

# Summary of the Northeast Regional Marine Fish Habitat Assessment (NRHA)

(DRAFT as of May 24, 2022)



Draft Report: May 24, 2022

Final Report Completed:

## Table of Contents

<b>1.0 Introduction and History of NRHA</b>	4
<b>2.0 Work Plan and Action Items</b>	<b>Error! Bookmark not defined.</b>
<b>3.0 The Teams</b>	5
The Steering Committee	6
Our Core Leads Work Team	6
The Action Team Members	6
Other Collaborators and Partners	6
<b>4.0 Process and Outreach</b>	7
<b>5.0 Scope and Species</b>	7
Inshore	7
Offshore	8
Outside the NRHA Region	8
Focus Species	8
<b>6.0 Data</b>	9
Species data	9
Habitat data	9
Metadata inventory	10
Fisheries survey crosswalk	10
<b>7.0 Modeling Approaches</b>	11
<b>8.0 Climate Vulnerability Assessment/NRHA Crosswalk</b>	11
<b>9.0 Data dissemination and sharing</b>	12
<b>10.0 Applications</b>	13
Essential Fish Habitat Applications	13
Integration of Habitat Science into EAFM and broader IEA Approaches	13
Habitat and Stock Assessment Applications	14
<b>11.0 Limitations and Data Gaps</b>	14
<b>12.0 Next Steps</b>	14
<b>13.0 References</b>	14

## Acronyms

ACFHP	Atlantic Coastal Fish Habitat Partnership
CUSP	Continuously Updated Shoreline Product
EEZ	Exclusive Economic Zone
EFH	Essential Fish Habitat
FSCVA	Fish and Shellfish Climate Vulnerability Assessment
GB	Georges Bank
GIS	Geographic Information System
GOM	Gulf of Maine
HAPC	Habitat Area of Particular Concern
HCVA	Habitat Climate Vulnerability Assessment
MHW	Mean High Water
MSA	Magnuson-Stevens Fishery Conservation and Management Act
NRHA	Northeast Regional Habitat Assessment

## 1.0 Introduction and History of NRHA

In late 2017, a Steering Committee composed of leadership from the major habitat conservation, restoration, and science organizations in the region, met and agreed to identify ways to improve fish habitat science within the region. They concluded that a Northeast Regional Marine Fish Habitat Assessment was needed to describe and characterize estuarine, coastal, and offshore fish habitat distribution, abundance, and quality in the Northeast. The project is working to align habitat science goals and priorities with human and financial resources to develop habitat science products that support an assessment.

The Steering Committee wanted an assessment that:

- Serves as a decision support tool for multiple audiences – for both inshore and offshore habitats, to assess habitat distribution, abundance, quality, species habitat use, and how it is changing in response to changes in climate.
- Provides foundational information to support the designation of essential fish habitat (EFH) for Councils and supports federal EFH assessments and EFH consultations (i.e., better data, better synthesis, more specific habitat information, finer scale information).
- Identifies what habitat areas are rare, sensitive, especially vulnerable to degradation, or are uniquely important to ecosystem function, to help prioritize consultations and conservation.
- Compiles information to support a regional National Fish Habitat Partnership (NFHP)<sup>1</sup> assessment, to identify areas that could be considered for habitat conservation or restoration.
- Addresses NOAA’s Habitat Assessment Improvement Plan (HAIP)<sup>2</sup> priorities.
- Characterizes habitats, their services, and vulnerabilities to better inform permitting agencies and industries in decision making with respect to multiple ocean uses (e.g. aquaculture, wild-caught fisheries, energy issues, etc.).
- Supports incorporation of ecosystem principles into fisheries management.

To meet these objectives, the Steering Committee supported the development of a detailed work plan to identify specific products and delivery dates, financial needs, and responsible parties to complete a regional assessment. The Steering Committee leadership specifically identified staff habitat scientists to participate on work plan development teams during July 2018 - December 2018. The completed work plan included specific actions to be addressed, including the identification of contractors and the formation of action teams that would support this work.

## 2.0 Work Plan and Action Items

Four actions were identified as necessary to describe and characterize estuarine, coastal, and offshore fish habitat distribution, abundance, and quality in the Northeast. These actions will address: 1) Abundance and trends in habitat types in the inshore area, 2) Habitat vulnerability, 3)

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<sup>1</sup> National Fish Habitat Partnership’s (<http://www.fishhabitat.org/about/>) mission is to protect, restore and enhance the nation's fish and aquatic communities through partnerships that foster fish habitat conservation and improve the quality of life for the American people.

<sup>2</sup> Habitat Assessment Improvement Plan: <https://www.st.nmfs.noaa.gov/ecosystems/habitat/publications/haip/index>.

Spatial descriptions of species habitat use in the offshore area and 4) provide a Habitat Data Visualization and Decision Support Tool. The core work to support these actions is proposed for July 2019 - July 2022, with anticipated project support to maintain and improve products beyond. Action team leads and action team members were identified in June 2019 to support work (see Section 3.0).

More specifically:

**1) Abundance and trends in habitat types in the inshore area.** This action will map the location and extent of habitat types utilized by the focus species and quantify the aerial coverage, status, and trends of these habitats. It will also compile metrics that may inform an assessment of habitat quality. Key outcomes from this action include A. Location and extent of habitat types as maps (Geographic Information System (GIS) framework; to finest scale practical). B. Quantity of habitat types in the entire region, sub or ecoregions, estuaries, mainstems/tributaries, to finest scale (1 km sq polygons or smaller, where possible). C. Status and trend of habitat types with 1) relative proportion of habitat types to one another, 2) a baseline to track each habitat type, 3) trends in habitat quantity relative to baseline if possible, and 4) development of habitat quality metrics, if possible. D. Written inventory and database of habitats, and habitat use for inshore focus species.

**2) Habitat vulnerability.** This action will involve Council and Commission staff coordination with, and participation in, the NOAA Habitat Climate Vulnerability Assessment (HCVA). That assessment will use habitat experts to examine fish habitat vulnerability to climate and non-climate stressors. Key outcomes from this action include A. Qualitative evaluation of the vulnerability of specific habitat types to non-climate and climate related stressors based on expert judgment. B. Recommendations from HCVA and staff leads if additional areas for future work are identified through this process.

**3) Spatial descriptions of species habitat use in the offshore area.** This action will use model-based and empirical approaches to identify, predict, and map habitat use for each of the focus species and track and quantify changes in habitat use over time (e.g., seasonal, annual, and future predicted use). Key outcomes from this action include A. Location and extent of habitat use (spatially depicted) by individual focus species (and, if possible, species groups), including annual, seasonal, and predicted future use. B. Quantify and track changes in habitat use for focus species throughout the region, and for each Ecological Production Unit (EPU): Mid-Atlantic Bight, Georges Bank, Gulf of Maine. C. Identification of most important factors (covariates) driving focus species distribution.

**4) Habitat data visualization and decision support tool.** Habitat information will be incorporated into a publicly accessible decision support tool, making this information available to partners to visualize habitat location, extent, and use throughout the region, and providing access to relevant data and habitat metrics developed by the assessment.

### 3.0 The Teams

In addition to the Steering Committee Core work team, and Action Teams, special thanks to the Councils and NOAA Fisheries Office of Habitat Conservation and Office of Science and Technology for the substantial support provided to NRHA. In addition, this work would not be

possible without the support of our many partner organizations and co-collaborators who provided data, input, and advice to the project along the way.

### *The Steering Committee*

Mid-Atlantic Fishery Management Council (MAFMC): Christopher Moore  
New England Fishery Management Council (NEFMC): Thomas Nies  
Atlantic Coast Fish Habitat Partnership: Bob Beal (designee Lisa Havel)  
Atlantic States Marine Fisheries Commission: Bob Beal (designee Patrick Campfield)  
Duke University, Marine Spatial Ecology: Patrick Halpin  
Monmouth University, Urban Coast Institute: Tony McDonald  
National Fish Habitat Partnership, Science and Data Committee: Gary Whelan  
NOAA Fisheries Offices of Habitat Conservation: Kara Meckley, Lou Chiarella  
NOAA NCCOS Marine Spatial Ecology Division: Mark Monaco  
NOAA Fisheries Offices of Science and Technology: Peg Brady, Tony Marshak  
NOAA Northeast Fisheries Science Center: Thomas Noji (retired), Dan Wieczorak  
The Nature Conservancy: Kate Wilke

### *Our Core Leads Work Team*

NEFMC, Michelle Bachman  
MAFMC, Jessica Coakley  
Monmouth University/NOAA, Christopher Haak  
MAFMC (Previously with NOAA/Integrated Statistics), Victoria Kentner  
NMFS NEFSC, Laurel Smith

### *The Action Team Members*

Gulf of Maine Research Institute - Kathy Mills  
Maryland DNR - Marek Topolski  
Massachusetts DMF - Mark Rousseau  
NOAA Fisheries GARFO - David Stevenson, Alison Verkade,  
NOAA Fisheries NEFSC - Kevin Friedland, Donna Johnson, Ryan Morse, Dave Packer, Vince Saba, Harvey Walsh  
NOAA NOS NCCOS - Andrew Leight  
The Nature Conservancy - Bryan DeAngelis, Rich Bell, Marta Ribera  
The PEW Charitable Trusts - Zack Greenberg  
Rhode Island DEM - Eric Schneider  
U.S. Fish and Wildlife Service - Julie Devers  
U.S. Geologic Service - Stephen Faulkner  
Virginia Institute of Marine Sciences - Robert Latour

### *Other Collaborators and Partners*

Other collaborators: David (Moe) Nelson (NOAA NOS), Aaron Kornbluth (PEW), Lisa Havel and Pat Campfield (ASMFC/ACFHP), Karl Vilacoba, Emily Shumchenia and Nick Napoli (MARCO/NROC), Sarah Gaiches and Kim Hyde (NOAA Fisheries NEFSC), Mike R. Johnson (NOAA Fisheries GARFO), and Emily Farr (previously with NOAA Fisheries).

## 4.0 Process and Outreach

With guidance from the Steering Committee through a detailed work plan, the core work team held regular meetings with members of the inshore and offshore action teams.

Initially, they met independently, but the inshore and offshore action team meetings merged in year 2 as discussions became more commingled, particularly with concepts of integrating and sharing products. Action Team members helped identify data sources, others in the region doing other useful or analogous work, and identified what could be feasibly developed given the data and resources available to do the work. In addition, Action Team members helped with preparation and review of some of the written products and metadata reports. Regular check-ins were held with the Core Leads Team (monthly), Action Teams (3 times per year), and the Steering Committee (twice a year) in an iterative manner.

## 5.0 Scope and Species

Overall, the scope of NRHA is estuarine, coastal and offshore waters of the Northeast U.S. Shelf, and extends from the North Carolina/South Carolina boundary to the western end of the Scotian Shelf and includes the Mid-Atlantic Bight, Southern New England, Georges Bank, and the Gulf of Maine.

### *Inshore*

The spatial extent of the inshore assessment is defined geographically for comparison with various habitat and fish data sources, and to conceptually indicate the overall scope of the inshore assessment. The inshore boundary of the inshore assessment is based largely on NOAA's Medium Resolution Shoreline. NOAA's continuously updated shoreline product (CUSP) was considered as an alternative, but that product is much higher resolution, encompassing many additional tributaries, and was thought to be unnecessarily detailed for a regional-scale analysis. This page provides an overview of the two shoreline products, plus NOAA's Office of Coast Survey shorelines, linking to the data sources and more detailed metadata: <https://shoreline.noaa.gov/data/national.html>. The medium resolution shoreline uses Mean High Water (MHW) as the tidal datum.

Tidal fresh salinity zones are encompassed within the inshore assessment extent. One source of salinity data is NOAA's Estuarine Salinity Zones of the United States (Nelson 2015), which was used to support NOAA's Estuarine Living Marine Resource (ELMR) assessment. The salinity zone product divides estuaries of the contiguous United States into three zones as follows: (1) Tidal Fresh Zone (0 to 0.5 parts per thousand); (2) Mixing Zone (0.5 to 25 parts per thousand); (3) Seawater Zone (25 parts per thousand or greater). Visually comparing the medium resolution shoreline and the salinity zones, the tidal fresh zones are encompassed by the medium-resolution shoreline. The resolution of the salinity zone polygons is coarser, so these data sets will be overlaid for illustrative purposes as needed, but not merged into a single GIS coverage. The inshore assessment extent also incorporates the 'Estuarine and Marine Wetland' and 'Estuarine Marine Deepwater' wetland types from the U.S. Fish and Wildlife Service's National Wetlands Inventory (NWI). NWI uses the Cowardin system for wetlands classification (Cowardin et al. 1979, FGDC 2013). The Cowardin system has been in use since 1976 and

became a National Standard in 1996. An overview of NWI is available at <https://www.fws.gov/program/national-wetlands-inventory>

Note that some NRHA species occur in riverine and tidal freshwater habitats during portions of their life history. These include Atlantic salmon, alewife, blueback herring, shad, Atlantic sturgeon, winter flounder, and summer flounder. This inshore habitat assessment does not encompass the full extent of habitat occupancy for these species, in large part because other related assessments have already done so. Specifically, two regional assessments that cover the NRHA geographic extent encompass both riverine and estuarine habitats. These include the Atlantic Coast Fish Habitat Partnership's Fish Habitat Conservation Area Mapping and Prioritization Project (<https://www.atlanticfishhabitat.org/science-and-data-projects/>) and the 2015 National Fish Habitat Partnership assessment (<http://assessment.fishhabitat.org/>). In addition, management of freshwater areas is beyond the purview of coastal and marine resource managers who are the primary audience for NRHA.

The offshore boundary of the inshore assessment is the state waters boundary, which is also the approximate extent of state trawl surveys.

### *Offshore*

The offshore assessment actions will generally focus on habitat from the coastal bays to the eastern boundary of the EEZ, although data available to support work only extend to the offshore canyon areas at its furthest extent.

### *Outside the NRHA Region*

While important habitat for some species may occur outside the geographic scope for the actions, it is not practical to identify and assess this fish habitat through this assessment in a transboundary way at this time.

### *Focus Species*

The Steering Committee identified 65+ focus fish species for this habitat assessment. All species are highly important to fisheries management organizations within the region.



**Table 1. NRHA focal species, by management entity.**

<b>MAFMC</b>	Atlantic mackerel, Atlantic surfclam, Black sea bass*, Bluefish* , Blueline tilefish , Butterfish, Chub mackerel, Golden tilefish , Longfin squid, Ocean quahog, Scup*, Shortfin (Illex) squid, Spiny dogfish* , ** , Summer flounder*
<b>NEFMC</b>	Acadian redfish, American plaice, Atlantic cod, Atlantic halibut, Atlantic herring*, Atlantic salmon, Atlantic wolffish, Barndoor skate, Clearnose skate, Cusk***, Haddock, Little Skate, Monkfish**, Ocean pout, Offshore hake, Pollock, Red crab, Red hake, Rosette skate, Sea scallop, Silver hake, Smooth skate, Thorny skate, White hake, Windowpane flounder, Winter flounder*, Winter skate, Witch flounder, Yellowtail flounder
<b>ASMFC (not noted above)</b>	American eel, American lobster, Atlantic croaker, Atlantic menhaden, Atlantic striped bass, Atlantic sturgeon, Black drum, Coastal sharks, Cobia, Horseshoe crab, Jonah crab, Northern shrimp, Red drum, Shad and river herring, Spanish mackerel, Spot, Spotted seatrout, Tautog, Weakfish
<b>Highly Migratory (with HAPC designations)</b>	Sandbar shark, Dusky shark
<p>* Also managed by ASMFC.  **Jointly managed between MAFMC and NEFMC.  *** Not a NEFMC managed species but occurring in the New England region.</p>	

## 6.0 Data

### *Species data*

Species data from as early as 1963 through 2019 were assembled from federal and state fisheries independent surveys. Most are trawl surveys, but longline, trap, and seine surveys were included as well. Data were pulled from NOAA databases where possible, but most state and regional survey data were obtained directly from project coordinators. Data sets were reformatted for consistency as needed. In general modeling was stage based, so total abundance and biomass per tow was summed individually for juveniles and adults, based on fish length.

### *Habitat data*

Diverse habitat data were assembled to support the project. These data sets can be visualized individually through the NRHA R-Shiny application or via other data portals, and also many were used as model covariates.

- **Sediment and benthic:** Sediment data include coast wide and local data sources that identify grain size by location. Other data products in this category represent habitat classification schemes, based in part on sediment data but also on other sources of information. Data in these categories are in point, polygon, and raster formats.
- **Bathymetry:** In the context of NRHA, bathymetry data are primarily used to describe the water depth at a particular location, although many digital elevation models include submerged as well as upland areas. Similar to the sediment data sets, bathymetry data may be coastwide or local. Various products can be derived from bathymetric surfaces, such as slope, aspect, or indices of bathymetric position. Contour lines connecting locations of equal depth and/or slope can also be generated. Many fishery independent resource surveys collect depth data as a station variable.
- **Temperature:** Water temperature is an important determinant of fish distribution, and therefore useful for NRHA modeling efforts. Temperature data may be taken at the sea surface, throughout the water column, or at the seabed. Temperature data are collected via remote sensing and via direct measurement. Many fishery independent resource surveys collect temperature data as a station variable.
- **Coastal Habitats:** Coastal habitats of interest include submerged aquatic vegetation, oyster reef, tidal marsh, and hard bottom. Submerged Aquatic Vegetation or SAV data document the location of aquatic plants such as eelgrass. Data are typically in polygon format and may include density information. SAV distributions are somewhat dynamic naturally, and there is also a restoration component whereby SAV in an area is deliberately increased via human intervention as a habitat enhancement technique. Thus, the timing over which SAV data were collected is an important data element.
- **Hydrodynamic Data:** Hydrodynamic data describe the movement of water at a particular location and depth, at varying spatial and temporal resolutions. These models may incorporate wave dynamics only, circulation dynamics only, or both.
- **Climate Model Outputs:** Climate models can be used to predict changes in temperature at a particular location, at varying spatial and temporal resolutions. In the context of NRHA, these temperature forecasts can be included in species distribution models to estimate how these distributions could change under various climate scenarios.

### *Metadata inventory*

An inventory as a spreadsheet and as 1-page metadata sheets were created for fishery-independent datasets and some environmental datasets. Those were reviewed by the data originators and action team members and are available in the R-Shiny applications.

### *Fisheries survey crosswalk*

Fishery independent surveys often use similar methods, but differences in gear type, tow duration, season, etc. are important to consider when developing analyses based on multiple datasets. As a first step towards integrating data from multiple surveys, NRHA analysts generated a crosswalk table to document and compare the attributes of each survey.

## 7.0 Modeling Approaches

Single species and joint species distribution models (SDMs) are a core element of NRHA. Single-species SDMs employed Generalized Additive Modeling (GAM) and Random Forest (RF) methods, derived in part from earlier work including that of Malin Pinsky (Rutgers) and Kevin Friedland (NOAA NMFS NEFSC). Joint SDMs were fitted using a novel statistical approach, the Community-level Basis Function Model (CBFM), a spatio-temporal framework for joint-species distribution modeling wherein species relationships with environmental predictors and their covariance with each other are evaluated simultaneously. See manuscript for CBFM methods details.

Single-species RF models were used for initial exploration and to aid in identifying influential covariates, while GAMs were used for the final models due to their greater transparency and interpretability. The predictions and ecological inferences drawn from single and joint-species models were compared.

## 8.0 Climate Vulnerability Assessment/NRHA Crosswalk

NOAA Fisheries recently completed the Northeast Habitat Climate Vulnerability Assessment that assesses the vulnerability of 52 marine, estuarine, and riverine habitats in the Northeast U.S. to climate change (Farr et al. 2021). The Northeast HCVA builds on the Northeast Fish and Shellfish Climate Vulnerability Assessment (FSCVA, Hare et al. 2016), which examined fishes' climate vulnerability based on life history. The HCVA complements the FSCVA by improving our understanding of how the vulnerability of habitats will impact fish and shellfish populations that depend on them. The Atlantic Coastal Fish Habitat Partnership habitat-species matrix (Kritzer et al. 2016) identified the importance of nearshore benthic habitats to each life stage of select fish species, which helps elucidate species that may be highly dependent on highly vulnerable habitats that were identified in the HCVA. This portion of NRHA integrates the outputs from the HCVA, FSCVA, and ACFHP assessments for use in fisheries management. The major objectives were to create a habitat-species vulnerability matrix and develop species narratives for 66 managed and forage species in the region.

The matrix identifies the dependence or occurrence of species on specific habitat types while conveying information about species and habitat vulnerability to climate change. Relative dependence of a species on a habitat was indicated for inshore species based on the ACFHP matrix, while simple occurrence was indicated for offshore species not scored in the ACFHP analysis. Habitat associations for offshore species were determined based on EFH designations, scientific literature, and expert knowledge. As the project is ongoing, species that were not included in the ACFHP project and do not have designated EFH may present additional challenges in terms of assigning habitat associations in the matrix. These species are part of the project because they were assessed via the FSCVA and are important components of the ecosystem.

Crosswalking the HCVA and ACFHP assessments presented several challenges. The ACFHP analysis did not identify dependencies on water column habitats, so water column species habitat relationships were added to the crosswalk based on EFH text descriptions, scientific literature,

and expert knowledge of the species' life history. In addition, the ACFHP and HCVA analyses did not use the same habitat classifications, with the ACFHP categories being more general, and the HCVA habitat types more narrow. While the HCVA types were able to be nested within the ACFHP categories, some of the HCVA habitat types falling under an ACFHP category do not apply to individual species, and these needed to be removed individually when writing the species narratives. Some ACFHP category names better encompass the cross-walked HCVA habitat types than others. For example, the "seaweed" ACFHP habitat designation was modified to "macroalgae" to more appropriately convey the dependencies on vegetated habitats. Shellfish habitats posed a complicated crosswalk as the HCVA did not include a category for non-reef forming shellfish and expert knowledge was used to sort equivalencies as fish weren't using scallop bed or hard clam bed habitat for sand or mud substrate but for food.

The species narratives describe the species climate vulnerability, the species habitat dependencies or associations across life stages, and the climate vulnerability of those habitats. The information is presented in both text and tables. The initial focus has been on species that are highly dependent on highly vulnerable habitats. Similar to the matrix, the narratives draw from several existing sources of information, including HCVA, FSCVA, and ACFHP results, essential fish designations, and the NRHA species profiles, which describe life history including reproduction, migrations/movement, and habitat use, in addition to food habits, the fishery, and management. The information pulled from these sources allows the narratives to provide a quick reference of a species' particular sensitivities and exposures as well as highlight any unique regional vulnerabilities. Species with different habitat dependency between New England and the Mid-Atlantic have descriptions and tables for each region. Species with identical dependency data for both regions are combined for those sections, and species without data in one region have a range disclaimer or explanatory note on data availability. Companion documents for the species narratives will include a glossary of key terms, expanded habitat descriptions and vulnerability summaries, and an overview of methodology.

The crosswalk will be included in the data sharing R-Shiny application described below. An objective when presenting this work is to highlight species that are highly climate vulnerable, depend on highly climate vulnerable habitats, or both, since these vulnerabilities create particular management challenges. The first 40 species narratives and the associated matrix will be included in the initial NRHA product launch, and the remainder will be added to the application by early 2023.

## 9.0 Data dissemination and sharing

A custom R-Shiny application is the primary vehicle for sharing NRHA results. R is a free software environment for statistical computing and graphics (<https://www.r-project.org/>). Shiny is a specific R coding package that allows users to build custom interactive web applications (<https://shiny.rstudio.com/>). The application includes tabs for displaying and summarizing fishery independent survey data, single species and joint model outputs, the NRHA-HCVA crosswalk results, habitat data sets and metadata files, species profiles, reports and publications, etc. The NRHA application can be found here: <https://nrha.shinyapps.io/dataexplorer/>.

A diverse array of marine spatial data portals are used for spatial planning and marine management in the northeast U.S. and worldwide. Among these are the Northeast Ocean Data Portal (<https://www.northeastoceandata.org/>) and the Mid Atlantic Ocean Data Portal (<https://portal.midatlanticocean.org/visualize/>). The NRHA team will collaborate with these two data portals to launch a curated set of products, and potentially will develop thematic and/or story maps to walk users through results for particular species, or focused on a certain application or location. As management applications arise over time through the Council or Commission processes, the data shared through the portals can be augmented to address these needs.

The recently launched NOAA Fisheries Distribution Mapping and Analysis Portal (DisMAP) provides easy access to information to track and understand distributions of marine species in the U.S. Marine Ecosystems. NRHA leads have held initial discussions with DisMAP staff to explore options for sharing NRHA modeling products via DisMAP, and will continue to engage with them on possible collaboration opportunities.

## 10.0 Applications

### *Essential Fish Habitat Applications*

Perhaps the most obvious use of NRHA products in federal fisheries management is for the refinement of essential fish habitat designations. The single species and joint habitat models will provide spatially specific estimates of habitat suitability for species and groups of species, along with information about which environmental factors influence distribution. These results can be applied to both the map and text elements of EFH designations. The Mid-Atlantic Fishery Management Council already envisions commencing an EFH Review/Redo in fall 2022. The EFH Review Fishery Management Action Team (FMAT) will consider NRHA model outputs and other information in detail for Council-managed species and recommend whether and how to revise existing designations. NRHA results could also be used to identify subsets of EFH for designation as Habitat Areas of Particular Concern, or HAPC.

### *Integration of Habitat Science into EAFM and broader IEA Approaches*

Information from the habitat assessment will be available to add into summary reports for the region, both at an ecosystem level and for individual species. This includes maps and metrics to track historic habitat use, and how that habitat is changing in the inshore or offshore regions, annually, seasonal, as well as how the habitat use is projected to change over time.

State of the Ecosystem (SOE) reports provide information for Ecosystem Approaches to Fishery Management (EAFM), Ecosystem Based Fishery Management (EBFM) and Integrated Ecosystem Assessment (IEA) approaches. Including multi-species information on ecosystem drivers of species distribution shifts will greatly enhance both the connectivity of various parts of the SOE reports and help to facilitate EAFM, EBFM, and IEA approaches that can be used by both the New England and Mid-Atlantic Fisheries Management Councils.

## *Habitat and Stock Assessment Applications*

High resolution habitat maps that include both static and dynamic aspects of habitat combined with geospatial statistical models have the potential to improve the indices of abundance that go into stock assessments as well as improve survey design. Each single species stock assessment includes a Term of Reference that requires a summary of stock distribution and changes over time. NRHA products can directly address this Term of Reference by providing maps at various spatial and temporal resolutions, as well as environmental covariates and single species model projections of future distributions. The significant environmental covariates for a given assessed species can also be used to determine if environmental regime shifts are occurring that affect the health, condition or recruitment of the species. This was informative at setting the recruitment stanza used for butterflyfish projections in the 2022 assessment. NRHA work on distribution shifts and environmental covariates are also being applied for the 2023 Atlantic mackerel assessment, and will likely be included in many other single species stock assessments going forward.

### 11.0 Limitations and Data Gaps

Some of the NRHA species are data limited with low catches in fishery independent surveys (due to low catchability, for example) which has precluded application of modeling approaches. Generally available data for these species are provided in the data explorer.

The NRHA teams discussed other potential work products during development of the three year assessment but needed to focus efforts given available resources. For example, analysts discussed compiling existing habitat status and trends evaluations, particularly for inshore habitat types such as wetlands, but resources were insufficient to complete this work.

### 12.0 Next Steps

Selected NRHA products incorporate climate change considerations. These include simplified single species Generalized Additive Models that assume future climate scenarios in order to predict species distributions given changes in ocean conditions, for example, increases in water temperature. The CVA-NRHA crosswalk work identifies key areas of vulnerability on which managers can focus their attention. East coast fishery managers are also engaged in determining how to approach decision making strategically, given environmental changes occurring now and into the future through a scenario planning initiative. As appropriate, NRHA products can be used to support this ongoing work. In addition, the joint models are closely aligned with methods being considered for use in a NSF-funded convergence accelerator project, which aims to estimate changing distributions of species and guilds under multiple climate scenarios. We are working with this team to ensure that their products build on NRHA work.

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