area that encompasses the environmental impact area to be considered in the following cumulative effects analysis is defined as the distribution of the Atlantic herring fishery (Section 4.3.1). The physical and biological environment included in the area covered by the herring fishery is described in detail in Sections 4.1 and 4.2 of this document.

The time context of the following analysis are the temporal boundaries created by and described below in the Past, Present and Reasonably Foreseeable Future Actions section. The past actions and current regulatory environment that have impacted or are impacting VECs analyzed in this document are considered factors that have contributed to and resulted in the current condition of each VEC (Section 4.2).

8.3 Past, Present and Reasonably Foreseeable Future Actions

The Affected Environment section of this document, Section 4.0, describes the current condition of each VEC, and provides some background information for each. Key actions that are relevant to the alternatives being considered as part of this DEIS are highlighted in this section.

Past and Present

Although not explicitly described in these discussions, numerous previous actions to protect fish habitat have contributed to existing conditions. For example, fishery management actions that include gear restrictions, time and area closures, and harvest restrictions have been implemented as part of many MSFMCA managed species' FMPs. Atlantic herring management measures were implemented in two related, but separate FMPs in 1999 – one by the federal government (NEFMC 1999) and one by the states (ASMFC 1999). Neither of these FMPs included any measures to protect habitat.

The history of the herring fishery is described in Section 4.3.1. The EFH designations for Atlantic herring were developed as part of an Omnibus Amendment prepared by the New England Fishery Management Council (NEFMC) for all NEFMC managed species. The EFH Omnibus Amendment was approved for Atlantic herring by the Secretary of Commerce on October 27, 1999. The final rule implementing the Atlantic herring FMP to allow for the development of a sustainable Atlantic herring fishery was published on December 11, 2000 (65 FR 77450).

The Habitat Closed Areas established in 2004 under Amendment 13 to the Northeast Multispecies FMP and Amendment 10 to the Atlantic Sea Scallop FMP currently prohibit all bottom-tending mobile gear (Table 8.41) as part of a level 3 closure. Prohibition of midwater trawls in the HCAs is under consideration in this document as Alternative 3. Groundfish closed areas, established in 1994 and 1998 to protect the overfished stocks of cod, haddock and other groundfish species, overlap in some areas with the HCAs.

Past and present actions that have affected valued ecosystem components considered in this DEIS are described below.

Herring Stocks

The history of the herring fishery has been described in Section 4.3.1. The offshore stock has recovered from its collapse in the early 1970's (Section 4.2.2.8) and, overall, the coastal Atlantic herring resource is underutilized. There is more concern for the inshore stock since it receives more fishing pressure.

EFH

Herring EFH has not been adversely affected in more than a minimal or temporary manner by fishing activities because the primary substrates utilized by herring for egg deposition are not affected by disturbance, and the fact that the noise produced by fishing operations only temporarily disperses schools of juvenile and adult herring (Section 5.1). The EFH of other species has been adversely affected by mobile tending bottom gear such as trawls and dredges that temporarily remove, alter or reduce bottom structure and benthic productivity and diversity (see, for example, NRC 2002 and Morgan and Chuenpagdee 2003). Recent changes in fishery management plans (NEFMC 2003 a and b) have included measures to protect bottom habitat from the adverse effects of bottom trawls and dredges. Such measures are anticipated to reduce EFH impacts over the next few years.

Protected Species

The protected species most likely to be affected by the herring fishery are minke whales, harbor seal, gray seals, harbor porpoise and leatherback sea turtles (Section 4.2.3). The populations of the four mammals are generally healthy with notable increases in recent years for the seals. There is a harbor porpoise Take Reduction Plan in place that is anticipated to reduce takes in gillnet gear, which will have a positive effect on the population of this species. Leatherback sea turtles are endangered and have been declining in the Western North Atlantic area.

Human Environment

The economic and social components of the Affected Environment are described in Section 4.3. The Atlantic herring fishery is stable. Landings have declined dramatically since the 1960's but have been variable since then, averaging about 100,000 mt/year, and have not shown a definite trend. There was a shift to more mobile gear (purse seines and mid-water trawls) from fixed gear in the early 1980's. With that change, the domestic fishery transformed from what was primarily a canning industry for human consumption to a fishery that supplies lobster bait and an overseas market for frozen herring. The economic and social structure of the industry has adjusted to these changes and has not changed significantly in recent years.

Based on the above conclusions, impacts of past and present actiond to the VECs considered in this DEIS are neutral for herring and the human environment, neutral for the four protected species of marine mammals and negative for leatherback turtles, neutral for herring EFH, and negative for EFH of other species. These impact evaluations are carried forward into the summary tables for each alternative in Section 8.4.

Table 8.41. Gears allowed and prohibited in year-round groundfish and habitat closed areas.

GROUNDFISH CLOSED AREAS		
	Gear Allowed	Gear Prohibited
WGOM	Pots and traps, Pelagic Longline, pelagic hook and line, harpoon, pelagic midwater trawl, tuna purse seine, clam/quahog dredge, single pelagic gillnet, shrimp trawl, scallop dredge,	Any gear capable of harvesting groundfish
Cashes Ledge	Lobster Pot. Hagfish Pot, Pelagic Longline, pelagic hook and line, harpoon, pelagic midwater trawl, tuna purse seine, scallop dredge	Any gear capable of harvesting groundfish
CAI	Lobster/hagfish pots, pelagic hook and line, pelagic longline, harpoon, tuna purse seine, pelagic midwater trawl	Any gear capable of harvesting groundfish
CA2	Lobster/hagfish pots, pelagic hook and line, pelagic longline, harpoon, tuna purse seine, pelagic midwater trawl, tuna purse seine (outside of the HAPC)	Any gear capable of harvesting groundfish
Nantucket Lightship	Lobster/hagfish pots, pelagic hook and line, pelagic longline, harpoon, tuna purse seine, pelagic midwater trawl, clam/quahog dredge	Any gear capable of harvesting groundfish
HABITAT CLOSED AREAS		
WGOM	Lobster Pot. Hagfish Pot, Pelagic Longline, pelagic hook and line, harpoon, pelagic midwater trawl, tuna purse seine,	Bottom tending mobile gear (trawls, dredges and seines)
Cashes Ledge	L Lobster Pot. Hagfish Pot, Pelagic Longline, pelagic hook and line, harpoon, pelagic midwater trawl, tuna purse seine,	Bottom tending mobile gear
Jeffreys Bank	Lobster Pot. Hagfish Pot, Pelagic Longline, pelagic hook and line, harpoon, pelagic midwater trawl, tuna purse seine,	Bottom tending mobile gear
CAI - North	Lobster Pot. Hagfish Pot, Pelagic Longline, pelagic hook and line, harpoon, pelagic midwater trawl, tuna purse seine,	Bottom tending mobile gear
CAI – South	Lobster Pot. Hagfish Pot, Pelagic Longline, pelagic hook and line, harpoon, pelagic midwater trawl, tuna purse seine,,	Bottom tending mobile gear
CA2	Lobster Pot. Hagfish Pot, Pelagic Longline, pelagic hook and line, harpoon, pelagic midwater trawl, tuna purse seine,	Bottom tending mobile gear
Nantucket Lightship	Lobster Pot. Hagfish Pot, Pelagic Longline, pelagic hook and line, harpoon, pelagic midwater trawl, tuna purse seine,	Bottom tending mobile gear

Reasonably Foreseeable Future Actions

In the spring of 2003, the NEFMC initiated a Habitat Omnibus Amendment that will be considered Amendment 2 to the Atlantic herring FMP. It will also amend the Northeast Multispecies (Amendment 14) the Sea Scallop (Amendment 11), Monkfish (Amendment 3), Skate (Amendment 1), Red Crab (Amendment 1) and Atlantic Salmon (Amendment 1) FMPs. This omnibus amendment will fulfill the five year EFH review and revision requirement specified in 50 CFR Section 600.815(a)(10). Section 2.3 for components of the Habitat Omnibus Amendment. Although it is not know at this time how the recommendations might change fisheries or fisheries management, the intention is to provide additional habitat and species protection where it appears to be needed.

Currently under development is Amendment 1 to the Herring Fishery Management Plan; it may include several of the options being considered in this EIS. While several options under consideration may be similar in this document and the Amendment 1 document, the preferred management measures chosen for implementation may be different, as the Purpose and Need and goals for each action differ. The management measures for consideration in Amendment 1 are currently being refined at the time this DEIS was being written.

Framework 40 to the New England Multispecies Management Plan will consider options that could provide access for several gear types to fish in Groundfish Closed Areas. In addition, the framework will consider changing the boundaries of the Western Gulf of Maine HCA. One option considered in this document is to prevent mid-water trawls from fishing in HCAs.

The Atlantic States Marine Fishery Commission is developing an amendment to herring management in state waters. One aspect of the ASMFC herring management plan that differs from the NMFS management plan is the inclusion of spawning closures (ASMFC 1999). Spawning closures prohibit the exploitation of mature, adult herring in the Gulf of Maine (state waters) during the spawning season (late summer and fall). As this plan is under development, it is not possible to predict any impact on the herring resource or herring EFH that would result from any management measures that may be considered in state waters. Management activities undertaken by the ASMFC are important to the herring resource because inshore (state) waters are important habitat for herring larvae, juvenile herring, and adult herring (Section 4.2.4.1).

It should be noted that all actions taken by the National Marine Fisheries Service under the authorization of the Magnuson-Stevens Fishery Conservation and Management Act are required to analyze the effects of any action upon EFH (Section 303 (a)(7)). For any fishery management plan, the impacts of fishing practices used in the fishery upon EFH of all species is evaluated and, if necessary and practicable, measures are implemented to minimize any adverse effects of the managed fishery on EFH (50 CFR 600.815).

Reasonably forseeable future actions (RFFAs) that may affect valued ecosystem components (VECs) considered in this DEIS are described below.

Herring Stocks

It is anticipated that Amendment 1 to the NEFMC Atlantic Herring FMP and changes to the ASMFC Atlantic Herring FMP will improve the status and sustainability of the inshore Gulf of Maine stock, while at the same encouraging the further utilization of herring in soutern New England and on Georges Bank. The major intent of these two management actions is to create a limited entry program for the Gulf of Maine fishery. The catch in this area is already limited by an annual quota. These amendments, if they are implemented, will limit the amount of fishing effort in the inshore fishery, thereby some ecomomic stability for fishermen and processors who rely on this resource.

EFH
Fishing activities will continue without much, or any, effect to the pelagic or benthic EFH for herring. Impacts to the EFH of other species will be reduced due to the implementation of habitat closed areas and gear restrictions/modifications provided in Amendments 10 and 13 (NEFMC 2003 a and b).

Protected Species
Forthcoming take reduction measures/planning are anticipated for Atlantic Large Whales relative to fixed gear in the near future and relative to trawls in the more distant future. The benefits of any approved measures to large whales should also benefit all five of the species that have been determined to be vulnerable to the Atlantic herring mid-water fishery. The long-line take reduction plan for tuna would reduce the take of sea turtles, including the leatherback.

Human Environment
It is anticipated that the amendments to the NEFMC and ASMFC management plans for Atlantic herring will provide some stability for the inshore fishery and the human communities that rely on it (see conclusions under Herring Stocks).

Based on the above conclusions, impacts of RFFAs to the VECs considered in this DEIS are low positive for herring, protected species, and the human environment, neutral for herring EFH, and low positive for EFH of other species. These impact evaluations are carried forward into the summary tables for each alternative in Section 8.4.

Non-fishing impacts

Non-fishing activities pose a risk to EFH for all species as well as to each herring life stage's EFH. As indicated in the discussion (Section 6.0) and the summary (Table 6.28), most of the impacts are unknown and/or unquantifiable. In general, the greatest potential for adverse impacts to herring and herring EFH occurs in close proximity to the coast where human induced disturbances, like pollution and dredging activities, are occurring. Because inshore and coastal areas support essential egg, larval and juvenile herring habitats (Section 4.2.1), it is likely that the potential threats to inshore and coastal habitats are of greater importance to the species than threats to offshore habitats. It is also likely that these inshore activities will continue to grow in importance in the future. Activities of concern include chemical threats, sewage, changes in water temperature, salinity and dissolved oxygen, suspended sediment and activities that involve dredging and the disposal of dredged material.

Impacts of non-fishing activities on all the VECs that were considered in this DEIS were evaluated to be low to moderately negative.

8.4 Summary of Direct and Indirect Impacts of Alternatives

A summary of the direct and indirect impacts of each alternative on each identified VEC is presented in the following section. The detailed analysis may be found in Section 7.0 of this document.

8.4.1 Alternative 1: No-Action Alternative (Preferred Alternative)

Impacts on Atlantic Herring
No net positive or negative impacts are expected to the Atlantic herring resource. Existing environmental conditions support healthy Atlantic herring stock production (Section 7.1).

Impacts on Protected Species
No net positive or negative impacts are expected to protected species. The status quo condition would continue.

Impacts on Essential Fish Habitat
No net positive or negative impacts are expected to EFH, as the status quo condition would continue. The gear impacts evaluation, Section 5.0, found there to be no adverse impact that is more than minimal or temporary in nature of gear used in the directed herring fishery (purse seines and mid-water trawls) on EFH in for Atlantic herring or for other species in federal waters.

Impacts on Human Environment
No net positive or negative impacts are expected to the Atlantic herring fishery or human communities under the No Action Alternative.

8.4.2 Alternative 2: Modifications to the Regulatory Definition of Mid-water Trawls

Impacts on Atlantic Herring
No net positive or negative impacts are expected to Atlantic Herring if the definition of mid-water trawl gear is modified. The amount of herring removed by fishing will not be impacted, and no stock-level impacts are anticipated.

Impacts on Protected Species
No net positive or negative impact is expected to Protected Species if the definition of mid-water trawl gear is modified. As mid-water trawl gear and purse seine gear does, in fact, occasionally contact the bottom and if the gear definition is modified such that enforcement of zero bottom contact is maintained, there would be no impact to endangered species and marine mammals. There is no indication that any marine mammals or endangered species are more vulnerable to fishing by mid-water trawls that are fishing near the bottom than mid-water trawls that are fishing higher in the water column.

Impacts on Essential Fish Habitat

While the overall impact to herring EFH or EFH for other species would be positive if no bottom contact occurred as a result of herring fishing by mid-water trawl vessels, it has been determined that the impacts of herring mid-water trawling do not need to be minimized, based upon the gear effects evaluation (Section 5). Moreover, EFH for herring larvae, juvenile and adults is pelagic, and would experience no impacts, positive or negative, if the definition of mid-water trawl gear were modified. Species that inhabit sand and mud substrates in the HCA's may benefit if bottom contact by mid-water trawls is reduced, but the benefits are not likely to be measurable.

Impacts on Human Environment

The gear could be fished differently as a result of a change in the regulatory definition of the gear, but this would have little to no effect on the total amount of herring landed or the ability of the fishermen to harvest the quota. There may be a localized effect in southern New England and the mid-Atlantic where herring are more likely to occur near the bottom in the winter. If a modified mid-water trawl definition is effective at reducing or eliminating bottom contact, the efficiency of the winter fishery could be negatively affected, requiring more fishing effort and higher costs to catch the same amount of fish.

8.4.3 Alternative 3: Prohibit the Use of Mid-water Trawls in Habitat Closed Areas

Impacts on Atlantic Herring

No net positive or net negative impacts are expected on Atlantic Herring if mid-water trawling is prohibited in the HCAs. While mid-water trawls would be prohibited from fishing in habitat closed areas, these vessels would be free to pursue herring elsewhere, thereby displacing the 12% of the fishing effort that occurs in HCAs to other areas. The result would be neither a negative nor a positive impact to the herring resource.

Impacts on Protected Species

A minor positive impact is expected to marine mammals and endangered species that inhabit HCAs, as they would be released from any stress or disturbance created by mid-water trawl fishing pressure. However, the net effect to protected species would be neutral, as the fishing effort previously focused on HPAs would be redirected to areas outside the HCAs.

Impacts on Essential Fish Habitat

Prohibiting any use of mid-water trawls in habitat closed areas would ensure that no disturbance of benthic habitats would occur from mid-water trawls, as well as from mobile, bottom-tending gears that are currently prohibited from the HCAs. Approximately 10 % of the area designated as herring egg EFH is inside the HCAs (Section 7.3). However, occasional bottom contact by mid-water trawls is not considered to reduce the functional value of herring egg EFH by any measurable amount. Mid-water trawling does not affect pelagic EFH for Atlantic herring larvae and effects to EFH for juveniles and adults are minimal and temporary (Section 7.3). By prohibiting mid-water trawling in HCAs, there will be no net positive or negative effects relative to the No Action alternative (Alternative 1).

Prohibiting mid-water trawling in HCAs could result in small improvements in the quality of benthic EFH for species and life stages of fish and shellfish that utilize sand and mud substrates in these areas (Section 7.3). In contrast, the prohibition of mid-water trawling in the HCAs would probably lead to an increased use of fixed gear such as lobster pots which could have cumulative negative impacts on EFH for benthic species. Overall, the EFH impacts of this alternative are neutral.

Impacts on Human Environment
No net positive or negative impacts are expected to human communities or the Atlantic herring fishery. Herring mid-water trawlers are highly mobile and, if prohibited from the HCAs, would redirect fishing to areas outside the HCAs (Section 7.3).

8.4.4 Alternative 4: Prohibit the Use of Mid-water Trawl Gear in the Gulf of Maine

Impacts on Atlantic Herring
A positive impact is expected to Atlantic herring if mid-water trawl gear is prohibited in Area 1, since purse seiners are not expected to harvest the amount of fish historically taken by mid-water trawlers (Section 7.4).

Impacts on Protected Species
A positive impact would be experienced by marine mammals and endangered species if mid-water trawls were prohibited from fishing in Area 1. As herring is an important prey species for some marine mammals, the competition for the resource would be reduced, as would the threat of capture or disturbance by mid-water trawl gear, which is known to take marine mammals. Protected species that are vulnerable to capture in herring mid-water trawls in Area 1 during the time of year when the fishery is operating there are harbor seals, harbor porpoises, minke whales, pilot whales, and leatherback turtles.

Impacts on Essential Fish Habitat
Prohibiting mid-water trawling from the Gulf of Maine would remove the threat of occasional disturbance to herring egg EFH from this gear (Section 7.4). However, any minor positive result of prohibiting mid-water trawl gear would be limited to the habitat closed areas, where mobile, bottom-tending gears are prohibited. Mid-water trawling does not affect pelagic EFH for Atlantic herring larvae and effects on EFH for juveniles and adults are minimal and temporary (Section 7.4). Prohibiting mid-water trawling in Area 1 could result in small improvements in the quality of benthic EFH for species and life stages of fish and shellfish that inhabit the WGOM, JB, and CL HCAs, especially those that utilize sand and mud substrates, but not in the rest of Area 1 that is adversely affected by bottom trawls and dredges (Section 7.3).

Impacts on Human Environment
This alternative would have a significant negative economic impact on fishing communities in Area 1 and on the Atlantic herring fishery. In 2003, 64% of the herring catch came from Area 1 and mid-water trawl gear harvested 70% of that amount (Section 7.4). In order to access the fishery in Area 1 during the spring and summer (when a large percentage of the herring resource inhabits Area 1), mid-water trawl fishermen would need to either refit their vessels to fish with purse seines or travel to Areas 2 or 3. Some of the negative impacts would be offset by the added opportunities for purse seiners to fish in Area 1. Indirect effects to fishing communities in along the western Gulf of Maine coast could include shortages or price changes in lobster bait,

socioeconomic impacts on fishing communities, and changes in the supply to certain processing plants.

8.5 Cumulative Effects of Alternatives

The overall cumulative effects of each alternative were determined by comparing the directionality and weight of each impact. Thus, for example, a low positive impact for RFFAs for any given VEC and alternative would balance out a low positive impact for non-fishing activities, producing an overall neutral cumulative impact, or a neutral and a high negatve impact would produce a low negative impact. For each alternative, the impact rankings for past and present, reasonably-forseeable future actions and non-fishing activities are the same. The only impacts which could change from one alternative to the next are the direct and indirect impacts for each VEC. The cumulative impacts for each alternative are summarized for each VEC in Table 8.45 to Table 8.45and for all VECs in Table 8.46.

8.5.1 Alternative 1: No-Action Alternative (Preferred Alternative)

The No Action alternative represents the status quo condition, and relies on existing EFH-protection provisions of fishery management measures such as closed areas and reductions in fishing effort by mobile, bottom-tending gears that would remain in place if none of the other proposed management measures are implemented. Herring mid-water trawls occasionally contact the bottom and do not adversely affect EFH for Atlantic herring or for any other MSA-managed species in the Northeast region in more than a minimal or temporary nature (Section 5.0). The herring stock is considered healthy (Section 4.2.2.6). The gear effects evaluation for the herring fishery (Section 5) indicates that the threshold for action by the agency has not been reached, and that the need to minimize the impacts of the herring fishery on EFH is not necessary. In addition, this alternative has no direct/indirect impacts to protected species, the Atlantic herring resource, or the human environment that have not been considered as part of past actions and that are significant or outside the status quo condition.

These direct and indirect impacts, in combination with the effects of the past/present, RFFAs, and non-fishing activities, result in neutral cumulative impacts for herring and the human environment. For protected species, cumulative impacts are neutral for marine mammals and low negative for leatherback turtles. This negative effect on turtles is primarily driven by past and present fishing and non-fishing activities and not by the direct/indirect impacts of the No Action Alternative. There are no cumulative impacts on herring EFH. The low negative cumulative effects on other species EFH is again driven by past and present fishing and non-fishing activities and not by the direct/indirect impacts of the No Action Alternative.

Table 8.42. Summary of Impacts to VECs of Alternative 1

	Herring	Protected Species	EFH	Human Environment
Direct/Indirect	Neutral	Neutral	Neutral	Neutral
Past & Present	Neutral	Mammals: Neutral Leatherback: Negative	Herring EFH: Neutral Other Species EFH: Negative	Neutral
RFFAs	Low Positive	Low Positive	Herring EFH: Neutral Other Species EFH: Low Positive	Low Positive
Non-Fishing	Low-Moderately Negative	Low-Moderately Negative	Low-Moderately Negative	Low-Moderately Negative
Cumulative	Neutral	Mammals: Neutral Leatherback: Low Negative	Herring EFH: Neutral Other Species EFH: Low Negative	Neutral

8.5.2 Alternative 2: Modifications to the Regulatory Definition of Mid-water Trawls

The options for a revised definition of mid-water trawl gear that are described in Section 3.2 are intended to increase the effectiveness of regulations that prohibit bottom contact by this gear. While the options provided will make it easier to detect if nets are in compliance with the regulation, it is uncertain if any of the options will succeed in eliminating all bottom contact that occurs during the fishing operations of mid-water trawls. It is assumed in this analysis that a modified definition will reduce the amount of bottom contact to some unknown degree, but not completely. Habitat benefits would be minimal since mid-water trawls only contact bottom habitats occasionally (Section 4.3.1.2). Based upon information provided in Section 4.3.3, virtually the entirety of the Gulf of Maine and the areas designated as EFH for herring and other species experience some disturbance by bottom tending mobile fishing gear. The benefits to EFH that would be realized by modifying the regulatory definition of midwater trawl gear are insignificant when compared to the No Action Alternative.

These direct and indirect impacts, in combination with the effects of the past/present, RFFAs, and non-fishing activities, result in neutral cumulative impacts for herring and the human environment. For protected species, cumulative impacts are neutral for marine mammals and low negative for leatherback turtles. This negative effect on turtles is primarily driven by past and present fishing and non-fishing activities and not by the direct/indirect impacts of the No Action Alternative. There are no cumulative impacts on herring EFH. The low negative cumulative effects on other species EFH is again driven by past and present fishing and non-fishing activities and not by the direct/indirect impacts of this alternative.

Table 8.43. Summary of Impacts to VECs of Alternative 2

	Herring	Protected Species	EFH	Human Environment
Direct/Indirect	Neutral	Neutral	Neutral	Neutral
Past & Present	Neutral	Mammals: Neutral Leatherback: Negative	Herring EFH: Neutral Other Species EFH: Negative	Neutral
RFFAs	Low Positive	Low Positive	Herring EFH: Neutral Other Species EFH: Low Positive	Low Positive
Non-Fishing	Low-Moderately Negative	Low-Moderately Negative	Low-Moderately Negative	Low-Moderately Negative
Cumulative	Neutral	Mammals: Neutral Leatherback: Low Negative	Herring EFH: Neutral Other Species EFH: Low Negative	Neutral

8.5.3 Alternative 3: Prohibit the Use of Mid-water Trawls in Habitat Closed Areas

The intent of the HCAs was to minimize adverse impacts of fishing on benthic EFH. Only bottom-tending mobile gears have been shown to have adverse effects on EFH that are more than minimal and temporary in nature and therefore have been prohibited from HCAs (NEFMC 2003 a and b). Because mid-water trawl gear is pelagic gear and is not used to catch groundfish, mid-water trawls are currently allowed in the groundfish and habitat closed areas (Table 8.41).

The elimination of mid-water trawlers from the closed areas would likely lead to an increased use of fixed gear, such as lobster pots, in the HCAs since there would no longer be any mobile gear interference with the use of fixed gear. Even though individual pots do not significantly affect the quality of benthic marine habitats, the collective effect of setting and hauling large numbers of pots could easily exceed the effects of mid-water trawls. Overall, therefore, this alternative could have a negative impact on EFH for other species inside the habitat closed areas. Any benefit to EFH derived from banning access to HCAs by mid-water trawls would be balanced by adverse impacts from other gear types or increased activity outside the HCAs.
In addition, the upcoming Habitat Omnibus Amendment will revisit the need to modify the boundaries of the HCAs.

These direct and indirect impacts, in combination with the effects of the past/present, RFFAs, and non-fishing activities, result in neutral cumulative impacts for herring. For this alternative, the low negative direct/indirect impact contributed to the low to moderately negative cumulative effect on the human environment. As with the previous two alternatives, cumulative impacts for protected species are neutral for marine mammals and low negative for leatherback turtles. This negative effect on turtles is primarily driven by past and present fishing and non-fishing activities and not by the direct/indirect impacts of the No Action Alternative. As well, there are no cumulative impacts on herring EFH. The low negative cumulative effects on other species EFH is again driven by past and present fishing and non-fishing activities and not by the direct/indirect impacts of this alternative.

Table 8.44. Summary of Impacts to VECs of Alternative 3

	Herring	Protected Species	EFH	Human Environment
Direct/Indirect	Neutral	Neutral	Neutral	Low Negative
Past & Present	Neutral	Mammals: Neutral Leatherback: Negative	Herring EFH: Neutral Other Species EFH: Negative	Neutral
RFFAs	Low Positive	Low Positive	Herring EFH: Neutral Other Species EFH: Low Positive	Low Positive
Non-Fishing	Low-Moderately Negative	Low-Moderately Negative	Low-Moderately Negative	Low-Moderately Negative
Cumulative	Neutral	Mammals: Neutral Leatherback: Low Negative	Herring EFH: Neutral Other Species EFH: Low Negative	Low-Moderately Negative

8.5.4 Alternative 4: Prohibit the Use of Mid-water Trawls in the Gulf of Maine

Prohibiting the use of mid-water trawl gear in the Gulf of Maine is the most restrictive of the alternatives considered in this document. Implementing this alternative would generate both the greatest costs and greatest benefits relative to the other three alternatives. Positive benefits include decreased interaction of mid-water trawl gear with protected species that inhabit the Gulf of Maine, release of herring resource from fishing pressure from mid-water trawls (which account for the majority of the catch in Area 1), and elimination of any bottom contact or disturbance to EFH created by mid-water trawls. However, since bottom contact by this gear is occasional and the effects on benthic habitats are no more than minimal and temporary in nature, there are no expected benefits of this alternative to herring egg EFH.

The western Gulf of Maine is a traditional area for herring fishing and historically accounts for the majority of herring landed in the fishery. Costs associated with this alternative include the loss of revenue to mid-water trawlers and associated indirect costs, such as shortages in the supply of herring for lobster bait (Section 4.3.1.3). Prohibiting the use of mid-water trawl gear in the Gulf of Maine would create the greatest economic hardship to herring fishery participants that fish with single and pair mid-water trawls. Vessels that use mid-water trawl gear will incur costs to steam to fishing locations beyond Area 1. Revenues will decrease because mid-water trawlers will lose access to nearly half the resource if they are not able to make it up by fishing in other areas. An additional factor is the cost to convert from mid-water trawling to purse seining in order to maintain access to Area 1.

Low positive direct and indirect impacts, in combination with the effects of the past/present, RFFAs, and non-fishing activities, result in low positive cumulative impacts for herring. Likewise, the prohibition of mid-water trawling in Area 1 would provide a larger forage base and reduce gear interactions for the affected species of marine mammals. Therefore, direct/indirect impacts are low positive for this alternative. This, combined with the exogenous actions, produce low positive cumulative effects for marine mammals, but low negative effects for leatherbacks because they are not often caught in herring gear and they don’t feed on herring. The high negative direct/indirect impact on the human environment, combined with the past/present, RFFAs, and non-fishing activities, produced a moderately negative cumulative effect. As with previous alternatives, there are no cumulative impacts on herring EFH. The low negative cumulative effects on other species EFH is again driven by past and present fishing and non-fishing activities and not by the direct/indirect impacts of this alternative.

Table 8.45. Summary of Impacts to VECs of Alternative 4

	Herring	Protected Species	EFH	Human Environment
Direct/Indirect	Low Positive	Low Positive	Neutral	High Negative
Past & Present	Neutral	Mammals: Neutral Leatherback: Negative	Herring EFH: Neutral Other Species EFH: Negative	Neutral
RFFAs	Low Positive	Low Positive	Herring EFH: Neutral Other Species EFH: Low Positive	Low Positive
Non-Fishing	Low-Moderately Negative	Low-Moderately Negative	Low-Moderately Negative	Low-Moderately Negative
Cumulative	Low Positive	Mammals: Low Positive Leatherback: Low Negative	Herring EFH: Neutral Other Species EFH: Low Negative	Moderately-High Negative

8.5.6 Summary of Cumulative Effects

The valued environmental component that is the focus of this document is EFH. The purpose of this DEIS is to evaluate the potential adverse effects of the Atlantic herring fishery on EFH and to minimize to the extent necessary and practicable any adverse effect of Atlantic herring fishing on EFH which is more than minimal and not temporary in nature.

Table 8.46. Comparison of Cumulative Impacts of Alternatives

	Herring	Protected Species	EFH	Human Environment
Alternative 1	Neutral	Mammals: Neutral Leatherback: Low Negative	Herring EFH: Neutral Other Species EFH: Low Negative	Neutral
Alternative 2	Neutral	Mammals: Neutral Leatherback: Low Negative	Herring EFH: Neutral Other Species EFH: Low Negative	Neutral
Alternative 3	Neutral	Mammals: Neutral Leatherback: Low Negative	Herring EFH: Neutral Other Species EFH: Low Negative	Low – Moderately Negative
Alternative 4	Low Positive	Low Positive	Herring EFH: Neutral Other Species EFH: Low Negative	Moderately - High Negative

These analyses support the conclusion that the impacts of the Atlantic herring fishery are minimal and temporary in nature and that measures are not necessary to minimize any impacts of fishing by gears used in the Atlantic herring fishery. The negative cumulative impacts associated with the human environment for alternatives 3 and 4 support the determination that these two alternatives are not preferred. Furthermore, the cumulative effects for Alternative 2 are indistinguishable from the No Action Alternative and there are no additional benefits to EFH.

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10.0 LIST OF PREPARERS

POINT OF CONTACT

David Stevenson	Habitat Conservation Division National Marine Fisheries Service One Blackburn Drive Gloucester, MA 01930 (978) 281-3118

LIST OF PREPARERS

Christopher Boelke	Habitat Conservation Division National Marine Fisheries Service One Blackburn Drive Gloucester, MA 01930
Louis A. Chiarella	Habitat Conservation Division National Marine Fisheries Service One Blackburn Drive Gloucester, MA 01930
Sarah Gurtman	Regulatory Effectiveness Group National Marine Fisheries Service One Blackburn Drive Gloucester, MA 01930
Michael Johnson	Habitat Conservation Division National Marine Fisheries Service One Blackburn Drive Gloucester, MA 01930
Andrew Kitts	Social Sciences Branch National Marine Fisheries Service 166 Water Street Woods Hole, MA 02543
Patricia Pinto da Silva	Social Sciences Branch National Marine Fisheries Service 166 Water Street Woods Hole, MA 02543
Marcy Scott	Habitat Conservation Division National Marine Fisheries Service One Blackburn Drive

Gloucester, MA 01930

David Tomey
NEPA Coordinator
Northeast Region
National Marine Fisheries Service
One Blackburn Drive
Gloucester, MA 01930

11.0 LIST OF REVIEWERS

This DEIS has been sent to the following individuals and organizations for review:

NEFMC:

Paul Howard, NEFMC, Newburyport, MA
Leslie-Ann McGee, NEFMC staff, Woods Hole, MA
Lori Steele, NEFMC staff, Newburyport, MA

NEFMC Habitat Committee:

Sally McGee, Mystic CT
Thomas Hill, Gloucester, MA
Ralph Boragine, Charlestown, RI
John Nelson, Durham, NH
Dana Rice, Birch Harbor, ME
John Williamson, Kennebunk, ME
Jim Lovgren, Brick, NJ

NEFMC Habitat Advisors:

Vincent Balzano, Saco, ME
Barbara Bragdon, Dennisport, MA
Harold Brown, Wiscasset, ME
Benjamin Cowie-Haskell, Scituate, MA
John Gates, Kingston, RI
CDR Greg Hitchen Boston, MA
Les Kaufman, Boston, MA
David Marciano, Beverly MA
Paul Parker, Chatham, MA
Maggie Raymond, So. Berwick, ME
Phil Rhule, No. Kningstown, RI
Russ Sherman, Gloucester, MA
Sima Freierman, Montauk, NY
Geoff Smith, Portland, ME
Ronald Smolowitz, E. Flamouth, MA
Richard Taylor, Gloucester, MA
Dave Wallace, Cambridge, MD
Stephen Welch, Hanover, MA
Bill Wells, Yorktown, VA
Bob Westcott, Wakefield, RI
Jon Williams, Westport, ME
Chris Zeman, River Vale, NJ

As part of the review process for consistency with applicable laws such as CZMA and ESA, the DEIS has been distributed to the following:

Kathleen Leydon, Maine Coastal Program
David Hartman, New Hampshire Coastal Program
Tom Skinner, Massachusetts Coastal Zone Management
Grover Fugate, Rhode Island Coastal Resources Council
Tom Oullette, Connecticut Office of Long Island Sound Programs
George Stafford, New York Division of Coastal Resources
Lawrence Totok, Hew Jersey Division of Coastal Resources
Nicholas Di Pasquale, Deleware DNREC
Gwynne Schultz, Maryland Coastal Zone Management Division
Laura McKay, Virginia Coastal Resources Management Program
Donna Moffitt, North Carolina Division of Coastal Management
E. James Tabor, Pennsylvania Department of Envirnmental Protection
Daniel Furlong, Mid-Atlantic Fishery Management Council
Robert Mahood, South Atlantic Fishery Management Council
Vincent O'Shea, Atlantic States Marine Fisheries Commission
US Coast Guard, Boston, MA
US Coast Guard, Portsmouth NH
Marine Mammal Commission
Office of Marine Conservation (US State Department), Washington, DC.

A Notice of Availability of the DEIS is also published in the *Federal Register*. At that time any member of the public may contact the NMFS Northeast Regional Office and request a copy of the DEIS for their review. The DEIS will also be available on the NMFS Northeast Regional Office website at: http://www.nero.noaa.gov/nero/.