**Mid-Atlantic Fishery Management Council**
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# MEMORANDUM

**Date:** May 25, 2022

**To:** Council

**From:** Jessica Coakley and Tori Kentner, Staff

**Subject:** Update on the Northeast Regional Marine Fish Habitat Assessment (NRHA)

The following is included for Council consideration on this subject:

1) Draft NRHA Summary Report

2) Sample of NRHA Metadata Inventory page

3) Sample of the NRHA Atlantic cod Crosswalk "Narrative" of the Habitat Climate Vulnerability Assessment (HCVA), Fish and Shellfish Climate Vulnerability Assessment FSCVA, and Atlantic Coastal Fish Habitat Partnership (ACFHP) habitat dependency assessment for use in fisheries management. (DRAFT)

4) Sample of the NRHA Species Profile for black sea bass (DRAFT)

During this meeting, the Council will receive a presentation from Chris Haak (Monmouth University/NOAA) and Tori Kentner (staff) updating the Council on the work in progress and anticipated deliverables after July 1.

The sample documents provided above are preloaded (and downloadable as pdfs) on the custom R-Shiny application (DRAFT). This site will be the primary vehicle for sharing NRHA results. The NRHA Data Explorer includes tabs for displaying and summarizing fishery independent survey data (e.g., by region, salinity zones), single species and joint model outputs, the NRHA-HCVA crosswalk results, habitat data sets and metadata files, species profiles, reports (e.g., modeling and inshore habitat data report), and other publications. The Draft NRHA Data Explorer can be found here: https://nrha.shinyapps.io/dataexplorer/.

# 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

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)[1] assessment, to identify areas that could be considered for habitat conservation or restoration.
- Addresses NOAA's Habitat Assessment Improvement Plan (HAIP)[2] 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

[1] 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.
[2] Habitat Assessment Improvement Plan: https://www.st.nmfs.noaa.gov/ecosystems/habitat/publications/haip/index.

address: 1) Abundance and trends in habitat types in the inshore area, 2) Habitat vulnerability, 3) 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.**

| | |
|---|---|
| **MAFMC** | 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* |
| **NEFMC** | 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 |
| **ASMFC (not noted above)** | 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 |
| **Highly Migratory (with HAPC designations)** | Sandbar shark, Dusky shark |
| * Also managed by ASMFC.<br>**Jointly managed between MAFMC and NEFMC.<br>*** Not a NEFMC managed species but occurring in the New England region. | |

# 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 butterfish 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 occuring 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.

## 13.0 References

Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe. 1979. Classification of Wetlands and Deepwater Habitats of the United States. U.S. Department of the Interior, Fish and Wildlife Service, Washington, DC. FWS/OBS-79/31.

Farr, E. R., M. R. Johnson, M. W. Nelson, J. A. Hare, W. E. Morrison, M. D. Lettrich, B. Vogt, C. Meaney, U. A. Howson, P. J. Auster, F. A. Borsuk, D. C. Brady, M. J. Cashman, P. Colarusso, J. H. Grabowski, J. P. Hawkes, R. Mercaldo-Allen, D. B. Packer and D. K. Stevenson (2021). "An assessment of marine, estuarine, and riverine habitat vulnerability to climate change in the Northeast U.S." PLoS One 16(12): e0260654.

Federal Geographic Data Committee. 2013. Classification of wetlands and deepwater habitats of the United States. FGDC-STD-004-2013. Second Edition. Wetlands Subcommittee, Federal Geographic Data Committee and U.S. Fish and Wildlife Service, Washington, DC.

Hare, J. A., W. E. Morrison, M. W. Nelson, M. M. Stachura, E. J. Teeters, R. B. Griffis, M. A. Alexander, J. D. Scott, L. Alade, R. J. Bell, A. S. Chute, K. L. Curti, T. H. Curtis, D. Kircheis, J. F. Kocik, S. M. Lucey, C. T. McCandless, L. M. Milke, D. E. Richardson, E. Robillard, H. J. Walsh, M. C. McManus, K. E. Marancik and C. A. Griswold (2016). "A Vulnerability Assessment of Fish and Invertebrates to Climate Change on the Northeast U.S. Continental Shelf." PLoS One 11(2): e0146756.

Kritzer, J. P., M.-B. DeLucia, E. Greene, C. Shumway, M. F. Topolski, J. Thomas-Blate, L. A. Chiarella, K. B. Davy and K. Smith (2016). "The Importance of Benthic Habitats for Coastal Fisheries." BioScience 66(4): 274-284.

Nelson, D.M. 2015. Estuarine salinity zones in the US East Coast, Gulf of Mexico, and US West Coast from 1999-01-01 to 1999-12-31 (NCEI Accession 0127396). NOAA National Centers for Environmental Information. Dataset.

# Long Island Sound Trawl Survey

**Data Source**
The Connecticut DEEP Marine Fisheries Program

**Data Type**
Trawl: catch and environmental data

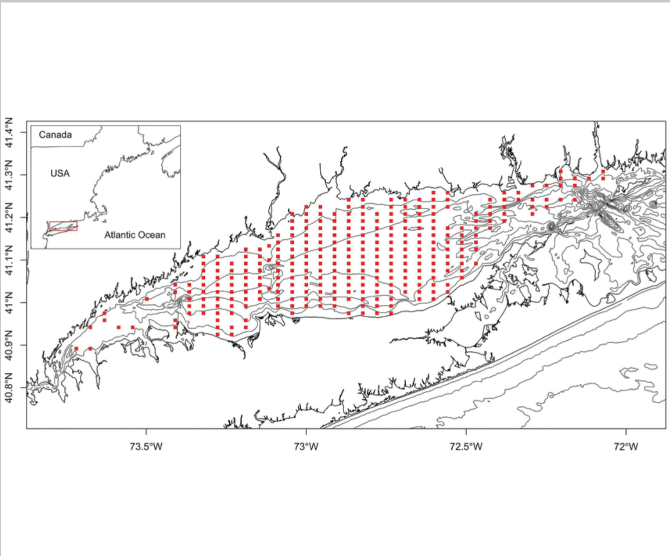
**Date Range**
1984-Ongoing Spring/Fall

**Data Resolution**
NA

**Data available online?**
Yes ☐ No ☑

## Geographic Range

Long Island Sound New London to Greenwich, Connecticut




## Methodology

The Long Island Sound Trawl Survey (LISTS) encompasses an area from New London to Greenwich, Connecticut and includes waters from 5 to 46 meters in depth in both Connecticut and New York state waters. Temperature, salinity and water depth are recorded at each site before the 46-foot-sweep trawl net is deployed for 30 minutes. Upon retrieval of the net, the sample is quickly sorted by species, counted, weighed and further processed as needed to support specific research and monitoring needs.

## Overview

The Long Island Sound Trawl Survey is a vital tool Marine Fisheries staff use to measure the abundance and distribution of finfish, squid and other macro-invertebrates (lobster, crabs, horseshoe crabs, whelks) in Long Island Sound, independent of commercial or recreational fishing. By comparing Trawl Survey data with current fishery data (landings, catch/effort, seasonal patterns) each species' harvest can be weighed against its abundance, providing a gauge to determine whether harvest limit targets are being met. The Trawl Survey also provides a measure of recruitment strength (abundance of young fish) entering the population each year, as well as detailed characterization of the size and age composition of several species entering the sound.

To date, the Trawl Survey has documented 99 finfish species and more than 60 invertebrate taxa. Each spring (April, May, June) and fall (September, October) the 50-foot R/V John Dempsey carries its crew of 4-6 scientists and vessel staff on the monthly cruises, sampling 40 stations selected at random from 12 depth and substrate categories (called "strata") between Groton and Greenwich in both Connecticut and New York waters.

## Data Caveats

Since 1984, several changes have been incorporated into the Survey. Just a few examples include changes in sampling schedule, using an onboard scale to provide aggregate weights by species and including length data for several species.

## Data Access

website: https://portal.ct.gov/DEEP/Fishing/Fisheries-Management/Long-Island-Sound-Trawl-Survey
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# Atlantic Cod

*Species Climate Vulnerability:*
Atlantic cod (*Gadus morhua*) is projected to be moderately vulnerable to climate change due to exposure to changing ocean temperature and acidification and sensitivity in terms of stock status (overfished with overfishing occurring), slow population growth rates, stock status, and specific early life history requirements (e.g., dependence on specific circulation patterns for larval retention and specific nursery habitats). Atlantic cod are projected to be negatively affected by climate change caused by resulting decreases in recruitment and suitable habitat (Hare et al. 2016). Temperature plays an important role in Atlantic cod recruitment, growth, and survival, and several studies have reported declines in populations in the southern extent of the range due to projected increased temperature (Drinkwater 2005; Fogarty et al. 2008; Pershing et al. 2015; Planque and Fredou 1999).

*Habitat Dependence:*
A number of estuarine and marine habitats are important to Atlantic cod. These include firm hard bottom habitat (corresponding to the HCVA categories of marine intertidal rocky bottom, marine rocky bottom <200 m, estuarine intertidal rocky bottom, and estuarine subtidal rocky bottom) and loose coarse bottom habitat (corresponding to the HCVA categories of marine intertidal rocky bottom, marine rocky bottom <200 m, estuarine intertidal rocky bottom, and estuarine subtidal rocky bottom). In addition, loose fine bottom habitat (corresponding to the HCVA categories of marine intertidal mud, marine intertidal sand, marine mud <200 m, marine mud >200 m, estuarine intertidal mud, estuarine intertidal sand, estuarine subtidal mud, and estuarine subtidal sand) and structured sand (corresponding to the HCVA categories of marine intertidal sand, marine sand <200 m, estuarine intertidal sand, and estuarine subtidal sand) were identified as important to Atlantic cod. Marine and estuarine water column habitats are important for all life stages, particularly for the survival and distribution of eggs and larvae (Clark et al. 2003). Egg and larval life stages use marine shallow/inner shelf and marine shelf surface water column habitats, while juveniles and adults are primarily demersal and use estuarine water column, marine shallow/inner shelf, and marine shelf bottom water column habitats.

Aquatic vegetation habitat is also critical to the species, as various life stages rely on mesohaline and polyhaline species habitat (corresponding to HCVA classifications marine submerged aquatic vegetation and estuarine submerged aquatic vegetation) and seaweed habitat (corresponding to HCVA classifications of marine kelp, estuarine kelp, marine red, green, and small brown algae and estuarine red, green, and small brown algae).

*Habitat Climate Vulnerability:*
All habitats ranked as important to Atlantic cod are vulnerable to projected increased sea surface and bottom temperatures (Farr et al. 2021). Marine and estuarine sand and rocky bottom habitats have moderate to high dependence for juvenile, adult, and spawning adult Atlantic cod. These habitats range from low vulnerability to climate

change (e.g., estuarine subtidal rocky bottom) to high vulnerability (marine intertidal rocky bottom and sand). Spawning is known to occur on the continental shelf, and eggs and larvae inhabit the water column both nearshore and offshore. Although the estuarine water column habitat was ranked as highly vulnerable, surface and bottom water column habitats were ranked as low. However, water column habitats were not included in ACFHP's assessment of habitat dependency and finer-scale information on the importance of specific pelagic habitats is needed for the species.

Critical points of high dependency and high vulnerability exist for Atlantic cod with mesohaline and polyhaline species habitat (corresponding to HCVA classifications marine submerged aquatic vegetation and estuarine submerged aquatic vegetation) and multiple intertidal habitats including firm hard bottom habitat, loose coarse bottom habitat, and structured sand habitat.

### Mid-Atlantic

While the ACFHP matrix did assess Atlantic cod habitats in the Mid-Atlantic, they are not included in this summary document due to the limited population and resulting absence of a directed commercial fishery for the species in the Mid-Atlantic.

### New England

Habitat dependency for Atlantic cod is based solely on the New England region.

Habitat dependence by life stage:

- *Eggs/larvae:*
    - Marine shallow/inner shelf water column habitat.
    - Marine shelf surface water column habitat.
    - Marine water column shelf bottom habitat.
- *Juveniles/Young-of-the-year, and Adults:*
    - Firm hard bottom habitat has high dependence.
    - Loose coarse bottom habitat has high dependence.
    - Loose fine bottom habitat has medium dependence.
    - Mesohaline and polyhaline species habitat has high dependence.
    - Structured sand habitat has high dependence.
    - Marine shallow/inner shelf water column habitat.
    - Marine shelf bottom water column habitat.
    - Estuarine water column habitat.
- *Spawning adults:*
    - Firm hard bottom habitat has high dependence.
    - Loose coarse bottom habitat has high dependence.
    - Loose fine bottom habitat has medium dependence.
    - Mesohaline and polyhaline species habitat has high dependence.
    - Structured sand habitat has high dependence.
    - Marine shallow/inner shelf water column habitat.
    - Marine shelf bottom water column habitat.

| Atlantic Cod (New England) | | | | | |
|---|---|---|---|---|---|
| | | Life Stage Dependency | | | |
| **Habitat Type** | **HCVA Climate Vulnerability Rank** | **Egg/ Larvae** | **Juvenile/ YOY** | **Adult** | **Spawning Adult** |
| Firm Hard Bottom | Marine intertidal rocky bottom- High (juveniles/YOY only)<br>Estuarine intertidal rocky bottom- Moderate (juveniles/YOY only)<br>Estuarine subtidal rocky bottom- Low<br>Marine rocky bottom <200m- Low | | H | H | H |
| Loose Coarse Bottom | Marine intertidal rocky bottom- High (juveniles/YOY only)<br>Estuarine intertidal rocky bottom- Moderate (juveniles/YOY only)<br>Estuarine subtidal rocky bottom- Low<br>Marine rocky bottom <200m- Low | | H | H | H |

| | | | | | |
|---|---|---|---|---|---|
| Loose Fine Bottom | Marine intertidal mud- High (juveniles/YOY only)<br><br>Marine intertidal sand- High (juveniles/YOY only)<br><br>Estuarine intertidal mud- Moderate (juveniles/YOY only)<br><br>Estuarine intertidal sand- Moderate (juveniles/YOY only)<br><br>Estuarine subtidal mud- Moderate<br><br>Marine mud <200m- Low<br><br>Marine sand <200m- Low<br><br>Estuarine subtidal sand- Low | | M | M | M |
| Mesohaline and Polyhaline Species | Marine submerged aquatic vegetation- High<br><br>Estuarine submerged aquatic vegetation- High | | H | H | H |
| Structured Sand | Marine intertidal sand- High (juveniles/YOY only)<br><br>Estuarine intertidal sand- Moderate (juveniles/YOY only)<br><br>Estuarine subtidal sand- Low<br><br>Marine sand <200m- Low | | H | H | H |
| Marine Water Column, Shallow Inner Shelf | Low | X | X | X | X |

| | | | | | |
|---|---|---|---|---|---|
| Marine Water Column, Shelf Surface | Low | X | | | |
| Marine Water Column, Shelf Bottom | Low | X | X | X | X |
| Estuarine Water Column | High | | X | X | |

Key: M=medium dependency H=high dependency VH=very high dependency
X: Water column habitat dependency ranking is not available in ACFHP matrix

# Species Profile - Black Sea Bass (*Centropristis striata*)

## Species range and distribution

Black sea bass range from southern Nova Scotia and the Bay of Fundy (Scott 1988) to southern Florida (Bowen and Avise 1990) and into the Gulf of Mexico.

## Habitat characteristics and habitat use by life stage

Eggs and larvae: Eggs and larvae are pelagic, and were more abundant in water depths of 10-90 m and water temperatures of 15-24°C during June-September on the continental shelf from northern NJ to Cape Hatteras between 1978 and 1987 (MARMAP survey data). Berrien and Sibunka (1999) showed that in the Mid-Atlantic Bight, areas with high average egg densities were generally located on the continental shelf in the vicinity of large estuaries including Chesapeake Bay, the Delaware River, and the Hudson River. Black sea bass eggs also occur infrequently in large bays such as Buzzards Bay, MA (Stone et al. 1994), but are rare in Long Island Sound (Merriman and Sclar 1952; Wheatland 1956; Richards 1959), and absent in Narragansett Bay RI (Bourne and Govoni 1988) and Delaware Bay (Wang and Kernehan 1979).

While black sea bass larvae are collected close to shore on the continental shelf, they rarely occur within estuaries. Able et al. (1995) speculated that most larvae settle in near shore continental shelf habitats and then move into estuarine nurseries where post-settlement stage juveniles can be abundant.

Young-of-the Year Juveniles: Larvae hatch from eggs at 1.5-2.1 mm TL and settle to the bottom as early juveniles at 10-16 mm TL (Kendall 1972; Fahay 1983; Able et al. 1995) primarily in nearshore shelf areas on shells (eg surfclams) and sandy substrates, then move into estuarine nursery areas on shallow (<50 m, mostly <20 m) shellfish, sponge, amphipod habitats, also seagrass beds, cobble habitats, and man-made structures. They are rarely found on non-vegetated sandy intertidal flats and beaches and in deeper, muddy bottom. In offshore areas, recently settled fish occur in accumulations of shell on sand substrata, complex micro-topographies on exposed clay, on rocky reefs, and on wrecks (Able et al. 1995).

Juveniles appear to be most abundant in oceanic waters and polyhaline regions of many estuaries, but can occur at salinities as low as 8 ppt (Drohan et al. 2005). Juveniles can be relatively common in estuaries south of Cape Cod, and are found in estuaries such as Narragansett Bay, Long Island Sound, the Hudson-Raritan estuary, Great Bay (NJ), Delaware Bay, Chesapeake Bay and tributaries, as well as many estuaries farther south (see references cited in Drohan et al. 2005).

Within estuaries, young fish use shallow shellfish (oyster and mussel), sponge (including *Microciona prolifera*), amphipod (*Ampelisca abdita*), seagrass beds (especially *Ruppia* sp.), and cobble habitats as well as manmade structures such as wharves, pilings, wrecks, reefs, crab and conch pots (see references cited in Drohan et al. 2005). Early juveniles are rare on unvegetated sandy intertidal flats and beaches (Allen et al. 1978) as well as deeper, muddy bottoms (Richards 1963b). According to Able and Fahay (2010), YOY juveniles are more frequently collected along with large amounts of shell hash (especially surfclams). In the Great Bay estuary (NJ) they occur at a variety of sites that include shells, amphipod tubes, and deep channels with rubble, also in marsh creeks and around pier pilings. Lab studies show a preference for oyster shells over barren sand substrate (Able and Fahay 1998). There seems to be a high degree of habitat fidelity during the summer and fall in the estuary (Able and Hales 1997). Temperature and oxygen seem to be especially important components of the habitat. In the lab, they occasionally buried in sand at 6°C and below 4°C they stopped feeding (Hales and Able 1995). Mortality increased sharply at 2-3°C.

The following is a detailed account of YOY juvenile growth, and inshore-offshore movements in New Jersey as reported by Able et al. (2005). "In New Jersey coastal waters larvae first appear in July but can occur into November. Recently settled individuals (15-24 mm total length [TL]) were collected at an inner continental shelf site and an adjacent estuary from July through October. By fall, fishes from these areas were 18-91 mm TL, and many had moved offshore from New Jersey estuarine waters and other estuaries to inner continental shelf waters between southern Massachusetts and Cape Hatteras. Subsequently, they continued to move offshore and during their first winter, they were concentrated near the shelf or slope break in the southern portion of the mid-Atlantic Bight. Some age 0+ individuals moved back into New Jersey estuaries in early spring, at sizes approximating those of the previous fall (150-96 mm TL). Thus, black sea bass reach relatively small sizes after 12 months of growth partly because little or no growth occurs during their first winter. This year class reached sizes of 78-175 mm TL by midsummer and 134-225 mm TL by the following fall."

Older Juveniles: Similar to YOY juveniles and adults, older juveniles are associated with structurally complex bottom habitats, display high site fidelity, use shallow estuarine habitats at age 1+ (<10 m) and are also found in deeper estuarine channels. Juveniles <19 cm T are common on the shelf at depths of 100-140 m in the spring at bottom temperatures between 9-12°C and at 5-50 m and 15-21°C in the fall (NEFSC survey data reported in Drohan et al. 2005). Juvenile black sea bass have been collected at temperatures as high as 27°C in Chesapeake Bay (Geer 2002). Growth is faster at intermediate salinities, suggesting that most suitable habitats are in lower reaches of estuaries (Berlinsky et al. 2000). In laboratory studies, 100% mortality was recorded at 2-3°C, increased use of shelter and burial at temperatures below 6°C, and reduced feeding at 4°C (Able and Hales 1997).

Adults: Adults are strongly associated with structured habitats such as rocky reefs, cobble/rock fields, stony coral and sponge patches (in the South Atlantic), exposed stiff clay, and mussel beds (Drohan et al. 2005). They use shelters, appear to remain near complex structures during the day, and move to adjacent soft-bottom habitats to feed at night (Steimle and Figley 1996). Juveniles and adults migrate to over-wintering habitats on the outer shelf in the fall and return inshore in the spring (see below). Primary summer habitats on the nearshore shelf are <60 m deep; black sea bass may also occupy complex habitats in lower reaches of large estuaries (~5 m depth). At temperatures near 6°C adults become inactive and rest in holes and crevices (Adams 1993). They are also known to burrow into soft sediments during especially cold winters off NC/SC coast (Parker 1990). Based on NEFSC trawl survey data, depth and temperature preferences on the shelf in spring are 70-140 m and 9-14°C, and 10-40 m/16-28°C in the fall (Drohan et al. 2005).

## Migrations

In the Mid-Atlantic Bight juvenile and adult black sea bass migrate from nearshore continental shelf habitats to outer shelf over-wintering areas as bottom temperatures decline in the fall. Juveniles begin to move into deeper warmer offshore water as temperatures decline below 14°C, and few individuals are collected in shallow areas when temperatures fall below 6°C (Able and Fahay 1998; Klein-MacPhee 2002). During warmer winters, juveniles may successfully over winter in deeper waters of lower Chesapeake Bay (MAFMC 1996; Chesapeake Bay Program 1996). In the Mid-Atlantic Bight, juveniles return to nearshore and estuarine habitats in the spring and are collected as early as March in the Chesapeake Bay region (Kimmel 1973). Larger fish appear to migrate earlier than smaller fish (Kendall 1977).

Tag returns from fish tagged in Nantucket Sound (Massachusetts) suggest that fish migrate south to the outer shelf near Block Canyon (south of Rhode Island) and then move southwest along the outer shelf toward Norfolk Canyon off Virginia (Kolek 1990). Acoustically tagged fish east of Sandy Hook, NJ, remained in the study area for 1-6 months and dispersed from the area in greater numbers in early summer (early June) and late fall (October-December) (Fabrizio et al. 2013a). Dispersal in early summer may have been larger males going to nearby spawning and feeding areas.

In a more recent tagging study, fish tagged in SNE moved south along the shelf break as far as Virginia, reaching the outer shelf in 4-9 weeks (Moser and Shepherd (2009). In the central MAB (middle of Long Island to Chesapeake Bay), tagged fish reached the shelf break in 3 weeks. In both cases, winter habitats were 140-150 m deeper than shelf areas occupied in the summer. Movement was initiated when bottom temperatures were between 10 and 12°C. Return migration in the spring is faster and more directed. Despite mixing among local groups during winter on the outer shelf, fish generally return to the area of previous summer residence, but degree of site fidelity was lower for fish that travel farther, i.e., the fish did not display strict "homing behavior."

Miller et al. (2016) performed a GAM analysis of spring NEFSC bottom trawl survey data from the MAB in relation to bottom temperatures, salinity, and shelf water volume and concluded that all three factors were significant features of over-wintering habitats. North of Hudson Canyon, temperatures >8°C had a positive effect on catch; south of Hudson Canyon the preferred temperature range was 7.9-15.7°C, with a peak at 12.5°C. Spring bottom temperatures in the north never get high enough to limit offshore migration. A temperature/salinity fronts on the outer shelf limits the extent of offshore migration and is preferred habitat, presumably due to upwelling, surface convergence and high productivity.

Within the stock area, distribution changes on a seasonal basis and the extent of the seasonal change varies by location. In the northern end of the range (New York to Massachusetts), black sea bass move offshore crossing the continental shelf, then south along the edge of the shelf (Moser and Shepherd 2009). By late winter, northern fish may travel as far south as Virginia, but most return to the northern inshore areas by May (NEFSC 2017). Black sea bass originating inshore along the Mid-Atlantic coast (New Jersey to Maryland) head offshore to the shelf edge during late autumn, traveling in a southeasterly direction. They return inshore in spring to the general area from which they originated (NEFSC 2017).. Black sea bass in the southern extent of the stock (Virginia and North Carolina) move offshore in late autumn/early winter. Given the proximity of the shelf edge, they transit a relatively short distance, due east, to reach over-wintering areas (NEFSC 2017).

## Climate change

A GAM analysis of NEFSC trawl survey data by Bell et al. (2015) showed that the center of biomass (COB) of BSB and scup in spring when fish are offshore moved north by 150-200 km between 1972 and 2008 and remained in north during 2008-2012. Fish size was a significant variable in the fall, but not temperature. BSB were spatially segregated in the fall, with larger individuals located further north. The COB is further south when the number of juveniles in survey catches is high, further north when more adults are caught.

## Food habits

Black sea bass are generalist carnivores. Primary prey are arthropods (45%) with 19% Cancer crabs and 16.5% other decapod crabs (Byron and Link 2010). Geographic region and fish size are important variables. Larger fish consume more sand lance and other fish, smaller ones eat more polychaetes, amphipods, miscellaneous arthropods, and mollusks. As reported by Drohan et al (2005), juveniles <20 cm consume almost exclusively crustaceans. YOY (<10 cm) eat amphipods and decapods, e.g. sand shrimp and rock crabs. Older juveniles eat euphausiids and decapods (hermit crabs, rock crabs). Adults consume mostly crustaceans, but they make up a smaller component of diet than for juveniles.

## Reproduction and maturity

Black sea bass are protogynous hermaphrodites, with some fish changing sex from female to male as they increase in age and size. Age of sexual transition varies with latitude with females maturing and undergoing sexual transition at greater ages in northern latitudes (McGovern et al. 2002). Fish in the Mid-Atlantic Bight begin to mature at age 1 (8-17 cm TL) and 50% are mature at 2-3 yrs and ~19 cm SL (O'Brien et al. 1993). The majority of fish less than 19 cm are females, while larger fish are transitional individuals or males (Mercer 1978).

Primary spawning habitats appear to be located in the nearshore continental shelf at depths of 20-50 m (Breder 1932; Kendall 1972; Musick and Mercer 1977; Wilk and Brown 1980; Eklund and Targett 1990; Berrien and Sibunka 1999). Gravid females are common on the continental shelf and generally not found in estuaries (Allen et al. 1978). Fish may spawn on sand bottoms broken by ledges and move to structurally complex habitats in deeper water after spawning (Kolek 1990; MAFMC 1996). Kolek (1990) showed that some tagged black sea bass return to the spawning grounds in Nantucket Sound and suggested that the animals may home to spawning grounds. Fabrizio et al. (2013b) reported that the home ranges of tagged black sea bass in the MAB were large, but highly variable, ranging from 0.14 to 7.36 km2. Mature males are territorial and have smaller home ranges than females, sub-ordinate males, and fish in transition. In the Mid-Atlantic Bight, black sea bass spawn from April through October (Able and Fahay 1998; Reiss and McConaughay 1999).

## Stock structure and status

The black sea bass population is currently managed as three separate stocks: Mid-Atlantic, South Atlantic,and the Gulf of Mexico. The geographic dividing line for the Mid- and South Atlantic stocks is located at Cape Hatteras, North Carolina. An operational assessment that incorporated new recreational harvest estimates was peer reviewed in August 2019. The assessment found that the black sea bass stock north of Cape Hatteras, NC was not overfished and overfishing (2021). For current details on stock status: https://www.fisheries.noaa.gov/national/status-stocks-reports

## Fishery

Black sea bass are highly sought by both commercial and recreational fishermen throughout the Mid-Atlantic. Fisheries change seasonally with changes in fish distribution. Fish pots and handlines are more common inshore and in the more southern commercial fisheries. When fish move offshore, they are primarily caught in trawl fisheries targeting summer flounder, scup, and *Loligo* squid. Recreational fisheries generally occur during the period that sea bass are inshore (May to September), but season duration varies among the states.

## Management

The black sea bass population is currently managed as three separate stocks by the Mid-Atlantic, South Atlantic, and Gulf of Mexico fishery management Councils. The management unit for the northern stock of black sea bass (*Centropristis striata*) is U.S. waters in the western Atlantic Ocean from Cape Hatteras, North Carolina northward to the U.S.-Canadian border. Since the fishery management plan's approval in 1997, the black sea bass commercial fishery has operated under a quota. The recreational fishery is restricted by a coastwide recreational harvest limit. NOAA Fisheries, the Mid-Atlantic Fishery Management Council, and the Atlantic States Marine Fisheries Commission cooperatively manage the black sea bass fishery north of Cape Hatteras. Annual catch limits are divided between the commercial and recreational fisheries. The commercial catch limit is further divided among the states based on historical harvests. Specific management measures for the commercial fishery include minimum size limits, minimum mesh requirements for trawls, a moratorium on entry into the fishery, and closed seasons.

## References


Able, K.W. and M.P. Fahay. 1998. The first year in the life of estuarine fishes in the Middle Atlantic Bight. New Brunswick, NJ: Rutgers Univ. Press. 342 p.

Able, K.W. and M.P. Fahay 2010. Ecology of estuarine fishes: Temperate waters of the western North Atlantic. John Hopkins University Press, Baltimore, Maryland. ISBN 0-8018-9471-9 (hardcover). 566 p.

Able, K.W., M.P. Fahay, and G.R. Shepherd. 1995. Early life history of black sea bass, Centropristis striata, in the Mid-Atlantic Bight and a New Jersey estuary. Fish. Bull. (U.S.) 93: 429-445.

Able, K.W. and L.S. Hales, Jr. 1997. Movements of juvenile black sea bass *Centropristis striata* (Linnaeus) in a southern New Jersey estuary. J. Exp. Mar. Biol. Ecol. 213: 153-167.

Adams, A.J. 1993. Dynamics of fish assemblages associated with an offshore artificial reef in the southern Mid-Atlantic Bight. M.A. thesis, Coll. William and Mary, Williamsburg, VA. 98 p.

Allen, D.M., J.P. Clymer, III, and S.S. Herman. 1978. Fishes of Hereford Inlet estuary, southern New Jersey. Lehigh Univ., Dept. Biol. and Cent. Mar. Environ. Stud. and Wetlands Instit. 138 p.

Bell, R.J. et al. 2015. Disentangling the effects of climate, abundance, and size on the distribution of marine fish: an example based on four stocks from the Northeast US shelf. ICES J. Mar. Sci. 72(5):1311-1322.

Berlinsky D., M. Watson, G. Nardi, and T.M. Bradley. 2000. Investigations of selected parameters for growth of larval and juvenile black sea bass *Centropristis striata* L. J. World Aquacult. Soc. 31: 426–435.

Berrien, P. and J. Sibunka. 1999. Distribution patterns of fish eggs in the United States northeast continental shelf ecosystem, 1977-1987. NOAA Tech. Rep. NMFS 145. 310 p.

Bourne, D.W. and J.J. Govoni. 1988. Distribution of fish eggs and larvae and patterns of water circulation in Narragansett Bay, 1972-1973. In: Weinstein, M.P., editor. Larval fish and shellfish transport through inlets. American Fisheries Society Symposium 3. Bethesda, MD: American Fisheries Society. p. 132-148.

Bowen, B.W. and J.C. Avise. 1990. Genetic structure of Atlantic and Gulf of Mexico populations of sea bass, menhaden, and sturgeon: influence of zoogeographic factors and life-history patterns. Mar. Biol. 107: 371-381.

Byron, C.J. and J.S. Link 2010. Stability in the feeding ecology of four demersal fish predators in the US northeast shelf large marine ecosystem. Mar. Ecol. Progr. Ser. 406:239-250.

Chesapeake Bay Program. 1996. Chesapeake Bay and Atlantic coast black sea bass fishery management plan. U.S. Environ. Prot. Agency Rep. 903-R-96-009 (CBP/TRS 151a/96). 57 p.

Drohan, A.F., J.P. Manderson, and D.B. Packer 2007. Essential Fish Habitat Source Document: Black sea bass, *Centropristis striata*, life history and habitat characteristics, 2nd edition. NOAA Tech. Memo. NMFS-NE-200, 68 pp.

Eklund, A.-M. and T.E. Targett. 1991. Seasonality of fish catch rates and species composition from the hard bottom trap fishery in the Middle Atlantic Bight (US east coast). Fish. Res. 12: 1-22.

Fabrizio, M.C., J.P. Manderson, and J.P. Pessutti 2013a. Habitat associations and dispersal of black sea bass from a mid-Atlantic Bight reef. Mar. Ecol. Progr. Ser. 482:241-253.

Fabrizio, M.C., J.P. Manderson, and J.P. Pessutti 2013b. Home range and seasonal movements of black sea bass (*Centropristis striata*) during their inshore residency at a reef in the mid-Atlantic Bight. Fish. Bull. 112:82-97.

Fahay, M.P. 1983. Guide to the early stages of marine fishes occurring in the western North Atlantic Ocean, Cape Hatteras to the southern Scotian Shelf. J. Northwest Atl. Fish. Sci. 4: 1-423.

Geer, P.J. 2002. Summary of essential fish habitat description and identification for Federally managed species inhabiting Virginia waters of Chesapeake Bay 1988-1999. Virginia Mar. Res. Rep. VMRR 2001-03, Jan. 2001, Revised June 2002. 169 p.

Hales, L.S., Jr. and K.W. Able. 1995. Effects of oxygen concentration on somatic and otolith growth rates of juvenile black sea bass, *Centropristis striata*. In: Secor, D.H., Dean, J.M., Campana, S.E., editors. Recent developments in fish otolith research. Univ. South Carolina Press. p. 135-153.

Kendall, A.W., Jr. 1972. Description of black sea bass, *Centropristis striata*, (Linnaeus), larvae and their occurrence north of Cape Lookout, North Carolina. Fish. Bull. (U.S.) 70: 1243-1259.

Kendall, A.W., Jr. 1977. Biological and fisheries data on black sea bass, *Centropristis striata* (Linnaeus). U.S. Natl. Mar. Fish. Serv., Northeast Fish. Cent. Sandy Hook Lab. Tech. Ser. Rep No. 7. 29 p.

Kimmel, J.J. 1973. Food and feeding of fishes from Magothy Bay, Virginia. M.S. thesis, Old Dominion Univ., Williamsburg, VA. 190 p.

Klein-MacPhee, G. 2002. Black sea bass/*Centropristis striata* (Linnaeus 1758). In: Collette, B.B., Klein-MacPhee, G., editors. Bigelow and Schroeder's fishes of the Gulf of Maine. 3rd Edition. Washington, DC: Smithsonian Institution Press. p. 392-395.

Kolek, D. 1990. Homing of black sea bass, *Centropristis striata*, in Nantucket Sound with comments on seasonal distribution, growth rates, and fisheries of the species. Massachusetts Div. Mar. Fish. Pocassett, MA. 12 p.

[MAFMC] Mid-Atlantic Fishery Management Council. 1996. Amendment 9 to the summer flounder Fishery Management Plan: Fishery Management Plan and draft environmental impact statement for the black sea bass fishery. June 1996. MAFMC. Dover, DE. 152 p. + appendices.

[MAFMC] Mid-Atlantic Fishery Management Council. 1999. Amendment 12 to the summer flounder Fishery Management Plan: Fishery Management Plan and draft environmental impact statement for the black sea bass fishery.

McGovern J.C., M.R. Collins, O. Pashuk, and H.S. Meister. 2002. Temporal and spatial differences in life history parameters of black sea bass in the southeastern United States. N. Am. J. Fish. Manage. 22: 1151-1163.

Mercer, L.P. 1978. The reproductive biology and population dynamics of black sea bass, *Centropristis striata*. Ph.D. dissertation, Coll. William and Mary, Williamsburg, VA. 195 p.

Merriman, D. and R.C. Sclar. 1952. The pelagic fish eggs and larvae of Block Island Sound. In: Riley, G.A., et al., editors. Hydrographic and biological studies of Block Island Sound. Bull. Bingham Oceanogr. Collect. 13. p. 165-219.

Miller, A.S., G.R. Shepherd, and P.S. Fratantoni 2016. Offshore habitat preference of overwintering juvenile and adult black sea bass, *Centropristis striata*, and the relationship to year-class success. PLoS ONE 11(1):e0147627.doi:10.1371/journal.pone.0147627, 19 pp.

Moser, J. and G.R. Shepherd 2009. Seasonal distribution and movement of black sea bass (*Centropristis striata*) in the Northwest Atlantic as determined from a mark-recapture experiment. J. Northw. Atl. Fish. Sci. 40:17-28.

Musick, J.A. and L.P. Mercer. 1977. Seasonal distribution of black sea bass, *Centropristis striata*, in the Mid-Atlantic Bight with comments on the ecology and fisheries of the species. Trans. Am. Fish. Soc. 106: 12-25.

[NEFSC] Northeast Fisheries Science Center. 2017. 62nd Northeast Regional Stock Assessment Workshop (62nd SAW) Assessment Report. US Dept Commer, Northeast Fish Sci Cent Ref Doc. 17-03; 822 p. Available from: National Marine Fisheries Service, 166 Water Street, Woods Hole, MA 02543-1026, or online at http://www.nefsc.noaa.gov/publications/

O'Brien, L., J. Burnett, and R.K. Mayo. 1993. Maturation of nineteen species of finfish off the northeast coast of the United States, 1985-1990. NOAA Tech. Rep. NMFS 113. 66 p.

Parker, R.O., Jr. 1990. Tagging studies and diver observations of fish populations on live-bottom reefs of the U.S. southeastern coast. Bull. Mar. Sci. 46: 749-760.

Reiss, C.S. and J.R. McConaugha. 1999. Cross-fronted transport and distribution of ichthyoplankton associated with Chesapeake Bay plume dynamics. Continent. Shelf Res. 19: 151-170.

Richards, S.W. 1959. Pelagic fish eggs and larvae of Long Island Sound. In: Riley, G.A., et al., editors. Oceanography of Long Island Sound. Bull. Bingham Oceanogr. Collect. 17. p. 95-124.

Richards, S.W. 1963a. The demersal fish population of Long Island Sound. II. Food of the juveniles from a sand-shell locality (Station 1). Bull. Bingham Oceanogr. Collect. 18: 32-72.

Richards, S.W. 1963b. The demersal fish population of Long Island Sound. III. Food of the juveniles from a mud locality (Station 3A). Bull. Bingham Oceanogr. Collect. 18: 73-93.

Scott, W.B. and M.G. Scott. 1988. Atlantic fishes of Canada. Can. Bull. Fish. Aquat. Sci. 219: 731 p.

Steimle, F.W. and W. Figley. 1996. The importance of artificial reef epifauna to black sea bass diets in the Middle Atlantic Bight. N. Am. J. Fish. Manage. 16:433-439.

Stone, S.L., T.A. Lowery, J.D. Field, C.D. Williams, D.M. Nelson, S.H. Jury, M.E. Monaco, and L.

Andreasen. 1994. Distribution and abundance of fishes and invertebrates in Mid-Atlantic estuaries. ELMR Rep. No. 12. NOAA/NOS Strategic Environmental Assessments Division, Silver Spring, MD. 280 p.

Wang, J.C.S. and R.J. Kernehan. 1979. Fishes of Delaware estuaries: a guide to the early life histories. Towson, MD: EA Communications, Ecological Analysts, Inc. 410 p.

Wheatland, S.B. 1956. Pelagic fish eggs and larvae. In: Riley, G.A., et al., editors. Oceanography of Long Island Sound, 1952-1954. Bull. Bingham Oceanogr. Collect. 15. p. 234-314.

Wilk, S.J., and B. E. Brown. 1980. A description of those fisheries, which take place in the western North Atlantic between the US-Canadian border and North Carolina, that presently have or potentially could have user group allocation conflicts. In: Grover, J. H., editor. Proceedings of the technical consultation on allocation of fishery resources, Vichy, France, April, 1980. Rome: FAO. p. 502–518.