Appendix E: Essential Fish Habitat Designation Methods for New England and Mid-Atlantic Council-Managed Species

Essential Fish Habitat Framework

Atlantic Herring Fishery Management Plan
Framework Adjustment 12

Monkfish Fishery Management Plan
Framework Adjustment 18

Northeast Multispecies Fishery Management Plan
Framework Adjustment 70

Northeast Skate Complex Fishery Management Plan
Framework Adjustment 13

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Essential Fish Habitat Designation Methods for New England and Mid-Atlantic Council-Managed Species

EFH Review Component 1 – Implemented Methods

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1 EXECUTIVE SUMMARY AND CONSIDERATIONS FOR MANAGEMENT

This report describes new methods and approaches developed for the designation of Essential Fish Habitat (EFH) in the Northeastern U.S. These methods were initially developed as part of the 2025 Five-year EFH Reviews for both the New England and Mid-Atlantic Fishery Management Councils and have since been applied to EFH designation maps and text descriptions for the New England Council's 2025 EFH Designation Framework and for the Mid-Atlantic Council's Omnibus EFH Amendment (final action anticipated 2026).

The updated designation methods result in greater consistency, connectivity, and comprehensiveness between life stages in EFH maps and text components for Council-managed species. Prior approaches relied on relatively few fishery-independent surveys (predominantly the federal surveys) to summarize relative abundance and environmental data (i.e., depth, temperature, salinity). In contrast, the updated methods draw upon a larger number of fishery-independent surveys—including additional inshore/state surveys not previously used—update datasets with more recent data, and better integrate abundance and environmental information to develop more comprehensive text and map designations. Additionally, the new approaches model relationships between relative abundance data and a larger suite of environmental covariates to predict where species are more likely to occur based on habitat conditions. For estuarine and coastal areas, where modeling approaches were not feasible, relative abundance data from fishery-independent surveys are summarized relative to depth and salinity zones to determine the spatial extent of EFH in these areas. This information, taken together with peer-reviewed literature, was used to develop more refined EFH text and map designations for the Councils' managed fish species. While the methods for most fish, squid, and shellfish species are standardized, some data-poor species and species life stages required alternative approaches to use available fishery independent, fishery dependent, environmental data, and literature review to generate EFH maps and text. Those variations in the approach are noted in this report.

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3 INTRODUCTION AND BACKGROUND

3.1 EFH regulatory requirements

As amended by the Sustainable Fisheries Act of 1996, the Magnuson-Stevens Fishery Conservation and Management Act (MSA) contains provisions requiring the regional fisheries management councils (Councils) and National Marine Fisheries Service (NMFS) to identify and conserve Essential Fish Habitat (EFH). The EFH regulatory guidelines (50 CFR Part 600 Subpart J) define EFH as:

> "Those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity. For the purpose of interpreting the definition of essential fish habitat: 'Waters' include aquatic areas and their associated physical, chemical, and biological properties that are used by fish and may include aquatic areas historically used by fish where appropriate; 'substrate' includes sediment, hard bottom, structures underlying the waters, and associated biological communities; 'necessary' means the habitat required to support a sustainable fishery and the managed species' contribution to a healthy ecosystem; and 'spawning, breeding, feeding, or growth to maturity' covers a species' full life cycle."

The EFH regulations specify that fisheries management plans (FMPs) should designate EFH by life history stage for all managed species of finfish and shellfish using both text descriptions and maps of the geographic locations or boundaries of EFH. These designations must clearly state the habitats or habitat types determined to be EFH and explain their physical, biological, and chemical characteristics. The EFH regulations also require a four-level approach be taken to organize the information needed for EFH designations and that Councils "strive to describe habitat based on the highest level of detail" possible. In order of increasing information, the four levels of EFH are as follows [50 CFR 600.815(a)(1)(iii)(A)]:

1) "***Level 1: Distribution data are available for some or all portions of the geographic range of the species.*** At this level, only distribution data are available to describe the geographic range of a species (or life stage). Distribution data may be derived from systematic presence/absence sampling and/or may include information on species and life stages collected opportunistically. In the event that distribution data are available only for portions of the geographic area occupied by a particular life stage of a species, habitat use 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. Habitat use may also be inferred, if appropriate, based on information on a similar species or another life stage."

2) "***Level 2: Habitat-related densities of the species are available.*** At this level, quantitative data (i.e., density or relative abundance) are available for the habitats occupied by a species or life stage. Because the efficiency of sampling methods is often affected by habitat characteristics, strict quality assurance criteria should be used to ensure that density estimates are comparable among methods and habitats. 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."

3) "***Level 3: Growth, reproduction, or survival rates within habitats area available.*** At this level, data are available on habitat-related growth, reproduction, and/or survival by life stage. The

habitats contributing the most to productivity should be those that support the highest growth, reproduction, and survival of the species (or life stage)."

4) "***Level 4: Production rates by habitat are available.*** At this level, data are available that directly relate the production rates of a species or life stage to habitat type, quantity, quality, 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."

As described in Section 4: Designation Methods, most of the managed species' approaches use Level 2 EFH information, given that these designations are informed by species distribution models (SDMs) that combine abundance data from fishery-independent surveys with environmental covariates. The designations also rely on relative abundance from other trawl surveys that were not included in the models. Level 1 EFH information is used selectively, for example to determine the maximum depth of EFH along the continental slope, beyond the footprint of fishery independent surveys.

3.2 Prior EFH designation approaches

Prior MAFMC and NEFMC EFH designation methods relied on similar data sources (albeit fewer) to those applied here. However, the new approaches process the information differently (newly developed models and methods), utilize more recent time series to better reflect changing climate, fish habitat use, and ecosystem changes, and incorporate updated research and information that was not previously included. These updates still rely heavily on Level 1 and 2 information as described above in the EFH requirements.

3.2.1 New England Council Approaches

The New England Council first identified EFH for 18 species through Omnibus EFH Amendment 1 (OHA1, 1998)[1] using Level 1 presence/absence and Level 2 relative abundance and distribution data from long term fishery independent resource surveys. The Council developed text descriptions that included geographic area, type of habitat (pelagic or benthic), and general information on substrates and ranges of depth, temperature and salinity for each species and life history stage. The EFH text descriptions were based on information from EFH Source Documents, a series of technical memoranda developed by staff at the Northeast Fisheries Science Center (NEFSC).

During OHA1 (NEFMC 1998)[2], the Council used different methods to develop EFH maps for different life history stages. For demersal life history stages (juveniles and adults except for Atlantic herring and Atlantic salmon), maps were based on average catch rates per ten-minute square of latitude and longitude (approx. 100 mi^2). For planktonic life history stages (eggs and larvae) and the juvenile and adult stages of Atlantic herring, maps were based on percentages of observed range. Primary information sources included the spring and fall NEFSC bottom trawl surveys (1963-1997), NEFSC Marine Resources Monitoring, Assessment and Prediction (MARMAP) ichthyoplankton surveys (1977-1987), and NEFSC scallop dredge surveys (1982-1997). EFH maps for inshore areas were based primarily on the results of a

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[1] The EFH requirements of FMPs that were not included in Omnibus EFH Amendment 1 were completed on the following schedule: Monkfish FMP (April 1999), Red Crab FMP (October 2002), and Skate FMP (July 2003). Amendment 16 (2010) added Atlantic wolffish to the NE Multispecies FMP and identified EFH for the species. EFH was identified for offshore hake in Amendment 12 to the Multispecies FMP in 2000.

[2] NEFMC Omnibus Habitat Amendment 1: https://www.nefmc.org/library/omnibus-essential-fish-habitat-efh-amendment

nationwide resource inventory of several coastal estuaries and embayments conducted by the National Ocean Service in the mid-1990s [NOAA's Estuarine Living Marine Resources Program (ELMR), 1994] and included a limited number of ten-minute squares based on state survey data.

The Council further refined EFH maps to focus on areas of high relative abundance. The EFH Technical Team (which is now referred to as the Habitat Plan Development Team, or PDT) developed a series of alternative maps for each species and life stage based on the 50th, 75th, 90th and 100th cumulative percentiles of the average catch rates (numbers per tow) in each ten-minute square. The Council relied on their general knowledge of each species to select a designation that best represented the areas where any given species and life stage was relatively abundant over the course of each survey. By averaging catches made over many years and at different times of year, this approach accounted for seasonal and temporal shifts in distribution. EFH maps for overfished species were more precautionary (i.e., higher percentiles / greater proportion of the species' distribution).

Following OHA1, EFH designations were developed for the seven skate species (relative abundance of juveniles, adults, or juvenile/adults combined, based on trawl survey data) and for Atlantic wolffish, which uses a simple species range map to accompany the descriptive text, given limited catches in fisheries independent surveys.

Omnibus Habitat Amendment 2 (OHA2)[3] was initiated in 2004 as a multipurpose review of both EFH designations and measures to minimize adverse impacts of fishing on EFH across all Council FMPs. The OHA2 EFH designations are based on relative abundance data from trawl surveys, and the approach is like the one taken in the Council's 1998 amendment. For OHA2, the Habitat PDT used updated EFH Source Documents to inform the text, when available. Updated maps relied upon NEFSC fall and spring trawl survey catch rate data through 2005 and layered on added data from all the inshore state surveys in the region. Federal vs. state survey data were processed and ranked separately and then layered together to form a single inshore/offshore EFH map. Like OHA1, relative abundance was mapped by ten-minute squares, but these ten-minute squares were limited to those that conformed to species and life stage specific temperature ranges, and then the temperature-limited data layers were clipped by species and life stage specific depth limits. EFH in OHA2 was identified for all species individually, and most life stages have distinct text descriptions and maps, except when data limitations required combining more than one life stage for mapping purposes.

The OHA2 EFH maps also fill in un-surveyed ten-minute squares (those with fewer than three observations over the time series) if EFH was designated in adjacent ten-minute squares based on relative abundance data. The maps for selected species include additional discretionary filling of ten-minute squares, where the Council estimated based on its expertise that certain locations provided suitable habitat but were not being mapped based on abundance data alone, due to data limitations. For inshore areas, in addition to ten-minute squares that were identified as EFH based on state trawl survey relative abundance, entire estuaries and embayments were designated based on the ELMR reports. Inshore areas included a buffer to accommodate uncertainty in the shape of the coastline in available spatial data (this approach is also adopted for the updated methods and explained further below).

OHA2 includes extensive documentation of the EFH designation methods. Generally, designation approaches are outlined in OHA2 Appendix A, and specific data sources and methods used for each species are summarized along with the preferred action designation in Volume 2.

[3] NEFMC Omnibus Habitat Amendment 2: https://www.nefmc.org/library/omnibus-habitat-amendment-2

3.2.2 Mid-Atlantic Council Approaches

The Mid-Atlantic Council completed initial EFH text designations and descriptive maps for most FMPs by 2001 and has completed reviews and updates for four FMPs since and created new descriptions of EFH for blueline tilefish and chub mackerel when those were added to FMPs in 2017 and 2020, respectively. The Council identified EFH using level 1 and/or level 2 data primarily from distribution and relative abundance data from the NEFSC bottom trawl surveys (spring and fall, 1963+), ichthyoplankton surveys (monthly, 1977+), information from species EFH source documents (technical memos) developed by NEFSC staff, and some inshore areas in EFH maps were based primarily on the results of a nationwide resource inventory of several coastal estuaries and embayments conducted by the National Ocean Service in the mid-1990s [NOAA's Estuarine Living Marine Resources Program (ELMR), 1994] and included a limited number of ten-minute squares based on state survey data. Additional broadly defined (level 1) areas south of Cape Hatteras and on the continental slope were added to maps for larvae and juveniles.

The EFH Technical Team (which is now referred to as the Fishery Management Action Team) developed a series of alternative maps for each species and life stage based on the 50th, 75th, 90th and 100th cumulative percentiles of the average catch rates (numbers per tow) in each ten-minute square. The Council and its Habitat Committee (prior to 2006)[4] relied on their general knowledge of each species, which level of information was available, and species stock status. EFH maps were developed for each life stage and displayed the distribution and abundance data by ten-minute square.

The EFH process was developed for bluefish and then applied to other individual FMPs. EFH designations for Mid-Atlantic managed species were historically updated as follows. The original designations (pre-2001) are still in effect for bluefish, Atlantic surfclam, ocean quahog, summer flounder, black sea bass, and scup. NEFMC has the lead for jointly managed monkfish, therefore it has revised those designations for both Councils through its actions, most recently, OHA2 (2018). Likewise, the MAFMC has taken the lead addressing EFH designations for spiny dogfish through its actions.

Table 1. MAFMC EFH designation actions and timing.

Year	Action
1999	EFH identified for all species managed in the Bluefish FMP (Amendment 1), Atlantic Mackerel, Squid (longfin and shortfin), and Butterfish FMP (Amendment 8), Atlantic Surfclam and Ocean Quahog FMP (Amendment 12), Summer Flounder, Scup, and Black Sea Bass FMP (Amendment 12), and Spiny Dogfish FMP (original FMP)
2001	EFH identified for golden tilefish (original Tilefish FMP)
2008	EFH identified for longfin eggs (Atlantic Mackerel, Squid (longfin and shortfin) and Butterfish FMP: Amendment 9)
2009	EFH updated for golden tilefish (Tilefish FMP: Amendment 1)
2011	EFH updated for all FMP species (Atlantic Mackerel, Squid (longfin and shortfin), and Butterfish FMP: Amendment 11)
2014	EFH updated for spiny dogfish (Spiny Dogfish FMP: Amendment 3)
2017	EFH identified for blueline tilefish (Tilefish (Golden and Blueline) FMP: Amendment 6)
2020	EFH identified for chub mackerel (Mackerel (Atlantic and chub), Squid (longfin and shortfin) and Butterfish FMP: Amendment 21)

[4] In 2006, MAFMC combined its former Ecosystems Committee, Habitat Committee, and Comprehensive Management Committee into a single Earth and Ocean Planning (EOP) Committee.

3.3 Model-based EFH mapping in other regions

The designation methods for this EFH Review drew inspiration from the model-based approach employed by the North Pacific Fishery Management Council (NPFMC) in its recently completed 2023 EFH 5-year Review (NPFMC 2023)[5]. The NPFMC was the first of the eight fishery management councils to utilize model-based approaches to support EFH maps and designations. The Northeast is the second region to apply these model-based methods for EFH purposes. As described further in Section 4: Designation Methods, this approach uses species distribution models (SDMs) to combine abundance data primarily from bottom trawl surveys with environmental covariates and map the extent of EFH for each managed species, which then informs EFH text descriptions.

In March 2017, the MAFMC EFH Fishery Management Action Team (FMAT) met at the James J. Howard Marine Sciences Laboratory with experts from the Northeast Fishery Science Center (NEFSC), Greater Atlantic Regional Fisheries Office (GARFO), NEFMC habitat staff, and several state agencies to provide their expertise and assist the FMAT in developing recommendations for improving EFH and Habitat Areas of Particular Concern (HAPC) text and map designations. The recommendations from that group were carried forward into the work of the Northeast Regional Marine Fish Habitat Assessment (NRHA) to support EFH and ecosystem initiatives in the Northeast Region. Following the FMAT meeting, MAFMC recommended stepping back from the EFH review to develop foundational information via NRHA. NEFMC and MAFMC signed on as co-leads of the assessment; initial work was completed between 2017-2022 with NRHA work and improvements to be ongoing.

NRHA served as the necessary foundation to inform this EFH Review, including the following elements: multi-disciplinary, regional collaboration; a holistic approach that evaluates, compiles, and integrates a variety of data sources (both state and federal); and publicly accessible mapping tools that visualize modeling outputs and habitat information. Other relevant resources for this EFH Review have included the NRHA Habitat Climate Vulnerability Crosswalk Project, which integrates outputs from the NOAA Fisheries' Fish and Shellfish Climate Vulnerability Assessment (FSCVA) and Habitat Climate Vulnerability Assessment (HCVA; Farr et al. 2021), and which helped inform the HAPCs component of this review. All NRHA products are shared via https://nrha.shinyapps.io/dataexplorer/.

3.4 EFH designation principles developed for this review

These principles were developed by the MAFMC's EFH FMAT and NEFMC's Habitat PDT to guide the work of the EFH Review, and Component 1 method development documented here. The principles were informed by lessons learned during development of NRHA, conversations with other Councils via the Council Coordinating Committee Habitat Work Group, and engagement with and consideration of the needs of NOAA Fisheries' EFH consultation work.

1. Consider the needs of our NOAA EFH consultation partners and how EFH maps and text are used and understood by project developers.
    - Coherence between map and text descriptions is important because developers often use EFH maps (especially via the NOAA EFH mapper) to first check whether EFH is present in their project area, and then consult the text descriptions.

[5] Additional information can be found on the NPFMC's Habitat Protections webpage: https://www.npfmc.org/fisheries-issues/issues/habitat-protections/

- Consider identification of HAPCs to be clear about which habitats are most important during consultations. This bolsters NOAA's conservation recommendations in specific habitats and at specific sites.

2. Consider applying new model-based approaches where possible for juveniles and adults, to inform both EFH maps and text.
    - Identify thresholds that can be used to delineate EFH maps from model outputs.
    - Consider whether important predictors should be incorporated into text descriptions.
3. Consider climate change and shifting distributions.
    - Where possible utilize more recent data (2000-2019) unless it is not indicative of a species range.
    - Consider areas on the margins of what would be presently considered EFH, and make decisions on inclusion/exclusion of these margins within the context of climate change.
4. Focus on bounding the spatial extent of EFH.
    - What is the southern to northern extent of the species distribution? Inshore to offshore?
5. Provide details on where species' life stages may be found and the specific habitat types being utilized. Use multiple data sources and primary and gray literature as appropriate.
    - Adopt common terminology for habitat types based on the NRHA Habitat Climate Vulnerability Crosswalk Project.
6. Emphasize connectivity between life stages.
    - Text descriptions should include information on movement/migration.
    - Text and maps should consolidate life stages that share similar distribution and habitat characteristics or where needed due to lack of data for a life stage.
7. Be mindful of continuity of sampling and sampling effects that may appear in the data.
    - Spatial component - are some areas of the Northeast US continental shelf not sampled? For example, trawl survey tows along the shelf break have a maximum depth of ~300 m.
    - Temporal component - given seasonal movements of some species, does spring and fall sampling miss locations where they are relatively abundant?
8. Methods should be clearly explained and replicable over time.

3.5 Iterative review of designation methods

EFH designation methods continue to evolve to reflect updates to fisheries science and management priorities. For example, NPFMC's 2023 EFH Review updated their previous 2017 approach after considerable internal and external discussion, review, and revisions. Similarly, the substantial efforts undertaken with this 5-year review have benefited from feedback from both the MAFMC and the NEFMC Scientific and Statistical Committees (SSCs)[6], as well as input from both Councils' Plan Development Teams (PDTs), Advisory Panels (APs), the MAFMC Ecosystem and Ocean Planning (EOP) Committee, the NEFMC Habitat Committee, and other regional and federal partners. These collaborative efforts to update and streamline the designation methods should also facilitate future updates to EFH designations. Updates may include:

- Incorporating additional years of data from surveys that are included in this round of designations.

[6] September 29, 2023 SSC Sub-Panel Report: https://www.nefmc.org/library/sep-29-2023-ssc-sub-panel-report-re-habitat-nrha-review

- Potentially adding data from additional fishery independent surveys that use different methods (e.g., longline) which provides additional information for species with lower catchability in trawl gear but requires additional work to configure species distribution models.
- Incorporating updated environmental covariates, including newly developed ocean models, such as MOM6 (Modular Ocean Model version 6).
- Including information from updated EFH Technical Memoranda (Source Documents) that will be developed via MAFMC's Inflation Reduction Act funded project. This is likely most relevant to the text descriptions but could also inform EFH maps.
- Incorporate optical data (i.e., hue angle and photosynthetically active radiation, or PAR) in the EFH models in lieu of depth.

4 DESIGNATION METHODS

Most Council-managed species occur within the US exclusive economic zone (EEZ) and/or inshore areas (coastal areas and estuaries) and have sufficient, life stage-specific abundance data from inshore and offshore trawl surveys for species distribution models (SDMs). In these cases, EFH designation maps are based on SDM prediction outputs and, where possible, are specific to each life stage; otherwise, we pool data from multiple life stages for a given species. We describe this model-based approach in greater detail in Section 4.1. Inshore, we combine fishery independent survey data with depth and salinity-based estuarine and coastal zones to map EFH (see Section 4.2). In some cases, there may be insufficient survey data across all life stages of a species, in which case, species are not modeled, and instead their geographic ranges are determined from the various available data sources and literature. We further describe these alternative mapping approaches in Section 4.3, as well as considerations for non-modeled species. Finally, we describe the process for revising EFH text descriptions based on these maps and other information sources in Section 4.4.

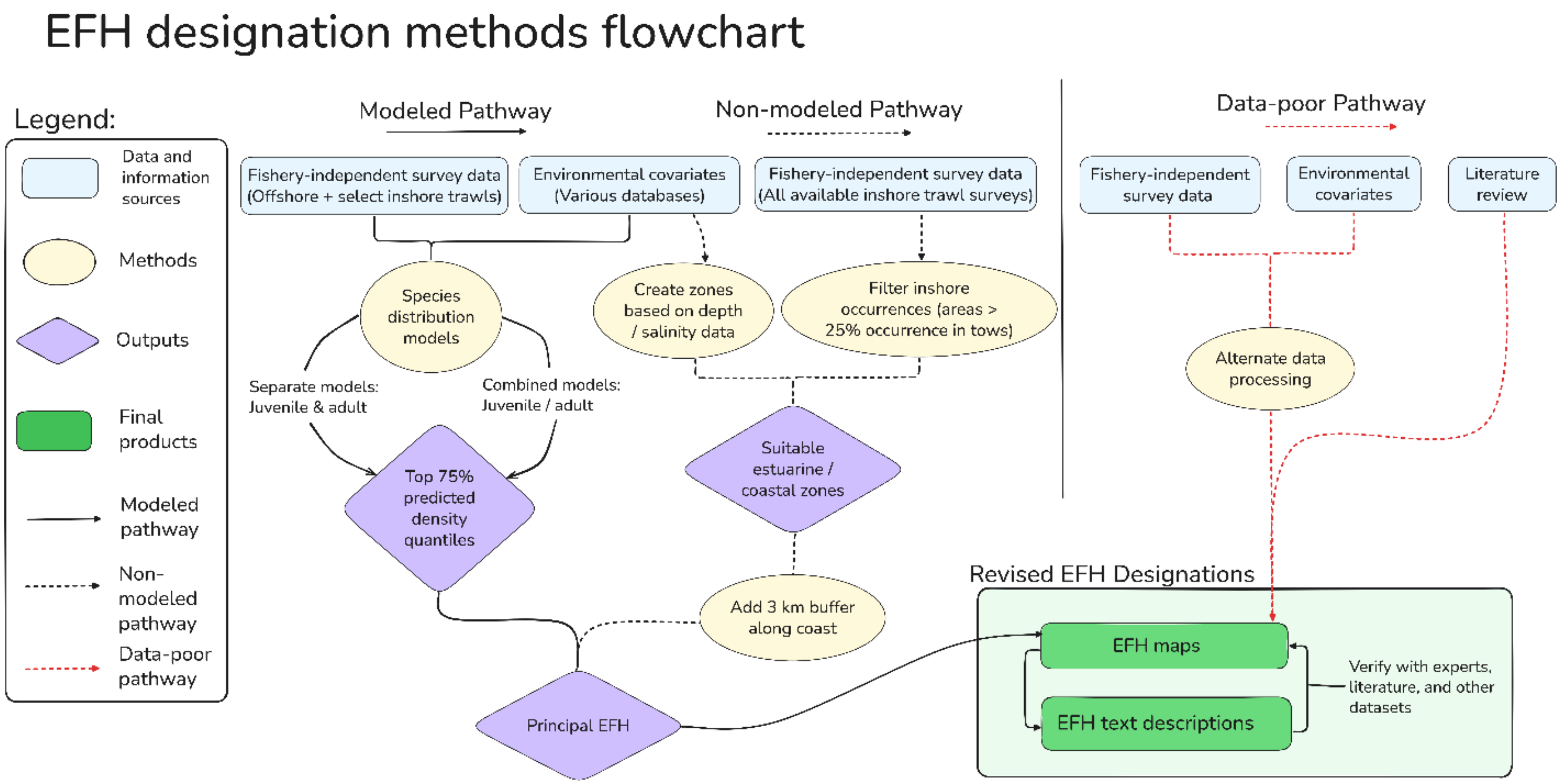
For both modeled and non-modeled species, several additional considerations and inputs inform the EFH designation maps:

- Discontinuities in sampling between inshore and offshore areas that may be the result of shifting seasonal distributions, where the trawl survey sampling seasons (fall and spring) used to inform the SDMs may not capture all locations used by the species throughout the year.
- Potential for species movements, shifting distributions, and range contractions, over the time series of the surveys.
- Occurrence of a species in continental slope depths, beyond the spatial domain of the SDMs and outside the areas sampled by spring and fall trawl surveys.

Additionally, EFH maps for all species will be verified with the best available knowledge through consultation with experts and through literature reviews.

The EFH designation process is summarized in Figure 1.

Figure 1. Flowchart summarizing updated Essential Fish Habitat (EFH) designation methods. With sufficient fish abundance data, designation methods use modeled and non-modeled pathways to update and revise the EFH designations.



4.1 Model-based EFH mapping

4.1.1 Data sources

4.1.1.1 Fish abundance data

The species distribution models (SDMs) described in Section 4.1.2 are built using life stage-specific abundance data (counts) and environmental data. Abundance data came mainly from the Northeast Fisheries Science Center's (NEFSC) bottom trawl survey, the survey with the greatest spatial coverage, but was supplemented with inshore and coastal surveys based on SSC recommendations. These inshore surveys include the NEAMAP[7] Southern New England and Mid-Atlantic Nearshore Trawl Survey (NEAMAP Mid-Atlantic, led by the Virginia Institute of Marine Science), Massachusetts Division of Marine Fisheries Bottom Trawl Survey, the Maine-New Hampshire Inshore Trawl Survey (conducted by the Maine Department of Marine Resources), Connecticut Long Island Sound Trawl Survey, and Chesapeake Bay Multispecies Monitoring and Assessment Program (ChesMMAP). Abundance data are available starting in 2000[8] for all surveys except for NEAMAP Mid-Atlantic, which starts in 2007. The SDMs use a 20-year time series, 2002-2022. For some species (see Table 2), abundance data mainly come from dredge surveys (Atlantic surfclam, Ocean quahog, Atlantic sea scallop) which covers most of the clam species distribution, or longline surveys (Golden tilefish); these have a more restricted spatial domain compared to the bottom trawls that survey a broader geographic area.

The models represent hindcasts of the period represented by the abundance data (i.e., 2002-2022). Knowledge gained from this work could be combined with climatological projections to predict where habitats may occur in the future as environmental conditions continue to change; this could be used to inform future habitat designation approaches or other fisheries management decisions.

Where possible, for species with sufficient data for modeling, we used life stage-specific abundance data for life stages excluding those not well sampled in the surveys (i.e., egg, larvae, and paralarvae). Table 3 depicts how these are separated into juvenile and adult categories based on length at maturity (L_{50}) or pre-recruitment vs post-recruitment status (e.g., shortfin squid). There are several instances where life stages were pooled together (see Table 5). If any species-life stage occurred in < 5% of trawl tows, we pooled the two life stages to ensure adequate representation. Any species that still occurred in < 5% of samples after pooling life stages was not modeled, and instead alternate mapping approaches were used (see Section 4.2). We also pooled data where life stage-specific breaks were not needed as the species is already mature when sampled (e.g., Atlantic surfclam and ocean quahog) or where sampling was adequate, but modeling was improved by pooling data (e.g., spiny dogfish, golden tilefish, barndoor skate, and smooth skate).

Data sources refer to the following:

- *NEFSC* refers to surveys conducted by the Northeast Fisheries Science Center
- *NEAMAP* refers to the Northeast Area Monitoring and Assessment Program: https://www.vims.edu/research/units/programs/multispecies_fisheries_research/neamap/
- *ChesMMAP* refers to the Chesapeake Bay Multispecies Monitoring and Assessment Program: https://www.vims.edu/research/units/programs/multispecies_fisheries_research/chesmmap/

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[7] Northeast Area Monitoring and Assessment Program: https://www.vims.edu/research/units/programs/multispecies_fisheries_research/neamap/

[8] There are gaps in the time series during 2020-2021 and some data sets are not available through 2023; however, 2023 and future years data may be added to future analyses

Table 2. Fisheries independent survey data used in joint species distribution models (SDMs). Here, fish refers to any combination of fish, shellfish, squid, crustaceans, etc.

Data Source	Data type
NEFSC Bottom Trawl	Fish abundance, multispecies
NEFSC Scallop Dredge	Fish abundance, predominately focused on areas where scallops occur, uses scallop dredge gear
NEFSC Clam Dredge	Fish abundance, predominately focused on areas where surfclams and ocean quahogs occur, uses hydraulic clam dredge gear
NEFSC Tilefish Longline Survey	Fish abundance, focused on areas where golden tilefish occur.
NEAMAP Bottom Trawl	Fish abundance, multispecies
Maine-New Hampshire Inshore Trawl	Fish abundance, multispecies
Massachusetts Bottom Trawl	Fish abundance, multispecies
Connecticut Long Island Sound Trawl	Fish abundance, multispecies
ChesMMAP	Fish abundance, multispecies

Table 3. Life stage size breakpoints[1] based on length at maturity (L_{50}) or recruitment status (for the two squid species). * denote lead Council for jointly managed species.

Species	Council	Life stages	Breakpoint Size (cm)
Atlantic mackerel	MAFMC	Juvenile, Adult	24
Atlantic surfclam	MAFMC	Juvenile, Adult	4.5
Black sea bass	MAFMC	Juvenile, Adult	19
Bluefish	MAFMC	Juvenile, Adult	35
Blueline tilefish	MAFMC	Juvenile, Adult	33
Butterfish	MAFMC	Juvenile, Adult	11
Chub Mackerel	MAFMC	Juvenile, Adult	28
Golden tilefish	MAFMC	Juvenile, Adult	47
Longfin Squid	MAFMC	Pre-recruit, Recruit	8
Ocean quahog	MAFMC	Juvenile, Adult	6.4
Scup	MAFMC	Juvenile, Adult	16
Shortfin squid	MAFMC	Pre-recruit, Recruit	10
Summer flounder	MAFMC	Juvenile, Adult	26
Spiny dogfish	MAFMC*/NEFMC	Juvenile, Adult	64
Monkfish	NEFMC*/MAFMC	Juvenile, Adult	37
Acadian redfish	NEFMC	Juvenile, Adult	22
American plaice	NEFMC	Juvenile, Adult	24
Atlantic cod	NEFMC	Juvenile, Adult	35
Atlantic halibut	NEFMC	Juvenile, Adult	75
Atlantic herring	NEFMC	Juvenile, Adult	25

Species	Council	Life stages	Breakpoint Size (cm)
Atlantic salmon	NEFMC	Juvenile – fry, Juvenile – parr, Juvenile - smolt, Adult	Fry (TL < 5 cm) Parr (5-10 cm TL) Smolt (10-20 cm TL) Adult (TL > 20 cm)
Atlantic sea scallop	NEFMC	Juvenile, Adult	10
Atlantic wolffish	NEFMC	Juvenile, Adult	40
Barndoor skate	NEFMC	Juvenile, Adult	102
Clearnose skate	NEFMC	Juvenile, Adult	59
Deep-sea red crab	NEFMC	Juvenile, Adult	8
Haddock	NEFMC	Juvenile, Adult	32
Little skate	NEFMC	Juvenile, Adult	44
Ocean pout	NEFMC	Juvenile, Adult	29
Offshore hake	NEFMC	Juvenile, Adult	26
Pollock	NEFMC	Juvenile, Adult	39
Red hake	NEFMC	Juvenile, Adult	22
Rosette skate	NEFMC	Juvenile, Adult	39
Silver hake	NEFMC	Juvenile, Adult	22
Smooth skate	NEFMC	Juvenile, Adult	55
Thorny skate	NEFMC	Juvenile, Adult	77
White hake	NEFMC	Juvenile, Adult	32
Windowpane flounder	NEFMC	Juvenile, Adult	22
Winter flounder	NEFMC	Juvenile, Adult	27
Winter skate	NEFMC	Juvenile, Adult	75
Witch flounder	NEFMC	Juvenile, Adult	28
Yellowtail flounder	NEFMC	Juvenile, Adult	24

Notes:

[1] Several managed species are data-poor in the NEFSC trawl surveys and will use alternate, non-modeled approaches to update EFH (Atlantic salmon, blueline tilefish, chub mackerel, deep-sea red crab) or were pooled across life stages for EFH modeling (see Table 5). Size breakpoints for these species are included for reference only.

4.1.1.2 Environmental data

Data for the environmental covariates in the models came from several remote sensing and ocean modeling products, the U.S. Geological Survey SBS Database, or were derived from seafloor bathymetry or trawl information (e.g., location / year). Table 4 lists each predictor variable, whether it is static or dynamic (using monthly composites), its source, and its resolution.

Table 4. Data sources of environmental covariates used in joint species distribution models (SDMs). Dynamic variables generally use monthly composites.

Data Set	Covariate and data type	Source and link
GLORYS 1/12th deg reanalysis (2000-2006)	Surface and bottom temperature and salinity; dynamic	Global Ocean Physics Reanalysis, available via the Copernicus Marine Environmental Monitoring Service (https://doi.org/10.48670/moi-00021)
DOPPIO ~1/16th deg reanalysis (2007-2019)	Surface and bottom temperature, salinity, currents; dynamic	"DoppioV3R3" ROMs-based (Regional Ocean Modeling System) assimilative reanalysis (Wilkin et al. 2022; https://doi.org/10.1016/j.pocean.2022.102919)
ADCIRC EC2015 Tidal Database	Tidal current velocities; dynamic	Includes the M2, S2, N2, K2, O1, K1, Q1, M4, M6 and STEADY tidal constituents. https://adcirc.org/
NREL WPTO wave hindcast	Wave Bottom orbital velocities' dynamic	National Renewable Energy Laboratory Water Power Technologies Office https://www.nrel.gov/water/wave-hindcast-dataset
NCEI 1-arcsecond Coastal Relief Model	Bathymetry & derived variables Bathymetric Position Index (BPI) and complexity; static	National Centers for Environmental Information https://www.ncei.noaa.gov/products/coastal-relief-model
USGS sediment texture & USSEABED databases	Sediment Grain Size; static	https://woodshole.er.usgs.gov/project-pages/sediment/ and https://www.usgs.gov/programs/cmhrp/science/usseabed
USGS SBS Database	Wave-current bottom stress and sediment mobility; static	U.S. Geological Survey's (USGS) Sea Floor Stress and Sediment Mobility Database (Dalyander et al. 2012)

4.1.2 Modeling

For most modeled Council-managed species, the EFH designation maps are based on the outputs of spatiotemporal joint species distribution modeling via community-level basis function models (CBFMs). Generally, species distribution models (SDMs) relate a species' occurrence or abundance to environmental information to estimate its habitat use or niche. Hui et al. (2023) describe the CBFM approach in much more detail than can be offered here; further information on these methods can also be found in the Councils' joint Scientific and Statistical Committee (SSC) Sub-Panel discussion of these methods from September 29, 2023 (see the meeting page on the NEFMC website and the memorandum addressing the terms of reference). In this section, we provide an overview, describe model inputs and parameters, and discuss how model performance and uncertainty are evaluated. Then, in the following sections, we describe how we use the model to generate maps that form the basis of the updated EFH designations.

The modeling approach applied includes a multispecies generalized additive model (GAM), which allows for flexibly modeling multiple species' relationships with their environment and covariance between species. The approach also allows community-level effects on species abundance to be modeled through space and time, including seasonal differences in estimated niche. The GAM uses a "hurdle" approach, which means it includes both a presence-absence component and a nonzero count component. The presence-absence component uses all observations of survey catch, coding anything greater than zero as "present" and zero-catches as "absent" for the response variable. The count portion of the model is fit to just the positive catches and treats the number of fish captured as the response variable. This hurdle approach helps to account for differences in variables driving an animal's occurrence (i.e., presence/absence) vs. its abundance.

Model domain generally matches the spatial and temporal extent of the bottom trawl surveys, though as noted earlier, dredge and longline surveys are more restricted spatially (Table 2). Spatially, the model ranges from 34° to 45°N and -77° to -65°W up to the 600 m depth contour and consists of 1 km resolution, equal-area grid cells (~312,000 water grid cells, including inshore and offshore). Temporally, the model includes spring (March through May) and fall (September through November) data from 2000-2022. As mentioned earlier, we use life stage-specific count data from multiple bottom trawl surveys as the response variable based on the length at maturity (L_{50}) or recruitment status for *Illex* squid. Predictor variables include the static and dynamic variables listed in Table 4, as well as a swept-area offset and parameters capturing survey effects (e.g., catchability), spatial effects (e.g., location), temporal effects (e.g., year), and their interactions (e.g., location X year). These parameters help to account for differences between multiple vessels and trawl surveys, sampling locations, times of year, and interannual differences. For dynamic environmental predictors (e.g., temperature, salinity), we include surface or bottom data on an individual species basis, depending on whether it is a pelagic or demersal species. For species where that distinction is less clear, models are fit separately with either surface or bottom data to determine which performs better. Table 5 summarizes how the Council-managed species are categorized with respect to water column use, modeling framework, and life stages modeled.

Table 5. List of Council-managed species categorized with respect to water column use, modeling framework, and life stages modeled. * denote lead Council for jointly managed species.

Species	Council	Water column use	Model framework	Life stages modeled
Atlantic mackerel	MAFMC	Pelagic	Pelagic joint	Juvenile, adult
Atlantic surfclam	MAFMC	Benthic	Dredge-Trawl Integration	Pooled
Black sea bass	MAFMC	Demersal	Demersal joint	Juvenile, adult
Bluefish	MAFMC	Pelagic	Pelagic joint	Juvenile, adult
Blueline tilefish	MAFMC	Demersal	DATA POOR - NOT MODELED	N/A
Butterfish	MAFMC	Demersal/Pelagic	Demersal joint / Pelagic joint	Juvenile, adult
Chub Mackerel	MAFMC	Pelagic	DATA POOR - NOT MODELED	N/A
Golden tilefish	MAFMC	Demersal	Longline-Trawl Integration	Pooled
Longfin Squid	MAFMC	Pelagic	Pelagic joint	Pre-recruit, Recruit
Ocean quahog	MAFMC	Benthic	Dredge-Trawl Integration	Pooled
Scup	MAFMC	Demersal	Demersal joint	Juvenile, adult
Shortfin squid	MAFMC	Pelagic	Pelagic joint	Pre-recruit, Recruit
Summer flounder	MAFMC	Demersal	Demersal joint	Juvenile, adult
Spiny dogfish	MAFMC*/NEFMC	Demersal	Demersal joint	Juvenile, adult
Monkfish	NEFMC*/MAFMC	Demersal	Demersal joint	Juvenile, adult
Acadian redfish	NEFMC	Demersal	Demersal joint	Juvenile, adult
American plaice	NEFMC	Demersal	Demersal joint	Juvenile, adult
Atlantic cod	NEFMC	Demersal	Demersal joint	Juvenile, adult
Atlantic halibut	NEFMC	Demersal	DATA POOR – SIMPLER SDM TBD	N/A
Atlantic herring	NEFMC	Pelagic	Pelagic joint	Juvenile, adult
Atlantic salmon	NEFMC	Pelagic	DATA POOR - NOT MODELED	N/A
Atlantic sea scallop	NEFMC	Benthic	Dredge-Trawl Integration	Juvenile, adult
Atlantic wolffish	NEFMC	Demersal	DATA POOR – SIMPLER SDM TBD	N/A
Barndoor skate	NEFMC	Demersal	Demersal joint	Pooled

Species	Council	Water column use	Model framework	Life stages modeled
Clearnose skate	NEFMC	Demersal	Demersal joint	Juvenile, adult
Deep-sea red crab	NEFMC	Benthic	DATA POOR - NOT MODELED	N/A
Haddock	NEFMC	Demersal	Demersal joint	Juvenile, adult
Little skate	NEFMC	Demersal	Demersal joint	Juvenile, adult
Ocean pout	NEFMC	Demersal	Demersal joint	Juvenile, adult
Offshore hake	NEFMC	Demersal	DATA POOR – SIMPLER SDM TBD	N/A
Pollock	NEFMC	Demersal	Demersal joint	Pooled
Red hake	NEFMC	Demersal	Demersal joint	Juvenile, adult
Rosette skate	NEFMC	Demersal	Demersal joint	Pooled
Silver hake	NEFMC	Demersal	Demersal joint	Juvenile, adult
Smooth skate	NEFMC	Demersal	Demersal joint	Pooled
Thorny skate	NEFMC	Demersal	Demersal joint	Pooled
White hake	NEFMC	Demersal	Demersal joint	Juvenile, adult
Windowpane flounder	NEFMC	Demersal	Demersal joint	Juvenile, adult
Winter flounder	NEFMC	Demersal	Demersal joint	Juvenile, adult
Winter skate	NEFMC	Demersal	Demersal joint	Juvenile, adult
Witch flounder	NEFMC	Demersal	Demersal joint	Juvenile, adult
Yellowtail flounder	NEFMC	Demersal	Demersal joint	Juvenile, adult

Notes:

Water column use – determines whether a species is modeled using surface or bottom data for dynamic environmental predictors.
Model framework – whether species are modeled with spatiotemporal joint distribution models (“joint”) using bottom trawl survey across the whole model domain, other surveys (“Integration”) that have a restricted model domain, or not at all (“data poor – not modeled”) owing to insufficient data (occurrence < 5% across all modeled surveys).
Life stages modeled – whether separate models are fit to juveniles and adults or if life stages are pooled into a single model fit.

We used 10-fold cross validation to evaluate out-of-sample prediction performance of models as well as assess whether overfitting is occurring. Briefly, 10-fold cross validation splits the dataset into ten equal-sized partitions (“folds”) and fits the model ten times, each time omitting a different fold as an unseen “test” set while training on the remaining nine folds. For each of these models, out-of-sample performance can then be evaluated by using the model to predict on the unseen test set to quantify how generalizable the model’s predictive power is. When the model performs well at predicting on training data but poorly on unseen observations, overfitting is said to be occurring. Out-of-sample model performance can be evaluated using several metrics, including RMSE (Residual Mean Square Error) to assess accuracy and Pseudo-R^2 (Spearman rank correlation) to address relative differences in density, and AUC (Area Under the ROC Curve) for binary presence / absence performance. Coefficient of variation (CV) can also be used as a measure of how sensitive the predictions are to the training data used; CV is calculated as the cellwise standard deviation divided by the mean value across the ten folds.

Model predictions were generally considered reliable within areas of the domain that also included fishery-independent data; caution was applied when interpreting model predictions at the edges of the domain, such as deep shelf waters beyond the depths sampled by trawl surveys, or in very low salinity areas of estuaries which are not well represented in the fishery-independent data used in the modeling. In these cases, other data sources (such as those used in the non-modeled inshore pathway), or literature and other information about species habitat use were used to help with interpretations.

4.1.3 Translating model outputs to EFH

In this section, we describe how fitted models for each species are translated into EFH designation maps. Fitted SDMs can be used to generate ("predict") the response variable, in this case species counts ("density"), from the suite of predictor variables used to build the model. Specifically, we generate density predictions for each modeled month (March-May, September-November), each cross-validation fold, and each distinct year across the full 22-year timeframe (2000-2022). Model predictions are based on monthly means for dynamic environmental variables (e.g. temperature, salinity, etc.) and use surface versus bottom data on an individual species basis, as occurs during model fitting. We then compute the mean density in each cell across the 22-year period for each modeled month across the model's spatial domain (collectively referred to as the "grid" or "prediction grid"). Additional outputs allow us to assess natural variability and trends over time, as well as model uncertainty across cross-validation folds.

To translate these density predictions into EFH footprints, we define model-based EFH as the upper 75% quantiles of the density predictions (i.e., the principal EFH area) constrained to a species' occupied habitat (NPFMC 2023), where "occupied habitat" is defined as areas where there is > 5% encounter probability (Laman et al., 2022). To estimate encounter probability, we first compute the maximum annual density from the 22-year average densities across the six modeled months, which represents the maximum species density occurring in a cell during any given month of the "average" year. Encounter probability, then, is estimated as the likelihood[9] of encountering at least one individual in the grid cell given this maximum annual density and is a standardized 0-1 scale that forms the basis to define occupied habitat (areas > 5% encounter probability; Laman et al., 2022). We then trim the density predictions footprint to the species' occupied habitat area and define model-based EFH areas as the upper 75% density quantiles within this trimmed area. These model-based areas are further supplemented by inshore occurrence data as described below.

While the SDMs include species abundance data from select inshore surveys (NEAMAP Mid-Atlantic Bottom Trawl, ME-NH Inshore Trawl, MA Bottom Trawl), there are many other inshore datasets that could potentially reveal important habitat for managed species. Therefore, we combine the model-based habitat footprints with inshore habitat footprints (see Section 4.2 for further details) and add a 3-km buffer along the entire coast to produce the draft revised EFH designation boundaries. These steps ensure that EFH designations are inclusive of small inlets, estuaries, and other inshore areas that may otherwise be omitted due to the resolution of the coastline.

Interactive, life stage-specific examples[10] of this process are illustrated in the EFH Demo R-Shiny application developed by the MAFMC. Managed species included in this demonstration include all species being updated in the Mid-Atlantic Council's 2026 Omnibus EFH Amendment and the ten NEFMC species updated in the 2025 EFH Framework; this demo app will be updated with additional species to reflect NEFMC's 2026 and 2027 EFH Frameworks. Users can toggle and explore various data input and model output layers. By overlaying the "Model Quantiles" and "Species Estuary Zones" layers, users can see how the SDMs and inshore survey data combine to form the draft revised EFH boundaries for each species ("Proposed EFH (Top 75%)"). These draft EFH boundaries are then verified by consulting experts and literature.

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[9] More specifically, estimated encounter probability is calculated as (1 – Poisson probability of drawing a zero, given the maximum density)

[10] The figures in Section 5: Worked Example illustrate the process of combining the model-based area (top 75% quantile) with the species estuary zones based on inshore occurrence and appropriate habitat conditions to form the principal habitat area as the revised EFH designation area.

4.1.4 Thresholds

We adopt the definition of "occupied habitat" as areas where encounter probability > 5% (Laman et al. 2022). We then define model-based EFH areas as the upper 75% density quantiles within this trimmed area of occupied habitat and join that remaining area to additional inshore areas as described below in section 4.2. We have adopted the approach to defining model-based occupied habitat and quantiles from the EFH subarea thresholds defined in the North Pacific Fishery Management Council (NPFMC) 2023 EFH Review. Within occupied habitat, we describe quantiles as "EFH hot spots" (top 25%), "core EFH area" (top 50%), "principal EFH area" (top 75%) "general distribution area" (top 95%). Based on input from the NEFMC Habitat PDT, MAFMC EFH Fishery Management Action Team (FMAT), MAFMC Ecosystem and Ocean Planning (EOP) Committee, and NEFMC Habitat Committee, we have adopted the principal EFH areas (top 75%) quantiles to designate EFH on the basis that our methods now integrate more informative, level 2 information, allowing for more refined, focused designations. In addition, the joint Councils' Habitat and EOP Committees (at their December 2024 Meeting), agreed it was useful to keep thresholds universal across managed species, rather than adjusting them on a species-by-species basis. Therefore, this 75% threshold was applied across all species with this similar level of information available. Information for other EFH quantile areas and other habitat use information will be available and can be considered supplemental to the EFH consultation process as needed.

4.1.5 Defining EFH on the Continental Slope

On the seaward extent along the continental shelf / slope interface, the SDMs can be used to estimate species density to depths of approximately 300-400 m, given the maximum depths sampled in the Northeast Fisheries Science Center (NEFSC) bottom trawl survey. Some Council-managed species occur at or below these depths. For species with potential deepwater habitat usage, we cross-referenced the text descriptions in previous Council EFH designations with the literature to update these continental slope depths. We note, however, that abundance data are somewhat limited for these slope depths, and instead these depths are typically reported as occurrences in the literature. We used best professional judgment, combining information from the literature with SDM outputs, to evaluate whether portions of the continental slope below 400 m should be identified as EFH. If the species occurs at slope depths but was described in the literature as being most common or primarily occurring at depths shallower than 400 m, we used the maximum depth derived from the survey data as the maximum depth of EFH (i.e., Atlantic cod, rosette skate). If there was no information about relative abundance in shallower vs. deeper areas of the continental slope, we relied on the model outputs. Where areas along the shelf-slope break were predicted to have lower densities (top 50% or 75% quantiles), we used the model-based extent (75% quantile) to delimit the EFH map and did not add the slope depths to the text description (i.e., smooth skate, thorny skate). Where the top 25% density quantiles run along the shelf-slope break, we inferred that deeper areas adjacent to but beyond the domain of the model are relatively more important to the species and based the maximum depth of EFH on values reported in the literature for the northeast U.S. region. These depths were added to the text description, noting the geographic extent, and to the EFH map in locations adjacent to the 25% quantile only.

4.2 Estuarine and inshore mapping approaches

To designate EFH for inshore and estuarine areas, we applied an alternate, non-modeled approach that identified suitable estuary and coastal zones using inshore fish abundance and environmental data (Table 6). We first defined nine zones from depth and salinity thresholds (Table 7; Map 1). Additionally, for each species and life stage, we defined latitudinal limits from the northern and southern extents of the model-predicted EFH area (top 75% quantile). Estuary or coastal zones were included where a species was caught in ≥ 25% of inshore survey tows (Table 8) and if it fell within this latitudinal band. We then included additional, adjacent zones without inshore occurrences if they both matched species' habitat descriptions (e.g., from environmental range data [see Section 4.4], previous EFH text descriptions, EFH Source Documents, literature reviews, etc.) and fell within the species' latitudinal band. Any resulting long coastal zones were constrained to the southern extent of any occurrence data. Finally, we appended these suitable estuarine and coastal zones to the model-based EFH area and added a 3-km buffer along the coast. This buffer ensured coverage of coastal habitats that are difficult to sample or prone to shifting (e.g., marsh) and to account for the coarse resolution of the coastline. See Table 14 in Section 5.1 for representative visual examples of the steps in this process.

Table 6. Environmental covariates used in inshore mapping workflow for estuaries and coastal zones.

Data Source	Data type
GEBCO global gridded bathymetry, ~500m resolution	Bathymetry
Estuarine Bathymetric DEM, 30m resolution	Bathymetry
NOAA Atlantic Regional Climatology, 1/10 degree	Surface and bottom temperature and salinity
Chesapeake Bay Atlas, ~600m resolution	Surface and bottom temperature and salinity
Wetland Salinity Maps of Select Estuary Sites in the United States, 2020	Salinity
Estuarine salinity zones in US East Coast, Gulf of Mexico, and US West Coast	Salinity zones
Marine Ecoregions of North America	Zones with common physiographic, oceanographic, biological characteristics

Table 7. Estuarine and inshore habitat zone definitions.

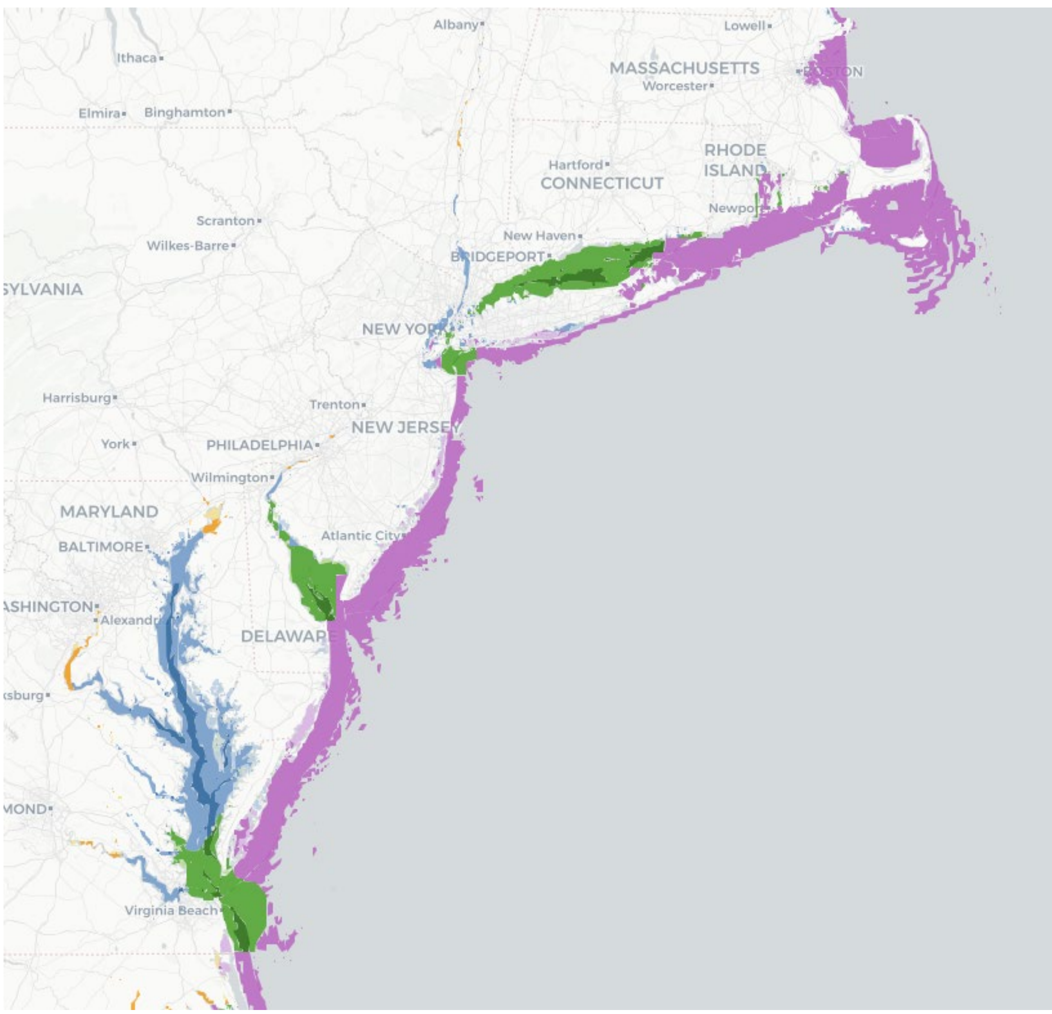
		Depths		
		Channel (> 75th percentile depth)	**Mid (2 m – 75th percentile)**	**Shallow (< 2 m)**
Salinities	**Marine (> 30 ppt)**	Marine Channel	Marine Mid	Marine Shallow
	Polyhaline (18-30 ppt)	Polyhaline Channel	Polyhaline Mid	Polyhaline Shallow
	Mixing (0.5-18 ppt)	Mixing Channel	Mixing Mid	Mixing Shallow
	Tidal Fresh (< 0.5 ppt)	Tidal Fresh Channel	Tidal Fresh Mid	Tidal Fresh Shallow

Table 8. Fisheries independent survey data (i.e., fish presence/absence and abundance) used in inshore mapping workflow for estuaries and coastal zones.

Data Source
NEAMAP Bottom Trawl
Maine-New Hampshire Inshore Trawl
Massachusetts Bottom Trawl
Rhode Island Narragansett Bay Trawl
Connecticut Long Island Sound Trawl
New Jersey Delaware Bay Juvenile Trawl

Data Source
New Jersey Ocean Stock Assessment
Delaware 30ft Bottom Trawl
Delaware Bay Juv. Finfish Trawl
Maryland Bottom Trawl
ChesMMAP
VIMS Juvenile Finfish Trawl Survey
North Carolina Nursery Area Juv. Survey (NC120)
North Carolina Pamlico Sound Survey (N195)
SEAMAP-SA Coastal Trawl Survey

Map 1. Illustrative example of estuarine zones in Southern New England and the Mid-Atlantic. Salinity and depth thresholds are as described in Table 7. Depth thresholds: Channel (> 75th percentile), Mid (2 m – 75th percentile), Shallow (< 2 m). Salinity thresholds: Marine (> 30 ppt), Polyhaline (18-30 ppt), Mixing (0.5 – 18 ppt), Tidal Fresh (< 0.5 ppt). An interactive version is available at in the EFH Demo R Shiny App.



4.3 Alternative mapping approaches for non-modeled species and/or early life stages

While most Council-managed species have sufficient abundance data across the various fishery-independent surveys, there are some species that could not be modeled due to insufficient data even when life stages are pooled. In addition, egg and larvae life stages were more data limited across all species. Improving data sources available and mapping methods for those early life stages has been suggested as an area for future work for the next 5-Year EFH Review. In both these cases, we used alternative mapping approaches that, where possible, made use of literature, available datasets, and appropriate proxies to determine the best approach to map the species or a species life stage geographic range of habitat use. Tables 9 and 10 document the specific approaches taken to mapping EFH in these cases. Overall, these methods rely in part or whole on some of the data and approaches described further above in Section 4.0.

In summary, these included the use of:

- Using adult or juvenile life stages as proxies for the egg/larvae distributions informed by literature that described timing of spawning, if available,
- Mapping information for that life stage by depth, temperature, salinity, or locations,
- Using a combination of these approaches, and,
- Validating that information with literature, species experts, and other secondary but not comprehensive datasets.

Table 9. Summary of data-poor egg and larval EFH mapping methods for MAFMC and NEFMC species.

Species	Council	Life stage(s)	Map Generation Methods
Atlantic mackerel	MAFMC	egg/larvae	Used the modeled spring adult distribution, kept areas above the 0.25 threshold (principal EFH), dissolved the footprint, and clipped it to the US EEZ.
Atlantic surfclam	MAFMC	egg/larvae	Single map egg/larvae/juv/adult (combined footprint) from model output and applied to all life stages. Clipped to EEZ.
Black sea bass	MAFMC	egg/larvae	Selected waters with bottom salinity above 0.5 ppt, depths 10–100 m, and latitudes at or above 36.55°, limited the footprint to an adult-distribution buffer, dissolved, and clipped it to the EEZ.
Bluefish	MAFMC	egg/larvae	Used the adult distribution as the egg and larvae footprint.
Blueline tilefish	MAFMC	egg/larvae	Single map egg/larvae/juv/adult. Selected waters with bottom salinity 32–40 ppt, depths 46–256 m, and latitudes at or above 36.55°, dissolved the footprint, clipped it to the EEZ, and removed areas on Georges Bank and the Gulf of Maine using a predefined mask.
Butterfish	MAFMC	egg/larvae	Selected areas with surface salinity above 25 ppt, rasterized these areas, masked them to the adult distribution, converted the result to dissolved polygons, and clipped to the EEZ.
Chub Mackerel	MAFMC	egg/larvae	Started with the US east-coast EEZ, removed all non-seawater salinity zones and areas with surface salinity below 18 ppt, kept only waters south of 36.55°N, and removed small, isolated fragments.
Golden tilefish	MAFMC	egg/larvae	Single map egg/larvae/juv/adult (combined footprint) derived from model output and applied to all life stages. Clipped to EEZ.

Species	Council	Life stage(s)	Map Generation Methods
Longfin Squid	MAFMC	egg/larvae	Selected areas with bottom salinity at or above 25 ppt, depths shallower than 50 m, and latitudes from 36.55° to 43°, dissolved the footprint, and clipped it to the EEZ. Reviewed squid egg mop data which is covered by the above polygon.
Ocean quahog	MAFMC	egg/larvae	Single map egg/larvae/juv/adult (combined footprint) derived from model output and applied to all life stages. No inshore data used. Clipped to EEZ.
Scup	MAFMC	egg/larvae	Used only waters with surface salinity between 0.5 and 40 and depths shallower than 37 m within the NY Bight–Nantucket region, dissolved the result, and clipped it to the EEZ.
Shortfin squid	MAFMC	egg/larvae	Selected areas with bottom salinity 32–40 ppt, depths 50–2300 m, and latitudes 38°–41°, dissolved the footprint, and clipped it to the EEZ.
Summer flounder	MAFMC	egg/larvae	Used the modeled fall adult distribution, applied a >0.25 threshold (principal EFH), dissolved the footprint, included adult SEAMAP/inshore species zones, and clipped it to the EEZ.
Atlantic cod	NEFMC	Egg/larvae	Used the union of the juvenile and adult distributions as a proxy; spring / fall trawl surveys do not fully cover known spawning season; eggs / larvae are pelagic and may be transported away from seasonal spawning grounds
Atlantic herring	NEFMC	Egg	Used the distribution of adults in the fall, which is a major spawning season for herring; herring eggs are demersal and adhere to the bottom as egg "beds.
Atlantic herring	NEFMC	Larvae	Used the union of the juvenile and adult distributions as a proxy to ensure broad coverage of both inshore and offshore areas; herring undergo a very long, pelagic larval stage, during which they are transported long distances to inshore and estuarine waters.
Barndoor skate	NEFMC	Egg	No distinct larval stage; egg methods used the adult distribution as a proxy; within this distribution, text references adult environmental ranges (depth, temperature, salinity) and geographical areas.
Clearnose skate	NEFMC	Egg	No distinct larval stage; egg methods used the adult distribution as a proxy; within this distribution, text references adult environmental ranges (depth, temperature, salinity) and geographical areas.
Little skate	NEFMC	Egg	No distinct larval stage; egg methods used the adult distribution as a proxy; within this distribution, text references adult environmental ranges (depth, temperature, salinity) and geographical areas.
Monkfish	NEFMC	Egg/larvae	Used the union of the juvenile and adult distributions as a proxy; spring / fall trawl surveys do not fully cover known spawning season; eggs / larvae are pelagic and may be transported away from seasonal spawning grounds
Rosette skate	NEFMC	Egg	No distinct larval stage; egg methods used the adult distribution as a proxy; within this distribution, text references adult environmental ranges (depth, temperature, salinity) and geographical areas.
Smooth skate	NEFMC	Egg	No distinct larval stage; egg methods used the adult distribution as a proxy; within this distribution, text references adult environmental ranges (depth, temperature, salinity) and geographical areas.
Thorny skate	NEFMC	Egg	No distinct larval stage; egg methods used the adult distribution as a proxy; within this distribution, text references adult environmental ranges (depth, temperature, salinity) and geographical areas.
Winter skate	NEFMC	Egg	No distinct larval stage; egg methods used the adult distribution as a proxy; within this distribution, text references adult environmental ranges (depth, temperature, salinity) and geographical areas.

Table 10. Summary of EFH mapping methods for other data-poor species and life stages for MAFMC and NEFMC.

Species	Council	Life stages(s)	Map Generation Methods
Blueline tilefish	MAFMC	Adult/juv	Single map egg/larvae/juv/adult. Selected waters with bottom salinity 32–40 ppt, depths 46–256 m, and latitudes at or above 36.55°, dissolved the footprint, clipped it to the EEZ, and removed areas on Nantucket shoals/Georges bank and the Gulf of Maine using a predefined mask.
Chub Mackerel	MAFMC	Adult/juv	Started with the US east-coast EEZ, removed all non-seawater salinity zones and areas with surface salinity below 18 ppt, and removed small, isolated fragments.
Atlantic salmon	NEFMC	All	Rarely caught in trawl surveys; maps and text will rely on alternate data processing methods (TBD) and literature reviews.
Atlantic wolffish	NEFMC	All	Data-poor in trawl surveys; simpler modeling approaches may be possible
Deep-sea red crab	NEFMC	All	Rarely caught in trawl surveys as their habitat lies beyond sampled depths; maps and text will rely on alternate data processing methods (TBD) and literature reviews.

4.4 EFH text descriptions

EFH text descriptions serve to summarize the key habitat areas and features and are derived from the EFH designation maps, consultation with experts, the literature, and NOAA Fisheries' Habitat Climate Vulnerability Assessment (HCVA; Farr et al. 2021). Revised text designations include descriptions of the occupied habitat areas (where model-estimated encounter probability > 5% or where inshore frequency of occurrence > 5%), seasonal movements, and environmental ranges and tolerance bounds for habitat conditions such as temperature or salinity, where feasible. Generally, EFH text descriptions aim to fill in gaps and emphasize connectivity between locations, time periods, and life stages for Council-managed species. Another important distinction from previous EFH Reviews is that, given advancements in modeling and mapping technologies as well as staff expertise, the mapping and text components of EFH designations are more comprehensive and inclusive of key habitat areas, whereas prior text descriptions were broken into discrete areas. Additionally, draft updates to habitat type descriptions will match the language used in the Northeast Regional Habitat Assessment (NRHA) HCVA Crosswalk Project, which integrates information in the NOAA Fisheries' Northeast Fish and Shellfish Climate Vulnerability Assessment (FSCVA), HCVA (Farr et al. 2021), and Atlantic Coastal Fish Habitat Partnership (ACFHP). Going forward, these EFH text descriptions will continue to evolve, but we emphasize the importance of consistency and comprehensiveness in the language and structure of EFH text across species, between regions, and with other habitat assessments and initiatives.

To address the EFH requirements described in Section 3.1, EFH text descriptions were revised to be consistent with the updated map footprints and include the following information where applicable: geographic range of the species (as depicted in the maps); appropriate depth, temperature, and salinity ranges (described below); associated habitat types (substrates such as sands and gravels, submerged aquatic vegetation, etc.); and other life history information relevant to species distributions and habitat (e.g., seasonal migrations, spawning areas). For these revisions, we drew upon best available sources as required by the EFH regulations (50 CFR 600.815(a)(1)(ii)(B)), specifically including the following: survey data and model outputs, peer-reviewed literature including the EFH Source Documents, and consultations with species experts.

The EFH text references specific depth, temperature, and salinity ranges (Tables 11-13). Environmental ranges for each species and life stage combination were derived by pooling depth, temperature, and salinity data associated with unique occurrences in offshore and inshore survey tows. These ranges do not reflect lethal limits or the full range of conditions each species can inhabit, especially since the underlying surveys cannot exhaustively sample each species. As Council-managed species vary in their water column usage (i.e., demersal, pelagic, etc.), temperature and salinity ranges are given for both bottom (Table 12) and surface (Table 13) data.

For salinity and temperature ranges used in the text, the lower and upper 2.5% of values were trimmed (i.e., retaining the interior 95% quantile) to represent a relatively broad range of values. Full salinity (34-36 ppt) is the upper bound for salinity range, regardless of species, but the lower bounds vary somewhat, and fishery independent surveys are limited in low salinity areas, so there are less data to support estimates of the lower bound of the salinity ranges. Temperature varies seasonally and by location. While the spring and fall trawl surveys are expected to reflect the coldest and warmest temperature periods, respectively, using 95% of the temperature range avoids a definition of EFH that is too narrow and does not reflect conditions experienced throughout the year.

For depth, the text description includes both a “full” depth range and the range that roughly matches the EFH map based on the 75% model outputs. The “full” depth range trims out the upper and lower 0.5% to exclude unrealistic, extreme outliers. The 75% depth range trims the upper and lower 12.5% (i.e., retaining the interior 75% quantile) to highlight the depth range at which the species is more “frequently” found. Table 11 depicts the differences between the “full” and 75% ranges; this table also provides the 95% range and No Action depth ranges for comparison. For some species, the text description includes the 95% depth range instead of the “full” depth range; these species-specific nuances to depth ranges are described in greater detail within their respective action documents. For the text descriptions, we rounded these values outward (i.e., rounding down for lower bounds and rounding up for upper bounds) to the nearest whole number. We also note that many of the surveys included for these range analyses cannot sample in extremely shallow areas, so the lower bound of the “full” range does not capture intertidal or highly shallow habitat use. To address this issue, we followed the approach in OHA2 where we report the minimum depth as 0 meters and explicitly reference the intertidal zone in the text description if species and/or life stages are known to utilize intertidal habitats.

Table 11. Depth (meters) ranges associated with unique species occurrences in offshore and inshore trawl survey data. The "Full" column depicts depth ranges estimated from the full set of survey data with extreme outliers removed (i.e., the interior 99% quantile); the 95% and 75% columns represent the respective quantile of survey data. Values in bold are referenced in the text descriptions. Atlantic salmon, Atlantic sea scallops, Atlantic surfclam, ocean quahogs are not included in this table as they are data-poor in the trawl surveys.

Council	Common name	Life stage	Depth full range (99%)	Depth range (95%)	Depth range (75%)
MAFMC	Atlantic mackerel	juvenile	7-249	**9-208**	**19-126**
MAFMC	Atlantic mackerel	adult	8-297	**12-229**	**22-150**
MAFMC	Black sea bass	juvenile	2-136	4-98	**7-35**
MAFMC	Black sea bass	adult	5-182	7-126	**9-67**
MAFMC	Bluefish	juvenile	0-108	**2-52**	**5-26**
MAFMC	Bluefish	adult	5-163	**7-99**	**10-49**
MAFMC	Blueline tilefish	juvenile	82-191	83-178	87-152
MAFMC	Blueline tilefish	adult	64-292	68-224	78-166
MAFMC	Butterfish	juvenile	3-232	**5-140**	**8-66**
MAFMC	Butterfish	adult	3-269	**5-188**	**8-97**
MAFMC	Chub mackerel	juvenile	6-293	**8-205**	14-100
MAFMC	Chub mackerel	adult	5-298	**7-288**	9-144
MAFMC	Golden tilefish	juvenile	16-278	91-240	105-192
MAFMC	Golden tilefish	adult	113-259	116-247	128-227
MAFMC	Longfin squid	recruit	**6-288**	8-212	**13-115**
MAFMC	Longfin squid	prerecruit	**6-301**	7-214	**11-103**
MAFMC	Northern shortfin squid	recruit	**25-362**	37-313	**59-223**
MAFMC	Northern shortfin squid	prerecruit	**9-351**	17-302	**45-212**
MAFMC	Scup	juvenile	3-131	6-100	**9-43**
MAFMC	Scup	adult	5-137	7-108	**10-52**
MAFMC	Spiny dogfish	juvenile	7-339	9-278	**18-202**
MAFMC	Spiny dogfish	adult	7-323	9-250	**16-185**
MAFMC	Summer flounder	juvenile	0-63	1-31	**4-18**
MAFMC	Summer flounder	adult	2-151	4-110	**7-44**
NEFMC	Acadian redfish	juvenile	**30-334**	46-274	**74-209**
NEFMC	Acadian redfish	adult	**48-355**	67-320	**106-230**
NEFMC	American plaice	juvenile	**23-273**	31-224	**48-179**
NEFMC	American plaice	adult	**26-313**	36-248	**53-200**
NEFMC	Atlantic cod	juvenile	**7-201**	8-153	**14-100**
NEFMC	Atlantic cod	adult	**9-291**	20-229	**37-177**
NEFMC	Atlantic halibut	juvenile	**13-214**	21-173	**42-125**
NEFMC	Atlantic halibut	adult	**30-255**	46-199	**70-175**
NEFMC	Atlantic herring	juvenile	**4-265**	7-217	**13-149**
NEFMC	Atlantic herring	adult	**6-295**	8-228	**14-175**
NEFMC	Atlantic wolffish	juvenile	**37-230**	45-205	**73-172**

Council	Common name	Life stage	Depth full range (99%)	Depth range (95%)	Depth range (75%)
NEFMC	Atlantic wolffish	adult	**24-205**	32-190	**52-153**
NEFMC	Barndoor skate	juvenile	**27-358**	38-302	**58-208**
NEFMC	Barndoor skate	adult	**32-361**	41-344	**61-248**
NEFMC	Clearnose skate	juvenile	**4-133**	6-68	**8-26**
NEFMC	Clearnose skate	adult	**5-207**	7-113	**9-36**
NEFMC	Haddock	juvenile	**14-271**	23-218	**44-159**
NEFMC	Haddock	adult	**32-338**	42-269	**62-205**
NEFMC	Little skate	juvenile	**6-220**	7-128	**11-74**
NEFMC	Little skate	adult	**6-214**	8-133	**12-82**
NEFMC	Monkfish	juvenile	**10-340**	21-282	**44-203**
NEFMC	Monkfish	adult	**9-360**	16-317	**42-223**
NEFMC	Ocean pout	juvenile	**9-243**	17-197	**30-144**
NEFMC	Ocean pout	adult	**8-239**	13-183	**23-115**
NEFMC	Offshore hake	juvenile	**81-430**	128-362	**193-323**
NEFMC	Offshore hake	adult	**63-496**	103-373	**168-327**
NEFMC	Pollock	juvenile	**6-253**	8-216	**17-166**
NEFMC	Pollock	adult	**26-319**	42-272	**72-221**
NEFMC	Red hake	juvenile	**6-296**	8-231	**15-162**
NEFMC	Red hake	adult	**8-329**	14-269	**33-199**
NEFMC	Rosette skate	juvenile	**27-338**	46-304	**75-229**
NEFMC	Rosette skate	adult	**54-299**	63-262	**81-210**
NEFMC	Silver hake	juvenile	**7-320**	9-246	**17-179**
NEFMC	Silver hake	adult	**11-341**	18-281	**34-201**
NEFMC	Smooth skate	juvenile	**39-355**	67-327	**103-237**
NEFMC	Smooth skate	adult	**54-361**	84-339	**115-266**
NEFMC	Thorny skate	juvenile	**30-353**	43-303	**66-214**
NEFMC	Thorny skate	adult	**37-361**	52-328	**83-213**
NEFMC	White hake	juvenile	**7-292**	11-231	**29-179**
NEFMC	White hake	adult	**29-361**	46-326	**80-236**
NEFMC	Windowpane flounder	juvenile	**3-116**	5-95	**8-55**
NEFMC	Windowpane flounder	adult	**5-127**	7-97	**10-58**
NEFMC	Winter flounder	juvenile	**5-140**	7-111	**11-75**
NEFMC	Winter flounder	adult	**6-173**	8-122	**12-83**
NEFMC	Winter skate	juvenile	**6-227**	7-146	**10-77**
NEFMC	Winter skate	adult	**6-242**	7-171	**12-87**
NEFMC	Witch flounder	juvenile	**34-376**	61-325	**84-217**
NEFMC	Witch flounder	adult	**23-357**	41-315	**71-219**
NEFMC	Yellowtail flounder	juvenile	**7-159**	11-112	**24-81**
NEFMC	Yellowtail flounder	adult	**8-183**	13-134	**27-93**

Table 12. **Bottom** **temperature (°C) and salinity (ppt) ranges associated with unique species occurrences in offshore and inshore trawl survey data. The "Full" column depicts ranges estimated from the full set of survey data with extreme outliers removed (i.e., the interior 99% quantile); the 95% and 75% columns represent the respective quantile of survey data. Values in bold are referenced in the text descriptions (95% range for temperature and salinity). Atlantic salmon, Atlantic sea scallops, Atlantic surfclam, ocean quahogs are not included in this table as they are data-poor in the trawl surveys.**

Council	Common name	Life stage	Bottom temp full range (99%)	Bottom temp range (95%)	Bottom temp range (75%)	Bottom salinity full range (99%)	Bottom salinity range (95%)	Bottom salinity range (75%)
MAFMC	Atlantic mackerel	juvenile	4-22	**4-20**	5-14	25-36	**30-35**	31-34
MAFMC	Atlantic mackerel	adult	4-18	**4-15**	5-13	26-36	**30-36**	31-35
MAFMC	Black sea bass	juvenile	5-30	**6-28**	10-25	12-37	**16-36**	20-34
MAFMC	Black sea bass	adult	5-29	**6-26**	9-22	16-37	**21-36**	27-35
MAFMC	Bluefish	juvenile	9-31	**13-29**	16-26	4-37	**9-37**	19-35
MAFMC	Bluefish	adult	8-27	**9-24**	12-22	17-36	**23-36**	27-33
MAFMC	Blueline tilefish	juvenile	10-17	10-17	11-15	33-36	33-36	34-36
MAFMC	Blueline tilefish	adult	8-18	8-18	10-15	33-37	33-37	33-36
MAFMC	Butterfish	juvenile	6-30	**7-28**	10-24	12-37	**17-36**	24-35
MAFMC	Butterfish	adult	5-30	**6-28**	9-24	13-37	**18-36**	25-36
MAFMC	Chub mackerel	juvenile	7-28	8-28	11-26	26-37	29-37	31-36
MAFMC	Chub mackerel	adult	6-26	8-25	11-23	30-36	30-36	30-36
MAFMC	Golden tilefish	juvenile	4-20	**5-16**	9-15	31-37	**33-36**	34-36
MAFMC	Golden tilefish	adult	9-14	**9-14**	10-13	35-36	**35-36**	35-36
MAFMC	Longfin squid	recruit	5-27	**6-24**	9-19	25-37	**26-36**	30-36
MAFMC	Longfin squid	prerecruit	5-27	**6-24**	8-21	22-37	**26-36**	29-35
MAFMC	Northern shortfin squid	recruit	4-19	**5-16**	7-14	31-37	**32-36**	32-36
MAFMC	Northern shortfin squid	prerecruit	5-23	**6-18**	7-14	27-37	**31-36**	32-36
MAFMC	Scup	juvenile	6-29	**8-27**	11-23	15-37	**19-36**	25-33
MAFMC	Scup	adult	5-27	**7-24**	9-22	18-37	**23-36**	26-33
MAFMC	Spiny dogfish	juvenile	4-21	**4-18**	6-14	25-36	**29-36**	31-36
MAFMC	Spiny dogfish	adult	3-19	**4-17**	5-14	24-36	**27-36**	31-35

Council	Common name	Life stage	Bottom temp full range (99%)	Bottom temp range (95%)	Bottom temp range (75%)	Bottom salinity full range (99%)	Bottom salinity range (95%)	Bottom salinity range (75%)
MAFMC	Summer flounder	juvenile	3-31	**5-29**	9-27	2-37	**8-36**	15-34
MAFMC	Summer flounder	adult	4-29	**5-27**	9-24	9-37	**13-36**	19-34
NEFMC	Acadian redfish	juvenile	2-13	**3-12**	4-10	30-36	**31-36**	32-35
NEFMC	Acadian redfish	adult	2-13	**3-11**	5-10	31-36	**32-36**	32-35
NEFMC	American plaice	juvenile	2-14	**3-12**	4-10	28-36	**31-35**	31-34
NEFMC	American plaice	adult	2-13	**3-12**	4-10	29-36	**31-35**	32-35
NEFMC	Atlantic cod	juvenile	2-17	**3-14**	4-12	25-35	**26-35**	31-34
NEFMC	Atlantic cod	adult	2-16	**3-13**	4-10	30-36	**31-36**	32-35
NEFMC	Atlantic halibut	juvenile	2-14	**3-13**	4-11	30-35	**31-35**	31-34
NEFMC	Atlantic halibut	adult	2-13	**3-12**	4-10	28-35	**31-35**	31-34
NEFMC	Atlantic herring	juvenile	1-22	3-19	4-13	12-36	20-35	29-34
NEFMC	Atlantic herring	adult	1-15	3-13	4-10	12-36	20-36	27-35
NEFMC	Atlantic wolffish	juvenile	1-13	**3-11**	4-9	31-35	**32-35**	32-34
NEFMC	Atlantic wolffish	adult	1-12	**2-11**	3-9	31-35	**31-35**	32-34
NEFMC	Barndoor skate	juvenile	3-18	**4-17**	6-14	31-36	**32-36**	32-36
NEFMC	Barndoor skate	adult	4-17	**5-16**	7-14	31-36	**32-36**	32-36
NEFMC	Clearnose skate	juvenile	6-32	**8-28**	11-23	19-37	**22-36**	26-34
NEFMC	Clearnose skate	adult	5-25	**6-24**	9-22	26-36	**27-36**	30-34
NEFMC	Haddock	juvenile	3-18	**3-15**	5-12	26-36	**31-36**	32-35
NEFMC	Haddock	adult	2-15	**3-13**	4-10	31-36	**32-36**	32-35
NEFMC	Little skate	juvenile	2-22	**3-20**	5-18	25-36	**28-36**	30-34
NEFMC	Little skate	adult	2-22	**3-21**	5-17	26-36	**29-36**	31-34
NEFMC	Monkfish	juvenile	3-18	**3-15**	5-13	27-36	**31-36**	32-35
NEFMC	Monkfish	adult	3-17	**4-15**	5-13	28-36	**31-36**	32-36
NEFMC	Ocean pout	juvenile	2-16	**3-14**	4-11	25-36	**30-36**	32-35
NEFMC	Ocean pout	adult	2-15	**3-13**	4-10	25-36	**29-36**	31-34
NEFMC	Offshore hake	juvenile	3-16	**5-15**	8-13	34-36	**35-36**	35-36
NEFMC	Offshore hake	adult	4-15	**5-14**	7-13	32-36	**34-36**	35-36

Council	Common name	Life stage	Bottom temp full range (99%)	Bottom temp range (95%)	Bottom temp range (75%)	Bottom salinity full range (99%)	Bottom salinity range (95%)	Bottom salinity range (75%)
NEFMC	Pollock	juvenile	2-18	**3-15**	4-12	26-36	**29-35**	31-35
NEFMC	Pollock	adult	3-13	**4-11**	5-10	32-36	**32-36**	32-35
NEFMC	Red hake	juvenile	2-22	**3-19**	4-14	14-36	**22-36**	30-34
NEFMC	Red hake	adult	3-21	**4-17**	5-13	23-36	**28-36**	31-35
NEFMC	Rosette skate	juvenile	6-24	**7-18**	9-15	32-37	**32-36**	33-36
NEFMC	Rosette skate	adult	6-16	**7-15**	9-14	32-37	**32-36**	33-36
NEFMC	Silver hake	juvenile	3-21	**3-19**	5-15	21-36	**27-36**	31-35
NEFMC	Silver hake	adult	3-19	**4-16**	5-13	27-36	**31-36**	32-35
NEFMC	Smooth skate	juvenile	3-13	**4-12**	5-10	31-36	**32-36**	32-35
NEFMC	Smooth skate	adult	3-12	**4-11**	5-10	31-36	**32-36**	32-36
NEFMC	Thorny skate	juvenile	2-14	**3-12**	4-10	30-36	**31-36**	32-35
NEFMC	Thorny skate	adult	2-12	**3-11**	4-9	31-36	**32-36**	32-35
NEFMC	White hake	juvenile	3-19	**3-16**	5-13	28-36	**31-35**	31-34
NEFMC	White hake	adult	3-14	**4-13**	5-11	31-36	32-36	32-35
NEFMC	Windowpane flounder	juvenile	2-28	**3-25**	5-21	12-36	17-34	24-33
NEFMC	Windowpane flounder	adult	2-24	**3-22**	5-19	18-36	24-35	27-33
NEFMC	Winter flounder	juvenile	1-24	**3-22**	4-18	17-36	24-34	27-33
NEFMC	Winter flounder	adult	2-22	**3-19**	4-15	23-36	**25-34**	27-34
NEFMC	Winter skate	juvenile	2-21	**3-20**	5-17	25-36	**28-36**	30-34
NEFMC	Winter skate	adult	2-20	**3-18**	5-16	25-36	**27-36**	31-34
NEFMC	Witch flounder	juvenile	3-14	**3-13**	4-11	28-36	**31-36**	32-35
NEFMC	Witch flounder	adult	3-14	**3-13**	5-10	31-36	**32-36**	32-35
NEFMC	Yellowtail flounder	juvenile	2-17	**3-15**	4-12	30-35	**31-34**	31-34
NEFMC	Yellowtail flounder	adult	2-17	**3-15**	4-12	29-36	**31-35**	32-34

Table 13. Surface temperature (°C) and salinity (ppt) ranges associated with unique species occurrences in offshore and inshore trawl survey data. The "Full" column depicts ranges estimated from the full set of survey data with extreme outliers removed (i.e., the interior 99% quantile); the 95% and 75% columns represent the respective quantile of survey data. Values in bold are referenced in the text descriptions (95% range for temperature and salinity). Atlantic salmon, Atlantic sea scallops, Atlantic surfclam, ocean quahogs are not included in this table as they are data-poor in the trawl surveys.

Council	Common name	Life stage	Surface temp full range (99%)	Surface temp range (95%)	Surface temp range (75%)	Surface salinity full range (99%)	Surface salinity range (95%)	Surface salinity range (75%)
MAFMC	Atlantic mackerel	juvenile	3-24	**4-22**	5-16	23-35	**27-35**	30-34
MAFMC	Atlantic mackerel	adult	2-22	**4-18**	5-14	18-36	**28-35**	31-34
MAFMC	Black sea bass	juvenile	5-30	6-29	11-27	9-37	12-36	17-34
MAFMC	Black sea bass	adult	5-29	6-27	9-24	13-37	20-36	26-34
MAFMC	Bluefish	juvenile	10-31	**13-29**	16-27	3-37	**8-37**	18-35
MAFMC	Bluefish	adult	7-27	**10-24**	13-22	15-36	**23-35**	26-33
MAFMC	Blueline tilefish	juvenile	6-27	7-27	8-26	31-36	31-36	32-35
MAFMC	Blueline tilefish	adult	7-29	7-27	9-25	32-37	32-37	32-35
MAFMC	Butterfish	juvenile	5-30	**7-28**	11-25	10-37	**14-36**	22-34
MAFMC	Butterfish	adult	4-30	**6-28**	9-25	11-37	**15-36**	24-35
MAFMC	Chub mackerel	juvenile	8-29	**11-28**	16-27	23-37	**26-37**	29-35
MAFMC	Chub mackerel	adult	11-27	**13-27**	17-25	29-37	**29-36**	30-36
MAFMC	Golden tilefish	juvenile	4-27	4-26	5-23	31-36	31-36	32-35
MAFMC	Golden tilefish	adult	3-22	4-22	4-16	34-35	34-35	34-35
MAFMC	Longfin squid	recruit	4-29	**5-26**	8-23	23-37	**25-36**	28-34
MAFMC	Longfin squid	prerecruit	4-29	**5-26**	8-23	21-37	**25-36**	28-34
MAFMC	Northern shortfin squid	recruit	4-29	**7-26**	10-23	12-37	**31-36**	31-35
MAFMC	Northern shortfin squid	prerecruit	3-29	**5-27**	8-23	23-37	**29-36**	31-35
MAFMC	Scup	juvenile	6-29	8-28	12-25	12-36	15-35	22-33
MAFMC	Scup	adult	5-28	7-25	10-22	17-36	23-35	26-33
MAFMC	Spiny dogfish	juvenile	2-25	4-22	5-17	23-36	27-36	31-34
MAFMC	Spiny dogfish	adult	2-21	3-19	5-16	20-36	25-35	30-34
MAFMC	Summer flounder	juvenile	2-31	5-30	10-28	2-37	6-36	13-33

Council	Common name	Life stage	Surface temp full range (99%)	Surface temp range (95%)	Surface temp range (75%)	Surface salinity full range (99%)	Surface salinity range (95%)	Surface salinity range (75%)
MAFMC	Summer flounder	adult	4-30	5-28	8-25	6-37	11-36	18-34
NEFMC	Acadian redfish	juvenile	1-18	3-16	5-14	12-34	28-34	31-33
NEFMC	Acadian redfish	adult	1-18	3-16	4-13	29-34	30-34	31-33
NEFMC	American plaice	juvenile	1-17	3-16	5-13	12-34	27-34	30-33
NEFMC	American plaice	adult	1-17	3-16	4-13	16-34	28-34	31-33
NEFMC	Atlantic cod	juvenile	1-21	3-16	4-13	12-34	25-34	30-33
NEFMC	Atlantic cod	adult	0-17	2-16	4-13	26-34	29-34	31-33
NEFMC	Atlantic halibut	juvenile	1-17	2-15	4-13	27-34	29-34	31-33
NEFMC	Atlantic halibut	adult	1-16	2-15	4-13	15-34	29-34	31-33
NEFMC	Atlantic herring	juvenile	1-24	**2-21**	4-15	9-35	**14-34**	26-33
NEFMC	Atlantic herring	adult	1-18	**2-16**	4-13	10-35	**17-34**	26-33
NEFMC	Atlantic wolffish	juvenile	0-17	2-14	3-12	29-34	29-34	31-33
NEFMC	Atlantic wolffish	adult	0-16	2-14	3-12	29-34	30-34	31-33
NEFMC	Barndoor skate	juvenile	2-23	3-21	5-17	30-36	31-35	32-34
NEFMC	Barndoor skate	adult	2-19	4-17	6-16	31-36	31-35	31-34
NEFMC	Clearnose skate	juvenile	6-29	8-27	12-24	14-37	17-36	23-33
NEFMC	Clearnose skate	adult	4-27	6-25	9-24	23-36	26-35	28-33
NEFMC	Haddock	juvenile	2-24	3-21	5-16	12-36	28-34	31-34
NEFMC	Haddock	adult	1-18	2-16	4-14	26-34	29-34	31-33
NEFMC	Little skate	juvenile	1-25	3-23	5-20	22-36	26-35	29-34
NEFMC	Little skate	adult	1-26	3-24	4-20	22-36	26-35	30-34
NEFMC	Monkfish	juvenile	2-27	4-25	5-20	12-36	27-36	31-34
NEFMC	Monkfish	adult	0-25	3-22	5-17	24-36	29-36	31-34
NEFMC	Ocean pout	juvenile	1-24	3-21	4-16	20-35	26-34	31-34
NEFMC	Ocean pout	adult	1-22	3-19	4-14	20-35	26-34	30-33
NEFMC	Offshore hake	juvenile	4-30	5-27	7-24	31-37	31-37	32-36
NEFMC	Offshore hake	adult	0-29	4-27	6-24	31-37	31-37	32-36
NEFMC	Pollock	juvenile	1-22	2-19	4-14	14-34	26-34	30-33

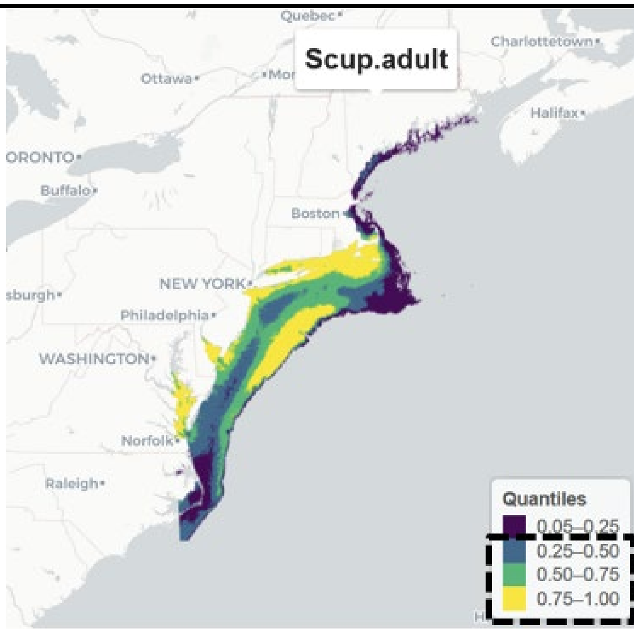
Council	Common name	Life stage	Surface temp full range (99%)	Surface temp range (95%)	Surface temp range (75%)	Surface salinity full range (99%)	Surface salinity range (95%)	Surface salinity range (75%)
NEFMC	Pollock	adult	1-17	2-16	4-13	30-34	31-34	31-33
NEFMC	Red hake	juvenile	2-25	3-22	5-17	10-36	15-34	28-33
NEFMC	Red hake	adult	2-25	3-22	5-17	13-36	25-35	30-34
NEFMC	Rosette skate	juvenile	6-30	6-29	8-26	31-37	31-37	32-36
NEFMC	Rosette skate	adult	5-28	6-27	7-25	31-37	31-36	32-36
NEFMC	Silver hake	juvenile	2-25	3-23	5-18	13-36	23-35	29-34
NEFMC	Silver hake	adult	2-25	4-23	5-18	16-36	28-35	31-34
NEFMC	Smooth skate	juvenile	2-18	3-16	4-14	28-34	30-34	31-34
NEFMC	Smooth skate	adult	1-18	3-16	4-14	29-34	30-34	31-33
NEFMC	Thorny skate	juvenile	1-18	2-16	4-13	26-34	29-34	31-33
NEFMC	Thorny skate	adult	1-17	2-15	4-13	28-34	29-34	31-33
NEFMC	White hake	juvenile	2-19	3-16	5-14	11-34	26-34	30-33
NEFMC	White hake	adult	2-21	3-17	5-14	12-36	30-34	31-34
NEFMC	Windowpane flounder	juvenile	1-28	3-26	6-23	9-35	13-34	21-33
NEFMC	Windowpane flounder	adult	1-26	3-24	5-21	14-36	21-34	26-33
NEFMC	Winter flounder	juvenile	1-27	3-24	5-20	12-35	21-34	25-33
NEFMC	Winter flounder	adult	1-24	3-22	4-18	16-36	24-34	26-33
NEFMC	Winter skate	juvenile	2-22	3-20	4-18	22-36	26-35	29-33
NEFMC	Winter skate	adult	2-21	3-19	4-16	22-35	25-34	29-33
NEFMC	Witch flounder	juvenile	2-25	4-20	5-14	12-36	29-35	31-34
NEFMC	Witch flounder	adult	1-23	3-18	4-14	22-36	30-35	31-34
NEFMC	Yellowtail flounder	juvenile	1-23	3-21	4-16	24-35	28-34	30-33
NEFMC	Yellowtail flounder	adult	1-22	3-19	4-15	16-35	28-34	30-33

5 WORKED EXAMPLES

This section illustrates the process for updating EFH designation maps and text descriptions using worked examples. For mapping methods, we use scup adults (Section 5.1) and for text revision methods we use Atlantic herring egg/larvae, black sea bass juveniles, and Atlantic cod adult as examples (Section 5.2).

5.1 Mapping Process Steps

Table 14. Visual examples of steps in the EFH designation mapping process.

<table>
<tr><th>Representative Visual</th><th>Description of Mapping Process Step</th></tr>
<tr><td>
</td><td>Modeled Pathway: In this example, scup adult SDM model-based outputs identified as the 75th quantiles (i.e., yellow, green, and blue area) of “occupied habitat” would be carried forward as part of the principal EFH area. Those quantiles shown in dark purple would therefore not be carried forward.</td></tr>
<tr><td>
</td><td>Non-modeled Pathway: Species estuary zones with inshore scup occurrences from fishery-independent survey data, shown in orange, that are greater than 25% (i.e., inshore occupied habitat) and species estuary zones with appropriate habitat conditions (i.e., salinity and depth) are retained and carried forward as part of the principal EFH area.</td></tr>
</table>

Representative Visual	Description of Mapping Process Step
	*Principal EFH Area*: The modeled and non-modeled parts that are retained and carried forward are combined, to create a unified EFH map.

5.2 Annotated Text Description Examples

Figures 2-4 below depict examples of updated text descriptions that are annotated to highlight steps in the revision process (described in Section 4.4) and common text elements. These annotations also show examples where key decision points in the text revisions are informed by the principal EFH maps, cross-reference with the literature (including the EFH Source Documents), and/or feedback from species experts. These examples are intended to illustrate how a consistent framework can be applied to updating EFH text descriptions, while still accommodating species- and life stage-specific nuances in habitat use. We chose examples from both MAFMC- and NEFMC-managed species, across multiple life stages for illustrative purposes.

Figure 2. Annotated example of updated text descriptions for Atlantic herring (*Clupea harengus*) eggs and larvae, illustrating common elements included in the revised text descriptions. Since eggs and larvae maps for this species were based off other life stages as proxies, additional habitat information typically drew upon literature reviews and consultation with species experts, especially for specific environmental ranges (e.g., temperature, salinity) if available.

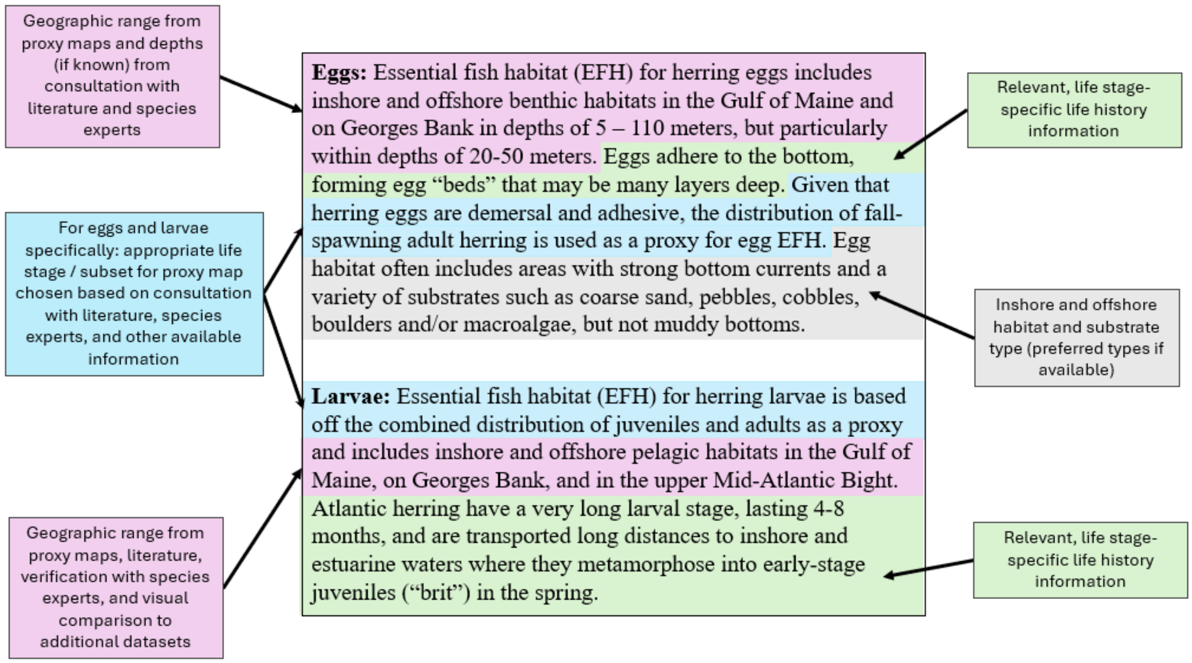


Figure 3. Annotated example of updated text description for black sea bass (*Centropristis striata*) juveniles, illustrating common elements included in the revised text descriptions.

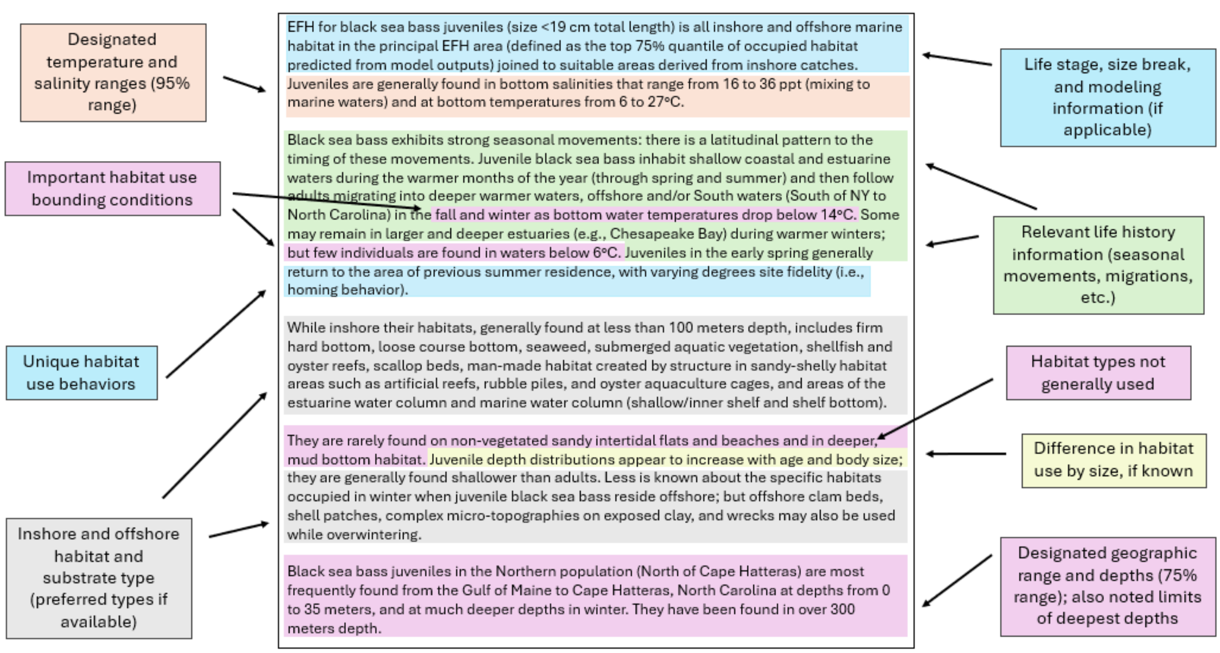
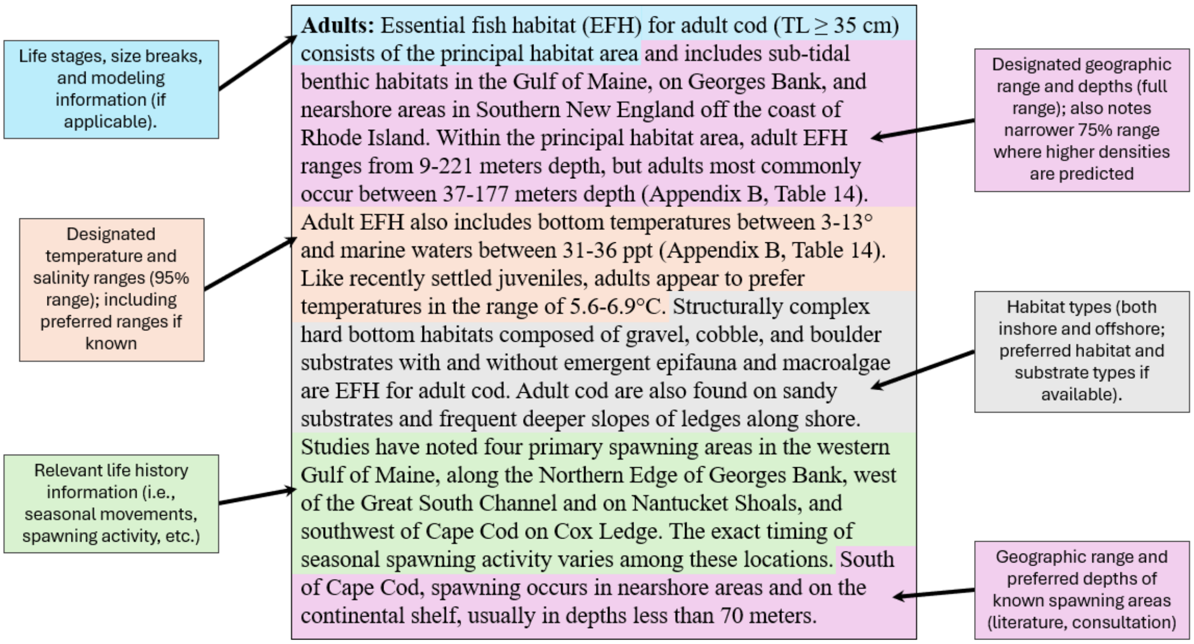


Figure 4. Annotated example of updated text description for Atlantic cod (*Gadus morhua*) adults, illustrating common elements included in the revised text descriptions.



6 FURTHER READING

6.1 Online Resources

- MAFMC Omnibus EFH Amendment Webpage:
    - VIDEO: EFH Demo App Intro & Walkthrough
    - VIDEO: EFH Modeling Methods
- NOAA Fisheries Northeast Fish and Shellfish Climate Vulnerability Assessment: https://www.fisheries.noaa.gov/new-england-mid-atlantic/climate/northeast-vulnerability-assessment
- NRHA EFH Demo R-Shiny Application: https://nrha.shinyapps.io/EFH_demo/
- NRHA Habitat Climate Vulnerability Assessment Crosswalk Project: https://nrha.shinyapps.io/dataexplorer/#!/crosswalk

6.2 References

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