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OMNIBUS ESSENTIAL FISH HABITAT AMENDMENT 2
FINAL ENVIRONMENTAL IMPACT STATEMENT

Appendix A: EFH designation methodologies

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2.0 Introduction

The New England and Mid-Atlantic Fishery Management Councils are responsible for managing the fishery resources within federal waters of the Greater Atlantic (Maine to North Carolina). Currently, the New England Fishery Management Council manages fisheries which target 28 species that are managed under seven different fishery management plans (FMPs) (Table 1):

Table 1 – List of species under management by the New England Fishery Management Council

FMP	Species – scientific name	Common names
Multispecies	*Anarhichas lupus*	Atlantic wolffish, Wolf eel
Multispecies	*Gadus morhua*	Atlantic cod (official), rock cod
Multispecies	*Glyptocephalus cynoglossus*	witch flounder (official), gray sole, Craig fluke, pole flounder
Multispecies	*Hippoglossus hippoglossus*	Atlantic halibut (official)
Multispecies	*Hippoglossoides platessoides*	American plaice (official), American dab, Canadian plaice, long rough dab
Multispecies	*Pleuronectes ferruginea*	yellowtail flounder (official), rusty flounder
Multispecies	*Macrozoarces americanus*	ocean pout (official), eelpout, Congo eel, muttonfish
Multispecies	*Melanogrammus aeglefinus*	haddock (official)
Multispecies	*Merluccius bilinearis*	Whiting, silver hake (official), New England hake
Multispecies	*Pollachius virens*	pollock (official), Boston bluefish, coalfish, green cod
Multispecies	*Pseudopleuronectes americanus*	winter flounder (official), blackback, Georges Bank flounder, lemon sole, sole, flatfish, rough flounder, mud dab, black flounder
Multispecies	*Scophthalmus aquosus*	windowpane flounder (official), sand flounder, spotted flounder, New York plaice, sand dab, spotted turbot
Multispecies	*Sebastes fasciatus.*	Acadian redfish (official), redfish, ocean perch, Labrador redfish, beaked redfish
Multispecies	*Urophycis chuss*	red hake (official), squirrel hake, ling, blue hake
Multispecies	*Urophycis tenuis*	white hake (official), Boston hake, black hake, mud hake
Multispecies	*Merluccius albidus*	Offshore hake (official), Blackeye whiting
Monkfish	*Lophius americanus*	monkfish (official), American goosefish, angler, allmouth, molligut, fishing frog
Sea Scallop	*Placopecten magellanicus*	Atlantic sea scallop (official), giant scallop, smooth scallop, deep sea scallop, Digby scallop, Ocean scallop
Skates	*Amblyraja radiata*	Thorny skate (official), Mud skate, Starry skate, Spanish skate
Skates	*Dipturus laevis*	Barndoor skate (official)
Skates	*Leucoraja erinacea*	Little skate (official), Common skate, Summer skate, Hedgehog skate, Tobacco Box skate
Skates	*Leucoraja garmani*	Rosette skate (official), Leopard skate
Skates	*Malacoraja senta*	Smooth skate (official), Smooth-tailed skate, Prickly skate
Skates	*Leucoraja ocellata*	Winter skate (official), Big skate, Spotted skate, Eyed skate
Skates	*Raja eglanteria*	Clearnose skate (official), Brier skate

FMP	Species – scientific name	Common names
Deep-Sea Red Crab	*Chaceon quinquedens*	Deep-Sea red crab (official)
Atlantic Herring	*Clupea harengus*	Atlantic sea herring (official), Labrador herring, sardine, sperling, brit
Atlantic Salmon	*Salmo salar*	Atlantic salmon (official), sea salmon, silver salmon, black salmon

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

Life stages are unique developmental periods and for the purposes of this action are defined as follows:

1. Egg stage – The life history stage of an animal that occurs after reproduction and refers to the developing embryo, its food store, and sometimes jelly or albumen, all surrounded by an outer shell or membrane. Occurs before the *larval* or *juvenile stage*.
2. Larval stage – The first stage of development after hatching from the *egg* for many fishes and invertebrates. This life stage looks fundamentally different than the *juvenile* and *adult stages*, and is incapable of reproduction; it must undergo metamorphosis into the juvenile or adult shape or form.
3. Juvenile stage – The life history stage of an animal that comes between the *egg* or *larval stage* and the *adult stage*; juveniles are considered immature in the sense that they are not yet capable of reproducing, yet they differ from the larval stage because they look like smaller versions of the adults. Young-of-the-year juveniles are juveniles less than one year old.
4. Adult stage – In vertebrates, the life history stage where the animal is capable of reproducing. Spawning adults are adults that are currently producing eggs.

This appendix describes the methods and data used to develop each major EFH designation alternative for all 28 species managed by the NEFMC. Because different methods were used to develop EFH designation alternatives for deep-sea red crab and Atlantic salmon, the methods for these species are described separately.

3.0 Development of the No Action designations

The 1998 Omnibus EFH Amendment 1 (NEFMC 1998) established EFH designations for 18 species managed by the New England Fishery Management Council. Designations for offshore hake, deep sea red crab, seven species of skate, and Atlantic wolffish were completed in subsequent management plans (NEFMC 1999; NEFMC 2002; NEFMC 2003, NEFMC 2009).

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

The map designations of essential fish habitat identify the geographic extent of area within which certain types of habitat (as defined in the corresponding text description) are considered EFH. Several sources of distribution and abundance data were used to develop the original EFH maps.[1] The NEFSC bottom trawl survey (1963 - 1997) and the NEFSC Marine Resources Monitoring, Assessment and Prediction (MARMAP) ichthyoplankton survey (1977 - 1987) provided the best available information on the distribution and relative abundance of Council-managed species in offshore waters. The bottom trawl survey was used for juveniles and adults, and the MARMAP survey was used for eggs and larvae.

The Council used other sources of information to map EFH in inshore areas, including the Massachusetts inshore trawl survey (1978 - 1997), the Connecticut Long Island Sound trawl survey (1990 - 1996), and information collected for a number of coastal bays and estuaries by NOAA's Estuarine Living Marine Resources (ELMR) program. Data on the distribution and relative abundance of fish in other inshore areas were not available in a timely enough manner to be used. The Council also considered information provided by the fishing industry, as well as several sources of historical information. Information on the distribution and abundance of sea scallops was obtained primarily from the NEFSC sea scallop survey (1982 - 1997) and from representatives of the scallop fishing industry. Information on the range and distribution of Atlantic salmon was obtained primarily from the available literature.

Detailed descriptions of the surveys and databases used by the Council to make the original EFH designations, including the sampling protocols and methods, are provided in Appendix C of the 1998 EFH Omnibus Amendment. A detailed discussion of the limitations associated with using these data and information sources as the basis for designating EFH is provided in Appendix D of the 1998 EFH Omnibus Amendment.

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

Four categories or levels of information needed to describe and identify EFH were defined in the Interim Final Rule.[2] They were:

- Level 1: Presence / absence data are available for portions of the range of the species. At this level, only presence / absence data are available to describe the distribution of a species (or life history stage) in relation to potential habitats. In the event that distribution data are available for only portions of the geographic area occupied by a particular life history stage of a species, EFH can be inferred on the basis of distributions among habitats where the species has been found and on information about its habitat requirements and behavior.
- Level 2: Habitat-related densities are available. At this level, quantitative data (i.e., density or relative abundance) are available for the habitats occupied by a species of life history stage. Density data should reflect habitat utilization, and the degree that a habitat is utilized is assumed to be indicative of habitat value. When assessing habitat value on the basis of fish densities in this manner, temporal changes in habitat availability and utilization should be considered.
- Level 3: Growth, reproduction, and survival rates within habitats are available. At this level, data are available on habitat-related growth, reproduction, and/or survival by life history stage. The habitats contributing the most to productivity should be those that support the highest growth, reproduction, and survival of the species (or life history stage).
- Level 4: Production rates by habitat are available. At this level, data are available that directly relate the production rates of a species of life history stage to habitat type, quantity, and location. Essential habitats are those necessary to maintain fish production consistent with a sustainable fishery and the managed species' contribution to a healthy ecosystem.

For most species, the best information consisted of relative abundance and distribution data (Level 2) and presence / absence data (Level 1). In a few cases, some Level 3 information was available, but there was then (and is now) a lack of detailed and scientific information relating fish productivity to habitat type, quantity, quality and location. Guidance provided in the Interim Final Rule suggested that when working only with Level 1 and Level 2 data, "the degree that a habitat is utilized is assumed to be indicative of habitat value." In other words, if all that is known is where the fish tend to be in relatively high concentrations, these areas are assumed to be the essential fish habitat. This is the approach the Council adopted in 1998 to define the spatial extent of EFH.

3.1 ELMR data

Used by the Council in 1998 as the primary source of information on species distribution and abundance in the bays and estuaries of New England and the Mid-Atlantic, NOAA's Estuarine Living Marine Resources (ELMR) program was conducted jointly by the Strategic Environmental Assessments (SEA) Division of NOAA's Office of Ocean Resources Conservation and Assessment (ORCA), NEFSC, and other agencies and institutions. The goal of

[2] The four levels of information are described a little differently in the Final EFH Rule, which went into effect in January 2002, but the distinctions are essentially the same as they were in the Interim Final Rule, which was in effect when the original EFH designations were developed.

this program was to develop a comprehensive information base on the life history, relative abundance and distribution of fishes and invertebrates in estuaries throughout the nation. The nationwide ELMR database was completed in 1994, and includes information for 135 species found in 122 estuaries and coastal embayments. The Jury et al. (1994) report summarizes information on the distribution and abundance of 58 fish and invertebrate species in 17 North Atlantic estuaries. The Stone et al. (1994) report summarizes information on the distribution and abundance of 61 fish and invertebrate species in 14 Mid-Atlantic estuaries.

The ELMR program was developed to integrate fragments of information on many species into a useful, comprehensive and consistent format. The framework employed for the ELMR program enabled a consistent compilation and organization of all available data on the distribution and abundance of fishes and invertebrates in the principal estuaries and embayments in the Northeast region. Thirty-one bays and estuaries (see are included in the Jury et al. (1994) and Stone et al. (1994) reports:

Passamaquoddy Bay
Englishman/Machias Bays
Narraguagus Bay
Blue Hill Bay
Penobscot Bay
Muscongus Bay
Damariscotta River
Sheepscot River
Kennebec/Androscoggin Rivers
Casco Bay
Saco River
Wells Harbor
Great Bay
Merrimack River
Massachusetts Bay
Boston Harbor
Cape Cod Bay
Waquoit Bay
Buzzards Bay
Narragansett Bay
Connecticut River
Gardiners Bay
Long Island Sound
Great South Bay
Hudson River/Raritan Bay
Barnegat Bay
New Jersey Inland Bays
Delaware Bay
Delaware Inland Bays
Chincoteague Bay
Chesapeake Bay

Species distribution and abundance information was compiled for egg, larval, juvenile, adult, and spawning adult life stages by month and salinity zone for these locations by conducting literature searches and examining published and unpublished data sets. Salinity zones were defined as tidal fresh (0-0.5 ppt), mixing (0.5-25 ppt), and seawater (>25 ppt) and maps showing the spatial extent of each zone in each location were produced (see NOAA 1985). To complement the information from these quantitative studies, regional, state, and local biologists were interviewed for their knowledge of estuary/species-specific spatial and temporal distribution patterns and relative abundance levels based upon their species expertise and research experience. More than 72 scientists and managers at 33 institutions were consulted (the ELMR reports list the individuals and their affiliations). The final level of relative abundance assigned to a particular species was determined from the available data and expert review. To rank relative abundance, ELMR staff used the following categories:

- *Not present* -- species or life history stage not found, questionable data as to identification of species, and/or recent loss of habitat or environmental degradation suggests absence.
- *No information available* -- no existing data available, and after expert review it was determined that not even an educated guess would be appropriate. This category was also

used if the limited data available were extremely conflicting and/or contradictory; in these cases, *no information available* actually describes a situation where the available information was indecipherable.

- *Rare* -- species is definitely present but not frequently encountered.
- *Common* -- species is frequently encountered but not in large numbers; does not imply a uniform distribution over a specific salinity zone.
- *Abundant* -- species is often encountered in substantial numbers relative to other species with similar life modes.
- *Highly abundant* -- species is numerically dominant relative to other species with similar life modes.

An important aspect of the ELMR program, because it was based primarily on literature and consultations, was to determine the reliability of the available information. The reliability of available information varied between species, life stage, and estuary, due to differences in gear selectivity, difficulty in identifying larvae, difficulty in sampling various habitats, and the extent of sampling and analysis in particular studies. Data reliability was classified using the following categories:

- *Highly certain* -- considerable sampling data available. Distribution, behavior, and preferred habitats well documented within the estuary.
- *Moderately certain* -- some sampling data available for the estuary. Distribution, preferred habitat, and behavior well documented in similar estuaries.
- *Reasonable inference* -- little or no sampling data available. Information on distributions, ecology, and preferred habitats documented in similar estuaries.

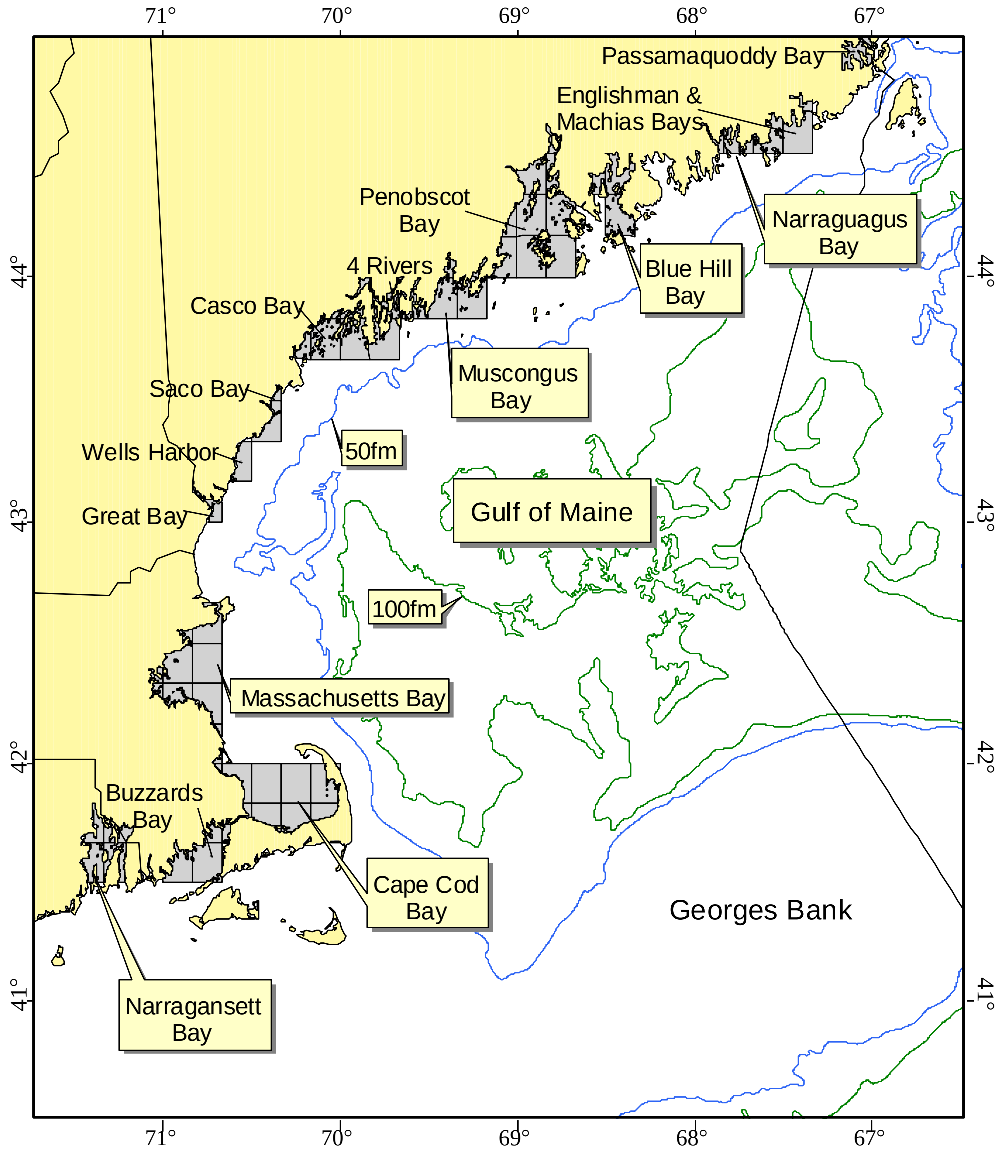
The seaward boundaries of each estuary or embayment were originally defined as straight lines from headland to headland or passing through islands, but these boundaries were modified in the No Action EFH designations to conform to ten minute squares of latitude and longitude that most closely represented the original boundary lines (Map 1 and Map 2).

For those species' life history stages for which the Council designated EFH based on the 100% alternative (i.e., EFH is designated as 100% of the range observed for the species' life history stage in the NMFS trawl survey), all bays and estuaries in which the species' life history stage was categorized as *rare, common, abundant*, or *highly abundant* were included in the EFH designation. For those species' life history stages for which the Council designated EFH based on the 90% alternative (see next section for an explanation of the percentile rankings used in the alternatives), all bays and estuaries in which the species' life history stage was categorized as *common, abundant*, or *highly abundant* were included in the EFH designation. For species for which the 50% or 75% alternative was used, all estuaries in which the species' life history stage was categorized as *abundant* or *highly abundant* were included in the EFH designation. The EFH maps included the salinity zone(s) for each bay or estuary where a given life stage and species met the defined abundance criteria.[3]

[3] The No Action EFH maps were based on ten minute squares of latitude and longitude that overlapped the ELMR salinity zone maps and therefore include more coastal area than is included in the ELMR designated areas.

Individual species of skates were not evaluated in the ELMR reports. Instead, a generically defined skate complex was included in the ELMR reports for the North Atlantic and Mid-Atlantic regions. Nevertheless, EFH was designated for three species of skate in 2003 (NEFMC 2003) in the Mid-Atlantic by using other available information describing their distribution along the coast. Corresponding designations for individual skate species were not done in the Gulf of Maine even though "skates" were included in the report for that region. No reference was made to salinity zones or preferences in the 2003 designations.

Map 1 – North Atlantic ELMR areas used in No Action EFH designations



Map 2 – Mid-Atlantic ELMR areas used in No Action EFH designations

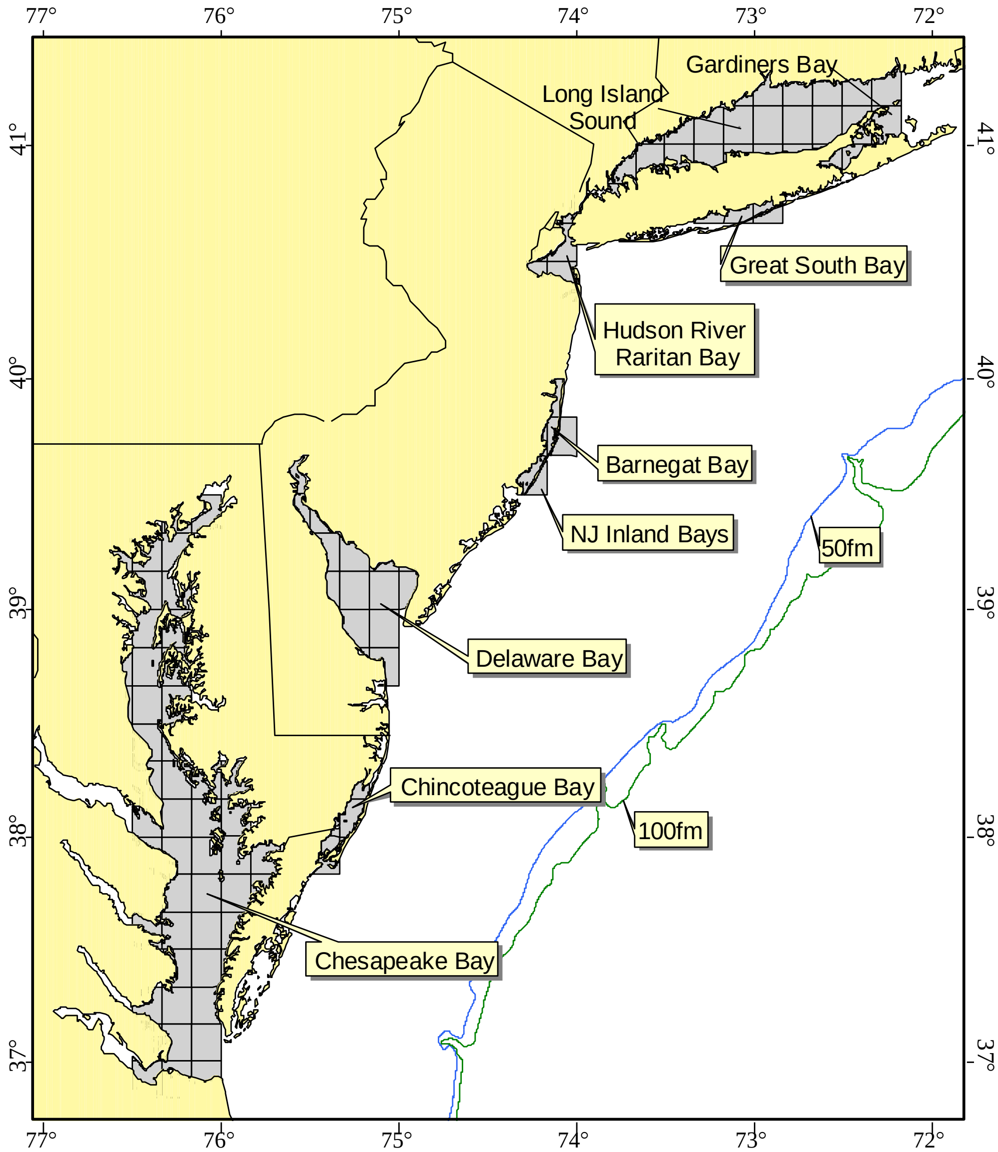


Table 2 – Distribution and abundance of the skate complex in northeast bays and estuaries

Estuaries and Embayments	Eggs	Juveniles	Mating	Adults
Waquoit Bay				
Buzzards Bay	L,W	L,W	L,W	L,W
Narragansett Bay	L,W	L,W	L,W	L,W
Long Island Sound	L,W	L,W	L,W	L,W
Connecticut River		L,W		L,W
Gardiners Bay		L,W		L,W
Great South Bay		L,W		L,W
Hudson River/Raritan Bay	C,L,W	C,L,W	C,L,W	C,L,W

Estuaries and Embayments	Eggs	Juveniles	Mating	Adults
Barnegat Bay				C,L,W
New Jersey Inland Bays				C,L,W
Delaware Bay				C,L,W
Delaware Inland Bays				C,L,W
Chesapeake Bay Mainstem	C,L,W	C,L,W		C,L,W
Chester River				
Choptank River				
Patuxent River				
Potomac River				
Tangier/Pocomoke Sound				
Rappahannock River				
York River				
James River				

The EFH information presented in this table is based on the NOAA Estuarine Living Marine Resource (ELMR) program (Stone et al. 1994). For the purposes of designating EFH, the bays and estuaries listed above were incorporated into the EFH designations for the species identified in the table (C = clearnose skate; L = little skate; and W = winter skate).

3.2 NMFS trawl survey, MARMAP, and scallop survey data

The alternatives considered by the Council in 1998 were based on the relative densities of fish (numbers per tow) observed in the fall and spring NEFSC bottom trawl and summer scallop dredge surveys and on the relative densities of pelagic eggs and larvae in the NEFSC ichthyoplankton (MARMAP) surveys on the continental shelf. The time periods used were 1963-1997 for the bottom trawl surveys, 1982-1997 for the scallop survey, and 1977-1987 for the MARMAP surveys. In addition, some information from the Massachusetts inshore trawl survey (1978-1997) and the Connecticut Long Island Sound trawl survey (1990-1996) were also used. For all species, a set of alternatives was developed for each of the major life history stages, with the exception of sea scallops, Atlantic salmon, and Atlantic halibut. Those stages include eggs, larvae, juveniles, and adults. The maps presenting the alternatives displayed the distribution and abundance data by ten minute squares of latitude and longitude.[4]

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

[4] Although their size varies according to latitude, each ten minute square includes about 75 square nautical miles.

Table 3 – Lengths-at-maturity used to distinguish juveniles and adults in EFH designations. Juveniles are less than the specified length; adults are equal to or larger.

Species	Length at Maturity (cm)	Species	Length at Maturity (cm)
American Plaice	27	Redfish	22
Atlantic Cod	35	Rosette Skate	46
Atlantic Herring	25	Sea Scallop	10
Barndoor Skate	102	Silver Hake	23
Clearnose Skate	61	Smooth Skate	56
Deep-sea Red Crab	8	Thorny Skate	84
Goosefish	43	White Hake	35
Haddock	32	Windowpane	22
Little Skate	50	Winter Flounder	27
Ocean Pout	29	Winter Skate	85
Offshore Hake	30	Witch Flounder	30
Pollock	39	Wolffish	47*
Red Hake	26	Yellowtail Flounder	27

* Not used in EFH designations – from Templeman 1986

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

Selection factors were applied to the NEFSC bottom-trawl and ichthyoplankton survey databases to construct the data sets for the Council alternatives and EFH designation maps. The selection factors were recommended by NEFSC Northeast Fisheries Science Center (NEFSC) scientists who collected and work with the data. Correction factors were used to standardize the bottom-trawl catch of various species due to variation in the size and type of trawl doors and nets, and/or the performance characteristics of vessels used in the surveys over time. Specific correction factors were applied to individual species (see NEFMC 1998, Appendix C, Table A-4). After the bottom-trawl and ichthyoplankton data were selected, the summarization process was the same. Data were assigned to a TMS based on the location of the starting point of the bottom-trawl or ichthyoplankton sample tow. Only those squares that had greater than three samples and one positive catch were selected. In order to minimize the effects of occasional large catches on the averages, catch data were transformed by taking the natural logarithm of the catch [ln(catch + 1)] and the mean of the transformed data was calculated for each ten minute square. The resulting values (indices) could be compared on a relative scale, but could not be expressed in units of numbers of fish per tow.

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

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

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

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

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

3.3 Limitations of the No Action EFH designations

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

Certain geographic regions were not represented in the data originally considered by the Council, such as Nantucket Sound and near shore waters of Maine, New Hampshire, Rhode Island, and eastern Long Island – where either no survey had been conducted, or where the data were not available – and smaller bays and estuaries not included in the ELMR database. These areas, therefore, were not considered in the EFH designation process. This does not mean that they are not potentially important, only that they represent data and information gaps. Similarly, the original EFH designations (text and maps) did not extend beyond the edge of the continental shelf (approximately 500 meters), which is the deepest extent of the NEFSC trawl survey.[5]

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

4.0 Development of updated designations

4.1 Abundance only method

4.1.1 Text descriptions

Text descriptions for this alternative differ from the descriptions in the No Action alternative because they were based on an explicit analysis of updated NEFSC trawl survey data, analysis of inshore survey data, and new evaluations of habitat-related information in updated versions of the EFH Source Documents. The updated text descriptions do not include any descriptions for a separate spawning adult life stage. Methods used to define habitat characteristics in the text descriptions (depth, temperature, and salinity ranges, and substrate types) of EFH were the same for this alternative and for the other two action alternatives, except that the abundance only maps and text descriptions do not include Level 1 information from the continental slope. The abundance only EFH designations (maps and text) were based, in most cases, on level 2 information. Proxies (other life history stages of the same species) were used to make one or more of the maps for ten species. Substrate types and depth, temperature, and salinity ranges used in the text descriptions are summarized in the supplementary species tables in Appendix B.

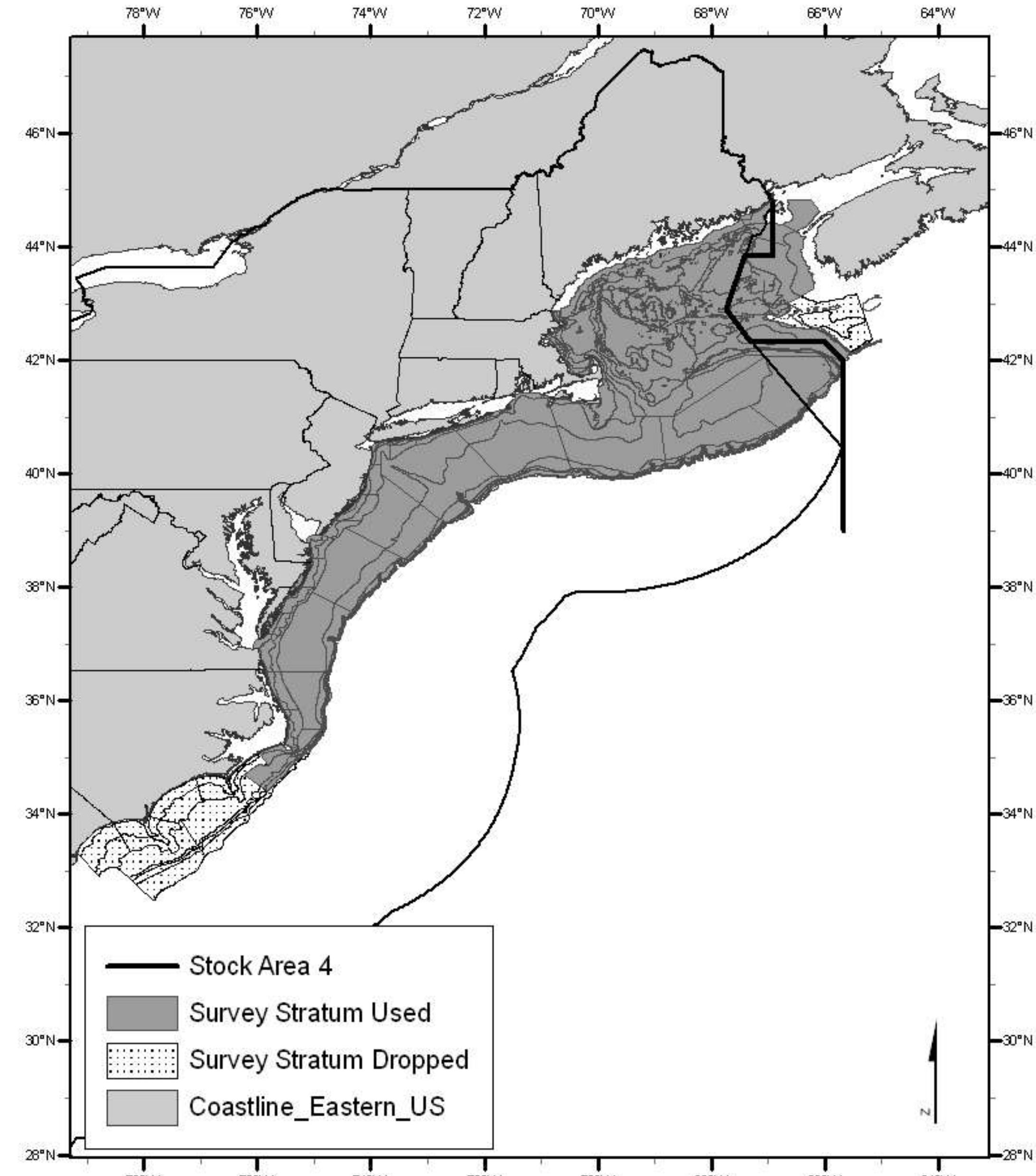
4.1.2 Maps

The "Abundance only" EFH maps were developed using a similar method as described above under No Action except that the time series of NEFSC spring and fall bottom trawl survey data for the continental shelf was updated to include data from 1968 to 2005. 1963-1967 data were eliminated from the analysis as no spring data were collected during those years. In addition, for many of the demersal species sampled in the NEFSC bottom trawl survey, ten minute squares (TMS) which were located entirely within poorly sampled survey strata were not included in the calculations nor were they mapped.[6] Strata that were excluded from the analysis are located south of Cape Hatteras and in Canadian waters on the southern and eastern Scotian Shelf (Map 3).

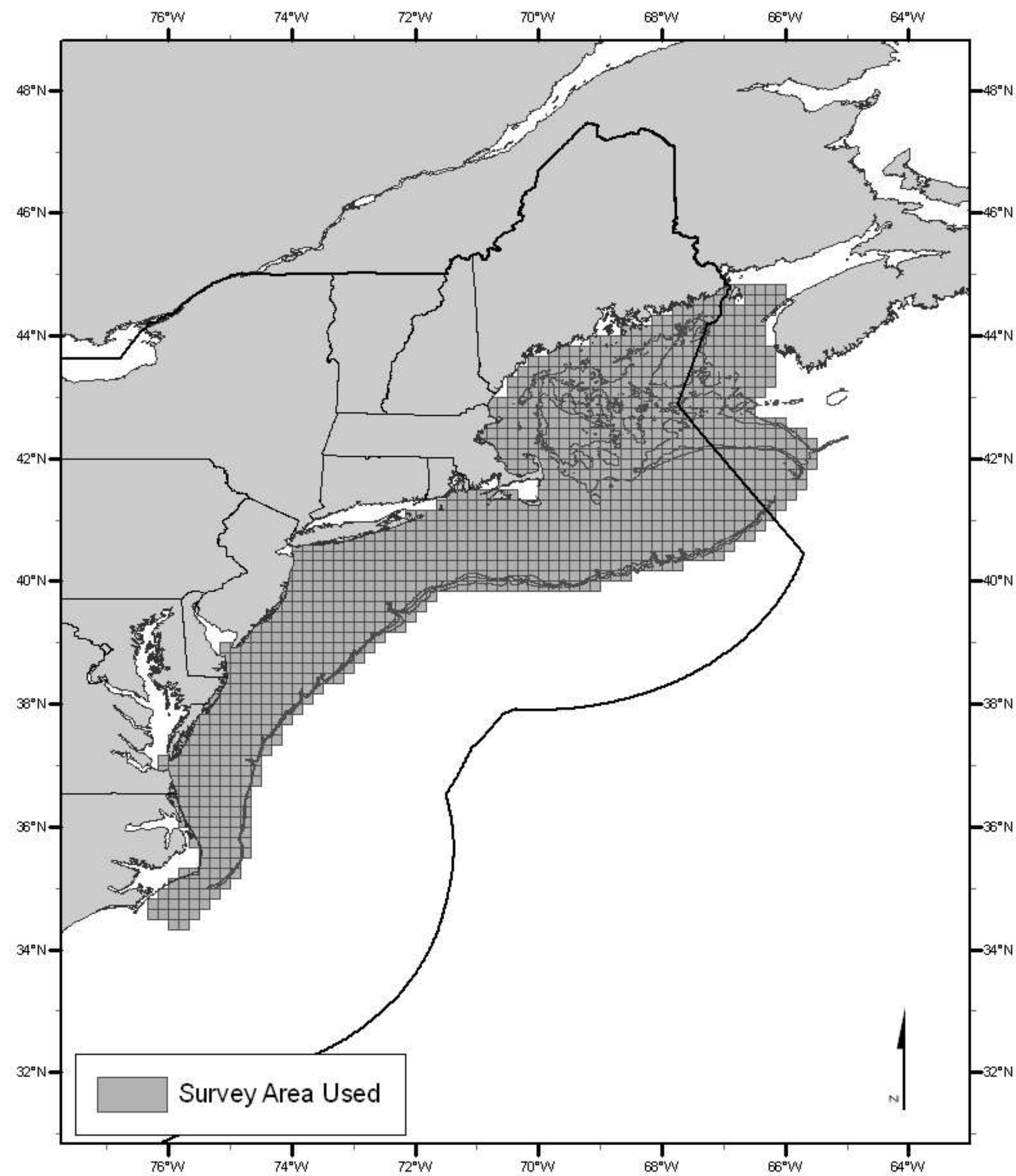
TMS on the shelf that were included in the analysis for most species are shown in Map 4. For the five species with stocks in the Gulf of Maine and/or on Georges Bank that are distinct from Canadian stocks on the Scotian Shelf (Atlantic cod, haddock, Atlantic herring, winter flounder, and yellowtail flounder), all TMS entirely within management area 4 (Map 5) were removed from the analysis, but TMS in Canadian waters on the Northeast Peak of Georges Bank were left in the analysis (but not mapped). With the exception of a few TMS in the entrance to the Bay of Fundy, all of management area 4 is in Canadian waters.

[6] Tows made in ten minute squares that overlap the U.S.-Canada border were included in the analysis.

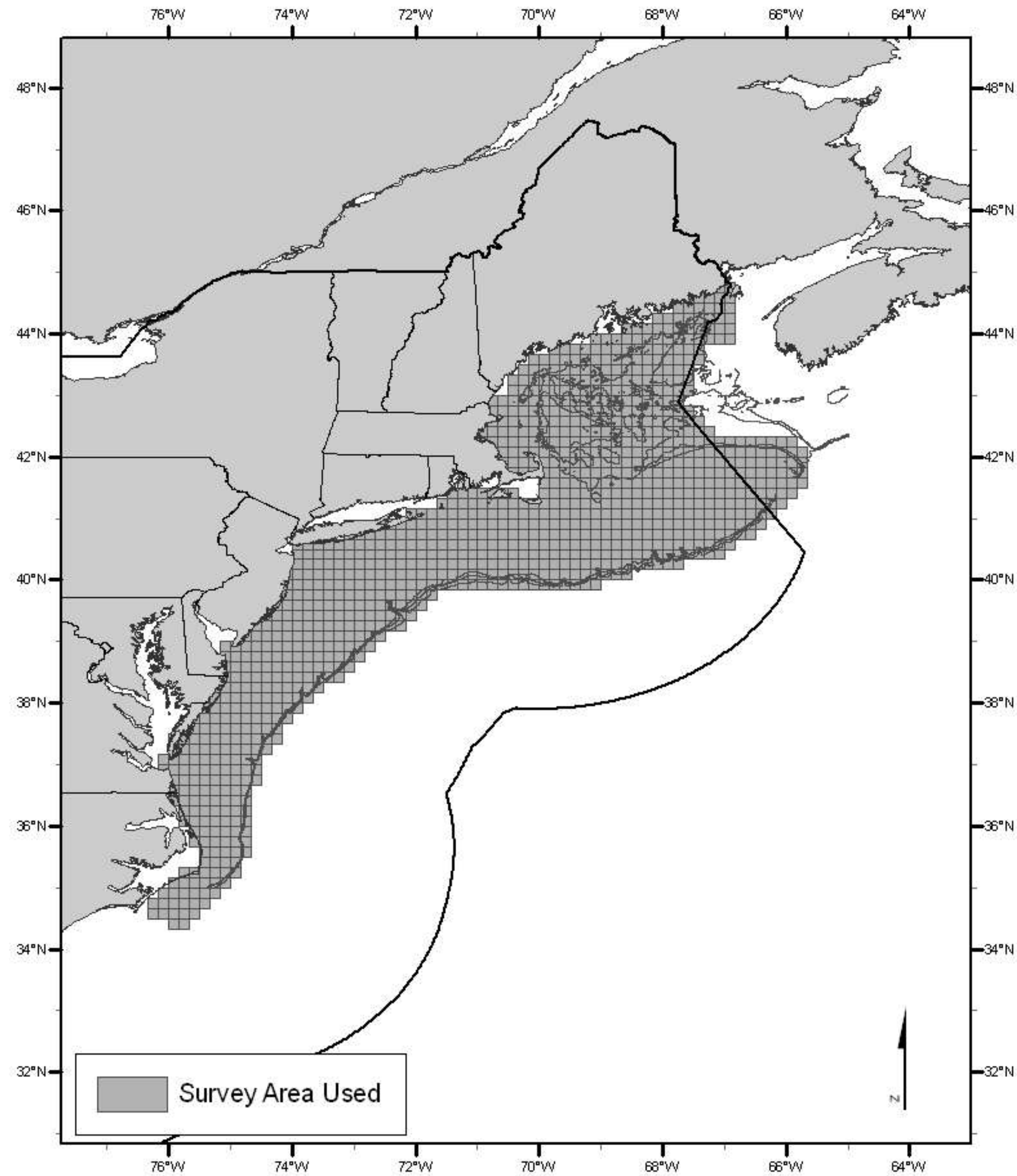
Map 3 – NEFSC bottom trawl survey strata for Northeast U.S. that were included in and excluded from the EFH analysis. Additional strata on the Scotian shelf that were surveyed in the early years of the time series were also excluded from the analysis and are not shown on this map. The heavy dark line is the western boundary of management area 4.



Map 4 – Ten minute squares used for most species in analysis of NEFSC trawl survey data



Map 5 – Ten minute squares used for species with distinct stock areas in U.S. and Canada (Atlantic cod, haddock, Atlantic herring, winter flounder, and yellowtail flounder).



As in the No Action alternative, EFH maps for benthic life stages were based on cumulative percentages of the average catch rates in each ten minute square (TMS) of latitude and longitude. However, NEFSC survey catch data for the continental shelf were processed slightly differently for all three action alternatives in order to further reduce the impact of high abundance tows on average catch rates for each TMS. For this alternative, the data were mapped by TMS as cumulative percentages (25, 50, 75, and 90%) of the back-transformed mean densities (representing a pseudo geometric mean), where the mean density per TMS was computed as:

$$\frac{\sum(\ln(d_i)+1)_j}{\sum n_j}$$

where $\sum(\ln(d_i)+1)_j$ is the sum of the log-transformed mean density plus 1 in tow *i* for TMS *j* and $\sum n_j$ the sum of the number of stations sampled within each TMS. Mean densities were not computed for TMS where fewer than four tows were conducted during the time series.

No updated designations were developed for the eggs and larvae of species where the No Action designation was based solely on 1977-1987 MARMAP survey data.[7] However, new egg and larval designations were developed for those species which were originally based on distributions of juveniles or adults as "proxies" because there was new bottom trawl survey information for juveniles and adults.

Finally, unlike the No Action alternative, no TMS were added to the EFH maps in this alternative to "fill in" gaps or areas of historical importance that might be under-represented in the trawl survey data. Also, the spatial extent of EFH in the abundance only maps does not extend beyond the edge of the continental shelf (depth of approximately 500 meters). Estuaries where the ELMR reports identified a species and lifestage as common, abundant, or very abundant were also mapped as EFH.

In addition to NEFSC survey and ELMR data, the state survey data sources listed in Table 4 were analyzed to produce data for the text descriptions and inshore portions of the maps. This set of state data sources was expanded considerably from those used in the No Action designations. A ten minute square (TMS) was considered EFH if more than 10 percent of the tows in the TMS were positive for a given species and lifestage. A positive tow was defined as any tow catching at least one fish. (For a complete listing of state surveys that were available, see Table 4).

4.2 Abundance plus habitat method

In order to develop a new approach for designating EFH that was based on peer-reviewed methodolgies, a Peer Review Committee of three independent experts was convened in June 2005 to recommend a course of action for the New England and Mid-Atlantic Fishery Management Councils, the NEFSC Greater Atlantic Regional Office, and the NEFSC Northeast Fisheries Science Center to follow in implementing new EFH designations for the Greater Atlantic. The purpose of the peer review exercise was to evaluate available EFH designation methodologies and to identify an approach that could be applied for identifying essential habitats and their characteristics for federally-managed species in the region. Preliminary work was

[7] An intensive series of ichthyoplankton surveys were conducted for several species on Georges Bank as part of the international Global Ocean Ecosystem Dynamics (GLOBEC) program during 1995-1999, but this information was not included in the text descriptions or maps for this alternative because it was more limited in geographic scope than the MARMAP surveys and did not include the months August-December. The results of the GLOBEC surveys are summarized in recent up-dates and revisions to the EFH Source Documents (NOAA Tech Memo series).

performed by a Habitat Evaluation Working Group made up of academic and government agency fishery scientists who held a series of meetings during the fall of 2004 and spring of 2005 and prepared a report which evaluated the potential applicability of six different methods. Candidate methodologies that were selected by the working group and evaluated by the panel of experts were: 1) the No Action method; 2) regression models, especially General Additive Models (GAM); 3) Habitat Suitability Index (HSI) models; 3) use of Geographic Information Systems (GIS); 4) an integrated approach used on the west coast; and 6) an optimization approach using a model called MARXAN.[8]

The peer review panel reached the following conclusions:

General Recommendations

- Until a thorough cross-calibration exercise is completed with the candidate EFH methods, the panel recommends the application of a method(s) that requires the minimum assumptions for any species or life-stage in order to stay as close to the available data as possible and provide the least ambiguous interpretation.
- The framework for development and use of EFH methods must be consistent across temporal and spatial scales for comparative analyses, visualization and interpretation of processes.
- The focus on methodological development should move from EFH Levels 1 and 2 data to EFH Levels 3 and 4 data as fast as possible to be consistent with the ecosystem-based management mandate.
- Habitat variables could be enriched by expanded exploratory data analyses to include other abiotic (circulation, salinity, rugosity, turbidity, patchiness, etc.) and biotic (primary productivity, prey availability, predation, etc.) covariates.
- Prioritization of methodologies will be based on the number of assumptions (i.e. simple to complex) required to implement them. For example, No Action, to HSI, to GAM, to West Coast, etc. Further, the HSI as a concept is appropriate, but not as analytically powerful as other candidate methods. Therefore the panel recommends that methodologies that are quantitatively robust such as the GAMs should replace the HSI approach as soon as reasonable. However, the panel recognized there are sufficient analytical restrictions on the use of GAM models that some cases might require supplementation by an HSI type approach. In the short term, the West Coast model and bioenergetics methods will be difficult to implement given the apparent lack of available data and analytical requirements. The West Coast method may have greater utility in the longer-term, but the method and results need to be compared and rectified relative to other competing approaches using data of comparable time and space scales. The panel also felt the spatial optimization methods (e.g. MARXAN) would likely be the downstream recipient of the outputs (e.g. spatial maps of presence-absence, density, and preference) from the comparative analyses and would likely be most useful in the delineation of EFH designations in single or multiple species contexts. The panel did not think GIS should be considered as a stand-alone analytical tool for EFH designation;

[8] More information regarding the peer review process, including the names of the three reviewers and the members of the working group, and a copy of the working group report, can be found on the NOAA Greater Atlantical Office web site.

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

Short-Term Recommendations
- Improve the text descriptions in the No Action EFH methodology source documents to be more comprehensive of the habitats that the species utilize.
- The panel believes the utility of evaluating EFH designation for eggs and larval life-stages is questionable at this time and efforts should be focused on EFH designation for juveniles and adults.
- Develop a comprehensive sensitivity analysis strategy to compare the candidate EFH methods that involves the following:
  - Data: An identification of those species that are sufficiently data rich such that all methods or models could be compared simultaneously in an objective manner (i.e. in space for selected areas, e.g. Eastern Georges Bank, Great Sound Channel, or New York Bight Apex; or in time for selected species, e.g. cod, Atlantic herring, summer flounder, redfish).
  - Time and space scales: Give high priority to defining the appropriate minimum mapping unit (e.g. at present analyses use 10-minute squares).
  - Species and life-stages: Develop the appropriate life history and population-dynamic contrasts for method comparisons (e.g., pelagic vs. demersal, fast-growing vs. slow growing, high mortality vs. low mortality).
- Improve the quality of the base maps ("habitat" layers) on which the methods analyses are predicated.
- Develop selection criteria for objectively assessing method performance. This will require a clearer articulation of management needs.
- For the EFH Omnibus Amendment 2, the No Action method should be pursued, with possible inclusion of Habitat Suitability Index- type information, until inter-calibration of models is completed.

Intermediate & Long Term Recommendations
- Attention should be paid to temporal and spatial dynamics of fish distributions and "habitats." For example, recast the data analyses to focus time on intervals (e.g. decades) in response to trends in climate, fishing impacts, shifting habitat, etc.

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

Based on the general advice provided by the Peer Review Committee, the NEFMC Habitat Plan Development Team (PDT) developed a GIS-based EFH designation methodology that combines the primary elements of the abundance only method (updated survey catch rate data for the continental shelf and ELMR and state survey information for inshore areas) with habitat features that are associated with high catch rates of benthic juveniles and adult life stages. To this end, the spatial extent of EFH was divided into four general geographic realms (inshore, continental shelf, continental slope and seamounts), largely because of the different data sets and levels of information that were available within each area.

As noted in the introduction, EFH designations include a text description and a map for each life stage of each managed species. The maps depict the geographic extent of the areas within which the text descriptions must apply in order for a particular location to be designated as EFH. In this alternative, the EFH text descriptions and maps are "linked" more explicitly than in the other designation alternatives. Depth and temperature ranges that are included in the text descriptions were also used to create the EFH maps for benthic life stages. Bottom temperature was displayed on a ten-minute-square basis, whereas depth was indicated at a much higher spatial resolution (see Section 4.2.2.2). Lengths at maturity used to distinguish juveniles from adults were the same as those used in the original EFH designations (see Table 3). Pertinent information on young-of-the-year juveniles and spawning adults was included in the juvenile and adult life stage text descriptions.

4.2.1 Text descriptions

The following methods were used to determine substrate types and ranges of depth, temperature, and salinity associated with individual life stages of each managed species in the inshore, continental shelf, continental slope, and seamount spatial realms. For benthic life stages, the text descriptions rely primarily on the geographic extent of EFH (as mapped), depth ranges, and substrate associations. EFH for pelagic life stages is described very generally in terms of the geographic range without reference to water depth or substrates, variables that have no meaning for a pelagic life stage. Substrate types identified in the EFH text descriptions were based on information from the EFH source documents (1st or 2nd editions) or unpublished update memos, or from other sources. When available, specific information related to the habitat characteristics of young-of-the-year juveniles and spawning adults was included in the appropriate text description. For each species and life stage, all relevant habitat information was summarized in tabular form in Appendix B along with information on primary prey types and spawning seasons and locations. The EFH text descriptions were based on a synthesis of the depth and substrate information in this appendix. The information in this appendix is intended to supplement the EFH text descriptions in Volume 2 for use in EFH consultations.

4.2.1.1 Inshore

Depth, bottom temperature, and salinity ranges were determined from spring and fall bottom trawl survey data histograms (see example in Figure 1) showing the percentages of tows, positive tows (i.e., tows which caught at least one of the target species and life stages), and total catch for the target species and life stage at each interval of depth, temperature, or salinity (see Appendix B). However, very little of this information was used in the text descriptions because they rely on depth ranges (for the benthic life stages) and because the maximum depths in the inshore surveys overlap with the NEFSC surveys, which extend into much deeper water (see, for example, Figure 1). For some species that occupy shallow coastal habitats, the state surveys provided a more reliable source of minimum depth information than the NEFSC surveys.[9] Inshore survey data used to derive depth, temperature, and salinity ranges that are summarized in Appendix B were available in histogram form from trawl surveys in Massachusetts (1978-2005), Maine/New Hampshire (2000-2005), Raritan Bay (1992-1997), Delaware Bay (State of Delaware, 1966-1997 or 1999), and the lower Chesapeake Bay (1988-2005).[10] Data from other surveys were either not available in this form or were insufficient to support a reliable analysis.

Depth ranges used in the text descriptions were defined as the range within which a species and life stage was most often captured (level 2 relative abundance EFH information), as opposed to the minimum and maximum depths at which a single fish was ever captured in the entire survey time series (level 1 presence only EFH information). In most cases, level 2 minimum and maximum values were based on the intervals where percent catch exceeded percent number of tows. In the example shown in Figure 1, the depth range is 41-85 meters and the temperature range is 4.5-10.5ºC.[11] In cases of low sample size and/or "noisy" data, percent occurrence (positive tows) was used instead of percent catch (minimum depth of 31-35 m in Figure 1 instead of 41-45 m). If a species' life stage was known to utilize intertidal habitats, the minimum depth of EFH was defined as 0 meters relative to the mean high water (MHW) datum and an explicit reference to the intertidal zone was made in the description. For surveys conducted at more than one time of year, the lowest minimum and highest maximum values were selected to represent an annual range.

[9] For the example shown in Figure 1, the minimum depth for juvenile American plaice in Massachusetts state waters was 40 meters compared to 50 meters in the NEFSC survey data; for adults, the discrepancy was even larger (40 m inshore vs. 70 m offshore). Note that the maximum depth surveyed in Massachusetts is 85 m whereas the NEFSC trawl survey extends to the edge of the continental shelf to depths greater than 400 m.

[10] Updated Massachusetts survey data (through 2005) were compiled in 2nd edition EFH source documents and update memos for individual species, Maine/NH data were provided by the Maine Department of Marine Resources, Raritan Bay data were in the original EFH source documents, Delaware Bay data were either in Morse (2000) or in 2nd edition EFH source documents and update memos, and Chesapeake Bay data in Geer (2002).

[11] Depths were "rounded off" in the text descriptions and for the maps (e.g., 41 to 40 meters).

Figure 1 – Distribution of fall juvenile American plaice catches and sampling effort in Massachusetts coastal waters by bottom temperature and depth, 1978-2003. Light bars show the percent distribution of all trawl tows, dark bars show the percent distribution of all tows in which juvenile American plaice occurred and medium bars show, within each interval, the percentage of the total number of juvenile American plaice caught. (Temperature values on the X-axis are interval mid-points, e.g., "10°C" represents the interval 9.5-10.5°C).

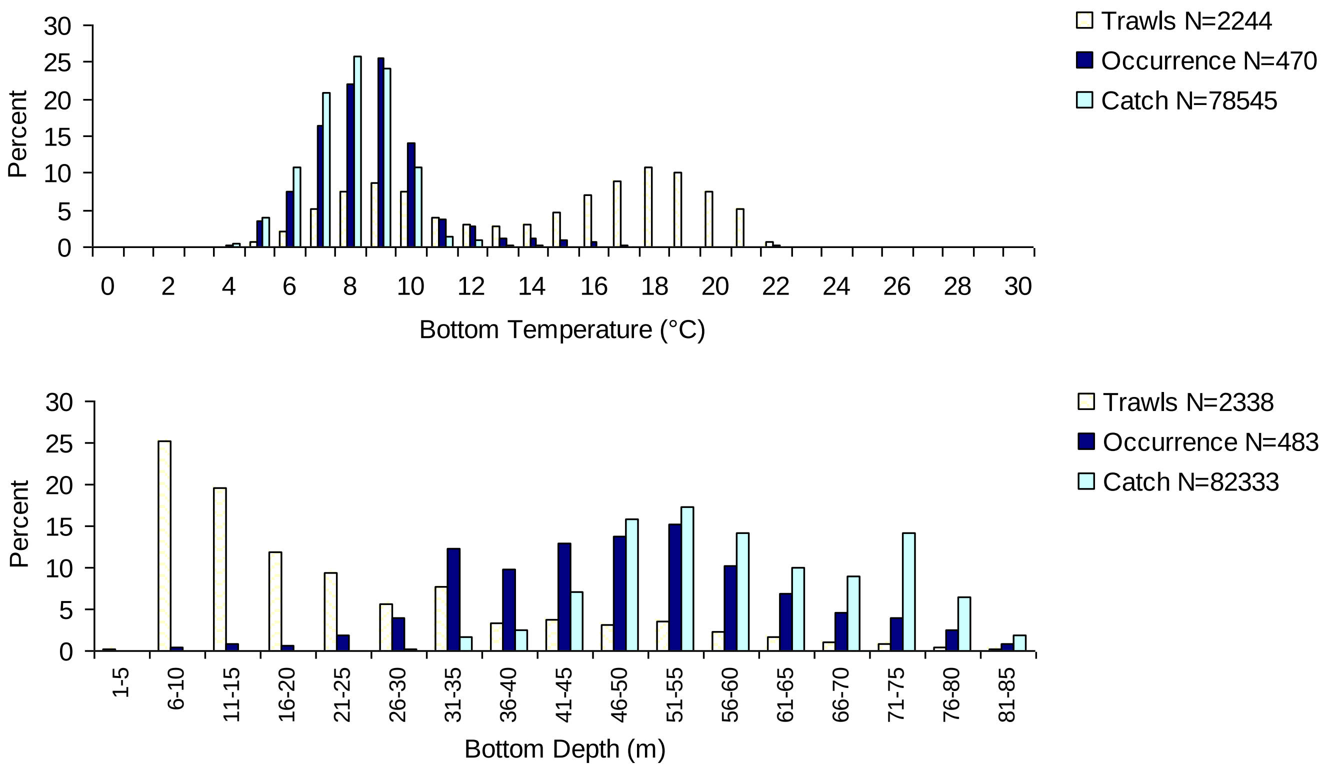


Table 4 – Details regarding state surveys used to derive habitat-related information for species managed by NEFMC in inshore waters

State	*Survey Location*	*Gear Type*	*Mesh Size*	*Survey Design*	*Headrope (ft)*	*Footrope (ft)*	*Tow Duration/Speed*	*Time of Year*	*Years Analyzed*
Connecticut	Long Island Sound	Bottom Trawl	4 inch with 2 inch cod end, no liner	Stratified random	30	46	30 min@ 3.5 kts	Spring (April–June), Summer (July–August), Fall (Sept–Oct), and November	1984–2004
Connecticut	Long Island Sound	Bottom Trawl	2 inch with 0.25 inch cod end liner	Stratified random	30	46	30 min@ 3.5 kts	?	1991-93, 1996
Delaware (16ft Trawl)	Delaware Bay and Delaware River	Bottom Trawl	1.5 inch, 0.5 inch liner	Fixed	16	21	10 min @ minimum hp	April - October (monthly)	1980–2004
Delaware (30ft Trawl)	Delaware Bay	Bottom Trawl	2 inch	Fixed	30	40	20-30 min @ minimum hp	March - December (monthly)	1966-2004
Maine	ME/NH Inshore Waters	Beam Trawl	0.125 inch	Random stations in fixed areas	6	N/A	5 min	Bi-Monthly April-Nov	2000-2004
Maine	ME/NH Coastal Waters	Bottom Trawl	2 inch with 1 inch cod end liner	Stratified random plus fixed stations	60	70	20 min @ 2.2-2.3kts	Spring & Fall	Fall 2000-Spring 2005
Maryland	Coastal Bay	Beach Seine	0.25 inch mesh	Fixed	100	N/A	N/A	June & Sept	1989-2005
Maryland	Upper Bay	Seine (striped bass)	0.25 inch bar mesh	Fixed	100	N/A	N/A	July, Aug & Sept	1954-2005
Maryland	Coastal Bay	Bottom Trawl	0.25 inch	Fixed	?	16	6 min @ 3.0 kts	Monthly, April-Oct	1989-2005
Massachusetts	Coastal	Bottom Trawl	1.25 inch mesh, 0.25 inch liner	Stratified random	39	51	20 min @2.5kn	Spring & Fall	1978-2005
Massachusetts	Coastal	Seine	0.25 mesh	Fixed	20	N/A	N/A	June	1975-2005
New Hampshire	Great Bay Estuary, Little Harbor, Upper Piscataqua River	Seine	0.25 inch	Fixed	100	N/A	N/A	Monthly, June-Nov	1997-2004

State	***Survey Location***	***Gear Type***	***Mesh Size***	***Survey Design***	***Headrope (ft)***	***Footrope (ft)***	***Tow Duration/Speed***	***Time of Year***	***Years Analyzed***
New Jersey	Delaware Bay	Bottom Trawl	1.5 inch with 0.5 inch liner	Fixed	16	N/A	20 min @ 2.1kts	April 2004-October 2004	1991-2005
New Jersey	Coastal Waters	Bottom Trawl	4.7/3 inches, 0.25 inch bar mesh cod end liner	Stratified random	82	100	20 min	5 times a year	1988-2004
New York	Hudson-Raritan Bay	Bottom Trawl	1.75 inch cod end, 1.375 Liner	Stratified random	28	34	10 min @ 2kts	Monthly (except May, Sept)	Jan 92-June 97
North Carolina	Pamlico Sound	Bottom Trawl (2)	0.9 inch bar mesh, 0.75 in cod end	Stratified random	30	?	20 min @ 2.5 kts	June and Sept (also March and Dec prior to 1991)	???
North Carolina	Pamlico Sound (Juvenile Survey)	Bottom Trawl	0.25 inch bar mesh, 0.125 in cod end	Fixed	7.5	?	1 min	May and June (Feb-Nov prior to 1990)	???
Rhode Island	Narragansett Bay	Bottom Trawl	1 inch cod end, 0.25 inch liner	Fixed	39	54	20 min @2.5kn	Monthly	1990-2005
Rhode Island	Coastal	Bottom Trawl	1 inch cod end, 0.25 inch liner	Fixed and stratified random	39	54	20 min @2.5kn	Spring and Fall	1983-2005
Rhode Island	Narragansett Bay	Seine	0.25 inch with 0.1875 inch in bunt	Fixed	200	N/A	N/A	Monthly, June-Nov	1988-2005
Rhode Island	Coastal Ponds	Seine	0.25 inch	Fixed	130	N/A	N/A	Monthly, May-Nov	1992-2004
Virgina	Lower Chesapeake Bay and major tributaries	Bottom Trawl	1.5-inch, 0.25 inch liner in cod end	Fixed and stratified random	30	?	5 min @ 2.5kts	Monthly	1988-2005
Virgina	Coastal Bays (striped bass)	Seine	0.25 in bar mesh	Fixed	100	N/A	N/A	Bi-weekly, April-Oct	1967-2005
Virgina	Coastal Bays (bluefish)	Seine	0.25 in bar mesh	Fixed	100	N/A	N/A	Bi-weekly, July-Sept	1993-2005

4.2.1.2 Continental shelf

Depth ranges for the portion of the continental shelf surveyed by the NEFSC used in the EFH text descriptions were derived using the same method that was used with the inshore state survey data (see Figure 1). As was the case with some of the state data, minimum and maximum values were determined by examining histograms of survey data in the up-dated (2nd edition) EFH source documents for the time periods 1963-2003 (fall) and 1968-2003 (spring). The minimum and maximum values for the fall and spring were combined to create a single annual range where any given species and life stage was relatively more abundant, or "common" (not just "present"- see tables in Appendix B).. For the benthic life stages, additional information regarding substrate associations on the shelf was obtained from the EFH source documents, or other sources such as Collette and Klein-MacPhee (2002). The numbers of fish caught during the survey time periods that were analyzed are shown by species and life stage in Table 5.

Table 5 – Numbers of NEFMC-managed species caught and numbers caught per tow (CPUE) in 1968-2003 spring and 1963-2003 fall NEFSC bottom trawl surveys in the Northeast region and included in the analysis.

		Spring		*Fall*		*Both*	
Species	**Lifestage**	**Number caught**	**CPUE**	**Number caught**	**CPUE**	**Number caught**	**CPUE**
American plaice	Juvs	27838	2.22	37217	2.62	65055	2.44
	Adults	27176	2.17	35655	2.51	62831	2.35
Atlantic cod	Juvs	6978	0.56	7661	0.54	14639	0.55
	Adults	26689	2.13	22413	1.58	49102	1.84
Atlantic halibut	Juvs/Adults	413	0.03	415	0.03	828	0.03
Atlantic herring	Juvs	184284	14.73	78453	5.53	262737	9.84
	Adults	84332	6.74	74283	5.24	158615	5.94
Barndoor skate	Juvs	252	0.02	629	0.04	881	0.03
	Adults	65	0.01	98	0.01	163	0.01
Clearnose skate	Juvs	1942	0.16	2072	0.15	4014	0.15
	Adults	1107	0.09	954	0.07	2061	0.08
Haddock	Juvs	30910	2.47	73837	5.20	104747	3.92
	Adults	49704	3.97	89807	6.33	139511	5.23
Little skate	Juvs	232621	18.59	72414	5.10	305035	11.42
	Adults	5062	0.40	4939	0.35	10001	0.37
Monkfish	Juvs	3062	0.24	3923	0.28	6985	0.26
	Adults	3859	0.31	3305	0.23	7164	0.27
Ocean pout	Juvs	3615	0.29	1299	0.09	4914	0.18
	Adults	34935	2.79	5698	0.40	40633	1.52
Offshore hake	Juvs	2065	0.17	1003	0.07	3068	0.11
	Adults	2394	0.19	1330	0.09	3724	0.14
Pollock	Juvs	7222	0.58	3683	0.26	10905	0.41
	Adults	9193	0.73	7957	0.56	17150	0.64
Red hake	Juvs	31561	2.52	53107	3.74	84668	3.17

Species	Lifestage	Spring Number caught	Spring CPUE	Fall Number caught	Fall CPUE	Both Number caught	Both CPUE
	Adults	66425	5.31	84046	5.92	150471	5.64
Redfish	Juvs	34433	2.75	57823	4.08	92256	3.46
	Adults	109959	8.79	140037	9.87	249996	9.36
Rosette skate	Juvs	566	0.05	468	0.03	1034	0.04
	Adults	2	0.00	0	0.00	2	0.00
Silver hake	Juvs	243107	19.43	385702	27.19	628809	23.55
	Adults	183013	14.62	210635	14.85	393648	14.74
Smooth skate	Juvs	2045	0.16	1924	0.14	3969	0.15
	Adults	353	0.03	407	0.03	760	0.03
Thorny skate	Juvs	7061	0.56	9356	0.66	16417	0.61
	Adults	695	0.06	1230	0.09	1925	0.07
White hake	Juvs	5862	0.47	13593	0.96	19455	0.73
	Adults	14178	1.13	23707	1.67	37885	1.42
Windowpane	Juvs	8633	0.69	20481	1.44	29114	1.09
	Adults	43919	3.51	38124	2.69	82043	3.07
Winter flounder	Juvs	20579	1.64	13639	0.96	34218	1.28
	Adults	30839	2.46	31422	2.22	62261	2.33
Winter skate	Juvs	47363	3.78	26676	1.88	74039	2.77
	Adults	3583	0.29	4839	0.34	8422	0.32
Witch flounder	Juvs	4240	0.34	4152	0.29	8392	0.31
	Adults	10076	0.81	9859	0.69	19935	0.75
Yellowtail	Juvs	13008	1.04	21251	1.50	34259	1.28
	Adults	48010	3.84	48341	3.41	96351	3.61

4.2.1.3 Continental slope and seamounts

On the continental slope and seamounts, text descriptions were based on level 1/presence only information. For species and life stages that extend beyond the edge of the continental shelf, the text descriptions identify a maximum depth that was determined by consulting relevant deep-sea experimental fishing project reports, the EFH source documents, and other publications (see Table 6).

Table 6 – Depth ranges and maximum depths for NEFMC-managed species that occur on the continental slope. The right hand column indicates maximum depths used in text descriptions of all EFH designation alternatives that include the continental slope and seamounts.

Species	Depth (meters)	Location	References	Maximum Depth Determined by PDT
Atlantic Halibut (Hippoglossus hippoglossus)	37-550 200-750	Virginia to Greenland Iceland Slope	Moore et al., 2003	700 (juvs/adults)

Species	**Depth (meters)**	**Location**	**References**	**Maximum Depth Determined by PDT**
juveniles/adults	typically 100-700, max 720-900	Virginia to Labrador	Haedrich and Merrett, 1998 Cargnelli et al., 1999	
Barndoor Skate (Dipturus laevis) juveniles/adults	0-750	Cape Hatteras to Grand Banks	Moore et al., 2003	750 (juvs/adults)
Monkfish/Goosefish (Lophius americanus) juveniles/adults	0-948 max 744-839 very few >823	Florida to Gulf of St. Lawrence SNE Slope GB/SNE Slope	Moore et al., 2003 Kvilhaug & Smolowitz 1996 Balcom 1997	1000 (juvs/adults)
Offshore Hake (Merluccius albidus) juveniles/adults	80-1170 (mostly 160-640) 200-750	Northern Brazil to Le Have Bank SNE Slope	Moore et al., 2003 Haedrich and Merrett, 1988	750 (juvs/adults)
Red Crab (Chaceon or Geryon quinquedens) juveniles/adults	200-599 360-540 max 915-932 274-1463 (juvs mostly 503-1280, adults mostly 320-914)	Continental Slope MAB thru GOM Continental Slope-Sable Island to Corsair Canyon SNE Slope Continental Slope (between 38° and 41°30 min N)	Wahle, 2005 Stone and Bailey, 1980 Kvilhaug & Smolowitz 1996 Wigley et al., 1975	1300 on slope (juvs) 900 on slope (adults) 2000 on seamounts (juvs/adults)
Redfish (Sebastes sp.) juveniles/adults	200-592 200-750 max 768-786 (mostly 490-616)	Virginia to Labrador/Greenland Slope Newfoundland; Iceland Slope GB/SNE Slope	Moore et al., 2003 Haedrich and Merrett, 1988 Balcom 1997	600 (juvs/adults)
Red Hake (Urophycis chuss)	37-792	North Carolina to Southern Newfoundland	Moore et al., 2003	750 (adults)

Species	Depth (meters)	Location	References	Maximum Depth Determined by PDT
juveniles/adults	200-750	SNE Slope	Haedrich and Merrett,1988	
Smooth Skate (Malacoraja senta) juveniles/adults	46-956	North Carolina to southern Grand Banks	Moore et al., 2003	900 (juvs/adults)
Thorny Skate (Amblyraja radiata) juveniles/adults	18-996	South Carolina to Greenland	Moore et al., 2003	900 (juvs/adults)
White Hake (Urophycis tenuis) juveniles/adults	0-1000	North Carolina to Labrador	Moore et al., 2003	900 (adults)
Witch Flounder (Glyptocephalus cynoglossus) juveniles/adults	18-1570 (mostly 45-366) max 635	North Carolina to Greenland GB/SNE Slope	Moore et al., 2003 Balcom 1997	1500 (juvs/adults)

GB – Georges Bank, GOM – Gulf of Maine, MAB – Mid-Atlantic Bight, NEFSC – Northeast Fisheries Science Center, SNE – Southern New England.

4.2.2 Maps

4.2.2.1 Inshore

For inshore and estuarine areas, the maps show the spatial extent of EFH for each target species and life stage as ten minute squares where at least 10% of the state survey tows (or hauls) caught at least one fish as well as entire ELMR bays and estuaries in the mixed or full salinity zones where the target species and life stage was "common," "abundant," or "very abundant." Although habitat characteristics (depth, temperature, salinity, and substrate types) were included in the text descriptions as described above, or described in the supplementary tables in Appendix B, they were not used in the development of the inshore portions of the maps.[12] The inshore TMS were not "clipped" by depth. The spatial extent of the state survey data that were analyzed for mapping purposes is shown in Map 6.

The 10% frequency of occurrence is an arbitrary threshold value that was applied by the PDT in order to identify inshore areas where any target species and life stage was relatively common. A conservative threshold value was selected (10% instead of, say, 20%) that could be applied across all surveys with the least risk of biasing the results in favor of sampling gear or survey

[12] "Inshore" in most cases refers to state waters – within three miles from shore – since this is the outer limit for most of the state surveys and the ELMR areas. However, some state surveys (e.g., the NH/ME trawl survey) extend into federal waters and some of the NEFSC trawl survey tows are made in state waters, so there is some overlap between the inshore and continental shelf spatial realms and the methods that were used to map EFH in them.

practices that might be more efficient at catching particular species or sizes of fish. A detailed description of survey designs, times of year, locations, and time periods (years), gear types, net and mesh sizes, and tow speeds and duration is given in Table 4.

Unlike the status quo (No Action) alternative and the other two action alternatives, the inshore ELMR areas in the abundance plus habitat EFH maps were mapped using the original GIS data layers (polygons) for the mixed and full salinity zones in the region (see Maps 7 and 8), not the ten minute square approximations of those areas that were created for the original EFH designations done by the New England Fishery Management Council (Maps 1 and 2). The original polygons provide the correct depiction of the two salinity zones as described in the NOAA National Estuarine Inventory (NOAA 1985).[13] ELMR area polygons also replaced the TMS-based ELMR areas in EFH maps that were generated for the other two action alternatives and approved by the NEFMC as preferred designations in 2007. For more details concerning the ELMR areas and how they were incorporated into the EFH designation process in 2003, see Section 3.1.

Revisions were made in this alternative to the original skate EFH designations that were developed by the NEFMC in 2003. Three modifications were made: 1) Maps that included ELMR areas were created for four individual species in the Gulf of Maine (North Atlantic region); 2) Revisions were made in some cases to the assignments of juveniles and adults to individual estuaries in both regions, and; 3) Three estuaries that were not included in the ELMR reports were added (indicated with an * in tables below). The revised designations are shown in Table 7 and Table 8. Changes in the Mid-Atlantic designations can be discerned by comparing the status quo table (Table 2) with Table 8.

Table 7 – Presumed presence of skates in North Atlantic estuaries and embayments based on ELMR classification for skate complex (common or abundant) and known geographic distributions of individual species. (L = Little Skate, W= Winter Skate, S = Smooth Skate, T = Thorny Skate)

Estuaries and Embayments	Juveniles	Adults
Passamaquoddy Bay	LWST	L
Englishman/Machias Bay	LWST	L
Narraguagus Bay	LWST	L
Blue Hill Bay	LWST	L
Penobscot Bay	LWST	L
Muscongus Bay	LWST	L
Damariscotta River	LWST	L
Sheepscot Bay	LWST	L
Kennebec / Androscoggin Rivers	LWST	L
Casco Bay	LWST	L
Saco Bay	LWST	L
Wells Harbor		

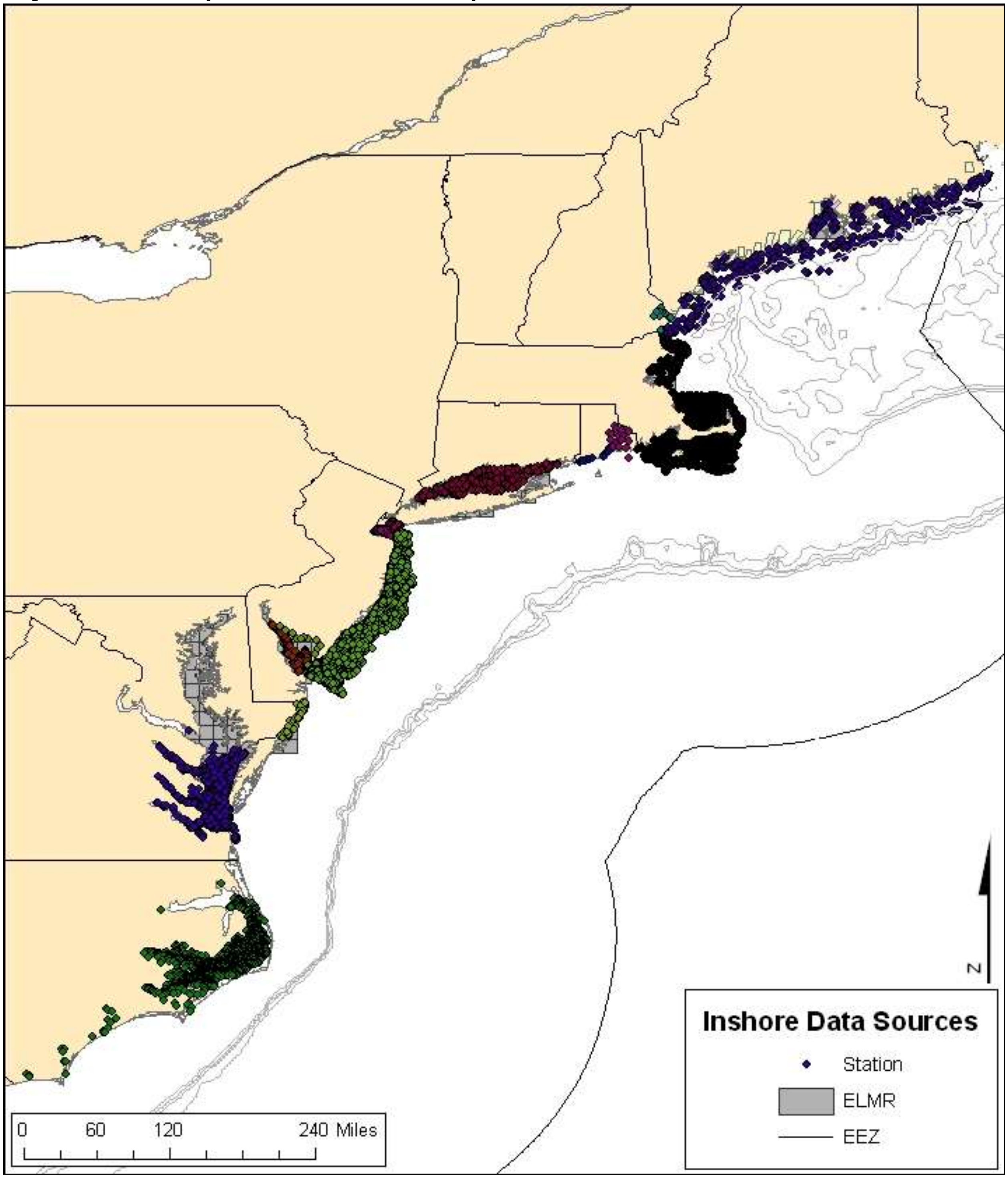
[13] Following publication of the inventory, NOAA created salinity zone polygons for some additional estuaries in the region that were not included in the inventory; when appropriate, these have been added to the maps .

Estuaries and Embayments	Juveniles	Adults
Great Bay	LWST	L
Hampton Harbor*	LWT	L
Merrimack River		
Plum Island Sound*	LWT	L
Massachusetts Bay	LWT	LW
Boston Harbor	LWT	LW
Cape Cod Bay	LWT	LW

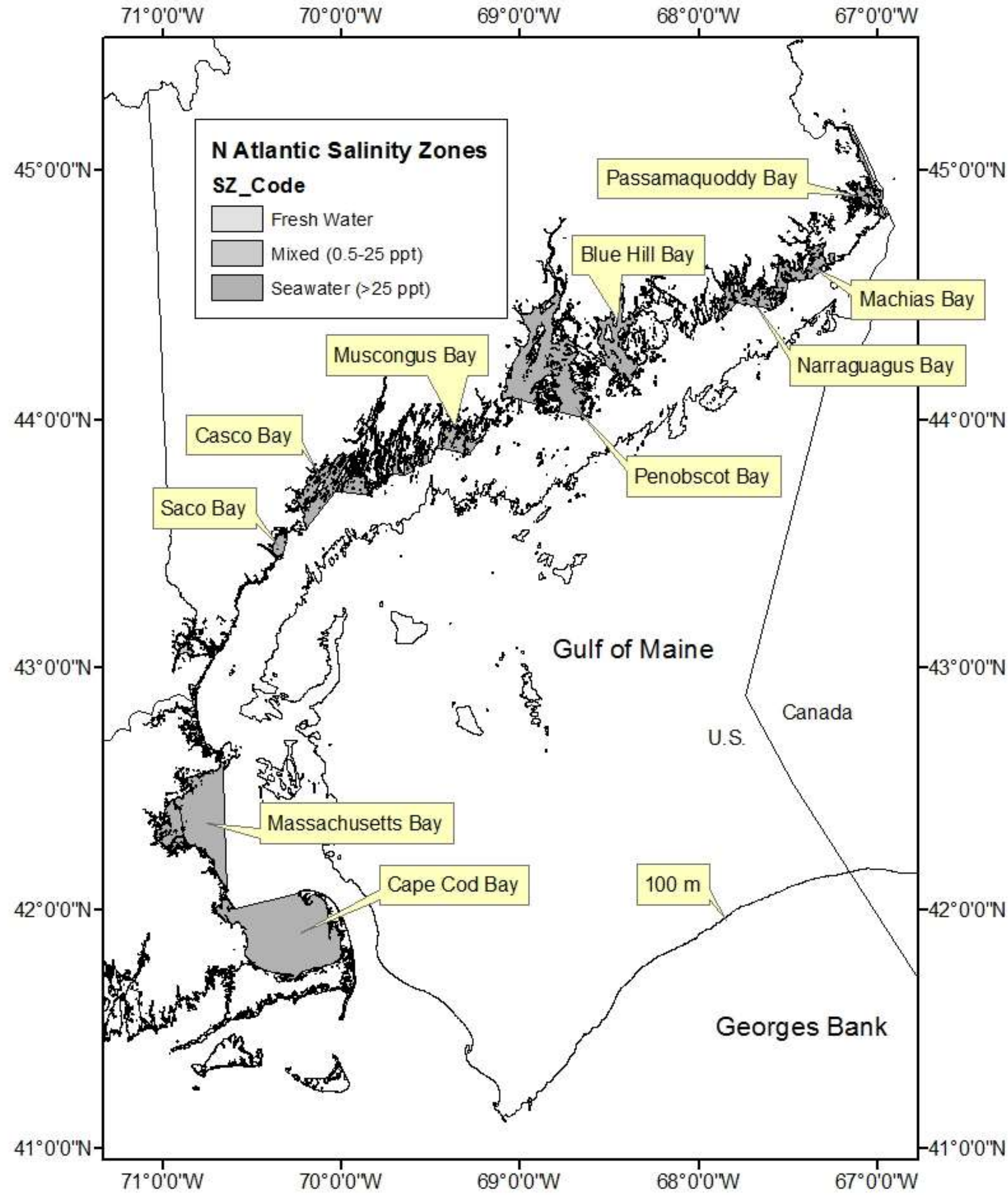
Table 8 – Presumed presence of skates in Mid-Atlantic estuaries and embayments based on ELMR classification for skate complex (common or abundant) and known geographic distributions of individual species. (L = Little Skate, W= Winter Skate, C = Clearnose Skate)

Estuaries and Embayments	Juveniles	Adults
Waquoit Bay		
Buzzards Bay	L,W	L,W
Narragansett Bay	L,W	L,W
Long Island Sound	L,W	L,W
Connecticut River	L,W	L,W
Gardiners Bay	L,W	L,W
Great South Bay	L,W	L,W
Hudson River/Raritan Bay	C,L,W	C,L,W
Barnegat Bay	C,L,W	C,L,W
New Jersey Inland Bays	C,L,W	C,L,W
Delaware Bay	C,L,W	C,L,W
Delaware Inland Bays	C,L,W	C,L,W
Maryland Inland Bays*	C,L,W	C,L,W
Chincoteague Bay	C,W	C,L,W
Chesapeake Bay Mainstem	C	C,L,W

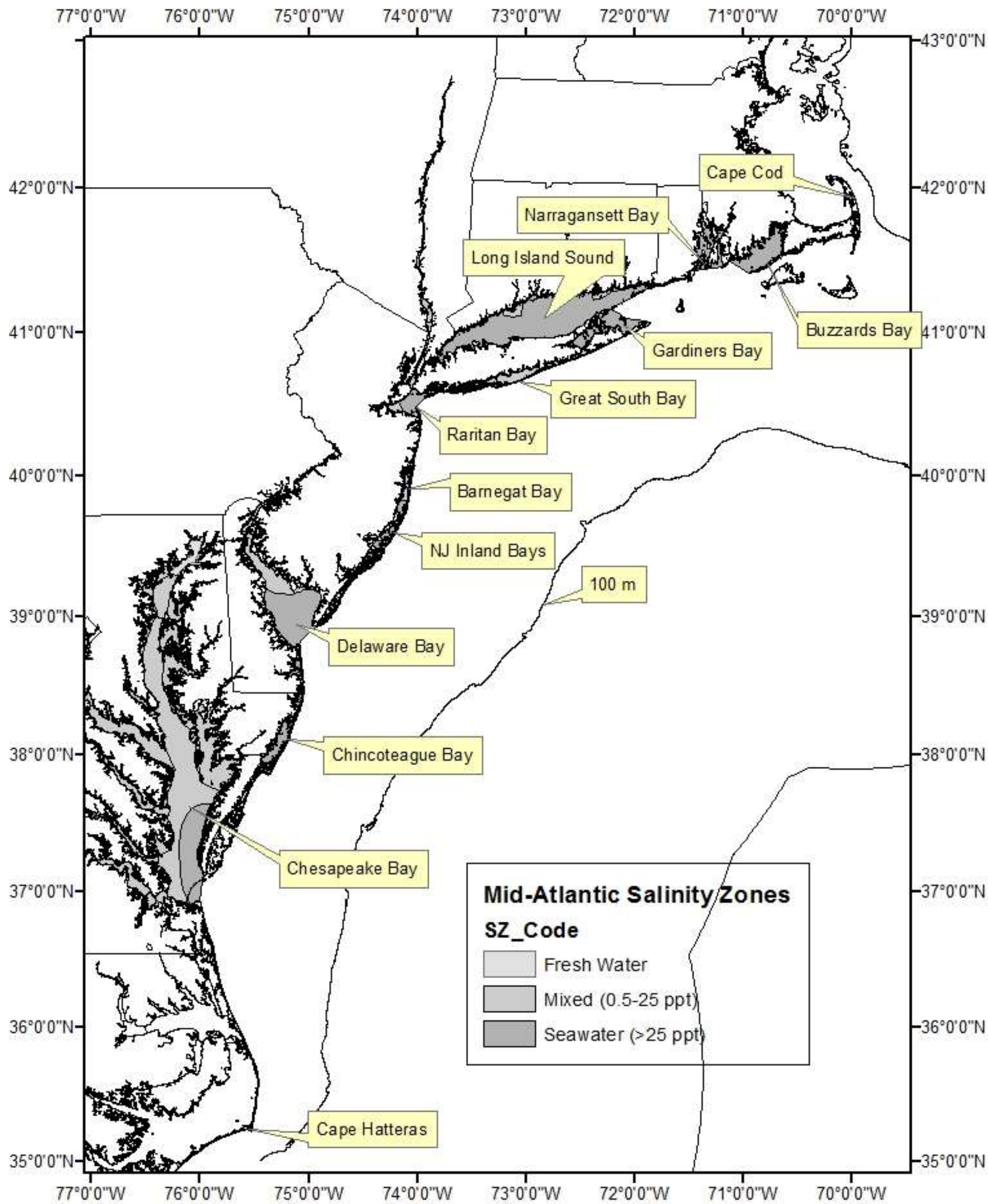
Map 6 – Inshore survey areas included in EFH analysis for the action alternatives



Map 7 – Inshore estuarine areas designated as EFH for a number of species in the Gulf of Maine. Sources: Jury et al. 1994 and NOAA 1985.



Map 8 – Inshore estuarine areas designated as EFH for a number of species in the Mid-Atlantic region. Sources: Stone et al. 1994 and NOAA 1985.



4.2.2.2 Continental shelf

EFH distribution maps were developed for benthic life stages within the NEFSC survey area by generating GIS habitat layers that were based on the depth and bottom temperature ranges that were derived from the analysis used to generate information for the text descriptions (see Section 4.2.1.2).[14] The maps combine these two habitat features with ten minute squares that correspond with the 25th, 50th, 75th, and 90th cumulative percentile thresholds (see sections 3.2 and 4.1.2) of average catch rates by ten minute square from the combined 1968-2005 spring and fall NEFSC trawl survey data. While the trawl survey data layers used in the abundance only and abundance plus habitat alternatives were the same, the abundance plus habitat maps were "clipped" so that they only included the portion of each square that corresponded with the annual depth range that was associated each target life stage and species. They also excluded ten minute squares (TMS) within the offshore survey area that failed to meet either the spring or fall bottom temperature criterion (see below). In order to avoid the addition of habitat data layers that extended beyond the geographic range of the species and life stage in question, habitat layers were added to the maps only if they overlapped spatially with squares defined at the next highest cumulative percentile:

Catch rate percentile used in map	Habitat layer bounded by
25%	50% catch TMS
50%	75% catch TMS
75%	90% catch TMS
90%	100% catch TMS

NEFSC trawl survey data (numbers caught per tow) analyzed for this alternative, and for the abundance only and species range methods, were associated with the survey strata and ten minute squares shown in Maps 3-5. Strata south of Cape Hatteras and on the Scotian shelf (in Canada) were excluded from analysis, but data from many ten minute squares in Canadian waters on Georges Bank and in the Gulf of Maine were included. In addition, the NEFSC survey data used to generate maps for all three action alternatives were processed using a different transformation method than was used for the original 1998 (No Action) EFH maps. This transformation method, which is described in detail in Section 4.1.2, further reduced the effect of occasional large catches (tows that catch a very large number of fish) on the average catch rates and shifted large numbers of ten minute squares from the "lower" (high catch rate) percentiles to the "higher" (low catch rate) percentiles.[15]

In some cases, additional areas were added to preferred maps because they were inadequately surveyed (effectively "unsurveyed", see Map 9) or because members of the Council's Habitat Committee believed they were, in fact, essential habitat areas that were not identified by the methodology used to create the map. Unsurveyed TMS had fewer than four tows and, to be added to any particular map, had to be surrounded by designated squares or have designated squares on three sides and land on the fourth side. Also, in some cases a different life stage was used as a proxy for a poorly-represented life stage if there was inadequate data to map EFH for

[14] For most species, benthic life stages were limited to juveniles and adults, but for Atlantic herring, ocean pout, and winter flounder EFH maps were also produced for benthic eggs.

[15] In other words, if the same data set was analyzed using the status quo transformation method, there would be more ten minite squares in 50th percentile category and fewer in the 75th and higher percentile categories.

the life stage in question. For example, if there was insufficient survey data available to map the distribution of larvae, the distribution of the adults was sometimes used as a proxy for the larvae and a single map produced that applied to both life stages. For the preferred designations, life stages that were mapped using a different life stage as a proxy are listed in Table 9.

Map 9 – Ten minute squares with fewer than four tows that in certain situations were added to preferred EFH maps.

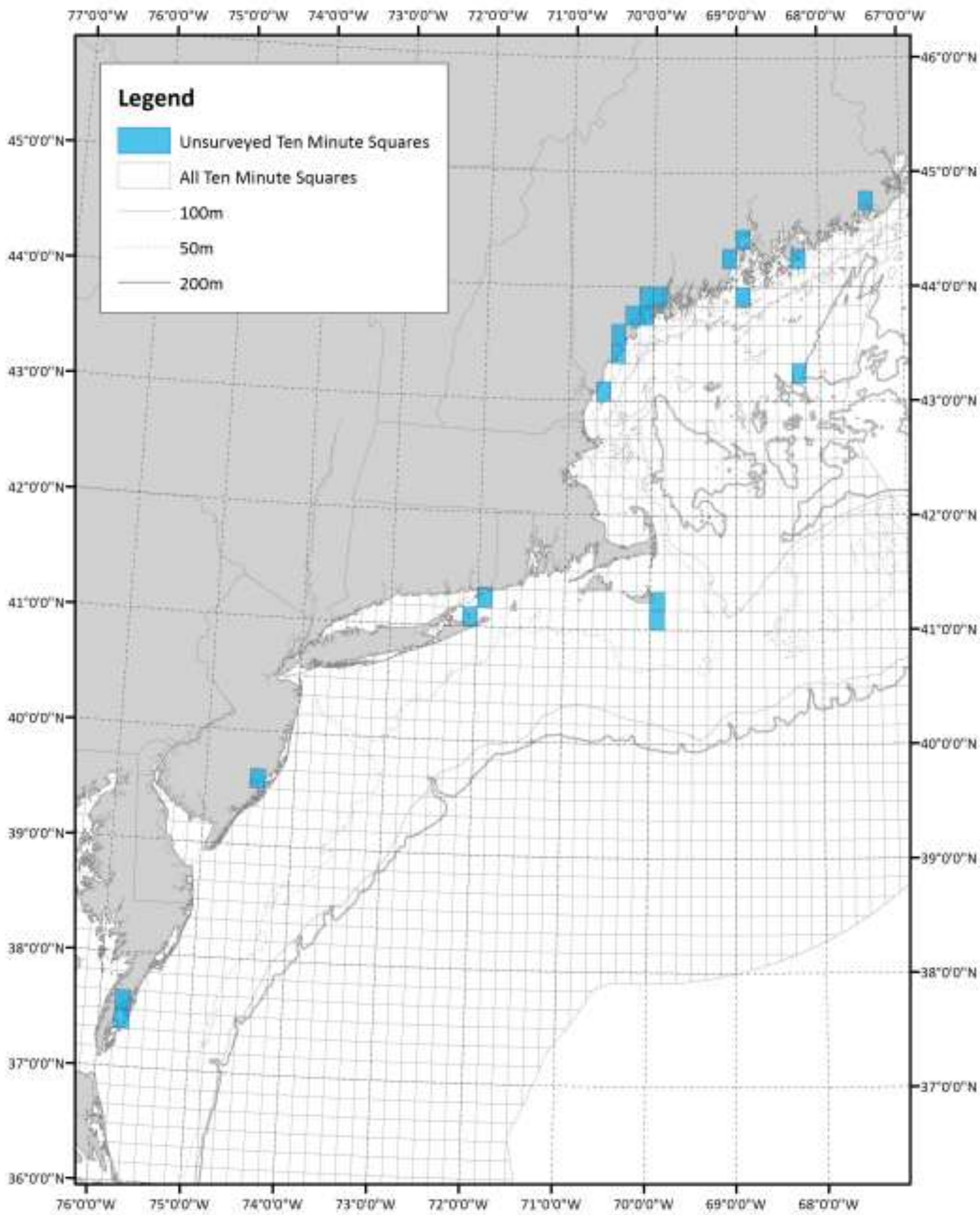


Table 9 - Other Species and Life Stages Used as Proxies in EFH Maps for Preferred Designation Alternatives

Species	Eggs	Larvae	Juveniles	Adults
Atlantic cod	Juvs + eggs	Juvs + larvae		
Atlantic halibut	Juvs + Adults	Juvs + Adults	Juvs + Adults	Juvs + Adults
Atlantic sea scallop	Juvs + Adults	Juvs + Adults	Juvs + Adults	Juvs + Adults
Barndoor skate				Juveniles
Deep-sea red crab	Adult females	Juvs + Adults		
Monkfish	Adults + larvae	Adults + larvae		
Ocean pout	Adults			
Offshore hake			Juveniles	Juveniles
Pollock	Adults + eggs	Adults + larvae		
Red hake	Juveniles	Juveniles		
Redfish		Juveniles		
Rosette skate				Juveniles
Silver hake	Juveniles	Juveniles		
White hake	Adults	Juveniles		
Winter flounder	Spawning adults	Adults		

Depth and Temperature

Depth and bottom temperature ranges (Table 10) were derived from the 1963-2003 NEFSC fall and spring survey catch rate distributions, as described in Section 4.2.1.2 and Figure 1. The annual depth ranges were used to “clip” the survey ten minute squares for the 25, 50, 75, and 90% designation options. The NDGC Coastal Relief Model 3 arc-second raster bathymetry was used to create the depth habitat layer. On the southern portion of Georges Bank nearest the outer boundary of the EEZ which is not covered by the Coastal Relief Model, the USGS 15 arc-second Gulf of Maine raster bathymetry was used instead.

Preferred bottom temperature ranges for each species and life stage were mapped throughout the region using spring and fall averages of bottom temperature by ten minute square (TMS) derived from the 1977-1987 NEFSC MARMAP surveys. A variation layer was then made using additional temperature data collected during a broader time series of hydrographic and bottom trawl surveys. The procedure also accounted for temporal variations in sampling intensity. Fall and spring maps of average bottom temperature are shown in Map 10 and Map 11. TMS with average seasonal temperatures that were below or above either the preferred fall or spring range for any given species and life stage shown in Table 10 were removed from the EFH maps of each percentile of catch option for that species and life stage.

Table 10 – Ranges of depth (meters) and bottom temperature (°C) associated with high catch rates of individual species caught in NEFSC spring and fall bottom trawl surveys in the northwest Atlantic during 1963-2003.

Species	Life Stage	Depth-Spr	Depth-Fall	Depth-Yr	BT-Spr	BT-Fall	BT-Yr
American Plaice	Juvs	50-180	50-180	50-180	2.5-5.5	3.5-10.5	2.5-10.5
	Adults	70-200	80-300	70-300	2.5-5.5	3.5-9.5	2.5-9.5
Atlantic Cod	Juvs	30-90	30-120	30-120	2.5-5.5	4.5-11.5	2.5-11.5
	Adults	30-120	30-160	30-160	2.5-6.5	3.5-11.5	2.5-11.5
Atlantic Halibut	Juvs/Adults	80-140	60-140	60-140	2.5-7.5	4.5-12.5	2.5-12.5
Atlantic Wolffish*	Juvs	70-184	71-160	70-184	max 6.0	3.7-9.6	3.7-9.6

Species	Life Stage	Depth-Spr	Depth-Fall	Depth-Yr	BT-Spr	BT-Fall	BT-Yr
	Adults	27-173	66-168	27-173	max 5.3	4.8-9.7	4.8-9.7
Barndoor Skate	Juvs	60-140	50-160	50-160	2.5-8.5	4.5-11.5	2.5-11.5
	Adults	90-400	40-160	40-400	2.5-8.5	4.5-11.5	2.5-11.5
Clearnose Skate	Juvs	0-30	0-30	0-30	9.5-16.5	14.5-25.5	9.5-25.5
	Adults	0-40	0-30	0-40	7.5-16.5	14.5-24.5	7.5-24.5
Haddock	Juvs	60-140	40-120	40-140	4.5-7.5	4.5-12.5	4.5-12.5
	Adults	50-140	60-160	50-160	3.5-6.5	4.5-10.5	3.5-10.5
Little skate	Juvs	10-60	20-80	10-80	2.5-6.5	11.5-17.5	2.5-17.5
	Adults	20-100	30-100	20-100	2.5-6.5	9.5-15.5	2.5-15.5
Monkfish	Juvs	50-400	50-400	50-400	5.5-12.5	4.5-13.5	4.5-13.5
	Adults	100-400	50-400	50-400	4.5-14.5	4.5-12.5	4.5-14.5
Ocean Pout	Juvs	30-70	40-120	30-120	2.5-5.5	5.5-11.5	2.5-11.5
	Adults	20-70	40-140	20-140	1.5-5.5	4.5-11.5	1.5-11.5
Offshore Hake	Juvs	160-500	180-500	160-500	7.5-12.5	8.5-12.5	7.5-12.5
	Adults	200-500	200-400	200-500	8.5-13.5	6.5-11.5	6.5-13.5
Pollock	Juvs	40-160	40-180	40-180	2.5-5.5	4.5-11.5	2.5-11.5
	Adults	90-200	80-300	80-300	5.5-9.5	4.5-9.5	4.5-9.5
Redfish	Juvs	120-200	100-200	100-200	3.5-9.5	3.5-9.5	3.5-9.5
	Adults	140-300	140-300	140-300	5.5-9.5	4.5-8.5	4.5-9.5
Red Hake	Juveniles	0-30	40-80	0-80	4.5-10.5	9.5-17.5	4.5-17.5
	Adults	60-300	50-160	50-300	5.5-10.5	5.5-12.5	3.5-13.5
Rosette Skate	Juvs	80-400	80-200	80-400	8.5-17.5	9.5-14.5	8.5-17.5
Silver Hake	Juveniles	140-400	40-100	40-400	4.5-9.5	6.5-18.5	4.5-18.5
	Adults	120-400	70-300	70-400	6.5-13.5	5.5-10.5	5.5-13.5
Smooth Skate	Juvs	100-400	100-400	100-400	5.5-8.5	4.5-9.5	4.5-9.5
	Adults	100-400	100-400	100-400	5.5-8.5	3.5-9.5	3.5-9.5
Thorny Skate	Juvs	70-400	70-400	70-400	2.5-8.5	3.5-10.5	2.5-10.5
	Adults	80-300	90-300	80-300	3.5-7.5	3.5-8.5	3.5-8.5
Windowpane	Juvs	0-60	0-60	0-60	2.5-6.5	13.5-20.5	2.5-20.5
	Adults	0-50	0-70	0-70	4.5-7.5	12.5-19.5	4.5-19.5
White Hake	Juvs	80-300	30-120	30-300	3.5-8.5	8.5-13.5	3.5-13.5
	Adults	160-400	100-400	100-400	6.5-9.5	5.5-10.5	5.5-10.5
Winter Flounder	Juvs	10-50	20-60	10-60	2.5-5.5	9.5-16.5	2.5-16.5
	Adults	10-60	20-70	10-70	2.5-6.5	8.5-15.5	2.5-15.5
Winter Skate	Juvs	10-70	20-90	10-90	2.5-5.5	10.5-17.5	2.5-17.5
	Adults	30-80	20-70	20-80	2.5-6.5	10.5-16.5	2.5-16.5
Witch Flounder	Juvs	80-400	80-400	80-400	3.5-11.5	4.5-11.5	3.5-11.5
	Adults	100-400	100-200	100-400	3.5-8.5	3.5-10.5	3.5-10.5
Yellowtail	Juvs	30-80	30-80	30-80	2.5-5.5	8.5-12.5	2.5-12.5
	Adults	30-90	30-80	30-90	2.5-6.5	8.5-14.5	2.5-14.5

* Data source = 2009 NOAA/NERO Atlantic Wolffish Status Review Report; all other species based on NEFSC bottom trawl survey-based depth and temperature data (vertical bar graphs) in EFH source documents and up-date memos

Methods used to estimate average bottom water temperatures

The seasonal temperature distributions were based on NEFSC databases. Bottom temperatures were extracted on 10/21/05 from the bottom trawl survey data base for each station having a bottom temperature value. Bottom temperature and salinity values were extracted from the hydrographic database on 09/14/05. There is redundancy in the two data bases, which is accounted for in the procedures described below.

To make seasonal average distributions of bottom temperature and salinity representing the time period of the trawl survey (i.e., 1963 to the present), the interannual variability in observations scattered over space and time had to be addressed in a rigorous manner. To do this a 'reference ocean' derived from the NEFSC MARMAP data was used. The MARMAP program occupied a set of over 150 standard stations (i.e., stations at set locations) over an eleven year period (1977-1987) and made about 50 observations of temperature and salinity at each location over that period. Characteristic annual cycles of bottom temperature were calculated from these data for each standard station location. By interpolating between the standard station locations, a method was developed to estimate the expected bottom temperature at any location on the shelf on any calendar day (see Mountain and Holzwarth, 1989 and Mountain et al., 2004 for explanation). Using this method, the difference between an observed value and the expected value (i.e., an anomaly) could be determined for every observation in the trawl survey and hydro databases.

The EFH temperature distributions were determined on a ten minute square (TMS) basis. The EFH value for each TMS was determined by adding a mean value derived from the MARMAP annual curves and an average anomaly derived from all of the observations in the data bases. This was done separately for four seasons, defined as spring (March-May), summer (June-August), fall (September-November) and winter (December-February). These seasons were based on the NEFSC spring trawl survey generally beginning in March, the fall survey generally beginning in September or later and the winter survey being in February.

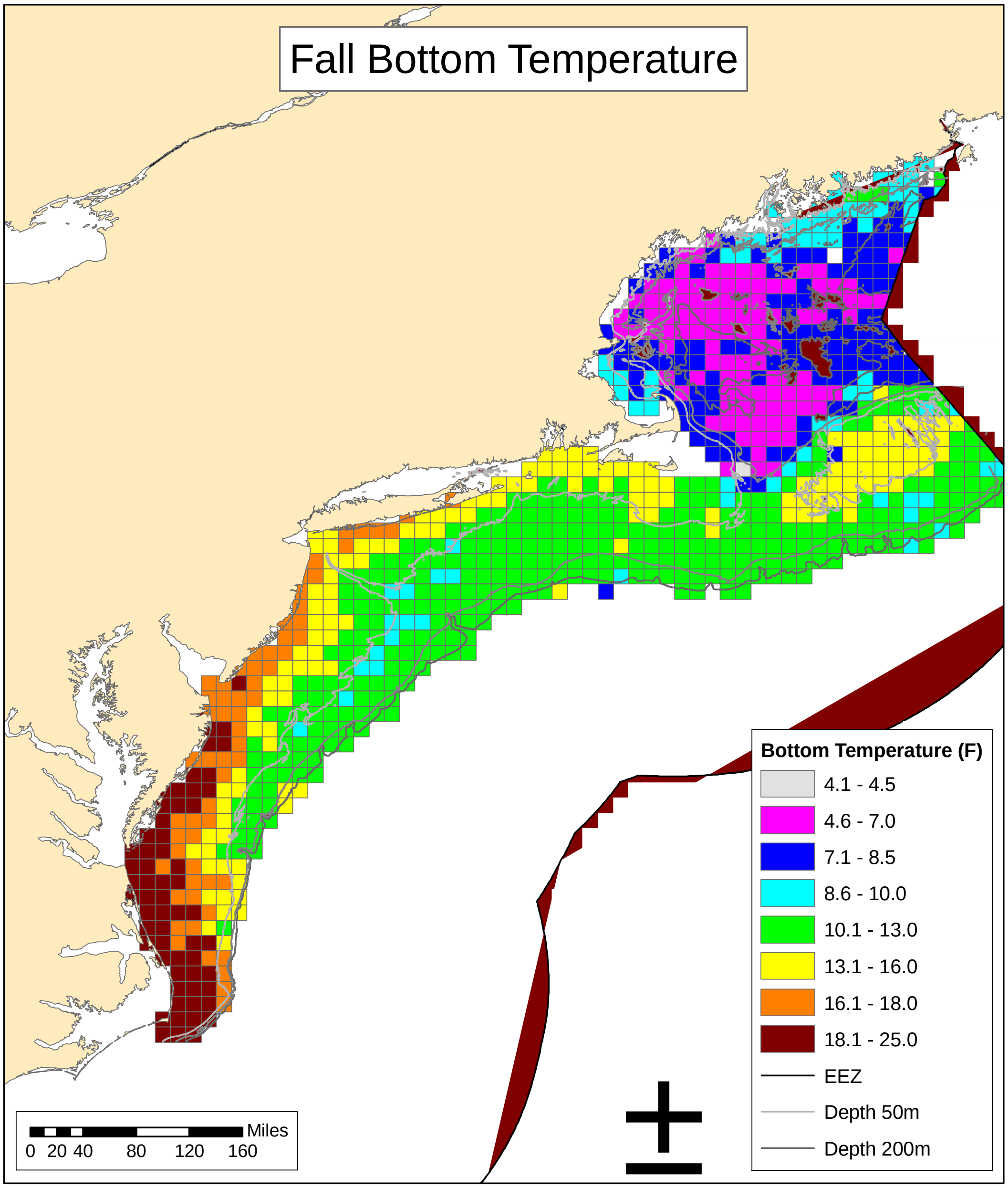
For each season the mean MARMAP value at the center of each TMS was derived by averaging the values estimated by the MARMAP annual cycles for each day of the three month season. This was done for bottom temperature for each season and for each TMS which contained at least one observation in the trawl survey data base.

The bottom temperature anomaly was calculated for each observation in the hydrographic data base. For a temperature observation to be considered a bottom value, it had to be taken within ten meters of the observed bottom depth. Similarly bottom temperature anomalies were calculated for all observations in the trawl survey data base through the end of 1991. Beginning in 1992 the survey observations were made by CTD instruments and are in the hydrographic data base.

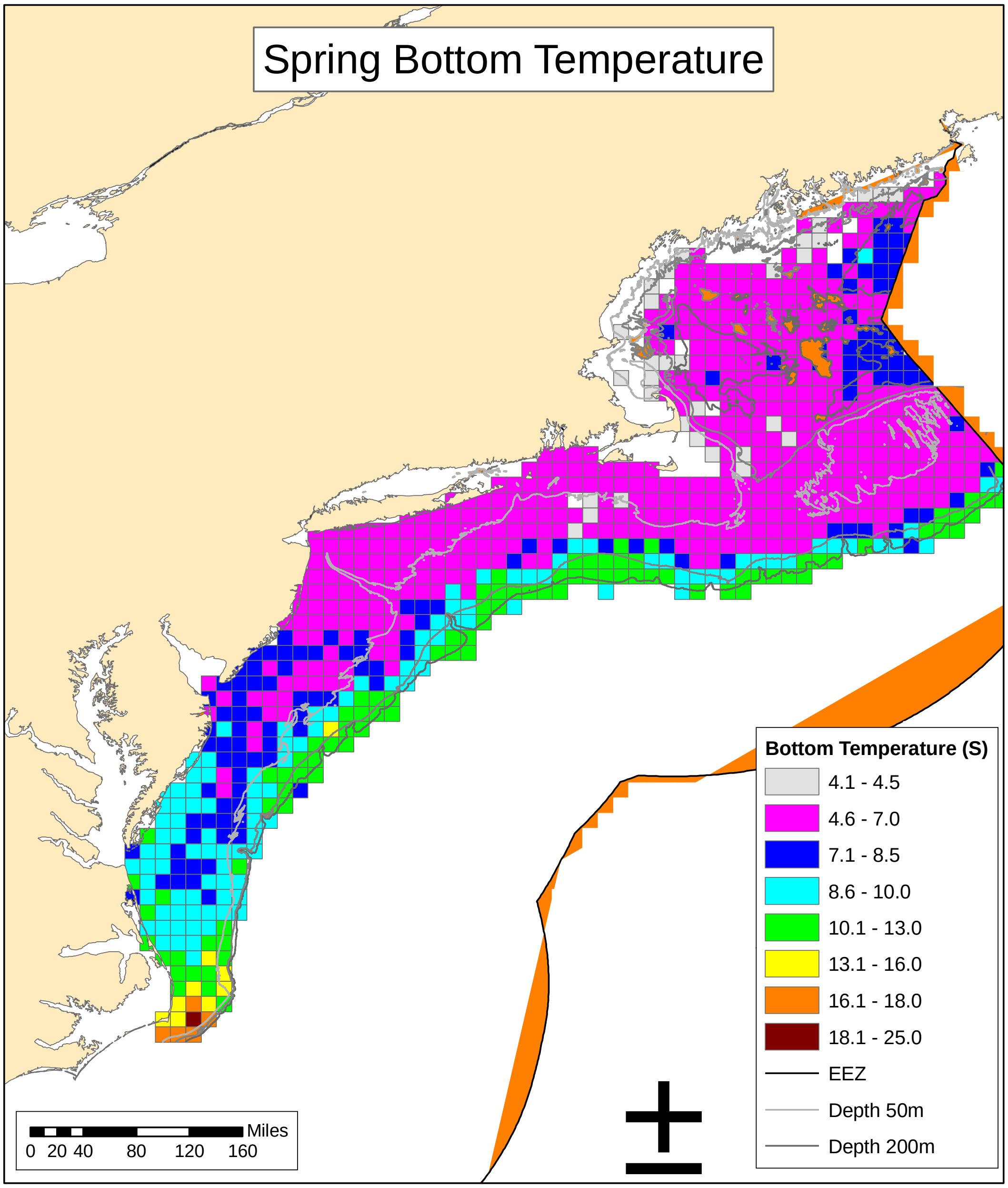
The bottom temperature anomalies in each TMS and within each season were then averaged for three time blocks (1963-1976, 1977-1991, and 1992-2005). For each square that had an anomaly value in each time block, the three average anomaly values were themselves averaged to get the average anomaly over the whole time period. This procedure was done 1) to insure that the whole time period was represented and 2) because the recent decade had many more observations than the earlier decades which could bias a straight average of all anomalies toward recent environmental conditions. For the TMS in which an average anomaly was not able to be calculated (i.e., which did not have a value in each of the three time blocks), a value was determined by averaging the anomalies of the neighboring squares that did have anomaly values. For each TMS and for each season, the anomaly was added to the MARMAP seasonal average value.

It is useful to recognize that the characteristic interannual variability in temperature is approximately +/- 1°C. Given the seasonal mean distributions, this magnitude of year-to-year change would correspond to spatial changes of many tens of kilometers, suggesting that the meaningful spatial scale for these parameters is fairly coarse.

Map 10 – Distribution of average fall (September-November) bottom water temperatures (°C) used to create habitat layers for EFH designation purposes



Map 11 – Distribution of average spring (March-May) bottom water temperatures (°C) used to create habitat layers for EFH designation purposes



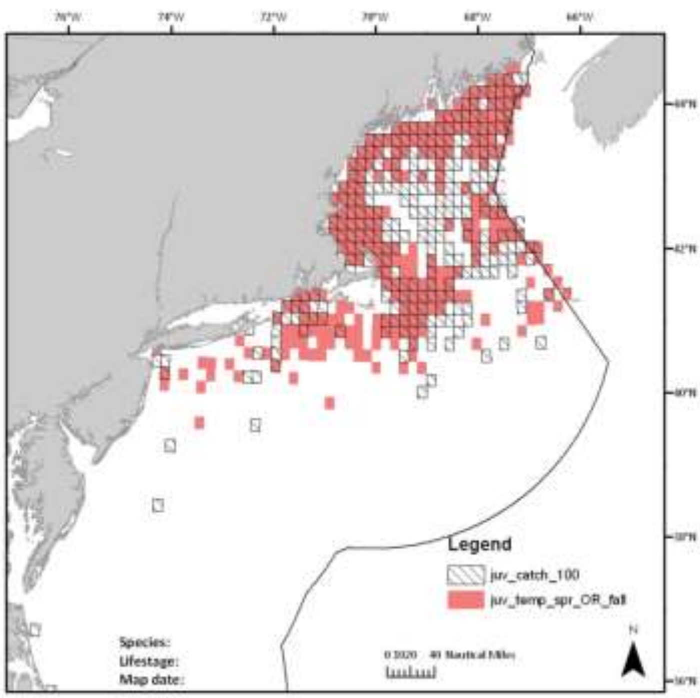
4.2.2.3 Continental slope and seamounts

For benthic life stages, continental slope habitat distributions were added to the abundance plus habitat maps based on level 1 (presence only) maximum depth information included in the text descriptions and knowledge of the geographic range of the species. In all cases, species that extended beyond the edge of the shelf were known or assumed to inhabit slope habitats within the entire north-south range of the region, i.e., from the southern edge of Georges Bank (where the shelf break intersects the U.S.-Canada boundary) to approximately 34°N latitude, south of Cape Hatteras. Depth was defined by the NGDC Coastal Relief Model bathymetry.

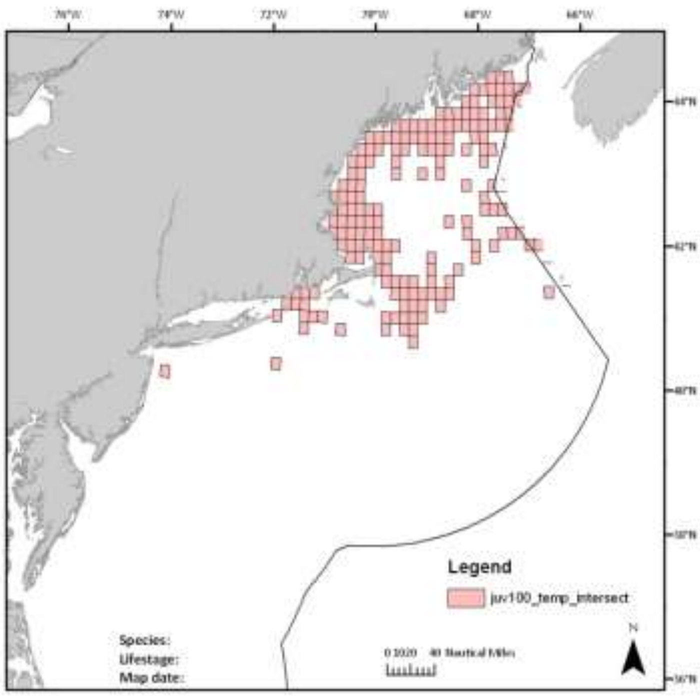
4.2.2.4 GIS protocol for creating maps

This section describes in detail the steps followed in creating the EFH maps that were based on the abundance plus habitat methodology described in this section of the appendix and approved by the Council in 2007. Subsequent to their approval, the PDT made some minor modifications to the sequence of steps used to create these maps, without making any changes to the data used to make the maps or the principals of the abundance plus habitat mapping methodology. The NEFMC's Habitat Committee approved the use of the modified GIS protocol in March 2011. This protocol is described in the following example which shows the sequence of steps used to create the preferred EFH map for juvenile pollock, which was based on NEFSC trawl survey data at the 90th percentile of abundance (average numbers caught per tow by ten minute square) as modified by preferred depth and bottom temperature ranges, with inshore data layers based on state trawl survey data and ELMR areas.

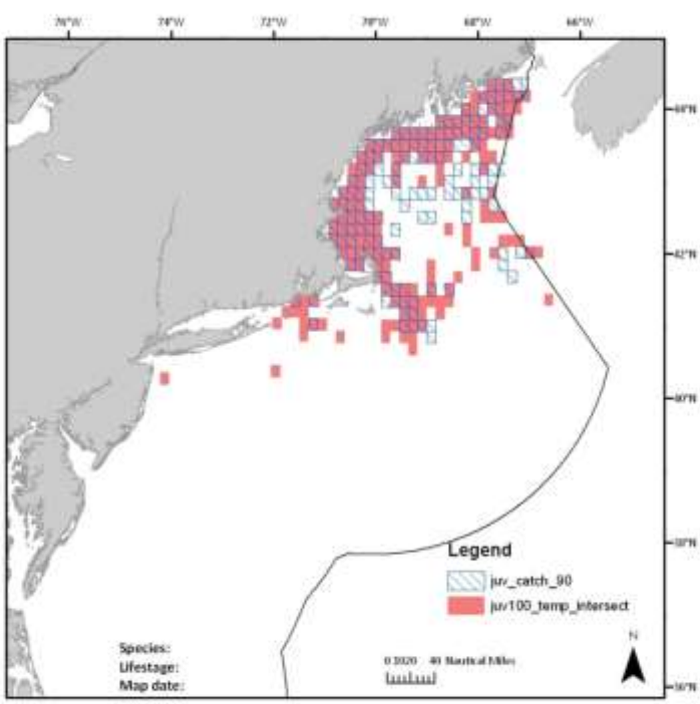
1) Fall or spring bottom temperature designation and average catch at next highest percentile (100%)



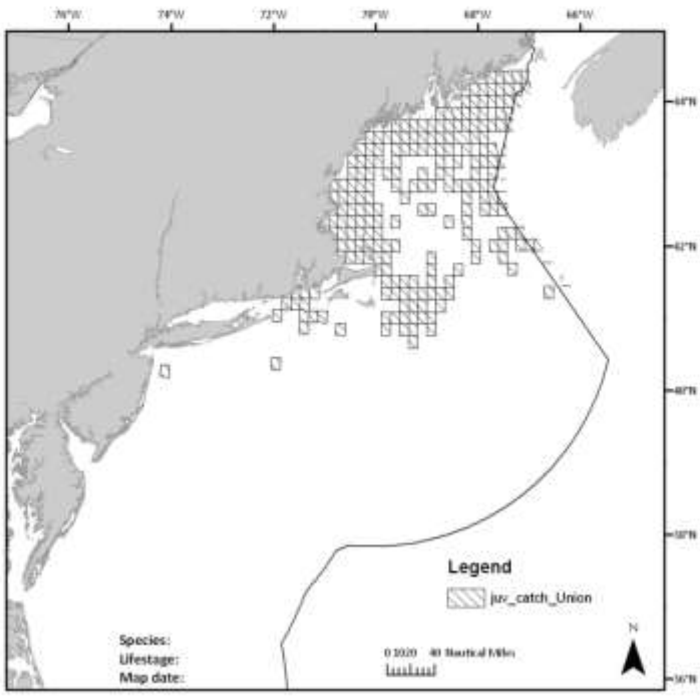
2) Intersection of 100% of catch and temperature designation



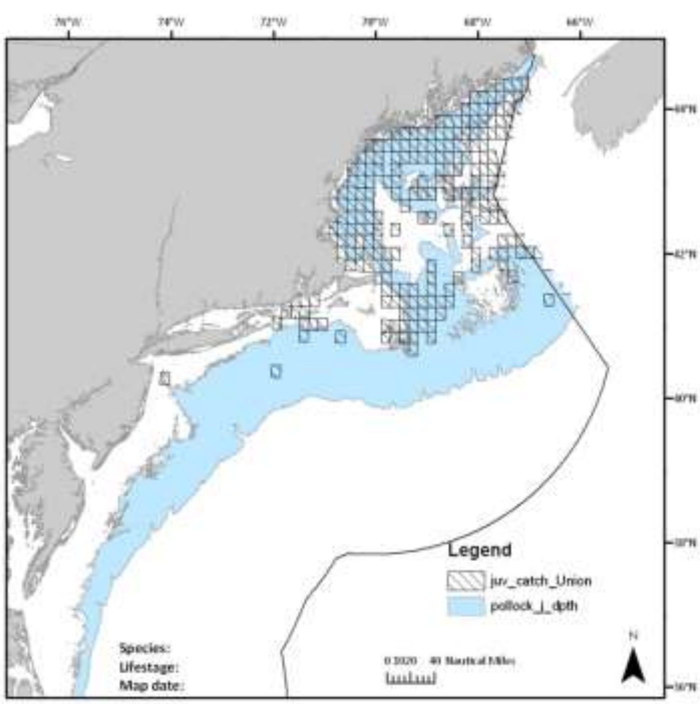
3) Catch layer (90%) added to bounded temperature designation



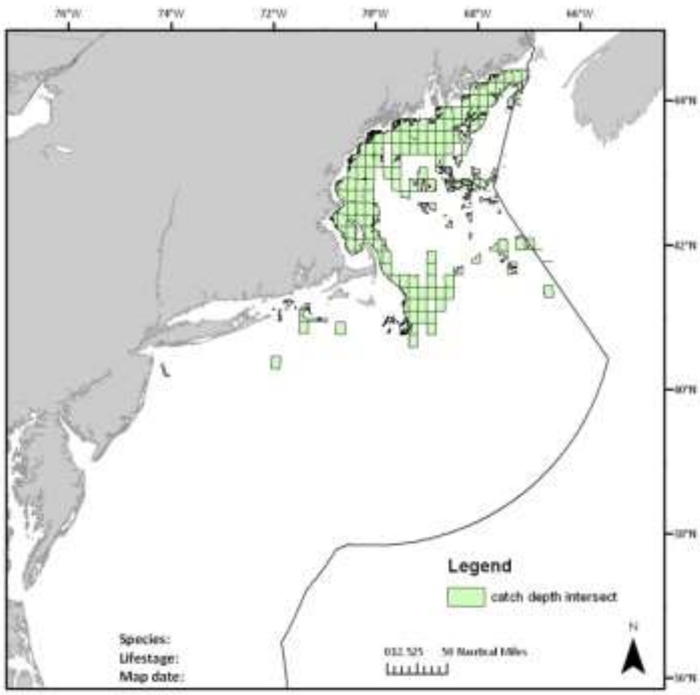
4) Union of catch (90%) with bounded temperature designation



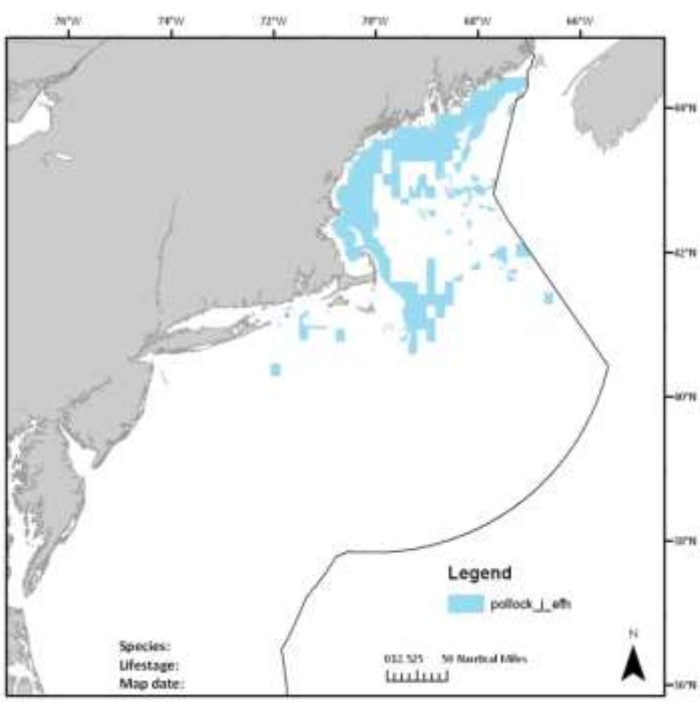
5) Designated depth added to combined catch plus temperature layer



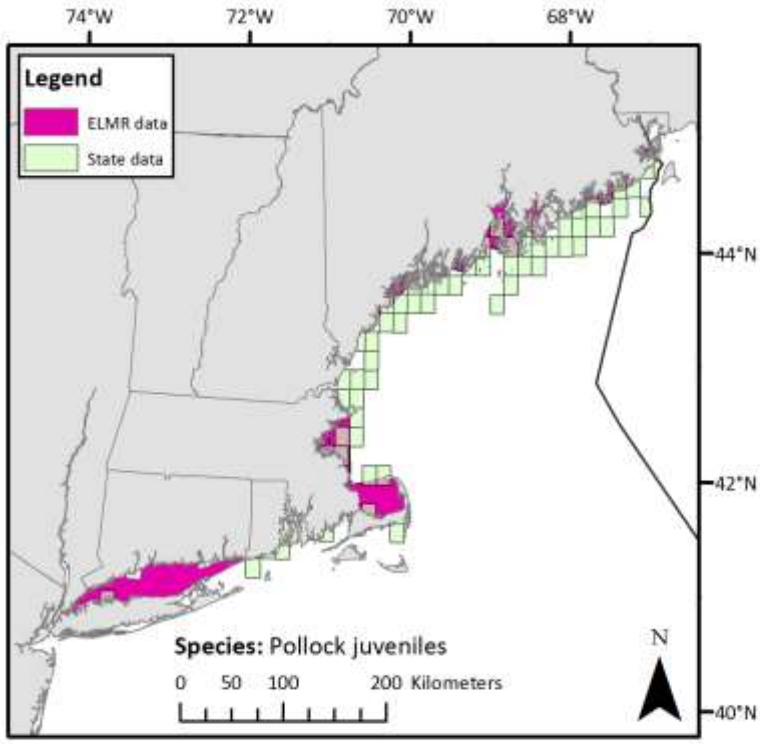
6) Intersection of the combined catch plus temperature layer with depth (note removal of portions of ten minute squares that do not meet depth range designation)



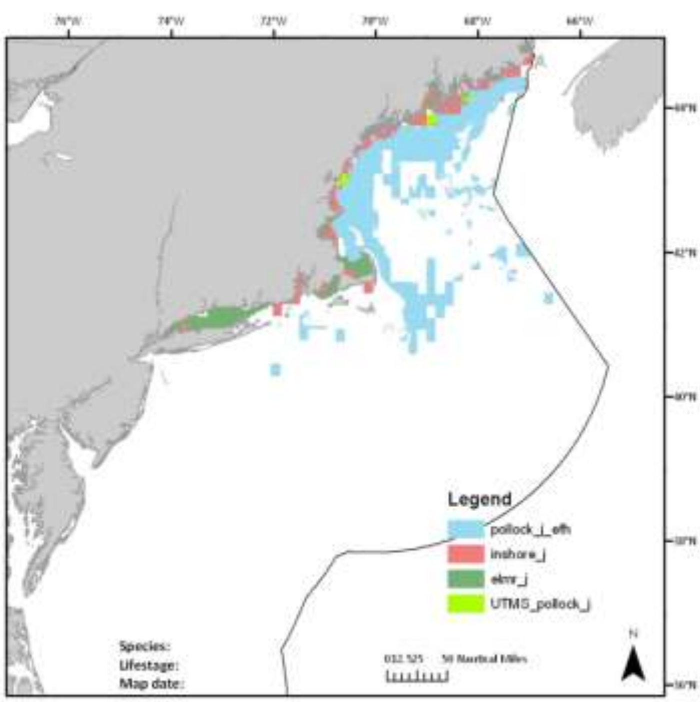
7) Catch plus temperature layer trimmed at EEZ



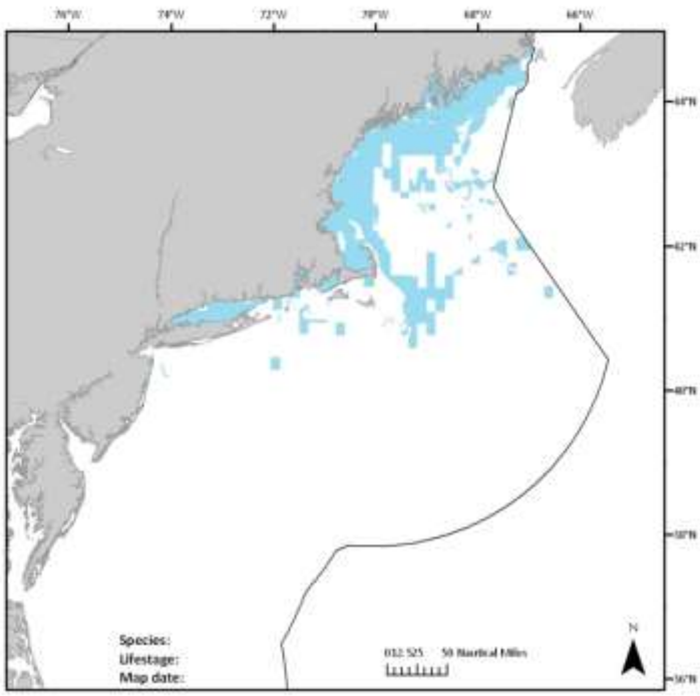
8) Inshore data layer (ELMR areas plus state survey TMS that satisfy the 10% frequency of occurrence criterion)



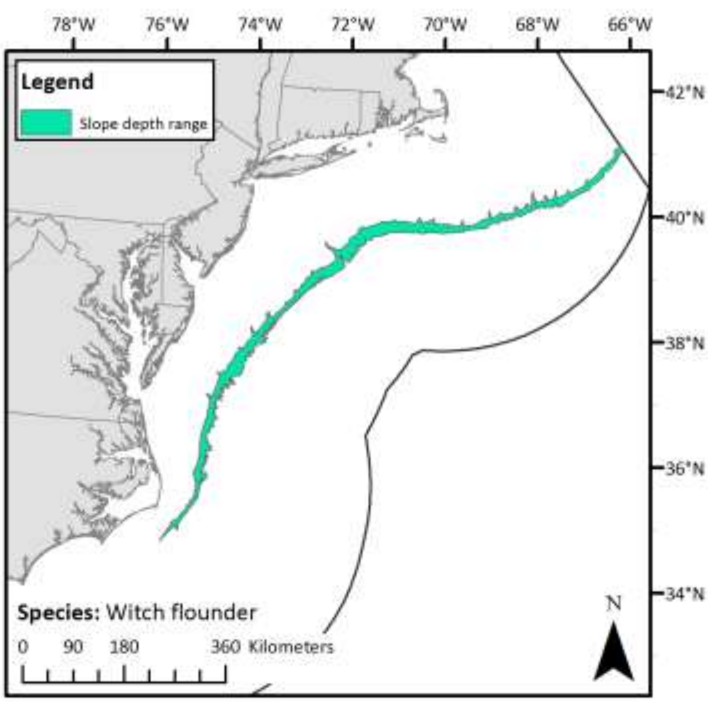
9) Add unsurveyed ten minute squares (fewer than four tows)



Final map:



Add (if appropriate) continental slope data layer based on maximum depth and geographic range (example witch flounder)



4.3 Species range method

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

4.3.1 Text descriptions

For pelagic lifestages, the only new information that was included in the text descriptions for pelagic eggs and larvae in this alternative was level 1 information for species that have been found in continental slope waters. This information was used to supplement maximum depths recorded during the MARMAP surveys and is summarized in the species tables in Appendix B.[16]

For benthic life stages in inshore areas, leve1 1 information on minimum and maximum depths, bottom temperatures, and salinities was derived from data recorded during individual bottom trawl tows or seine hauls that were made in ten minute squares that met the 10% frequency of occurrence criterion (see Section 4.2.2.1). Data were compiled for each survey (see Table 4) and generalized for all ten minute squares in which the target life stage and species was caught in at least 10% of the state survey tows (or hauls). For the continental shelf, maximum depths at which any given life stage and species was caught during 1968-2005 NEFSC bottom trawl surveys were used to identify the upper limit of a depth range that in most cases included a minimum depth based on inshore survey data. For species and life stages with ranges that extend beyond the edge of the shelf, level 1 maximum depth information was derived from EFH source documents and up-date memos, reports of exploratory fishing projects conducted on the northeast continental slope, and from other relevant information sources. Ranges of bottom water temperatures and salinities for inshore and continental shelf areas were derived using the same method that was used for depth.[17] Substrate information was the same as in the abundance plus habitat alternative. All the information that was available for use in developing the alternative 4 text descriptions is summarized in the species tables in Appendix B.

4.3.2 Maps

For most pelagic species no maps were developed because no new information was available. Juvenile and/or adult distributions for inshore, continental shelf and slope areas were used as proxies for a few species. For these species, maps for the continental shelf were based on ten minute squares (TMS) that represented 100% of the 1968-2005 NEFSC spring and fall trawl survey data, sometimes in combination with MARMAP egg and larval survey data. EFH for the

[16] This information was collected for certain species during the 1995-1999 GLOBEC ichthyoplankton surveys on Georges Bank.

[17] As in the other action alternatives, minimum and maximum depths and temperatures were based on the lower or upper limits of data intervals such as illustrated in Figure 1.

inshore and continental slope areas was mapped using the same GIS coverages that were developed for the abundance plus habitat alternative.

Maps for benthic juveniles and adults in inshore and continental slope areas were based on the same GIS coverages that were used in the abundance plus habitat alternative.[18] For the continental shelf, EFH was mapped as TMS that represented 100% of the 1968-2005 NEFSC spring and fall trawl survey data. The trawl survey data were compiled using the same methods that were used in the other action alternatives. For two species with benthic eggs (ocean pout and winter flounder) distributions of adults or juveniles and adults were used as proxies.

[18] The juvenile and adult life stages of Atlantic herring are pelagic, but they are well represented in bottom trawl surveys. Herring eggs are benthic, but no alternative 4 designation was developed for them.

5.0 Atlantic salmon

5.1 No Action

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

5.2 Ten year presence (preferred alternative)

Under this alternative, river systems and estuaries in New England were designated as EFH as long as they met one of three criteria: 1) the presence of adults has been documented in one or more of the most recent ten year period for which data are available; 2) the river is listed as "occupied" and included in the geographic range of the Gulf of Maine Distinct Population Segment (DPS)[19] in Maine; and 3) the river was included in the original 1998 list of designated rivers. Use of a river or drainage system in any particular year is based on the presence of returning adult salmon, as documented in the 2006 and 2014 Annual Reports to the North Atlantic Salmon Conservation Organization of the U.S. Atlantic Salmon Assessment Committee (USASC 2006; 2014), and includes wild adults and hatchery-raised adults. The list of the rivers that the Council approved in 2007 was based on data available through 2005; this list was up-dated for the final designations with data through 2013 and by adding the second and third criteria. "Presence" was based on the capture of one or more fish anywhere in a given river system.[20] Use of this criterion alone proved to be insufficient because some of the smaller rivers are not monitored regularly, or have not been monitored at all in recent years. EFH for the freshwater life history stages was defined to include all rivers and streams in each designated river system that exhibit the environmental conditions identified in the EFH text descriptions.

Text descriptions were based on new information obtained from the No Action EFH descriptions (NEFMC 1998), an unpublished and draft 2nd edition Atlantic salmon EFH source document, and other published sources. They were written in two different formats, one according to life history stages and another according to primary habitats types that included the relevant information for each life history stage that utilizes each habitat (the preferred approach). The information included in each case was the same. Life history stages that were described included eggs, larvae (alevins), juveniles (fry, parr, smolts, and post-smolts), and adults (spawning and non-spawning). Fry were defined as less than 5 cm total length (TL), parr as 5-10 cm TL, and smolts as greater than 10 cm TL. Post-smolts were defined as oceanic-phase juveniles. Habitat types were fresh water spawning and rearing, emigration-immigration, and marine habitats. All the information

[19] The DPS defines a genetically distinct population and provides guidance to NOAA's Greater Atlantic Regional Fisheries Office for determining whether human activities threaten the species or its habitat, as required by the Endangered Species Act.

[20] This was done because there was no way of knowing which tributaries might be utilized for spawning by adults that are captured as they enter the lower part of the main river. This approach was consistent with the method used to develop the No Action designations.

that was utilized in developing the text descriptions for Atlantic salmon is summarized in Appendix B. This information includes habitat requirements by life stage for substrate, water depth, temperature, salinity, dissolved oxygen, current velocity, pH, and primary prey organisms.

Freshwater EFH text descriptions for eggs, larvae, fry and parr were defined to include 1st to 3rd or 4th order tributaries, and for smolts and spawning adults they included 1st to 5th order stream, rivers, and estuaries (i.e., entire riverine/estuarine drainage systems).[21] Lakes, ponds, and impoundments were also included in the text descriptions for smolts. Post-smolts were described as inhabiting near-surface waters in coastal and open ocean marine habitats. In addition to freshwater and estuarine habitats, spawning and non-spawning adult EFH included coastal and open ocean marine habitats.

Three options were developed by the Habitat PDT for depicting the spatial extent of Atlantic salmon EFH. The freshwater portion of EFH was the same in each case. In option 1, there was no fully oceanic component. Coastal areas included in the map were limited to estuarine waters (salinities less than 25 ppt) of ELMR-designated bays and estuaries that form a direct connection between the designated rivers and the sea. In option 2, the map included an area adjacent to the mouth of each designated river out to the 3-mile limit.[22] In option 3, the entire U.S. EEZ was mapped north of 41 degrees north latitude, the presumed southern limit of the area that is potentially used by adults during their migrations to and from their summer feeding grounds in the North Atlantic Ocean (outside the U.S. EEZ). The preferred alternative is Option 2.

5.3 Three year presence

This alternative was developed exactly the same way as the 10-year alternative, except that the only rivers and streams that were included were those where the presence of adult salmon was documented at least once during 2003-2005. Use of a 3-year instead of a 10-year time period resulted in the elimination of 12 rivers and seven coastal bays from the list of designated areas, all of which are located in Maine.

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[21] 1st order streams refer to the headwaters of a river system and the numbering proceeds seaward until reaching 5th order rivers and estuaries.

[22] Long Island Sound was excluded from this alternative because there was no obvious basis for defining which portion of the sound constitutes a migratory pathway for juvenile or adult salmon entering or leaving the Connecticut River.

6.0 Deep-sea red crab methods

6.1 No Action

Text descriptions for this alternative were based on depths, substrates, bottom temperatures, salinities, and dissolved oxygen concentrations where juvenile and adult red crab are found on the continental slope, as described in the EFH Source Document for this species. Maps of the No Action EFH designations cover the geographic area of the continental slope included in the depth zones where deep-sea red crab is found between the U.S.-Canada border and Cape Hatteras. The methods used for defining this depth zone varied between life stages.

- Eggs: Based on known depth zone affinities for female adults (200-400 meters).
- Larvae: Based on the known depth zones as defined by the union of the full (female and male) adult and juvenile depth ranges (200-1800 meters).
- Juveniles: Based on known depth zone affinities for juveniles (700-1800 meters).
- Adults: Based on known depth zone affinities for all adults (200-1300 meters).

For the purpose of determining the geographic extent of EFH for this species (all life stages), its range was defined as continental slope waters (for larvae) and benthic habitats along the continental slope off the southern flank of Georges Bank and extending to Cape Hatteras, North Carolina. Information relating to depths, water temperatures, salinities, dissolved oxygen concentrations, and substrates used in the text descriptions was obtained from the EFH source document for this species and is included in the red crab species table in Appendix B. All the information used in the No Action EFH descriptions and maps for this species was level one (presence only).

6.2 Refined No Action

Alternative 2 includes the No Action text descriptions as revised for refined level 2 slope depth occurrences of deep-sea red crab and modifies the map representations to depict the new depth ranges on the continental slope. New depth ranges were based on relative abundance trawl survey data for juveniles, adults, and spawning adult females on the continental slope reported by Wigley et al. (1975). Text descriptions included revised information on substrate types, bottom water temperatures, and oxygen concentrations, and new information on prey. Maps were developed for eggs, larvae and juveniles, and adults.[23]

6.3 Refined No Action Plus Observed Seamounts

Alternative 3 includes the refined depth ranges for the continental slope used in Alternative 2 as well as a maximum depth (2000 meters) for juveniles and adults on two seamounts (Bear and Retriever) where deep-sea red crabs have been observed during bottom trawl and underwater video surveys. Two maps were generated, one showing the portions of these two seamounts that are within 2000 meters of the surface and the other feature-defined, each showing a “block” of the seafloor that includes the entire seamount. In either case, however, EFH would only apply to the portion of each seamount that is within 2000 meters of the surface. All seamount distribution

[23] As was done in Alternative 1, the depth range for larval EFH was assumed to include the extreme range designated for the species, which in this case was the same as the juvenile EFH depth range (adult EFH was limited to a narrower depth range), so both life stages were mapped together in this and the following alternatives.

information is Level 1 presence only information. Seamount bathymetry was defined using the UNH Center for Coastal and Ocean Mapping/Joint Hydrographic Center Law of the Sea multi-beam bathymetry dataset. This data provides the most accurate available bathymetric data for the seamount complex.

6.4 Refined No Action Plus Gulf of Maine

Alternative 4 includes the Alternative 2 continental slope designations as well as most of the Gulf of Maine where red crabs are reported in the EFH source document to be present in depths below 40 meters. The text descriptions for larvae, juveniles, and adults were revised accordingly. There was no information indicating that red crabs reproduce in the Gulf of Maine, so the text description for eggs was not modified.

6.5 Refined No Action, Observed Seamounts and Gulf of Maine

Alternative 5 includes the Alternative 2 continental slope, Alternative 3 seamount, and Alternative 4 Gulf of Maine designations. Maps for larvae and juveniles and for adults were developed for two options, 5A (depth-defined seamounts) and 5B (feature-defined seamounts).

6.6 Species Range

Alternative 6 designates EFH for deep-sea red crab in the Gulf of Maine, on the continental slope, and on three of the four seamounts located in the U.S. EEZ. Text descriptions and maps were based on the same level 2 information used in alternatives 2-5, but a third seamount (Physalia) was added because a very small portion of it is shallower than 2000 meters. So, even though red crabs have not been observed on this seamount, it seemed reasonable to assume that they are present there.

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