The Northeast Regional Habitat Assessment:

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

Michelle Bachman, New England Fishery Management Council, NRHA Inshore Team Co-Lead
Jessica Coakley, Mid-Atlantic Fishery Management Council, NRHA Coordinator, Inshore Team Co-Lead
Chris Haak, Monmouth University/NOAA Northeast Fisheries Science Center, NRHA Post-Doc
Tori Kentner, Mid-Atlantic Fishery Management Council, NRHA Spatial Ecologist
Laurel Smith, NOAA Northeast Fisheries Science Center, NRHA Offshore Team Lead

NEFMC and MAFMC Scientific and Statistical Committees Sub-Panel
June 1, 2022 - Via Webinar

Terms of Reference for today’s review

1. Review the approved NRHA workplan and the related fish habitat science products under development, including decision support tools.

2. Consider the modeling goals, methods used, and inferences made from the single species and community level basis function models. Provide input on whether:
   a) Species responses to predictor variables conform with what would be expected given a species' biology, physiology and/or ecology.
   b) Species' predicted spatial distributions are consistent with expectations and other sources of data.
   c) Estimated between-species relationships (i.e., spatiotemporal correlations in their presence/absence or abundance) make sense from an ecological perspective.
   d) Identify additional work that would improve analysis or interpretation of results.

3. Consider and comment on the overall utility of NRHA, including the use of specific products in stock assessment, habitat management and conservation (including Essential Fish Habitat and Habitat Area of Particular Concern designations), and ecosystem approaches for the Councils.
    a. Is the work sufficient and appropriate to support the habitat and ecosystem needs of both Councils?
    b. Is there additional work, enhancements to NRHA that would improve its utility?

4. Are there alternative ways to present and communicate the data and analyses to various end-users (Councils, assessment scientists, stakeholders and public, etc.) more effectively?

Assessment overview

Goals, scope, and contributors

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

Project teams and partners

- **Project coordination/leads:** Michelle Bachman, Jessica Coakley, Chris Haak, Tori Kentner, Laurel Smith
- **Inshore team members:** Bryan DeAngelis, Stephen Faulkner, Zack Greenberg, AK Leight, Dave Packer, Mark Rousseau, Eric Schneider, Alison Verkade
- **Offshore team members:** Rich Bell, Kevin Friedland, Rob Latour, Kathy Mills, Ryan Morse, Dave Packer, Marta Ribera, Vince Saba, David Stevenson, Marek Topolski, Harvey Walsh
- **Habitat Climate Vulnerability Assessment:** Jon Hare, Mike Johnson, Mark Nelson, Emily Farr, others
- **NRHA/FSCVA/HCVA Crosswalk:** Gavin Fay, Madeleine Guyant, NRHA and HCVA PIs, Mike Johnson, Tauna Rankin, Wendy Morrison
- **Regional data portal teams** at MARCO and NROC, also may collaborate with NOAA DisMap

Summary of products

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: Brief summary of life history and habitat use for each focus species
- Stage-based, single species and joint distribution models

Climate vulnerability

- 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

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

Data inventory and metadata library

- Worked with project teams and partners to identify data
- Focused on data sets useful for modeling
- Metadata documents provide caveats, contacts for access and more information
- Most of the fishery independent survey data viewable on NRHA Data Explorer
- Many applications and potential users

A	B	C	D	E	
Name	Region	Inshore/Offshore	Source	Type	Data
Simple Ocean Data Assimilation (SODA3.3.1)	Entire Atlantic Co	Offshore	NOAA, University o	Point	bottom
Northwest Atlantic Regional Climatology		Offshore	NOAA		surface
NOAA OI SST V2 High Resolution Dataset	Global	Offshore	NOAA	gridded	Surfac
HYCOM + NCODA Global 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 (assimlated, reanalysis)		Offshore	NOAA		High-re
eMOLT		Offshore	NOAA		Bottom
Estuarine salinity zones in US	US	Inshore	NOAA	shapefile	Salinity
NASA Ocean Color	Global		NASA		ocean
2_nes_zoo - Kevin F.					
NOAA NMFS Water Column Properties Data	NC to Maine	Offshore	NOAA	spredshe	sufrace
USGS Water Data for the Nation	US		USGS		realtim
Chesapeake Bay Program Water Quality	Chesapeake Bay	Inshore	Chesapeake Bay P	points	physic
Seafloor Salinity (pss)	Global	Inshore/Offshore	Marine Conservatio	shapefile	bottom
Salinity Zones for the Gulf of Maine	Gulf of Maine	Inshore	Fish and Wildlife Se	gridded	Salinity

+ | Sediment and Habitat | Bathymetry | Water Chemistry (temp, salinity, chlor, pH) | Coasta

usSEABED

Data Source	Data Type	Date Range	Data Resolution	Data available online?
USGS, University of Colorado and partners	Grainsize, Percent Gravel, Sand, Mud (GSM)	1960-2002	NA	Yes ☑ No ☐

Geographic Range

US Coast

Overview

usSEABED contains data from small and large marine research efforts by many entities—federal and state agencies, local authorities, universities, as well as private and public consortiums.

The usSEABED datasets currently hold georeferenced point data for more than 300,000 data sites in U.S. waters from the beach to the deep sea, rivers, lakes, and estuaries. In usSEABED, existing data from the USGS and other research groups are processed and extended to maximize their density and usability creating unified, comprehensive, relationally linked datasets for mapping and analysis. Source data include surficial and subbottom data from physical sampling equipment (grabs and cores) and virtual sampling such as descriptions from seafloor photographs and videos.

In addition to quantified lab-derived data, the datasets of usSEABED also include estimated numeric values for those typical seabed characteristics—noted above—based on the extensive accumulation of word-based data in U.S. waters. These data are rich in information, but were previously difficult to quantify, map, plot, or use in comparative analyses or models.

These descriptive data—from short sentences, small essays, or single phrases—are treated as a mathematical equation that is considered as a whole. Filters based on fuzzy set theory assign relative weight to each word in the description, and estimate the values of textural and other parameters. In addition, the textural implications of non-textural terms—such as 'broken shells' or Halimeda—are included in the calculation of grain-size parameters.

The resulting numeric data, now useable in a GIS or model, should be considered "fuzzy"; that is, they give an approximation—not a rigorous measurement—of the assessed values.

Methodology

Data sources were compiled using the dbSEABED system to combine unique datasets into a standardized database. dbSEABED is a data-mining program that applies fuzzy set theory to marine geological and biological data. Sediments including core logs, sample descriptions, photos, and videos, as well as the more standard numeric data from a laboratory were classified using Folk and Shepard systems. Statistical comparisons are made between lab-based and word-based outputs as a ground truth to improve classification. The goal is accurate classification within one phi size.

Data Caveats

Some small additions 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 so classifications are estimates and not exact measurements of grain size. Lastly, due to limitations in sample gear usSEABED does a poor job representing larger sediment such as cobbles, boulders and bedrock outcrops.

Data Access

usSEABED data is available for download and is broken into three regions, Pacific Coast, Gulf of Mexico and Caribbean and Atlantic Coast. Digital data catalog: https://coastalmap.marine.usgs.gov/national/usseabed/data.html
The sediment data sources included in usSEABED: https://www.usgs.gov/data-tools/usseabed-data-sources
Contact: Brian Buczkowski Woods Hole Coastal and Marine Science Center bbuczkowski@usgs.gov 508-457-2361

Citation

Buczkowski, B.J., Reid, J.A., Schweitzer, P.N., Cross, V.A., and Jenkins, C.J., 2020, usSEABED—Offshore surficial-sediment database for samples collected within the United States Exclusive Economic Zone: U.S. Geological Survey data release, https://doi.org/10.5066/P9H3LGWM.

Trawl Survey Comparison

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	State	Survey Name	Survey Location	Gear Type	Mesh Size	Survey Design	Headrope (ft)	Footrope (ft)	Tow Duration/Speed	Time of Year	Years Surveyed	NRHA Years	Strata & Stations
2	Maine	ME/NH Inshore Trawl Survey	ME/NH Coastal Waters	Bottom Trawl	2 inch with 1 inch cod end liner	Stratified random plus fixed stations	57	70	20 min @ 2.2-2.3kts	Bi-annual for 5 weeks starting first	2000-ongoing	2000-2019	20 total: 4 depth strata to 12 mile
3	Massachusetts	MA Inshore Trawl Survey	Coastal	Bottom Trawl	3.5 inch mesh wings 2..5 inch mesh belly, 0.25 inch	Stratified random	39	51	20 min @2.5kn	May (Spring) & Sept (Fall)	1978-ongoing	1978-2019	Since 1982, stations have been assigned
4	Rhode Island	Narragansett Bay Monthly Trawl	Narragansett Bay	Bottom Trawl	4.5 inch mesh 2" cod end, 0.25 inch liner	Fixed	40	55	20 min @2.5kn	Monthly	1990-ongoing	1990-2019	13 fixed stations chosen to represent
5	Rhode Island	Rhode Island Seasonal Trawl	Coastal	Bottom Trawl	4.5 inch mesh 2" cod end, 0.25 inch liner	Fixed and stratified random	40	55	20 min @2.5kn	Monthly & Seasonal Spring (April-May)	1979-ongoing	1979-2019	12 montly fixed stations & 14
6	Connecticut	CT Long Island Sound Trawl Survey	Long Island Sound	Bottom Trawl	4 inch with 2 inch cod end, no liner	Stratified random	30	46	30 min@ 3.5 kts	1984 -1991: Monthly April-November	1984-ongoing	1984–2019	40 random stations sampled monthly,
7	Connecticut	CT Small Mesh Trawl Survey	Long Island Sound	Bottom Trawl	2 inch with 0.25 inch cod end liner	Stratified random	30	46	30 min@ 3.5 kts	?	1991-93, 1996	-	-
8	New York	NY Raritan Bay Survey	Hudson-Raritan Bay	Bottom Trawl	1.75 inch cod end, 1.375 Liner	Stratified random	28	34	10 min @ 2kts	Monthly (except May, Sept)	1992-1997	-	-
9	New York	Peconic Estuary fishery trawl survey/	Peconic Bay	Bottom Trawl	.5 inch stretch mesh codend liner, 0.25 inch cod	Random	16	?	10 min @ 2.5 kts	Weekly, May-Oct	1985-ongoing	1987-2019	Allocation of stations is based on 77
10	New York	Nearshore Ocean Trawl Survey	Atlantic Ocean from Breezy Point to Block	Bottom Trawl	-	-	-	-	-	Year-round	2017-ongoing (10 year project)	-	-
11	New Jersey	NJ Delaware Bay Trawl Survey/ The	Delaware Bay	Bottom Trawl	1.5 inch with 0.5 inch liner	Fixed	16	N/A	20 min @ 2.1kts	Monthly April to October	1991-ongiong	1991-2019	11 stations within the bay for a yearly
12	New Jersey	NJ Trawl Survey/ New Jersey Ocean	Coastal Waters	Bottom Trawl	4.7 & 3 inches, 0.25 inch bar mesh cod end liner	Stratified random	82	100	20 min	1988/89 sampling was Feb, April, June,	1988-ongoing	1988-2019	To reduce potential sampling bias, each
13	Delaware (16ft Trawl)	DE 16ft Trawl Survey/ Delaware	Delaware Bay and Delaware River	Bottom Trawl	1.5 inch, 0.5 inch liner	Fixed	17	21	10 min @ minimum hp - tow against the	April - October (monthly)	1980-ongoing	1980–2019	The sampling design is a fixed site grid on
14	Delaware (30ft Trawl)	DE 30ft Trawl Survey	Delaware Bay	Bottom Trawl	3 inch wings & body, 2 inch cod end	Fixed	30	40	20-30 min @ minimum hp	March - December (monthly)	Since 1966 (1966-1971,	1966-2019	Nine fixed stations throughout the
15	Maryland	Coastal Bays Fisheries	Coastal Bay	Bottom Trawl	0.25 inch cod end	Fixed	?	16	6 min @ 2.5-2.8kts	April-Oct (monthly)	1972 - ongoing but standardized	1989-2019	Trawl sampling was conducted at 20
16	Virgina	VIMS Chesapeake Bay Juvenile Fish and	Lower Chesapeake Bay and major	Bottom Trawl	1.5-inch, 0.25 inch liner in cod end	Fixed and stratified random	20	?	5 min @ 2.5kts	Monthly April - Dec	1955-ongoing	-	Sampling in the Bay occurred monthly
17	Virginia	ChesMMAP:Chesapeake Bay Multispecies	Mainstem, Ches Bay (ChesMMAP)	Bottom Trawl	4.72 & 2.36 inch mesh with 1 inch cod end liner	Stratified random	32.7	36.5	20 min @ 3 kts	March, June, Sept & Nov	2002-ongoing	2002-2015	The coverage includes 80 stations
18	Virginia	NEAMAP: NorthEast Area Monitoring and	Coastal, RI to NC (NEAMAP)	Bottom Trawl	4.72 & 2.36 inch mesh with 1 inch cod end liner	Stratified random	80	88.6	20 min @ 2.9-3.3 kts	April-May and Sept-Oct	2007-ongoing	2007-2019	150 stations broken down into 15 regions
19	North Carolina	NCPamlico Sound Survey (Program	Pamlico Sound	Bottom Trawl	1.875 inch strech mesh, 1.5 inch cod end	Stratified random	31	34	20 min @ 2.5 kts	June and Sept (also March and Dec prior	1987-ongoing	1987-2019	Each trawl sweeps an area of approx.
20	North Carolina	NC Juvenile Trawl Survey (Juvenile	Albemarle Sound and tributaries	Bottom Trawl	4 inch in wings to 1/8 inch tail bag	Fixed	18	?	10 min @ ?	May and June (Feb-Nov prior to	1971-ongoing	-	Fixed. Some of the current stations
21	North Carolina	Estuarine Trawl Survey /Nursery	Estuarine	Bottom Trawl	.25 inch bar with .125 inch bar tail bag	Fixed	10ft	-	1 min calibrated to span 75 yards	Core stations: May and June	1971 - ongoing	1972-2019	105 stations in shallow water areas
22	Offshore/ Northeast U.S.	NMFS bottom trawl survey	Northeast U.S. Continental Shelf	Bottom Trawl	4.72 & 2.36 inch mesh, 1 inch cod end liner	Stratified Random	79.5	88.6	20 min @ 3 kts	Spring & Fall	1963-ongoing	1963-2019	Stratified random sampling design.

Climate Vulnerability Assessment Crosswalk

- Synthesis of information from NOAA's FSCVA, HCVA, ACFHP species-habitat matrix, and EFH designations
- <u>Matrix</u> that indicates species' dependency on (or association with) habitat types, by life stage
- <u>Narratives</u> 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 will be 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) Estuarine subtidal rocky bottom- Low Marine rocky bottom <200m- Low		H	H	H

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 [illegible]

Modeling Framework

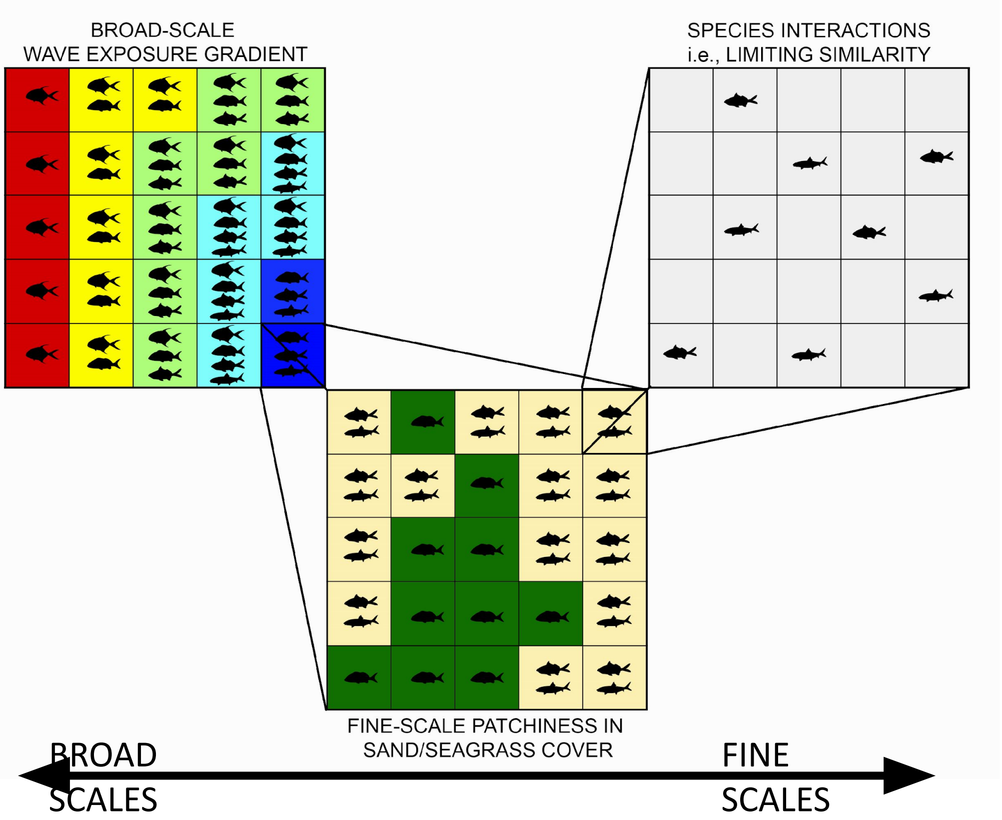
Characterizing Habitat Use

Characterizing habitat use: A comprehensive strategy

- **Stage-based approach** - partitioning spp. into distinct classes based on ontogeny (e.g., size or maturity)
  - Better resolution of habitat shifts?
  - Improved inferences about species relationships?
- **Single Species & Joint SDMs**
  - Using GAMs and a novel spatiotemporal Joint modeling approach (CBFM)
  - Comparison of Joint vs single-species spatiotemporal GAMs
- **Dynamic & Ecologically Relevant Covariates**
  - Temporally varying predictor variables that reflect dynamic nature of systems
  - Predictors with direct consequences for ecological function of animals

Habitat Use & Community Ecology

- Habitat use patterns are shaped by multiple processes:
  1. **“Environmental filtering” -** Are abiotic conditions compatible with the limitations of the animal?
  2. **Biotic interactions –** Animals act upon one another, influencing their use of space
  - **Induce (+) or (-) correlations in spp pres/abs or abundance**

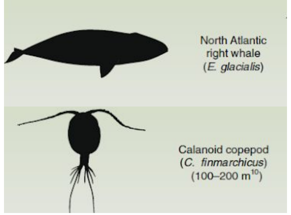


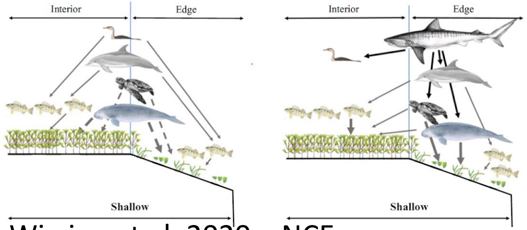
How Can Biotic Interactions Affect Habitat Use?

- **Competition: (-)** Species with similar niches may exclude each other
- **Migratory coupling: (+)** Movement of a consumer is driven by that of its prey
- **Non-consumptive effects: (-)** "Fear" of predators alters use of space by prey
- **Social interactions: (+)** Information exchange b/w species that share common predators or prey
- **Cascading effects can "scale-up" to the ecosystem level**

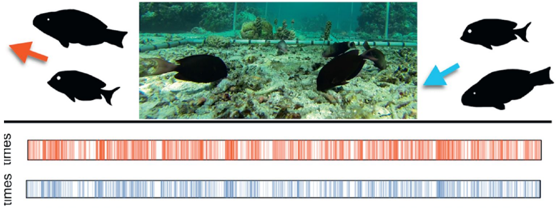
Connel 1961 – Competition

Furey et al. 2018 – Migratory coupling





Wirsing et al. 2020 – NCEs

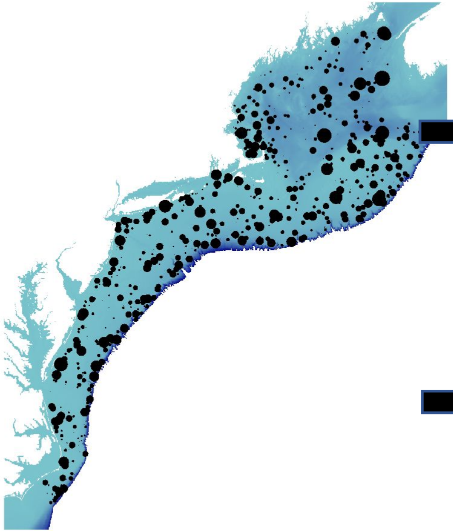


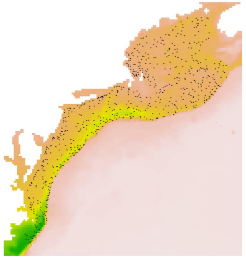
Gil & Hein 2017 – Social Interactions

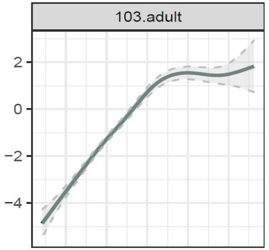
SDMs: A Mechanistic View of Habitat

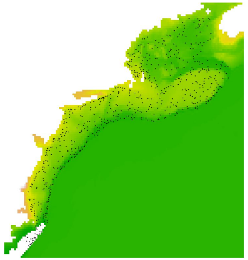
- **Species Distribution Models** (SDMs) estimate the habitat "niche" of organisms by relating observed densities to measured **environmental** predictor variables

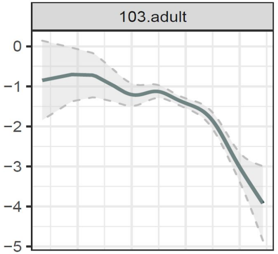
"Environmental filters"

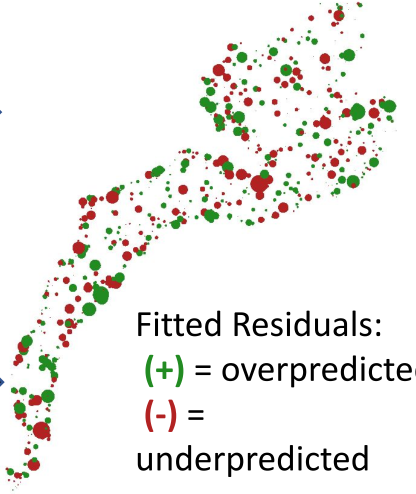












Fitted Residuals:
(+) = overpredicted
(-) = underpredicted

Species A – Observed Density

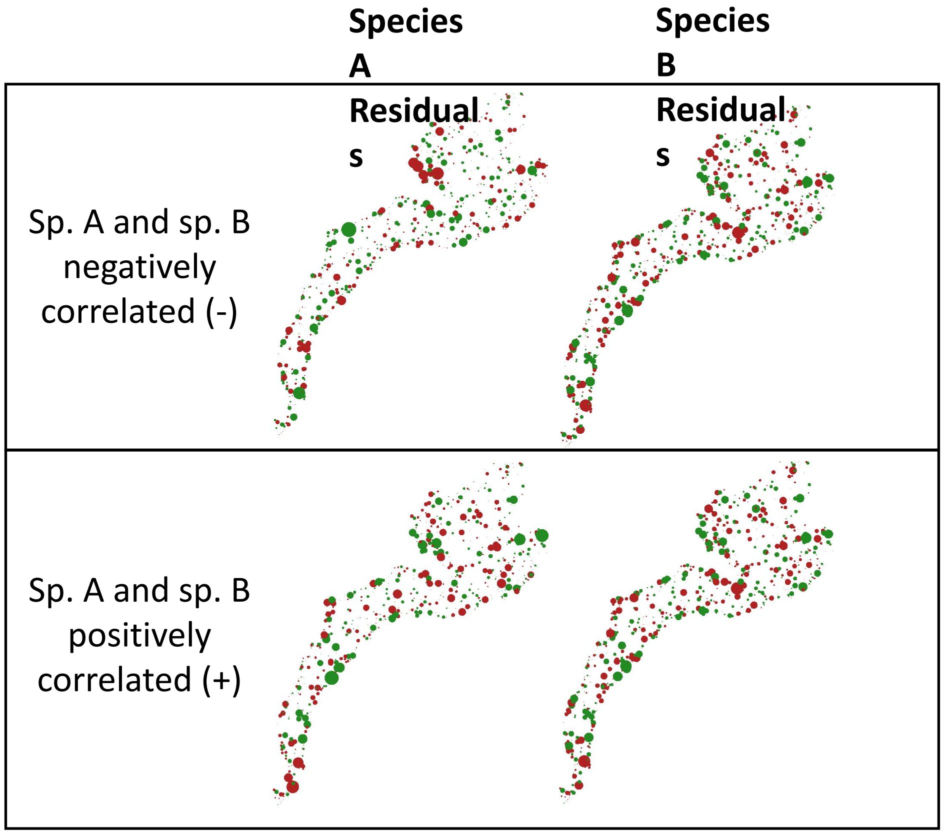
Enviro. Predictors

Estimated Niche

Species A – Model Residuals

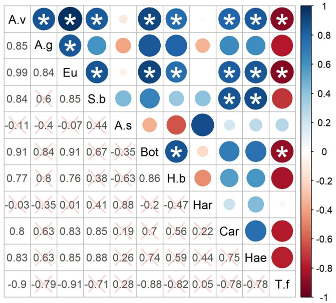
Joint SDMS: Making More of Model Residuals

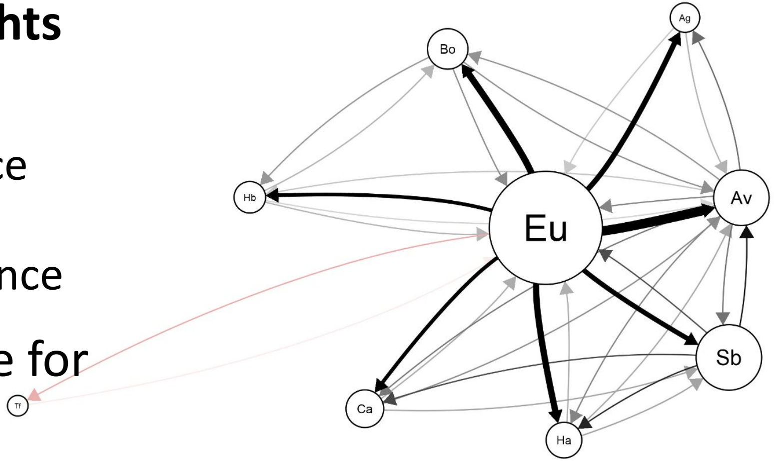
- In single-species SDMs, **residuals = “error”**
- In a multi-species context, **residual patterns across species contain information** about underlying processes (i.e., missing predictors, dispersal, interactions)
- Joint SDMs model residual covariance & exploit it for joint predictions = **more realistic estimates of species assemblages**



Joint-species distribution models (JSDMs)

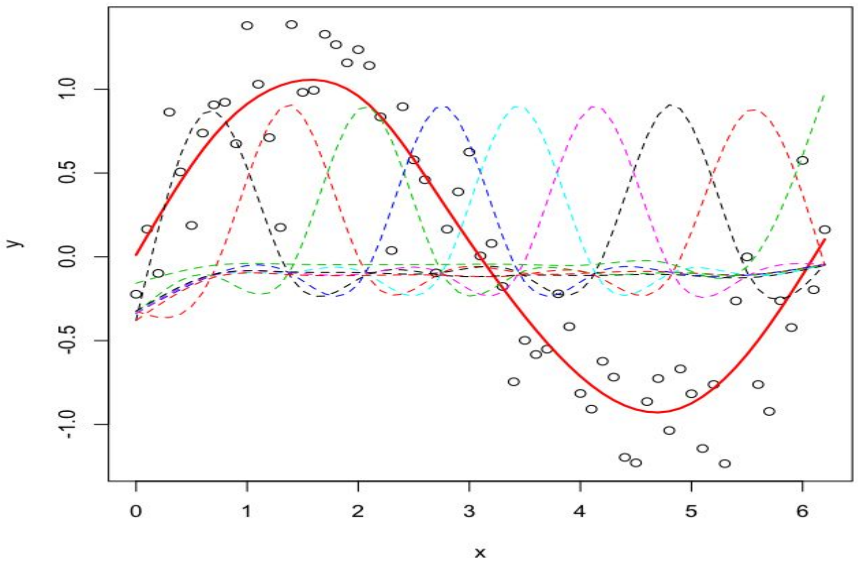
- JSDMs model groups of species together, simultaneously estimating:
  1. Species-environment relationships (“**environmental filtering**”)
  2. Species covariation with each other (**interactions** or **“missing” predictors**)
- **Improved predictions & ecological insights**
  - Better propagation of error/uncertainty
  - Sharing information across spp to enhance estimation
  - Joint predictions that include spp covariance
- Computationally expensive – not feasible for large datasets

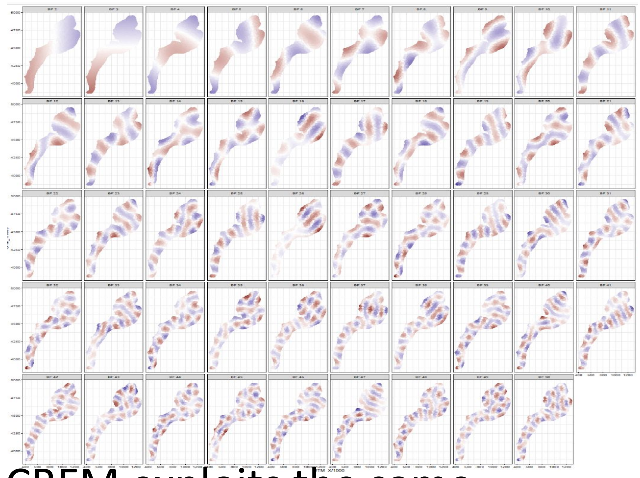




Community-Level Basis Function Model (CBFM)

- **GAMs** model complex species relationships with environmental variables as a linear combination of basis functions (“building blocks”)





- CBFM exploits the same “machinery” that GAMs use to model species responses to the environment, but also to (flexibly and efficiently) model covariance in space and time

CBFM: Development & Proof of Concept

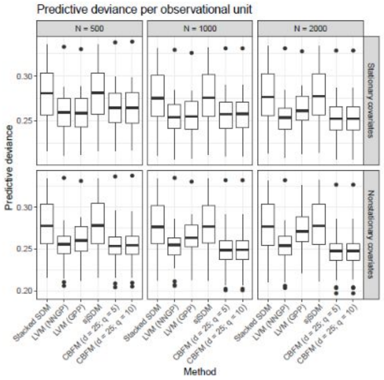
- **Methods manuscript** (MEE)
  - Simulation studies
- **R package**
  - Github repository
  - June Public release

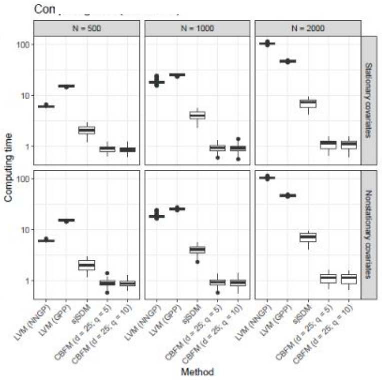
GitHub

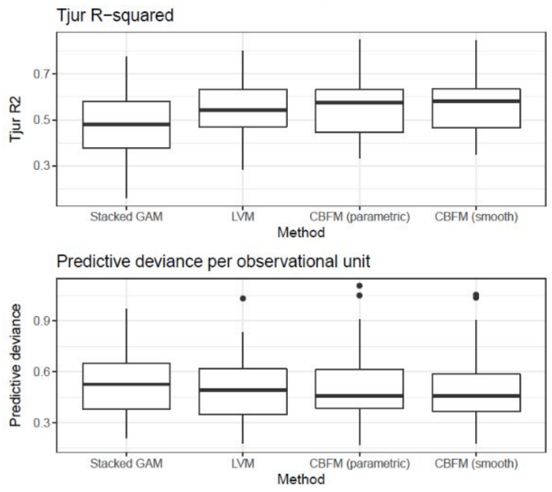
Spatio-Temporal Joint Species Distribution Modeling:
A Community-Level Basis Function Approach

Francis K.C. Hui*[1], David I. Warton[2], Scott D. Foster[3], Nicole A. Hill[4], and Christopher R. Haak[5]

[1]Research School of Finance, Actuarial Studies and Statistics, The Australian National University, Canberra, Australia
[2]School of Mathematics and Statistics, The University of New South Wales, Sydney, Australia
[3]Data61, Commonwealth Scientific and Industrial Research Organization, Hobart, Australia
[4]Institute for Marine and Antarctic Studies, University of Tasmania, Hobart, Australia
[5]Northeast Fisheries Science Centre, National Oceanic and Atmospheric Administration, Highlands NJ, USA



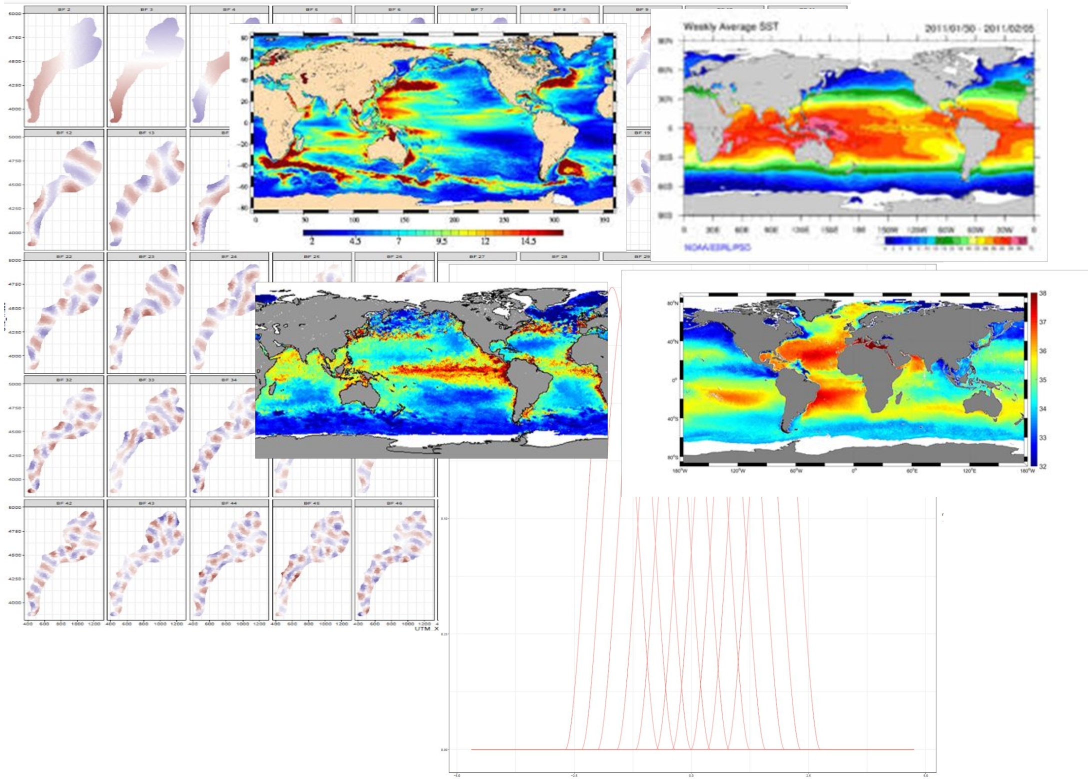




- Performs as well or better than existing methods, but with considerable speed improvements

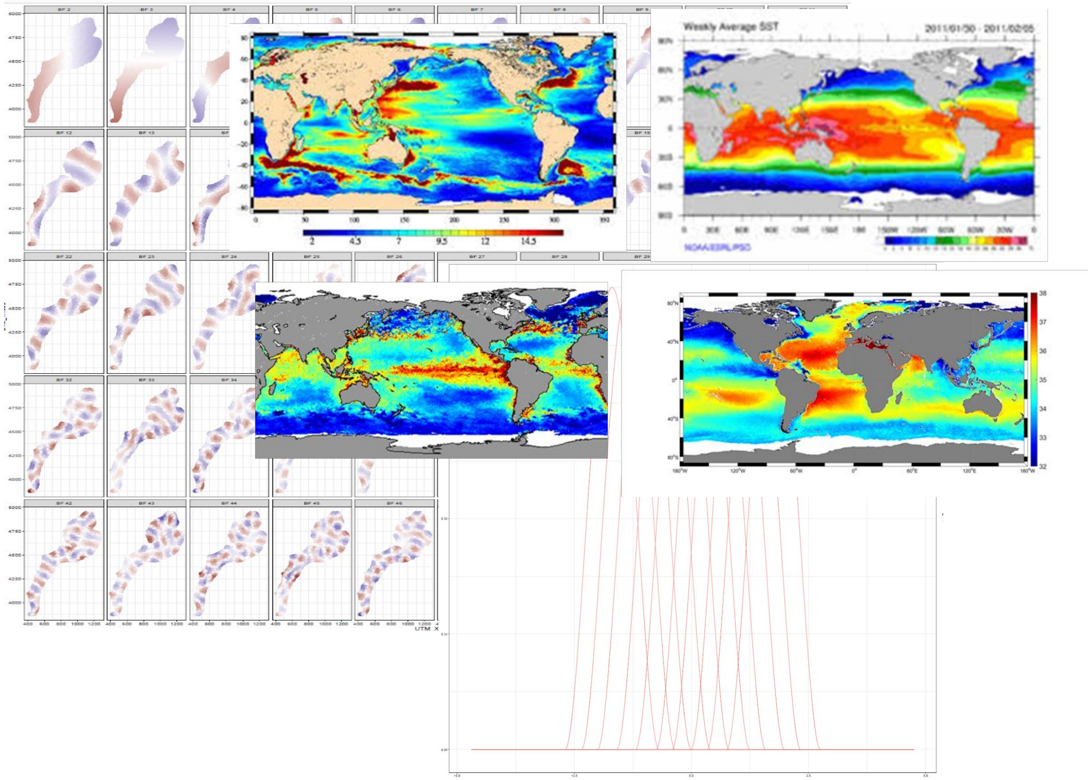
NRHA Application

- Abundance of 97 spp-stages from NMFS-BTS (Spring & Fall)
    - Demersal & pelagic sp., managed, common, & prey
    - Training 2000-2014 (n > 9000)
    - Testing 2015-2019 (n > 3000)
- “Hurdle” Model
    - Binomial pres/abs
    - ZTNB counts
- Combined Spring & Fall surveys



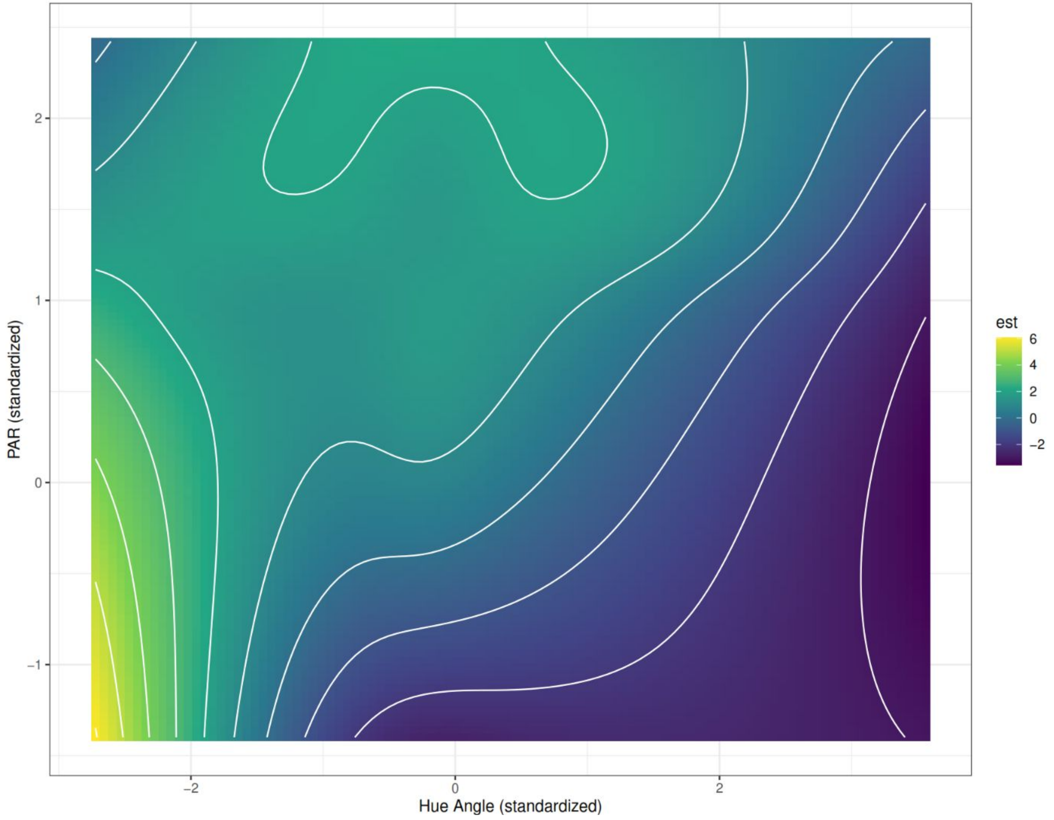
NRHA Application

- 11 enviro Predictors (+ vessel)
  - Surface & Bottom temp (monthly means)
  - Surface & Bottom Salin (monthly means)
  - Annual min & max surface temps
  - Annual min & max bottom temps
  - Sea Surface height (monthly mean)
  - Bottom stress (static, hydrodynamic)
  - PAR (monthly mean, optical)
  - Hue angle (monthly mean, optical)



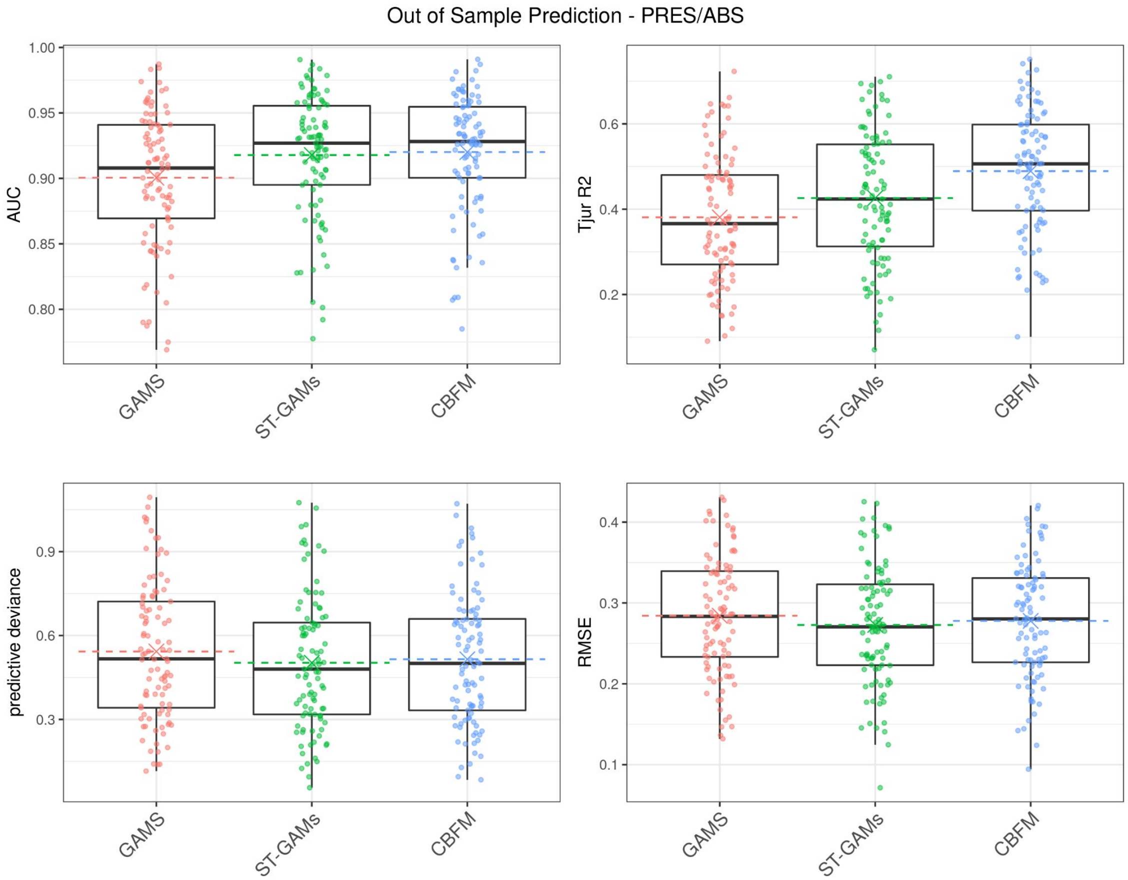
NRHA Application: Covariates

- Correlates of depth:
  - Underwater optical environment
  - Intensity of wave and current driven water movement
- Optical parameters (te)
  - PAR = Light intensity
  - Hue Angle = Light color (red-blue spectrum)
- Bottom stress
  - 95th quantile (extreme events)



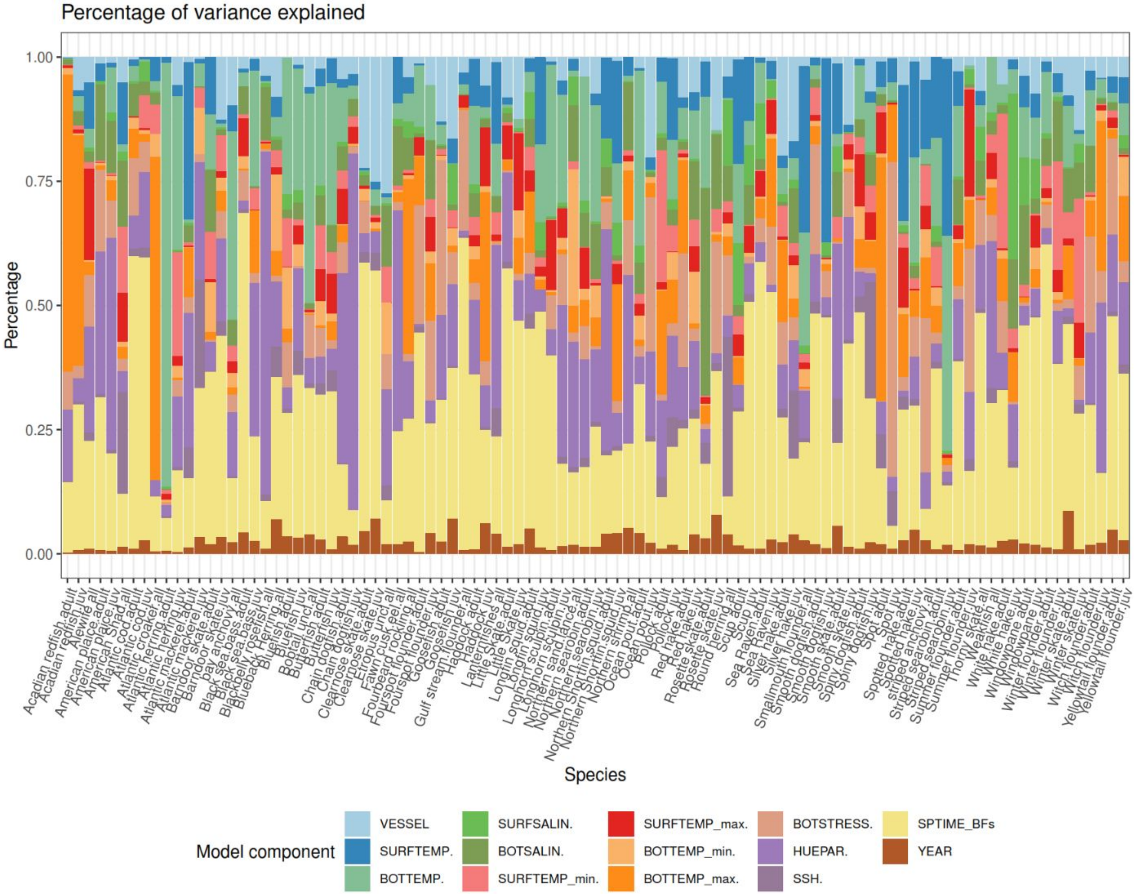
NRHA Application: Performance

- Out-of-sample prediction P/A
  - Median AUC = 0.93 (range from 0.78 - 0.99)
  - Median Tjur R^2 = 0.50 (0.1 - 0.75),
  - Median RMSE = 0.28 (0.09 - 0.42)
- Outperforms stacked single-species S-T GAMS

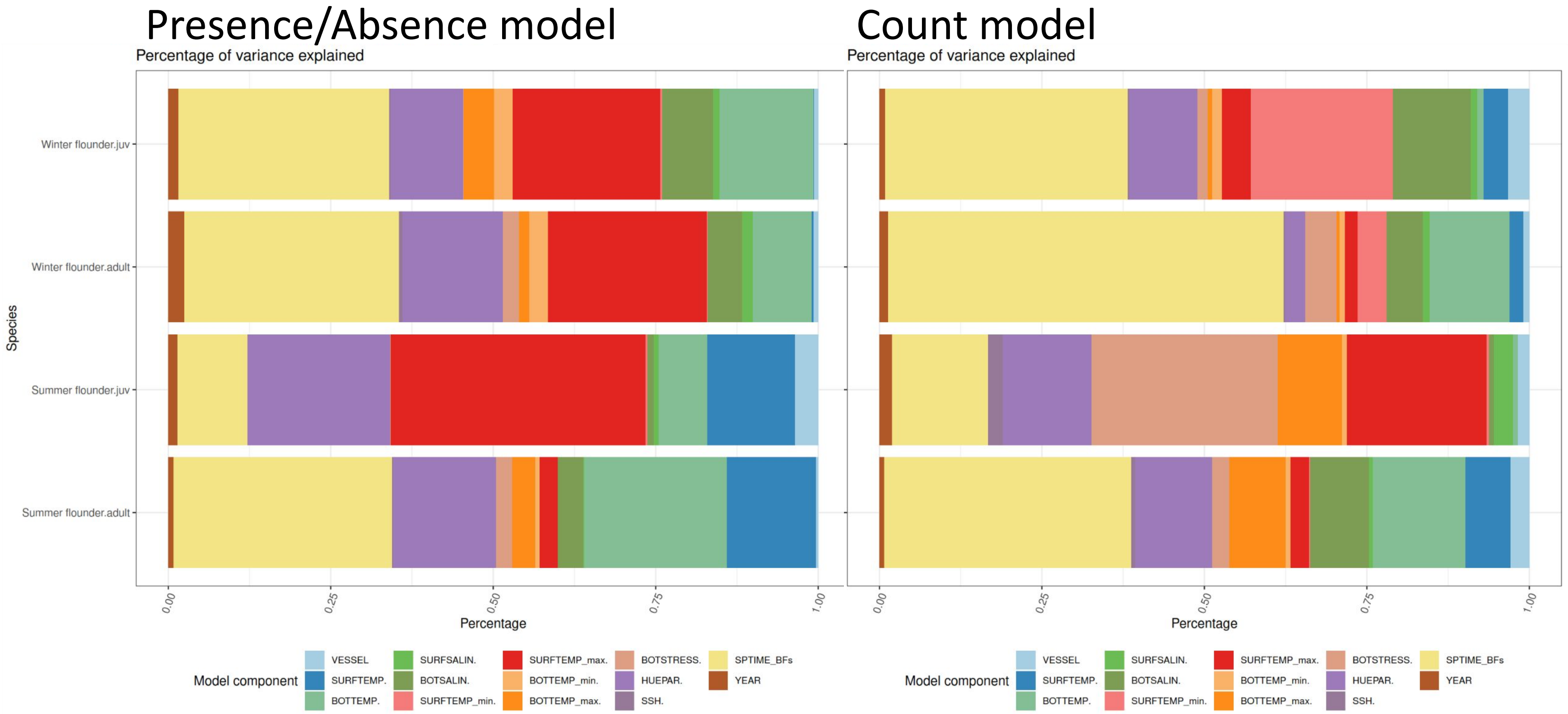


CBFM Outputs: Covariate Importance

- % variance explained by each predictor, and spatial & temporal BFs
- Which factors are most influential in driving habitat use of spp.

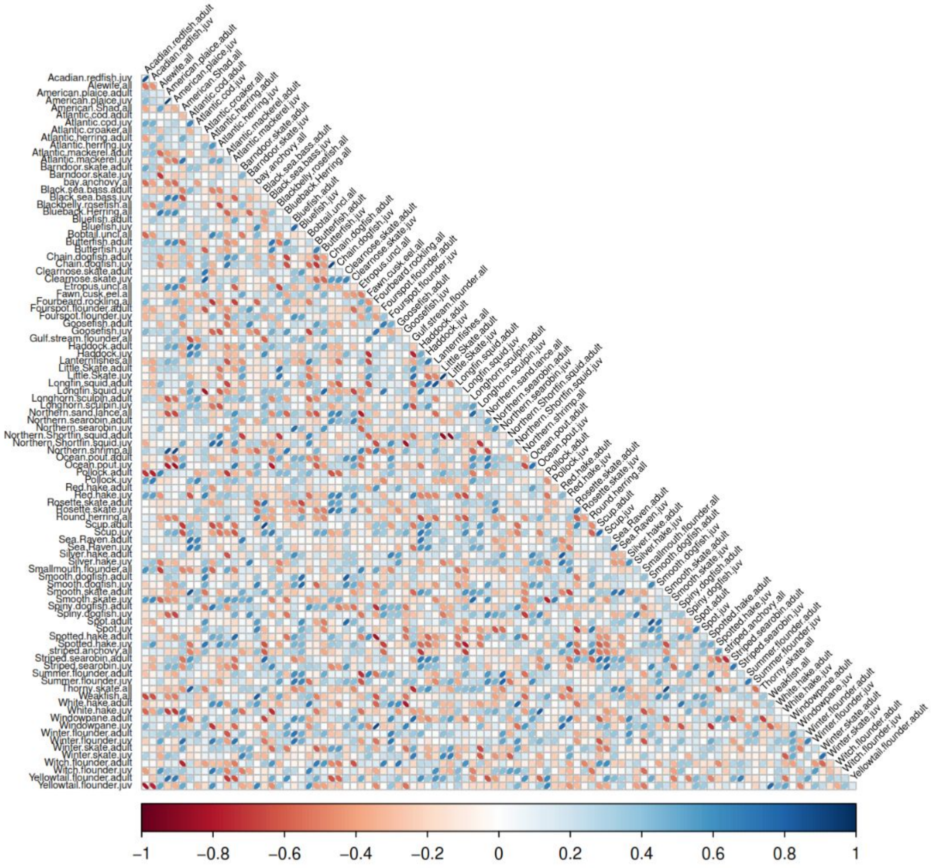


Covariate Importance: Flounders



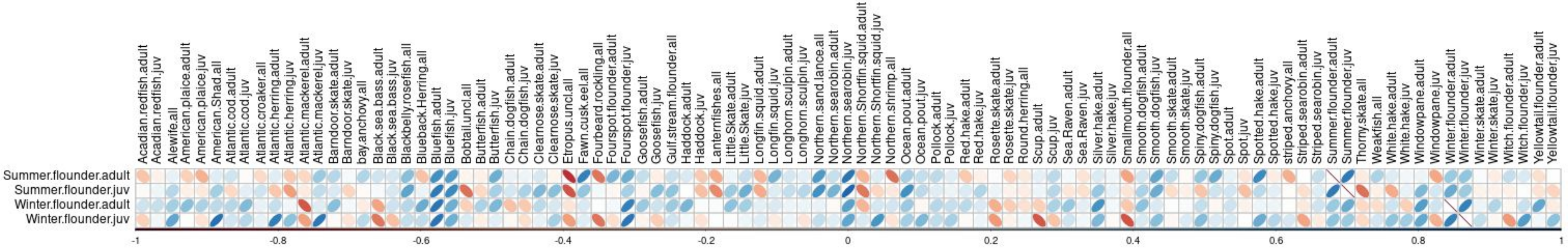
CBFM Outputs: Residual/Partial Correlations

- Correlation among spp. that is **not** explained by measured predictors
    - Evidence of **biotic interactions** or responses to **“missing” covariates**?
- Overall, strong positive corrs b/w adults and juvs may evidence a phylogenetic signal or dispersal limitations



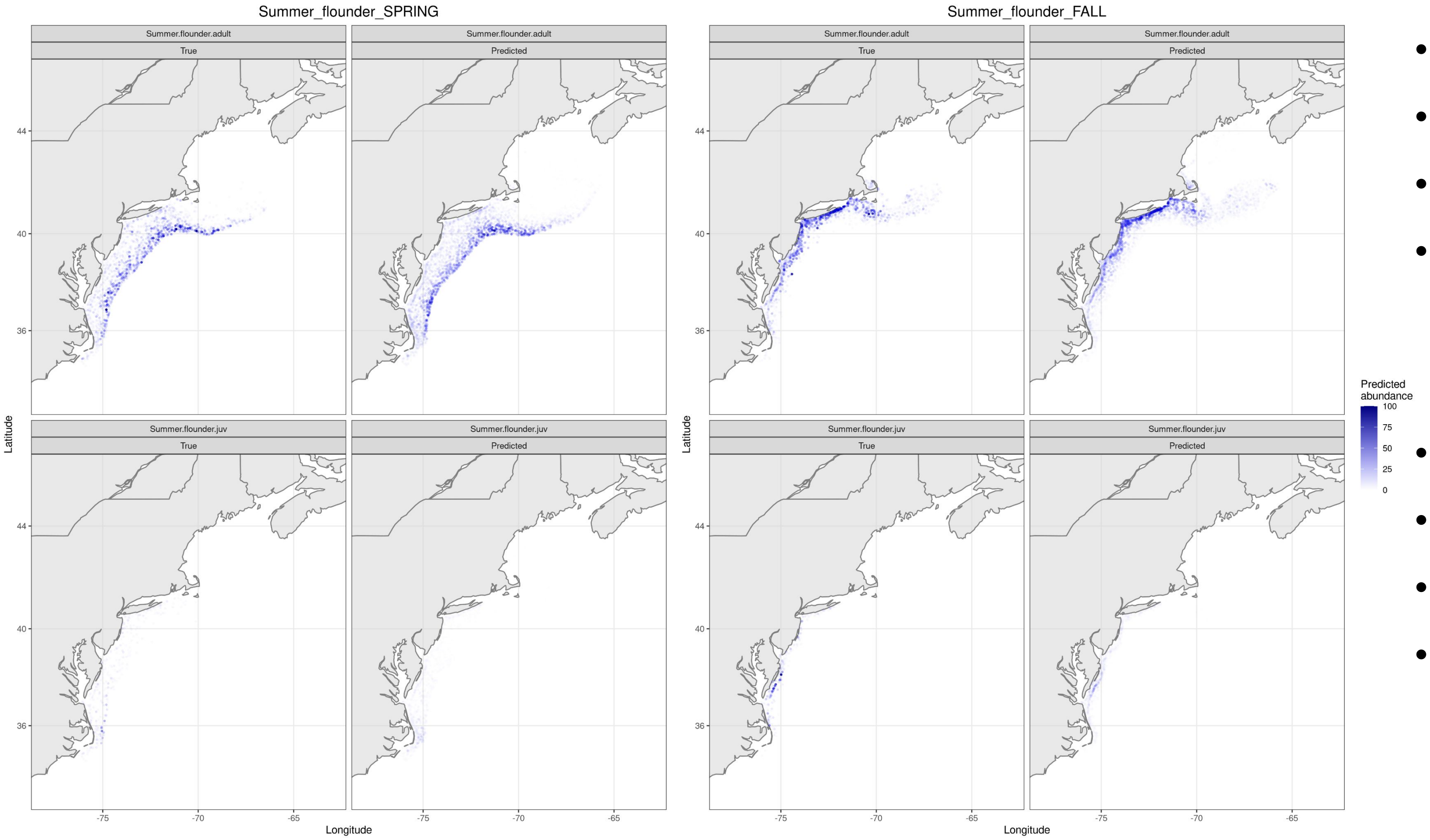
Partial Correlations: Flounders

- Spatio-temporal correlations b/w species after accounting for the effect of covariates (i.e., environmental preferences)



- \+ Corrs b/w adults and juv within species
- \+ Corrs w/ Bluefish and Northern Searobin?
- \- Corrs w/ Etropus & Smallmouth flounders

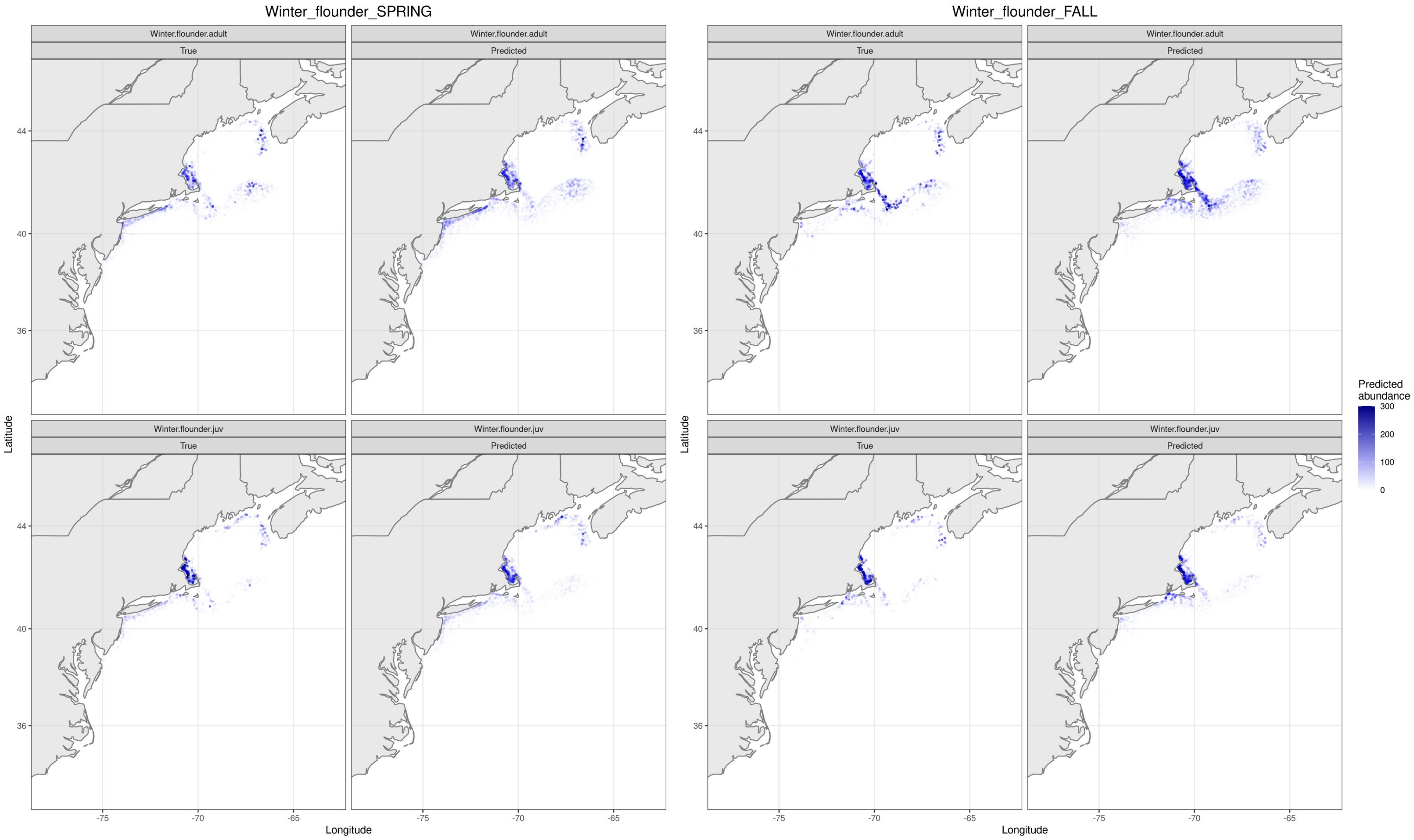
Predictions: Summer flounder



- Adults
- AUC = 0.94
- TjurR2 = 0.62
- RMSE = 0.34

- Juveniles
- AUC = 0.93
- TjurR2 = 0.30
- RMSE = 0.22

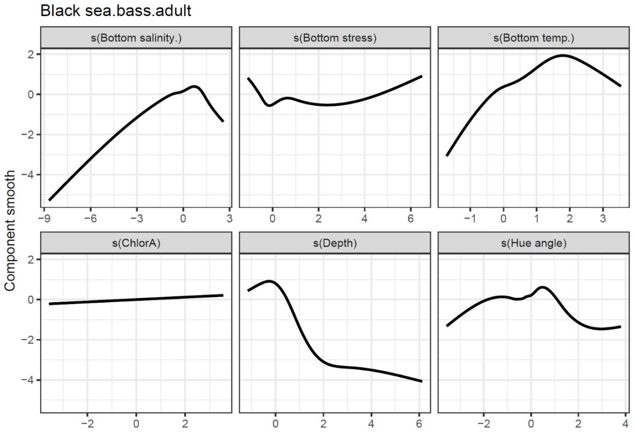
Predictions: Winter flounder

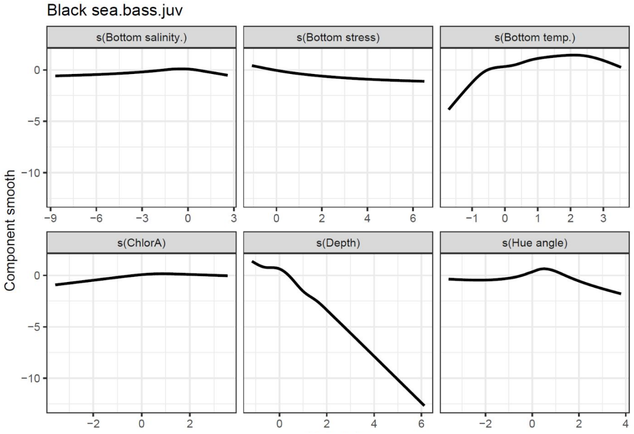


- Adults
- AUC = 0.95
- TjurR2 = 0.66
- RMSE = 0.30

- Juveniles
- AUC = 0.96
- TjurR2 = 0.65
- RMSE = 0.26

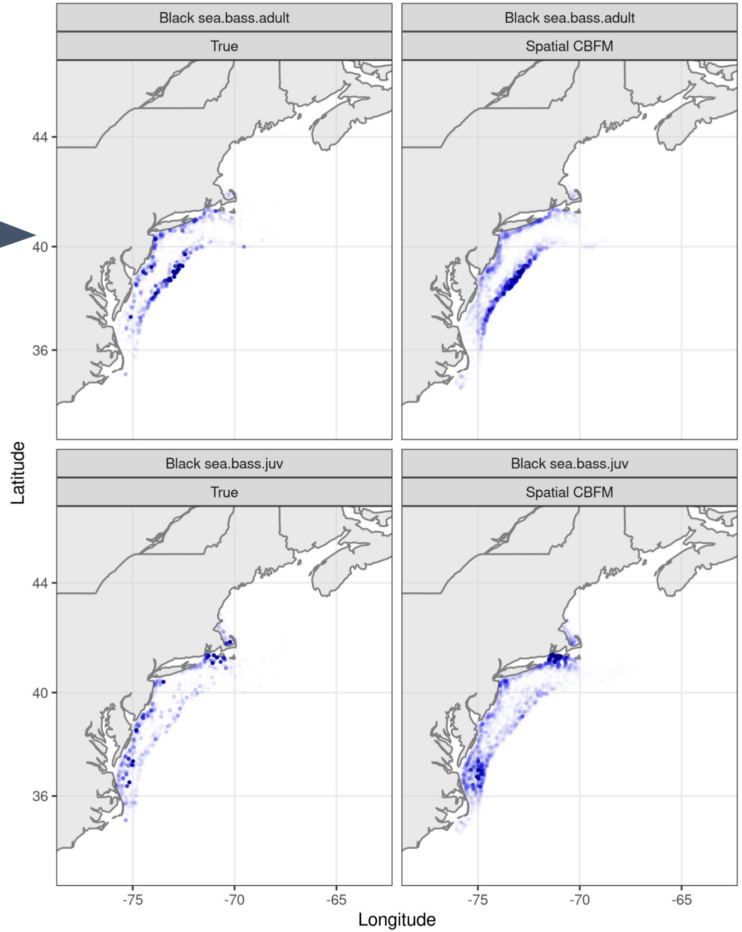
Prediction: Black sea bass (stages)





- Differing use of space by adults and juveniles
- Stage-specific differences in response to Depth and Salinity

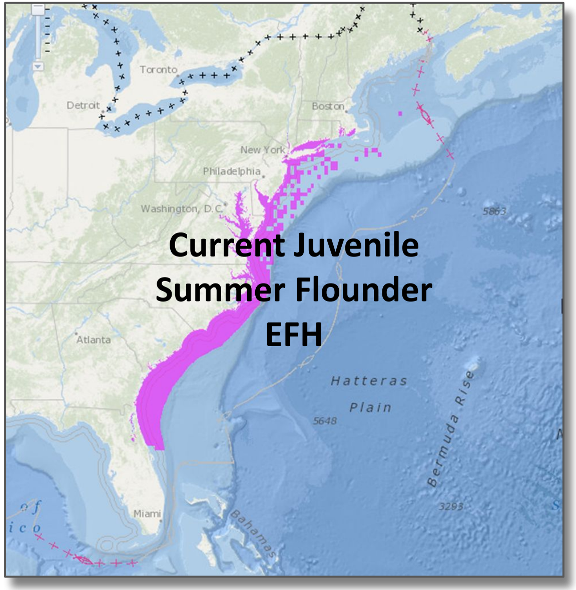
TRUE (observed) Model (predicted)



Selected applications for NRHA products

Essential Fish Habitat application

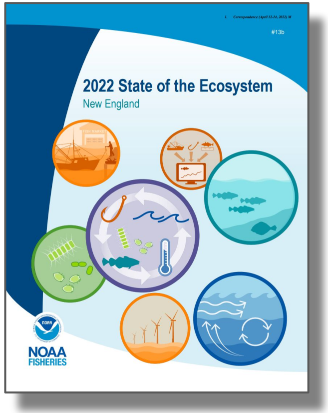
- NRHA provides more specificity on which environmental factors influence species distribution. Will benefit:
  - EFH text descriptions
  - Habitat area of particular concern (HAPC) designations
- Spatial model outputs will serve as a robust foundation for EFH maps
  - May still need to incorporate additional information from outside NHRA geographic scope
- Information about spatial shifts in habitat, e.g., under different climate scenarios
  - Possible to include in EFH designations?
- Consider an adaptive approach and/or ways to automate EFH designation updates



Juvenile summer flounder EFH designation (CURRENT): North of Cape Hatteras, EFH is the area which encompasses the top 90% of the area where summer flounder juveniles are found in the MARMAP and NEFSC trawl surveys. South of Cape Hatteras, EFH is the nearshore waters (out to 50 miles from shore) of the Continental Shelf, from Cape Hatteras to Cape Canaveral Florida. Inshore, EFH is all the estuaries where summer flounder were identified as being present in the ELMR database, in the "mixing" and "seawater" salinity zones.

SOE application

- 2022 State of the Ecosystem report includes a description of NRHA in Habitat Risks subsection
- Future SOE reports will expand on how managed species distributions have changed and may continue to change related to habitat and climate changes
- Included in annual SOE presentations to Councils



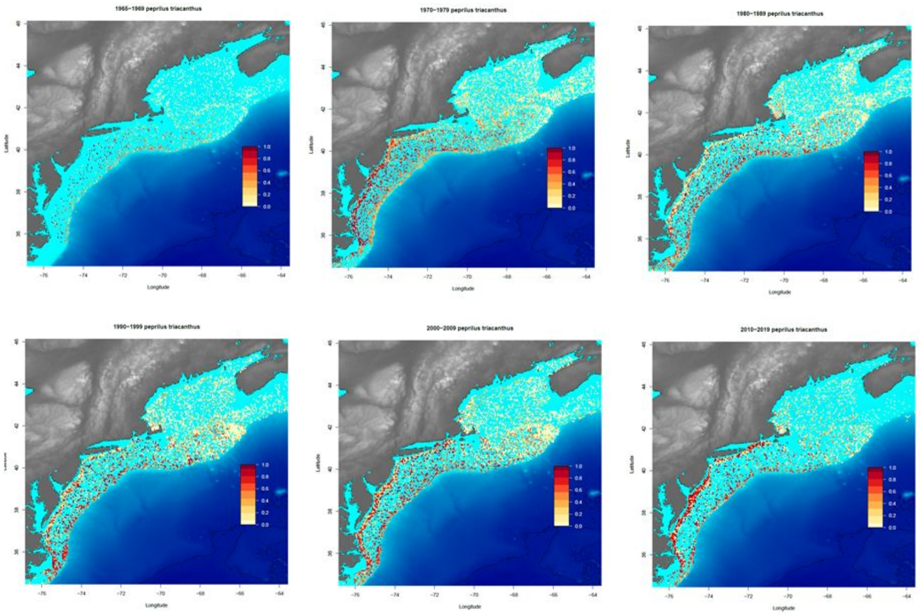
Habitat Risk Indicators: habitat assessments, harmful algal blooms, fishing gear impacts

Habitat Climate Vulnerability The Northeast Regional Marine Fish Habitat Assessment (NRHA) is a collaborative effort to describe and characterize estuarine, coastal, and offshore fish habitat distribution, abundance, and quality in the Northeast. This includes mapping inshore and offshore habitat types used by focal fish species, summarizing impacts of habitat climate vulnerability on these species, modeling predicted future species distributions, and developing a publicly accessible decision support tool to visualize these results. This is a three-year project led by the New England and Mid-Atlantic Fishery Management Councils in collaboration with many partners including NOAA Fisheries, and will be completed in July 2022[11].

As part of the NRHA work, climate vulnerability information from NOAA's Habitat Climate Vulnerability Assessment [37] and the Northeast Fish and Shellfish Climate Vulnerability Assessment [38][12] is synthesized for approximately 70 species in the northeast region. In particular, winter founder, a species deemed highly vulnerable to climate change, is highly dependent on vulnerable habitats such as submerged aquatic vegetation, kelp, intertidal sand and mud, and tidal wetlands throughout New England and in the Mid-Atlantic. Details on highly vulnerable habitats with linkages to a variety of species, including which life stages have different levels of dependence on a particular habitat, are available in a detailed table[13].

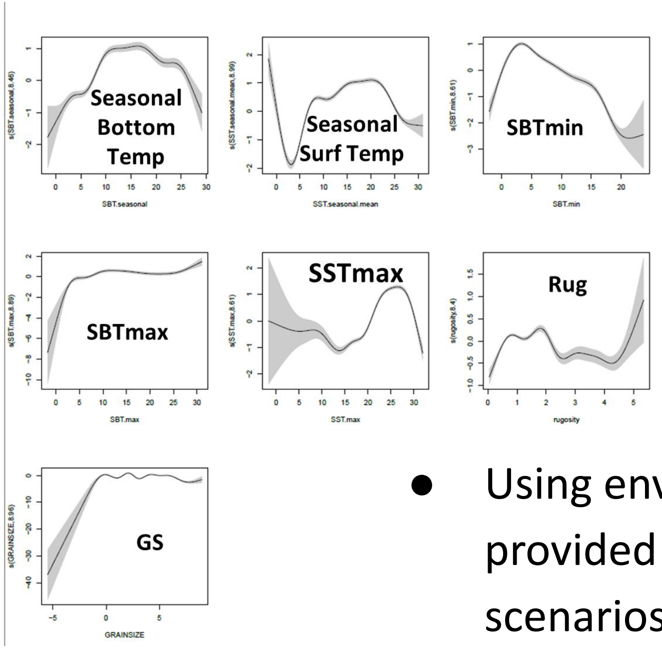
Stock assessment application

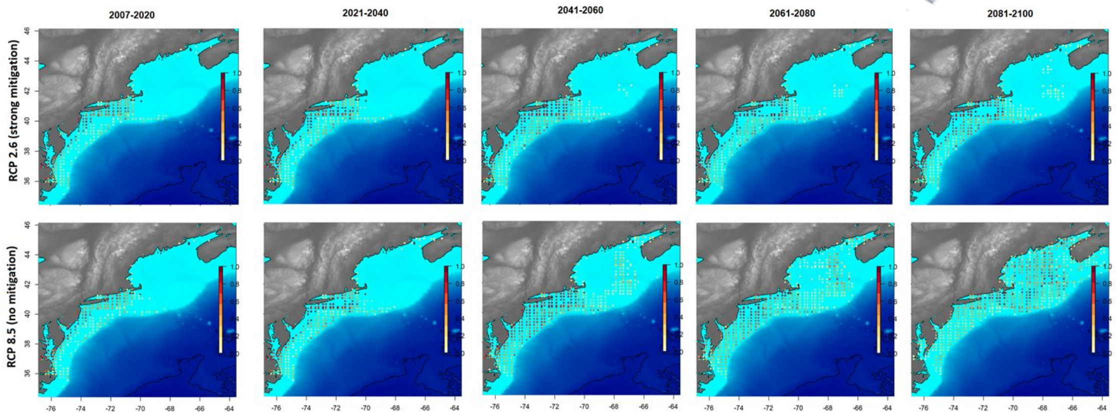
- Stock assessments have an ecosystem TOR, and NRHA products can be useful in addressing this
- In fall 2021 Tori provided a habitat paper to the working group for the research track butterfish assessment



Additional TOR 1: Describe life history characteristics and the stock's spatial distribution, including any changes over time. Describe ecosystem and other factors that may influence the stock's productivity and recruitment. Consider any strong influences and, if possible, integrate the results into the stock assessment.

Stock assessment application



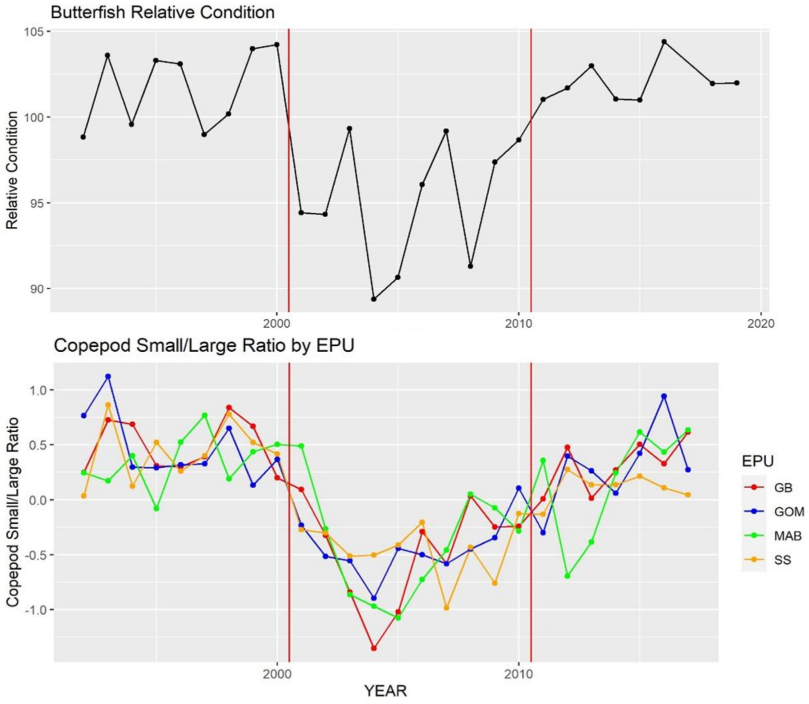


- Using environmental drivers and historic butterfish distributions, provided distribution projections based on two climate change scenarios

Additional TOR 1: Describe life history characteristics and the stock's spatial distribution, including any changes over time. Describe ecosystem and other factors that may influence the stock's productivity and recruitment. Consider any strong influences and, if possible, integrate the results into the stock assessment.

Stock assessment application

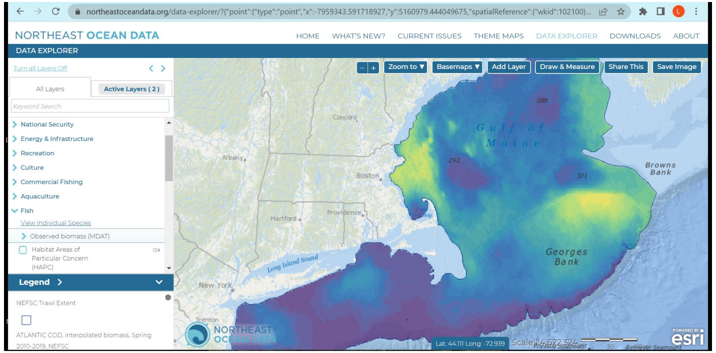
- Regime shift work linking changes in butterfish health and recruitment to environmental indices
- These environmental drivers were used to determine the average recruitment time period for butterfish projections
- NRHA products designed to address these types of questions
  - parsed data into juveniles and adults
- Distribution and regime shift work will be applied to Atlantic mackerel in 2023

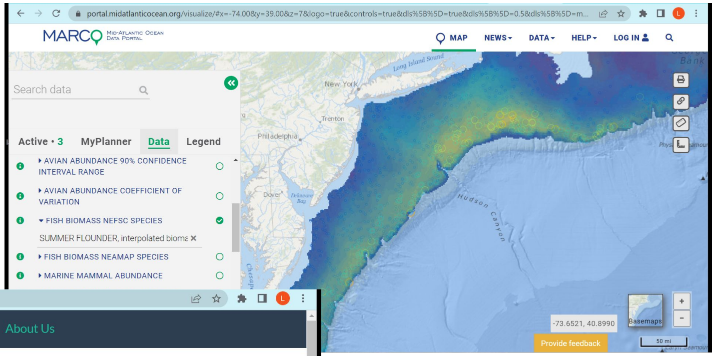


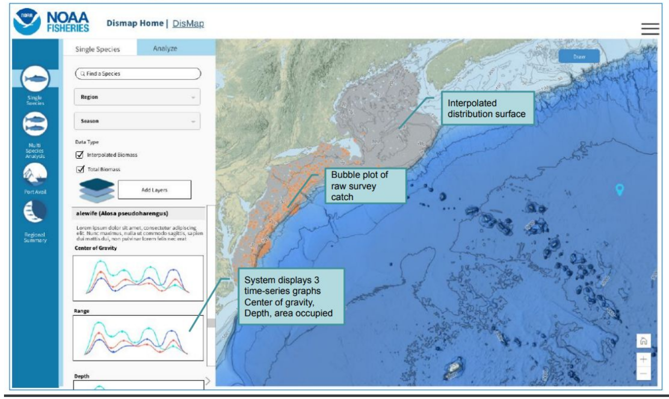
Additional TOR 1: Describe life history characteristics and the stock's spatial distribution, including any changes over time. Describe ecosystem and other factors that may influence the stock's productivity and recruitment. Consider any strong influences and, if possible, integrate the results into the stock assessment.

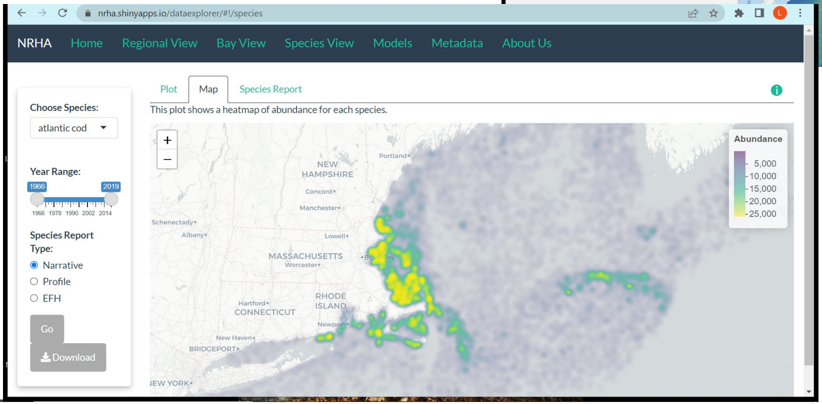
Publicly Available Data Portals

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



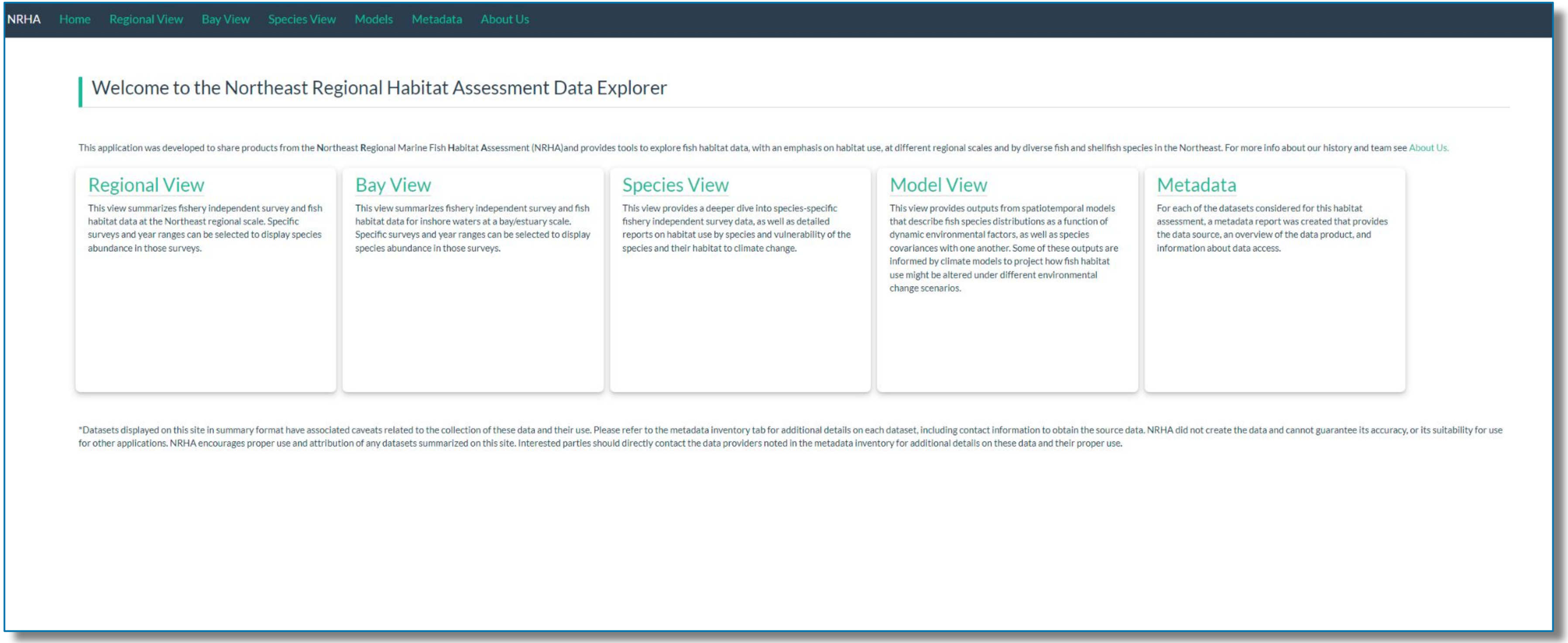






NRHA Data Explorer Demonstration

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



Thank you!
Questions?

mbachman@nefmc.org
jcoakley@mafmc.org
tkentner@mafmc.org
laurel.smith@noaa.gov
chrishaak@gmail.com