

The Northeast Regional Habitat Assessment:

A collaborative, multi-disciplinary project to develop decision support products for marine fish habitat management

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Presentation to the Council Coordination Committee

October 2022

Acknowledgments

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NRHA Goal: To describe and characterize estuarine, coastal, and offshore fish habitat distribution, abundance, and quality in the Northeast.

Four actions were identified as necessary to meet this goal:

- 1) Inshore fish habitat assessment
 - a) Fish distribution and abundance
 - b) Habitat distribution, status, and trends
- 2) Habitat vulnerability including response to changes in climate,
- 3) Spatial descriptions of species habitat use in the offshore area, and,
- 4) Habitat data visualization and decision support tools.

Geographic Scope: Northeast U.S.

South to North

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 to Offshore

Mean high water including estuaries to the shelf-slope break



Focus Species (65+, important to managers)

- **Mid-Atlantic Council:** Atlantic and chub mackerel, butterfish, longfin and shortfin squid, surfclam, ocean quahog, summer flounder, scup, black sea bass, bluefish, golden and blueline tilefish, spiny dogfish
- **New England Council:** Cod, cusk, haddock, pollock, Acadian redfish, plaice, halibut, winter flounder, witch flounder, yellowtail flounder, wolffish, windowpane, ocean pout, offshore, red, and white hake, monkfish, Atlantic herring, salmon, skates (seven species), red crab, sea scallop
- **Additional Atlantic States Marine Fisheries Commission (ASMFC):** Eel, lobster, croaker, menhaden, striped bass, Atlantic sturgeon, black drum, cobia, horseshoe crab, Jonah crab, northern shrimp, red drum, shad and river herring, Spanish mackerel, spot, spotted seatrout, tautog, weakfish, coastal sharks
- **Highly migratory with Habitat Areas of Particular Concern (HAPC) designations:** Sandbar shark, dusky shark

Assessment Products at a Glance

Data inventory

- Catch data from state and federal fisheries-independent surveys; including comparison table
- Environmental datasets (used as model covariates)
- One page metadata document for each survey or data set

Habitat use

- Species profiles: Summarize life history and habitat use for each focus species
- Stage-based, single species and joint (“community”) species distribution models (SDMs)
- Inshore Habitat Report

Climate vulnerability - Species-Habitat Crosswalk

- Species-habitat matrix and climate vulnerability narratives

Habitat data visualization and decision support tools

- NRHA Data Explorer: R-Shiny application used to show trends in species distribution and abundance at state and regional scales, and to share other products and documentation
- Working with partners at Mid-Atlantic Ocean Data Portal, Northeast Ocean Data Portal, and possibly NOAA DisMAP to share selected products

Scientific publications/reports

- Community-level Basis Function Modeling methods paper and R package; others in development

Data inventory

A	B	C	D	E
Name	Region	Inshore/Offshore	Source	Type
Simple Ocean Data Assimilation (SODA3.1.3.1)	Entire Atlantic Cr	Offshore	NOAA, University of Point	bottom
Northwest Atlantic Regional Climatology		Offshore	NOAA	surface
NOAA OI SST V2 High Resolution Dataset	Global	Offshore	NOAA	gridded surface
HYCOM + NCODA Annual 1/12' Reanalysis	Global	Offshore	COAPS	gridded 3D Hig
Ocean Acidification tool for the Chesapeake Bay	Chesapeake Bay	Inshore/Offshore	VIMS/NOAA	gridded surface
NARR Model based (assimilated, reanalysis)		Offshore	NOAA	High-w Bottom
eMOLT		Offshore	NOAA	Bottom
Estuarine salinity zones in US	US	Inshore	NOAA	shapelite Salinity
NASA Ocean Color	Global		NASA	ocean
2_nes_zoo - Kevin F.				
NOAA NMFS Water Column Properties Data	NC to Maine	Offshore	NOAA	spredshe surface
USGS Water Data for the Nation	US		USGS	realtime
Chesapeake Bay Program Water Quality	Chesapeake Bay	Inshore	Chesapeake Bay P points	physical
Seaforce Salinity (psa)	Global	Inshore/Offshore	Marine Conservatic	shapelite bottom
Salinity Zones for the Gulf of Maine	Gulf of Maine	Inshore	Fish and Wildlife St	gridded Salinity

Metadata (1-pagers)

usSEABED

Data Source: USGS, University of Colorado and partners

Data Type: Gridded, Percent Cover, Mud (GSW)

Geographic Range: US Coast

Overview: usSEABED contains data from small and large marine research efforts by many inshore- and off-shore scientists. Local authorities, universities, as well as private and public contractors.

Metadata: usSEABED contains currently best georeferenced point data for more than 300,000 deep-sea sites. Values from the seabed to the deep sea, near, inner, and estuarine. usSEABED's existing data from the USGS and other research groups are processed and enhanced to maximize their density and usability including unified, comprehensive, consistently named datasets for mapping and analysis. usSEABED also includes a metadata system that provides detailed metadata including geographic and context and virtual sampling such as descriptions from section profiles and videos.

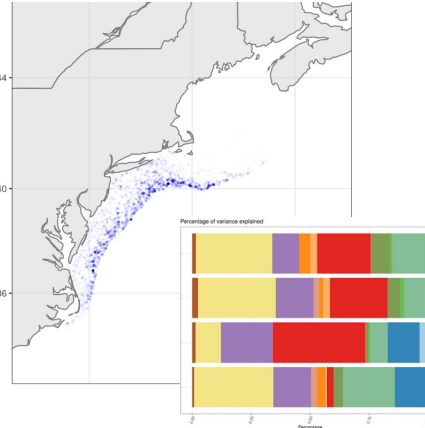
Methodology: Data sources were compiled using the usSEABED system to combine unique datasets into a standardized database. usSEABED is a data-mining program that applies logic and filters to existing geospatial and metadata datasets. Metadata is stored in a central metadata database, which is used to describe the data sources, photos, and videos, as well as the most appropriate data from a laboratory were collected using Fish and Shrimp systems. Statistical comparisons are made between lab-based and world-based as a ground truth to improve classification. The goal is accurate classification within one percent.

Data Curation: Some small activities have been made but overall usSEABED has not been updated since 2002. Absences cannot be assumed because data is based on observation records. Additionally, much of the dataset is based on descriptive data to classifications are estimates and not exact measurements of grain size. Lastly, due to limitations in budget and usSEABED is a pilot project representing larger settlement such as corals, lobsters and bryozoans.

Data Access: usSEABED data is available for download and is broken into two regions: Pacific Coast, Gulf of Mexico and Caribbean and Atlantic Coast. Digital data delivery: <https://seabed.usgs.gov> provides access to the data. The sediment data sources included in usSEABED: <https://www.govinfo.gov/olc/fulltext/dois/data.do>. Current: <https://www.usgs.gov/locations/atlantic-coast> <https://www.usgs.gov/locations/pacific-coast>

Citation: Beckler, R.J., Neal, J., Schreiner, P.W., Davis, V.A., and Walters, C.J. 2008. usSEABED: multi-institutional database for seafloor habitat. *Marine Ecology Progress Series* 369: 1-10.

Model-based Approaches



Inshore Fish Data

NRHA Home Regional View Bay View Species View Models Metadata About Us

Choose Species:

View Range: 1980 - 2020

Species Report Type: Narratives Photo/Video PDF

Download

Percent Occurrence: Distribution Abundance Percent

ID	Date	Species	Abundance	Depth	Latitude	Longitude	Year	Month	Day	Time	Observer	Location	Depth	Abundance	Notes
1	1980-01-01	Whitefish	10	100	42.0	-70.0	1980	1	1	10:00	John Doe	Chesapeake Bay	100	10	Initial survey
2	1980-02-01	Whitefish	15	100	42.0	-70.0	1980	2	1	10:00	John Doe	Chesapeake Bay	100	15	Continued survey
3	1980-03-01	Whitefish	20	100	42.0	-70.0	1980	3	1	10:00	John Doe	Chesapeake Bay	100	20	Continued survey

Data Explorer

NRHA Home Regional View Bay View Species View Models Metadata About Us

Regional Data Viewer

This view summarizes fishery independent surveys and fish watch data at the Northeast regional office. Species surveys and very frequent can be selected to display species abundance in the time series.

Select surveys: NMB Srawl, CI Long Island Sound Trawl, NLAB

Select Year Range: 1980 - 2020

Top 20 Species by Abundance **Top 20 Species by Diversity** **Species List** **Seasonal Temperature** **Seasonal Salinity**

This plot shows the top 20 most abundant species in the selected surveys.

The resulting graphic will be available in GIS or model, should be considered "heavy" that is they are approximately used a rigorous measurement of the assessed values.

Trawl Survey Comparison

NRHA/CVA/HCVA Crosswalk

Habitat Type	Atlantic Cod (New England)				
	HCVA Climate Vulnerability Rank	Eggs/Larvae	Juvenile YOY	Adult	Spawning Adult
Fine Sand Bottom	Marine intertidal rocky bottom - High (untested/YOY only)				
	Estuarine intertidal rocky bottom - Moderate (untested/YOY only)		H	H	H
	Estuarine sub-littoral - Low (untested/YOY only)				

Lots of Reports...

Spotted Puffer - Black Sea Bass (*Centropristis striata*)

Species range and distribution: Black sea bass occurs from New York and the Gulf of Fund (St. John) westward through Chesapeake Bay 1990 and into the Gulf of Mexico.

Historical catch and habitat use (1980-1990):

Eggs and larvae: Eggs and larvae are pelagic, and were once abundant in some depths of 10-50 and water temperatures 15-20°C during August through the continental shelf from western NY to Cape Cod between 1970 and 1975. During 1980's eggs and larvae were generally found in western side of the Bay. Right now with high energy eggs larvae were generally located in continental shelf in the western side of the Bay, including Chesapeake Bay, the Delaware Bay and the Hudson River. Black sea bass also occur frequently in large bays such as Buzzards Bay, N. Sea of New England, but are less abundant in Long Island Sound/Oceano and the Pacific. The Hudson River and the Hudson Bay and offshore in Narragansett Bay (Stewart and Lawrence 1981) and between Bay of Fundy and Miramichi 1970's.

Wild fish has been taken in estuarine areas in the continental shelf, but only when within estuary. Also in 1980's reported that most larvae were from the continental shelf between and between two estuarine sources where post-larval stage juveniles can be abundant.



Atlantic Cod (*Gadus morhua*)

Species Climate Vulnerability: Species with a projected net temperature increase to estimate change due to response to changing ocean temperature and acidification and sensitivity to sea level rise combined with overfishing, over-exploitation, and overfishing. Species with a projected net temperature increase to estimate change due to response to changing ocean temperature and acidification and sensitivity to sea level rise combined with overfishing, over-exploitation, and overfishing. Species with a projected net temperature increase to estimate change due to response to changing ocean temperature and acidification and sensitivity to sea level rise combined with overfishing, over-exploitation, and overfishing.

Water column: young fish are shallow water (less than 200m) and spend much of their life in the water column. They are found in shallow water (less than 200m) and spend much of their life in the water column. They are found in shallow water (less than 200m) and spend much of their life in the water column.

Climate Vulnerability Assessment Crosswalk

- Synthesis of information from NOAA’s FSCVA, HCVA, ACFHP species-habitat matrix, and EFH designations
- Matrix that indicates species’ dependency on (or association with) habitat types, by life stage
- Narratives that describe species and habitat climate vulnerabilities and habitat dependencies, in text and tables
- Will highlight critical/most concerning intersections of species and habitat climate vulnerability
- Products shared via NRHA Data Explorer

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)				
	Estuarine intertidal rocky bottom- Moderate (juveniles/YOY only)		H	H	H
	Estuarine subtidal rocky bottom- Low Marine rocky bottom <200m- Low				



Atlantic Cod (*Gadus morhua*)

Species Climate Vulnerability:

Atlantic cod 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).

Characterizing Habitat: A comprehensive modeling strategy

- **Stage-based approach**

- Partitioning spp. into distinct classes based on ontogeny (i.e., juveniles & adults)
- Better resolution of stage-specific requirements or habitat shifts?

- **Joint-species distribution model**

- Using a novel spatiotemporal approach (CBFM) w/ comparison to GAMs
- Improved predictions & possible ecological insights?

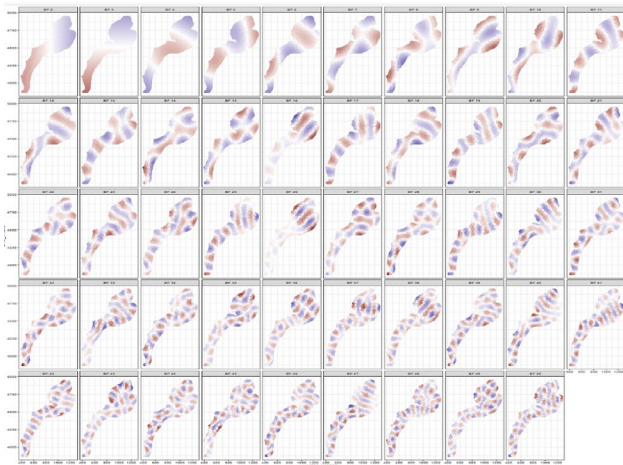
- **Dynamic & ecologically relevant covariates**

- Temporally varying predictors that reflect dynamic nature of the system
- Predictors with direct consequences for ecological function of animals

CBFM: Community-level Basis Function Model

- **Related to GAMS**

- Basis functions (BF) model covariance in space & time



- **Methods Manuscript** w/ Simulation Studies
- **R package** (Github repository, June public release)

Spatio-Temporal Joint Species Distribution Modeling: A Community-Level Basis Function Approach

Francis K.C. Hui^{*1}, David I. Warton², Scott D. Foster³, Nicole A. Hill⁴, and Christopher R. Haak⁵

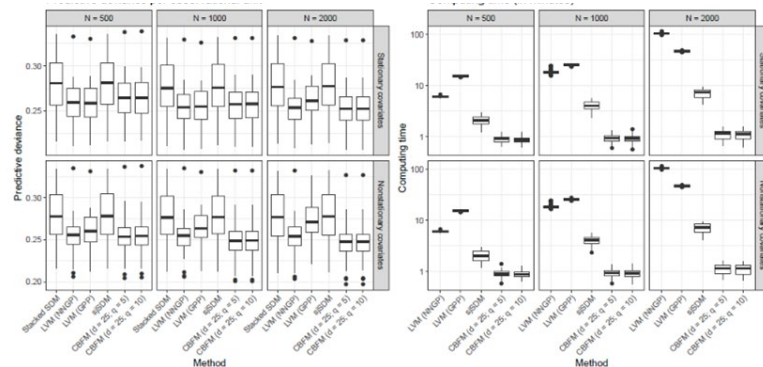
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NRHA CBFM Application

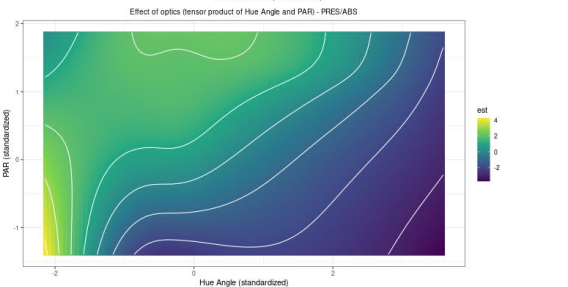
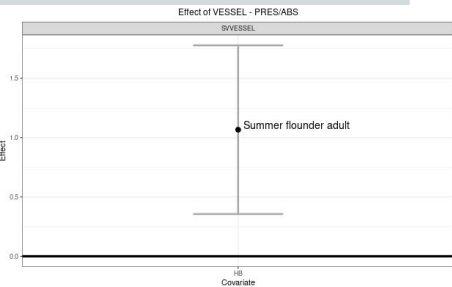
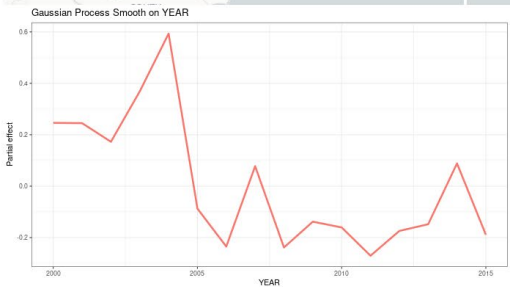
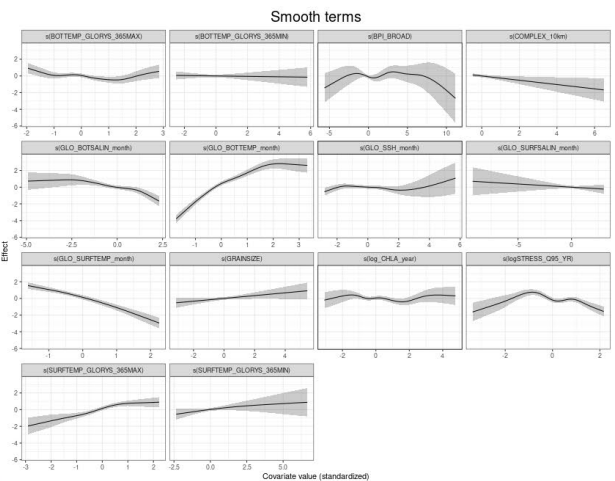
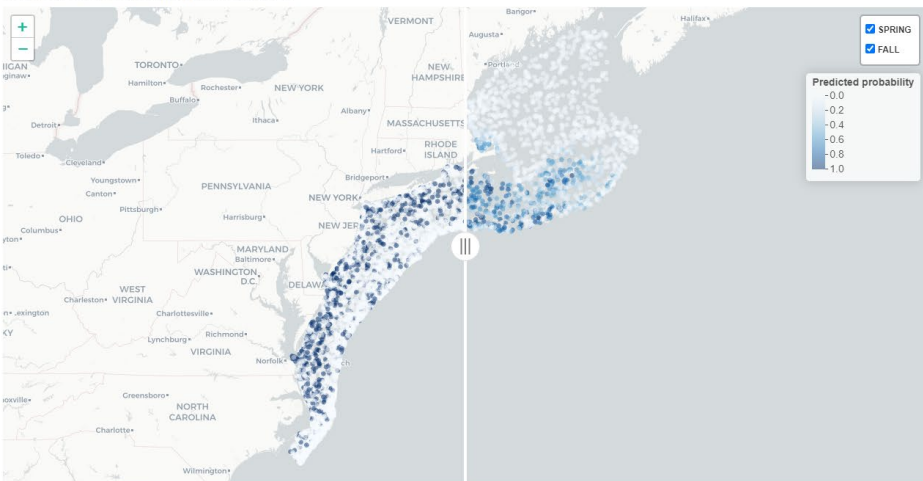
- **97 spp-stages** from NMFS bottom-trawl surveys
 - Demersal, pelagic, benthic spp. (managed, common & prey)
 - Training 2000-2015 (n > 10000 obs), testing 2016-2019 (n > 2700 obs)
- Combined **Spring & Fall** surveys
- Predictors:
 - Surface & bottom **temperature** (monthly & annual min/max), **salinity** (surface & bottom), **sea surface height**, depth (or correlates of depth including **optical environment & hydrodynamic stress**), benthic habitat characteristics (topographic position, complexity & sediment type)
- **Hurdle & ZINB models** (presence/absence & count conditional on presence, or covariate-dependent zero inflation)
- Spatiotemporal Basis Functions (intra-year) & GP smooth on year

Example Predictions: Summer flounder adult (beta test)

Model Distribution Variance explained and significance Species correlation matrix

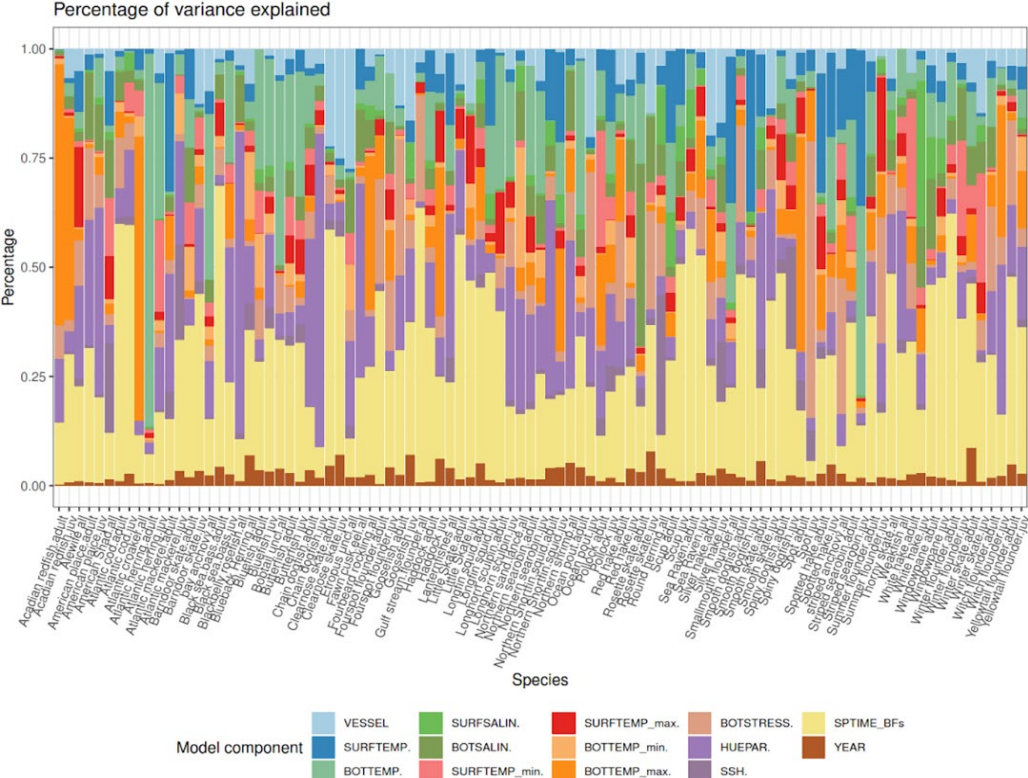
Map Left pane is True catch and Right pane is Predicted catch

Select Species:
Summer flounder adult



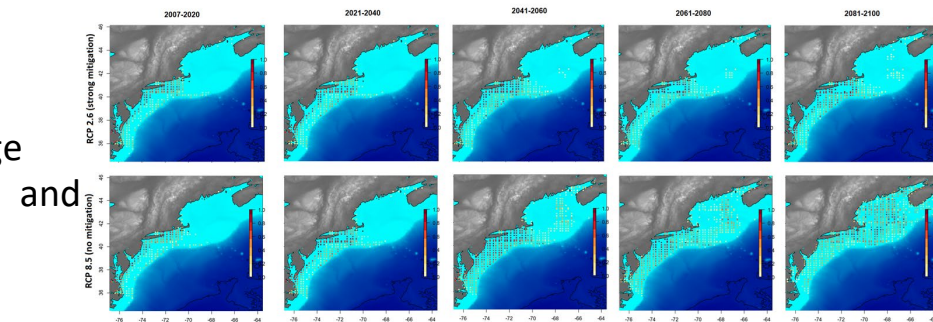
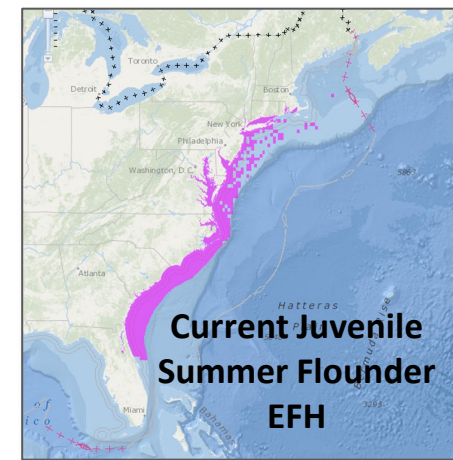
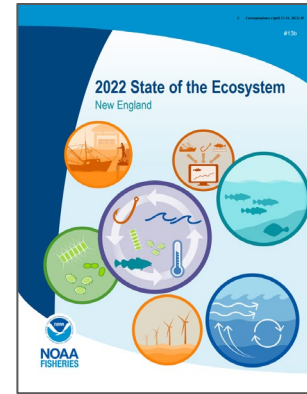
Predictor Importance

- % variance explained by each predictor (and spatiotemporal BFs & year effect)
- **What factors are most influential** in driving habitat use of a spp?



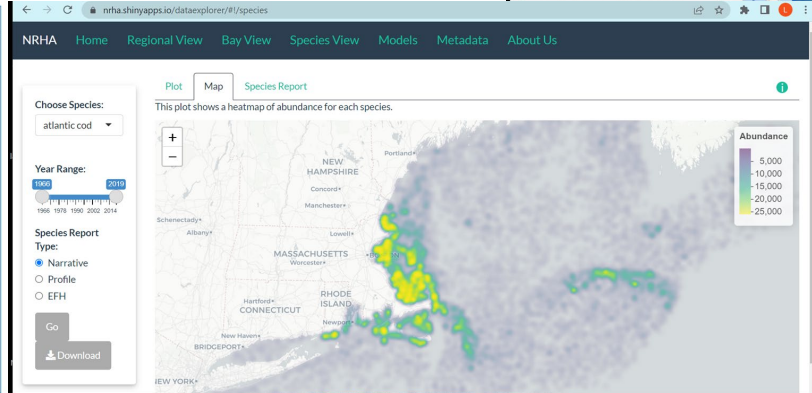
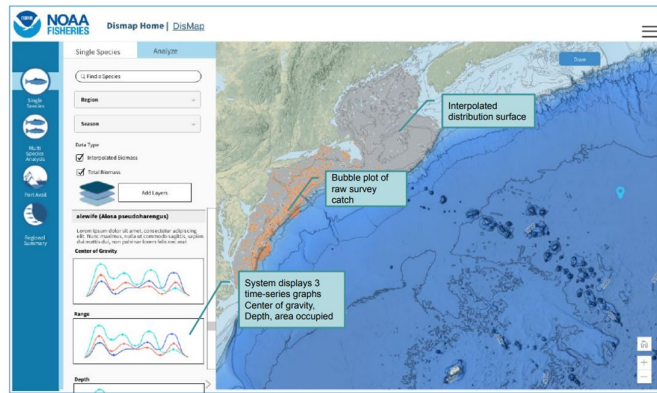
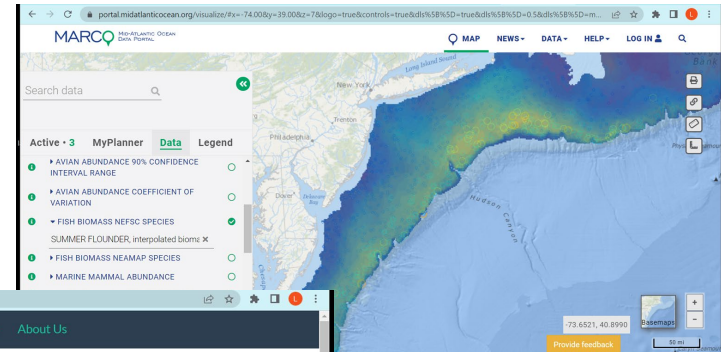
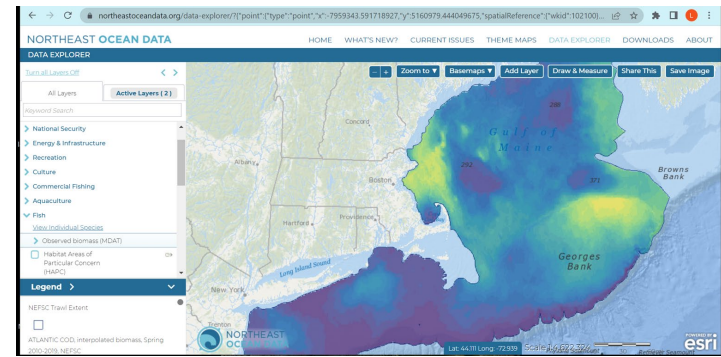
Applications for NRHA Products

- **Essential Fish Habitat:** NRHA provides more specificity on which environmental factors influence species distribution.
 - EFH text descriptions and maps
 - Habitat area of particular concern (HAPC) designations
 - Potential for shifts due to climate change and adaptive approach with automated updates
- **State of the Ecosystem Reports:** NRHA provides habitat and climate change information on managed species
- **Single Species Assessments:** Addresses Ecosystem TORs (e.g. butterflyfish 2022)
 - NRHA provides historic distributions and projected distributions due to climate change
 - Links between environmental drivers stock health and recruitment



Publicly Available Data Portals

- Intent is to make NRHA products as widely available as possible
- NRHA Data Explorer (R-Shiny) – main host,
 - Northeast Ocean Data Portal
 - Mid-Atlantic Ocean Data Portal (MARCO)
 - Possibly NMFS Distribution Mapping and Analysis Portal (DisMAP)



NRHA Data Explorer Demonstration

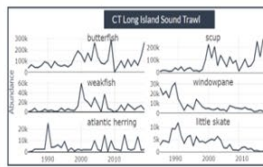
Available here: <https://nrha.shinyapps.io/dataexplorer>

NRHA Home Survey View Species View Models Habitat Crosswalk Reports About Us

Welcome to the Northeast Regional Habitat Assessment Data Explorer

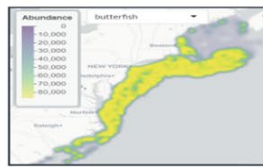
Survey View

Northeast regional and inshore bay/estuary view of fishery independent survey data including top 20 species abundance and biomass, similarity clusters, and survey temperature and salinity data.



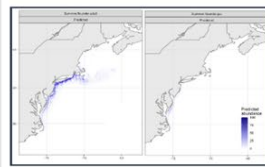
Species View

Species view of fishery independent survey data, including distributions, relative abundance, and reports on habitat use and vulnerability to climate change.



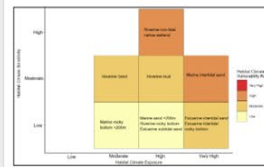
Model View

Outputs from spatiotemporal models that describe species distributions as a function of dynamic environmental factors, species interactions and predicted change in habitat use under various climate scenarios.



Habitat Crosswalk

Habitat species vulnerability matrix and species narratives for 66 managed and forage species in the region.



This application shares products from the Northeast Regional Marine Fish Habitat Assessment (NRHA) and provides tools to explore fish habitat data, with an emphasis on habitat use at different regional scales and by diverse fish and shellfish species in the Northeast. For more info about our history and team see [About Us](#).

*Datasets displayed on this site in summary format have associated caveats related to the collection of these data and their use. Please refer to the [Reports](#) page for additional details on each dataset, including contact information to obtain the source data. NRHA did not create the data and cannot guarantee its accuracy, or its suitability for use for other applications. NRHA encourages proper use and attribution of any datasets summarized on this site. Interested parties should directly contact the data providers noted in the metadata inventory for additional details on these data and their proper use.