Butterfish Environmental Drivers, Consumptive Removals and Condition

Laurel Smith[1], Tori Kentner[1,2], Brian Smith[1]
and Robert Vincent[3]

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[2]Mid-Atlantic & New England Fishery Management Councils
[3]MIT Sea Grant

5/10/2022

Butterfish Historic Distributions & Climate Predictions

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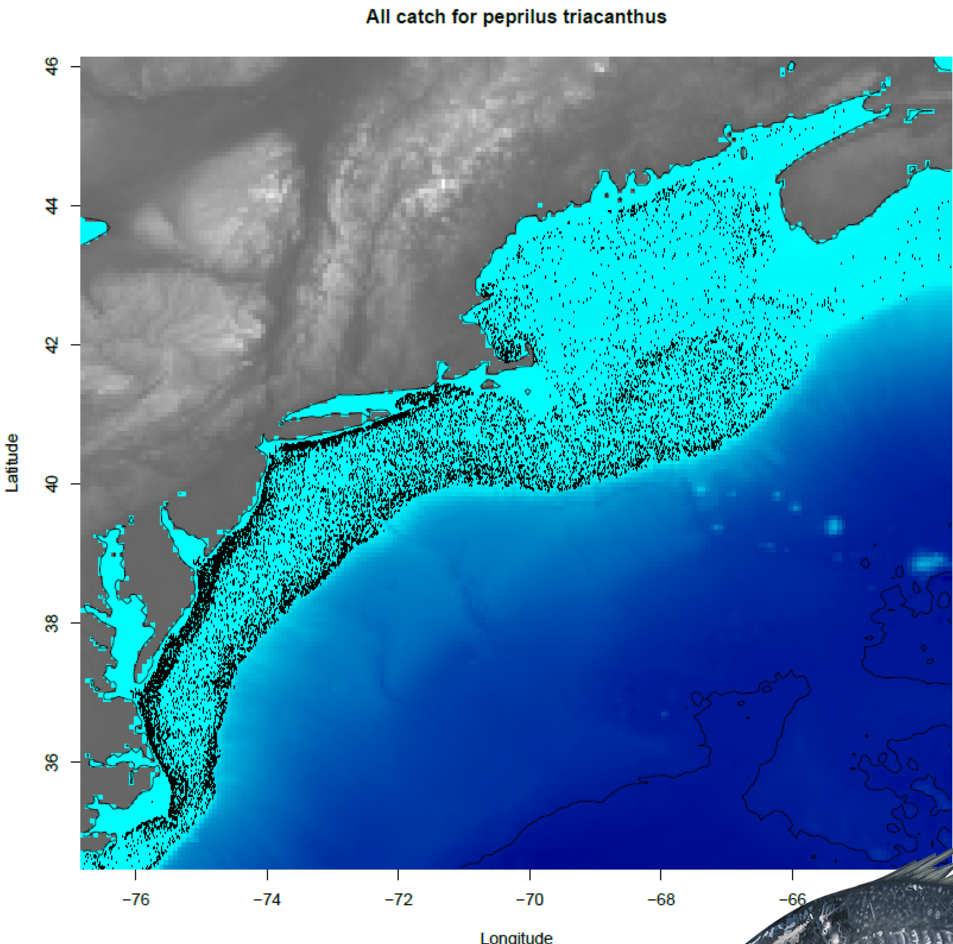
Mid-Atlantic & New England Fishery Management Councils

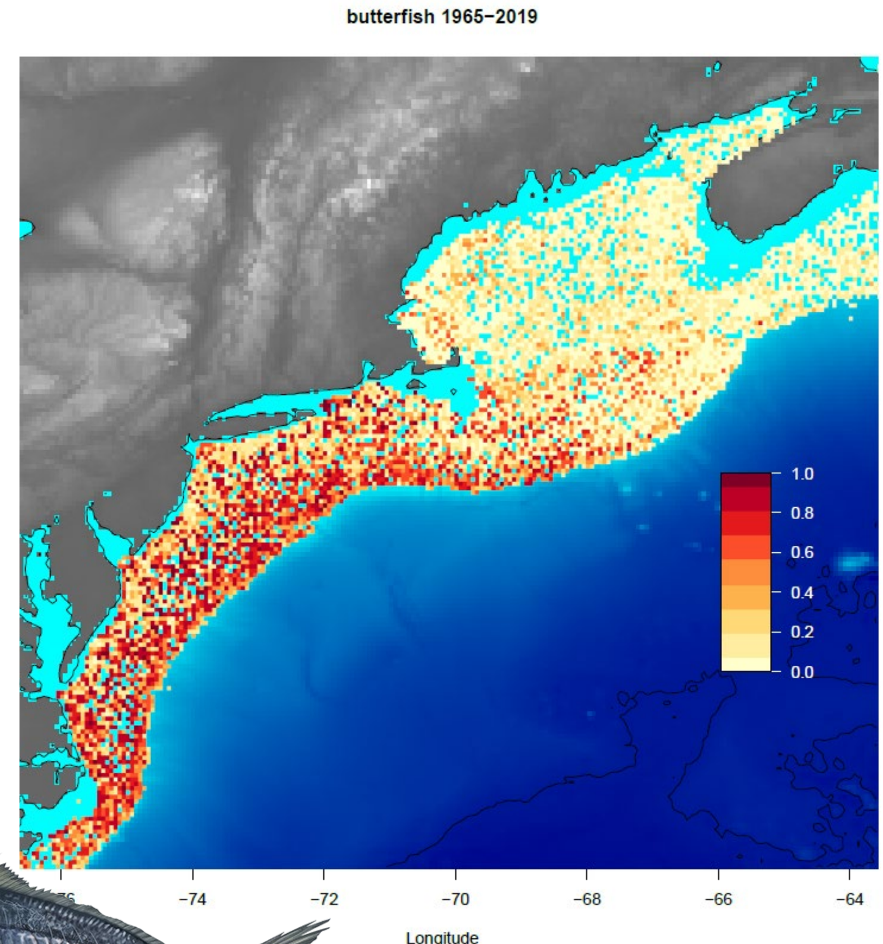
11/16/2021

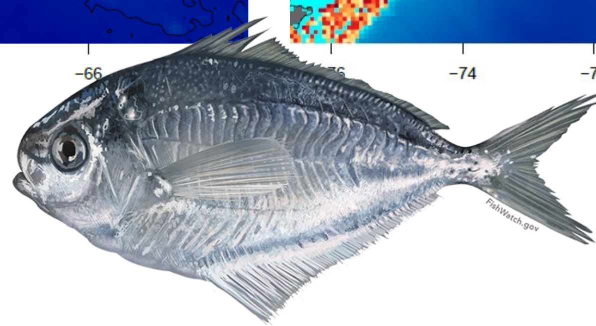
Northeast Regional Habitat Assessment: **To describe and characterize estuarine, coastal, and offshore fish habitat distribution, abundance, and quality in the Northeast.**

Historical Catch Locations



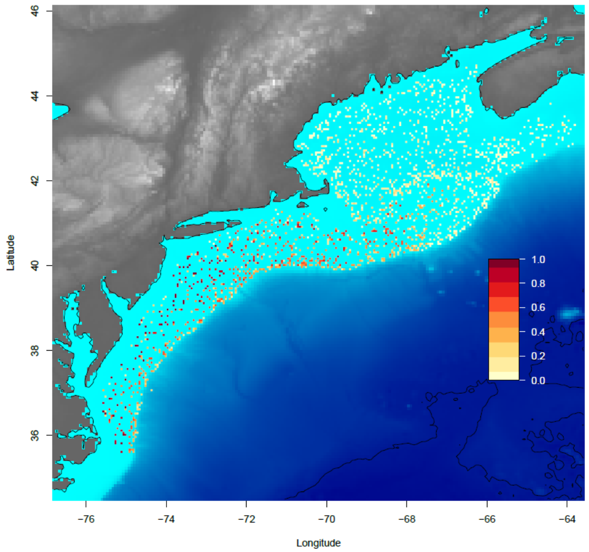
Predicted species distribution



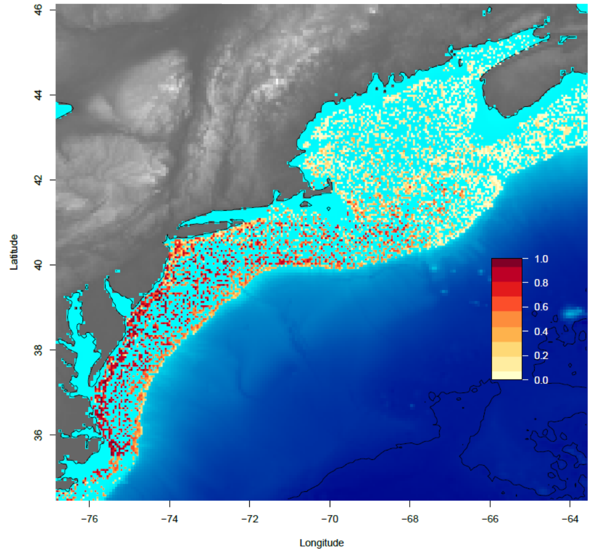


Decadal Butterfish Distributions

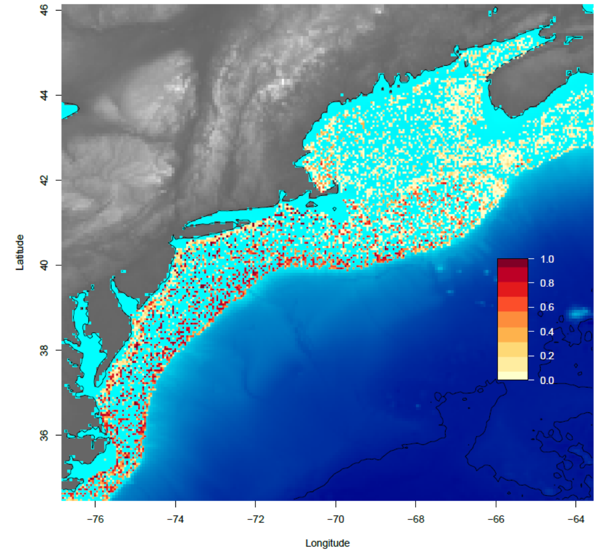
1965-1969



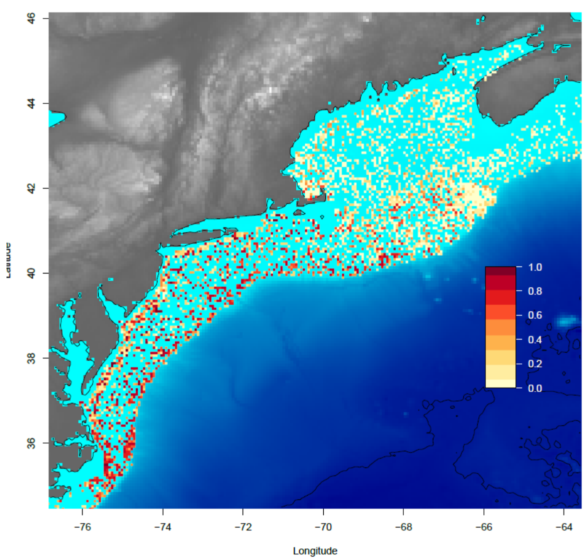
1970-1979



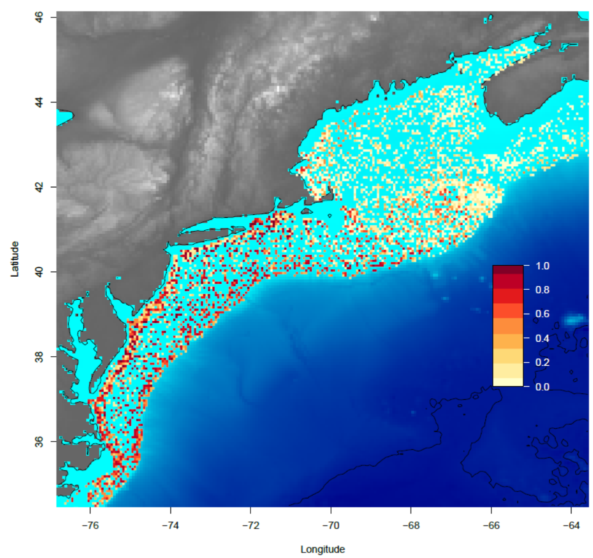
1980-1989



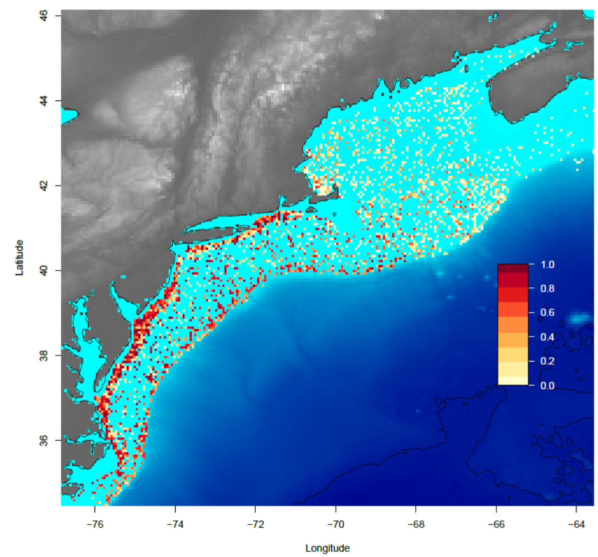
1990-1999



2000-2009



2010-2019

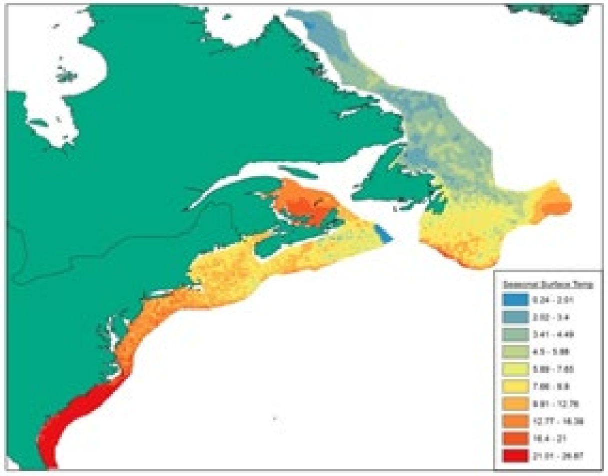


Environmental Variables

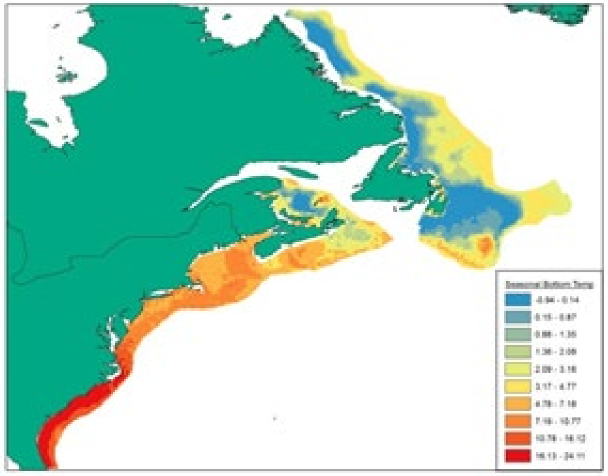
Ocean water temperature data obtained from Simple Ocean Data Assimilation

Resolution: 0.25 deg (~28 km)

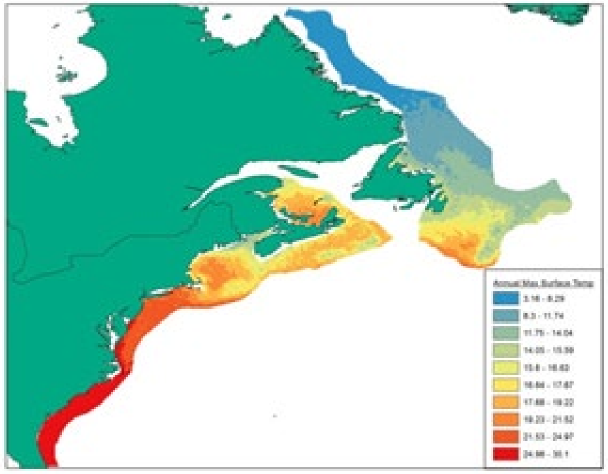
Seasonal Surface Temperature



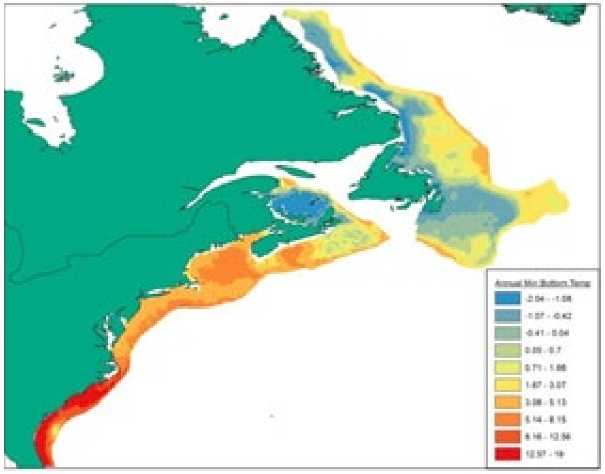
Seasonal Bottom Temperature



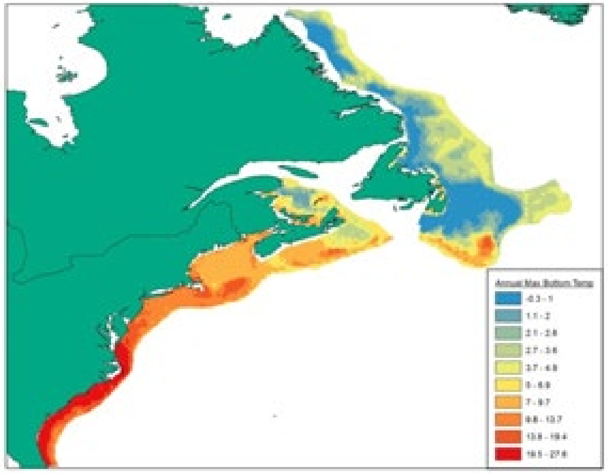
Maximum Surface Temperature



Minimum Surface Temperature



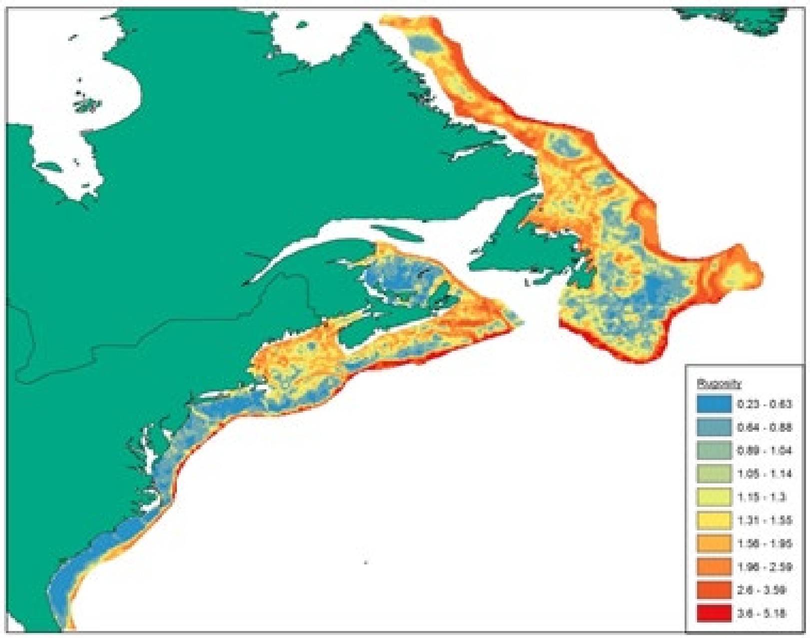
Maximum Bottom Temperature



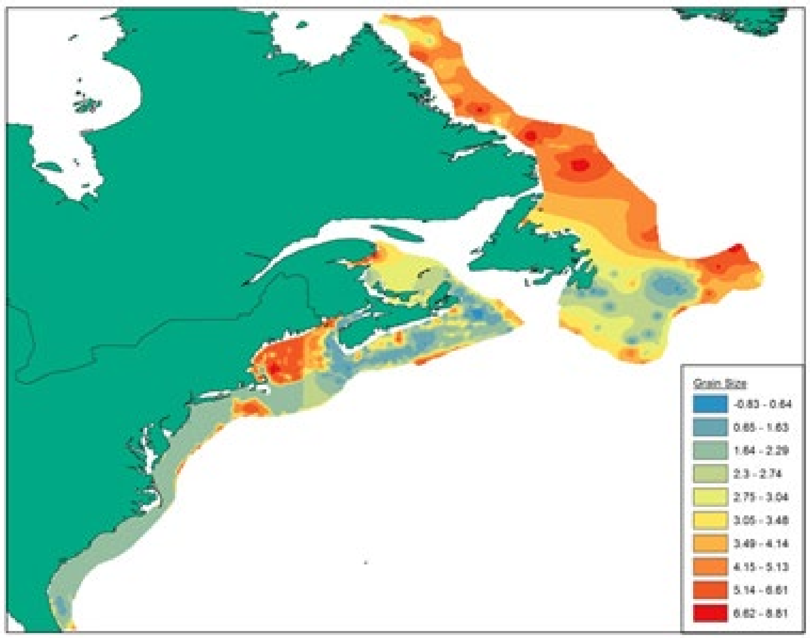
Environmental Variables cont.

Rugosity (roughness) was calculated from GEBCO gridded bathymetric dataset
Grain size from a variety of sources including CONMAP and usSEABED: adjusted to 0.25 deg resolution

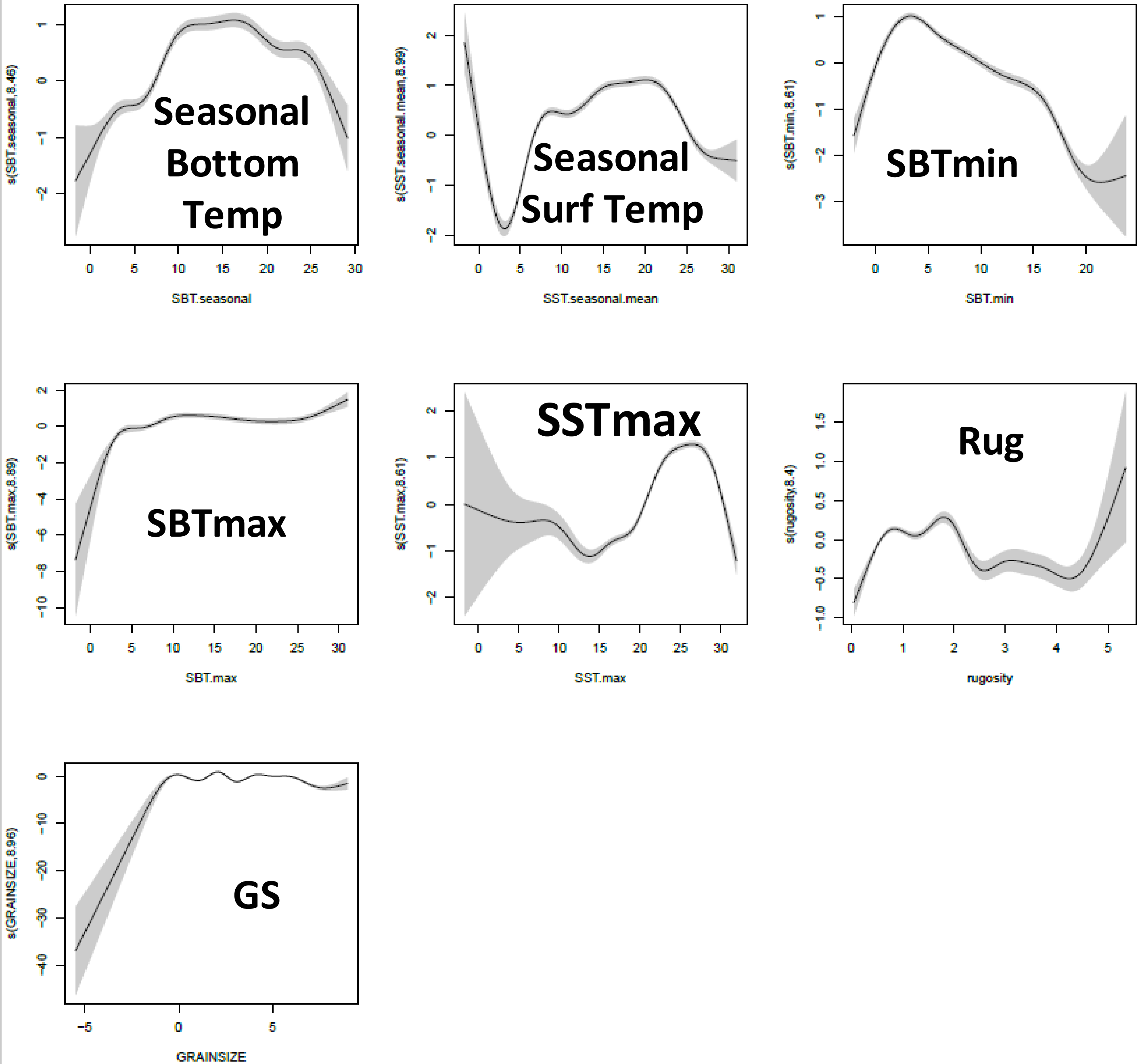
Seafloor Rugosity



Grain Size



Butterfish Variable Response Curves



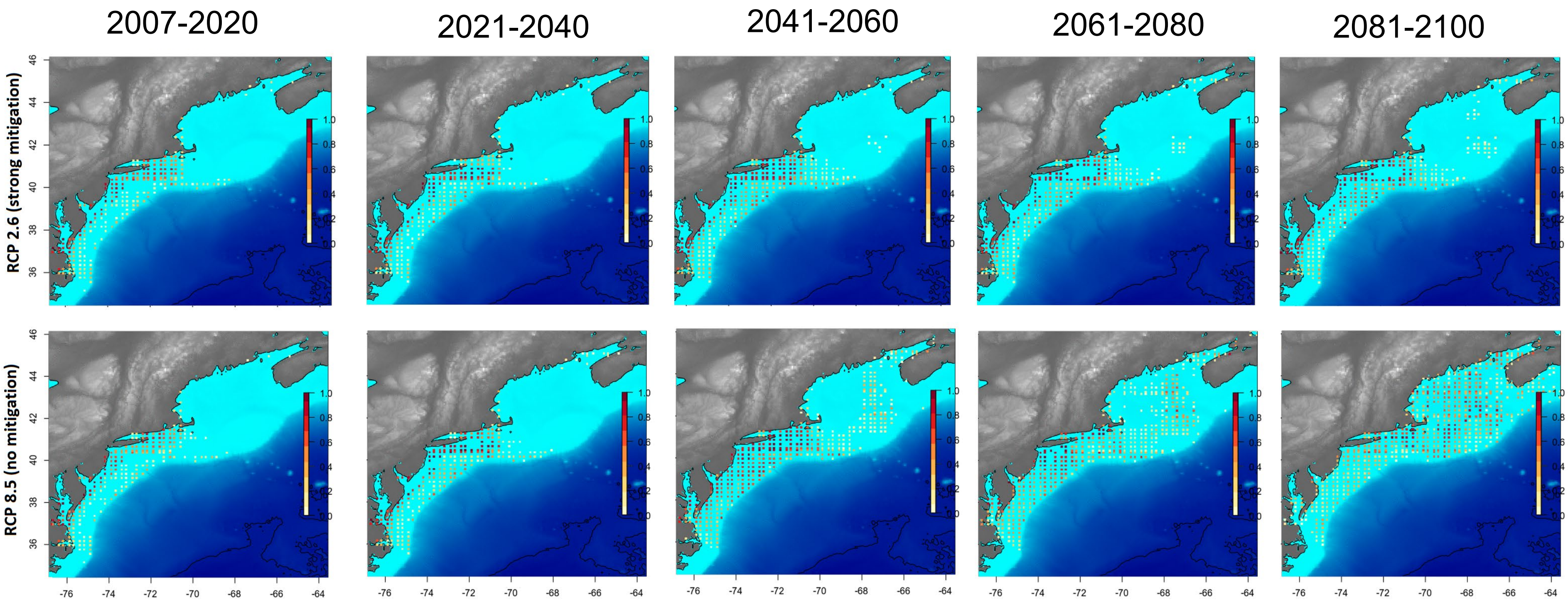
Two climate scenarios of greenhouse emission effects

RCP 2.6 – high mitigation

RCP 8.5 - business as usual

Predicted Species Distribution for Butterfish

Predictions are based on temperatures in July - September



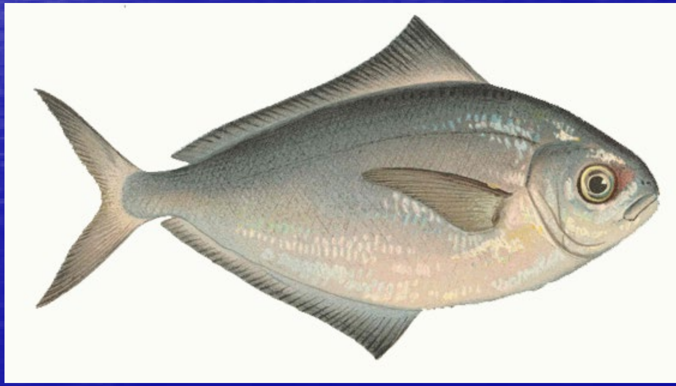
Consumptive Removals of Butterfish by Marine Mammals

Laurel Smith, Marjorie Lyssikatos and Frederick Wenzel

Additional TOR 2: Evaluate consumptive removals of butterfish by its predators, including (if possible) marine mammals, seabirds, tunas, swordfish and sharks.













Ecological Applications, 25(2), 2015, pp. 373–389

Consumption by marine mammals on the Northeast U.S. continental shelf

Laurel A. Smith,[1,3] Jason S. Link,[1] Steven X. Cadrin,[2] and Debra L. Palka[1]

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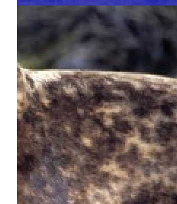
[2]*School for Marine Science and Technology, 200 Mill Road, Suite 325, Fairhaven, Massachusetts 02719 USA*

Abstract. The economic and ecological impacts of fish consumption by marine mammals, the associated interactions with commercial fish stocks, and the forage demands of these marine mammal populations are largely unknown. Consumption estimates are often either data deficient or not fully evaluated in a rigorous, quantitative manner. Although consumption estimates exist for the Northeast United States (NEUS) Large Marine Ecosystem, there is considerable uncertainty in those estimates. We examined consumption estimates for 12 marine mammal species inhabiting the regional ecosystem. We used sensitivity analyses to examine metabolically driven daily individual consumption rates, resulting in a suite of feasible parameter-pair ranges for each of three taxonomic groups: mysticetes,



School for Marine Science and Technology
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Woods Hole, MA USA

P30

	A	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
1	Harbor Seal Diet Conf 1999								Boulva and McLaren (1979); Behrends (1982); Haaker et al. (1984); Ha¨rko¨nen (1987							
2	source	980 (Gulf	Brown et a	Ferland 1999 (Cape Cod, N.			Craddock	Craddock	Pauly et al	Payne and Selzer 1989						
3	region	ska	Oregon	Cape Cod, N. GOM			GOM and s	GOM and slope		1984-1987	Race Poin	Jeremy P	Monomoy	Monomoy	Monomoy	1984-19
4	# animals						22	33								
5	Year/Season						Oct. 2004-	Oct. 2003-Sept. 2004								
6	Catch method						bycaught	bycaught								
7	primary						yes, interi	yes, interi	no							
8	unit	95% cv		% freq	%mass	% freq stra	% freq (l ca	% freq (l ca	% diet							
9																
10	herring			0.13		0.13	0.0266	0.00129					0.5	0.16		
11	Norway pout															
12	haddock						0.00213	0.00129								
13	sand eel															
14	poor cod															
15	cod			0.04	0.08	0.03	0.06277	0.01028								
16	redfish					0.03	0.12872	0.07969								
17	silver hake					0.56	0.69362	0.58548								
18	pollock						0.01064	0.00835								
19	squid					0.03						0.22				
20	red/white hake					0.12	0.03511	0.06877								
21	walleye pollock	3.9														
22	Osmeridae (capelin/s	3.4														
23	Pacific herring	2.4														
24	Pacific cod	2.3														
25	Pleuronectidae	2.2	0.116													
26	sand lance	2	0.389	0.85	0.5	0.08				0.846	0.868	0.5	0.99	0.66	0.32	0.9
27	Octopods	3.9														
28	Gonatidae squid	2														
29	shrimp	1.9														
30	winter flounder				0.32											
31	mackerel				0.09		0.00213	0.00129								
32	benthic invertebrates								0.1							
33	small squid								0.1							
34	large squid								0.05							
35	small pelagics								0.3							
36	miscellaneous fish								0.45							
37	alewife															
38	ocean pout						0.00213	0.00064								
39	butterfish						0.00745									
40	invertebrates															
41	fourbeard rockling						0.01064	0.00707								

Diet Comp_grayseal | Diet Comp_harborseal | Butterfish in Diet | Diet Items

Table 1. Proportion of butterfish in the diets of marine mammals found on the Northeast US continental shelf.

Predator	Butterfish as Proportion of Diet Composition: Min	Mean	Max
Harbor seal	0	0.00192	0.011
Gray seal	0	0.00056	0.016
Harbor porpoise	No butterfish recorded in diet		
Humpback whale	No butterfish recorded in diet		
Fin whale	No butterfish recorded in diet		
Sei whale	No butterfish recorded in diet		
Minke whale	No butterfish recorded in diet		
Right whale	No butterfish recorded in diet		
Pilot whales	No butterfish recorded in diet		
Bottlenose dolphin	No butterfish recorded in diet		
Atlantic white-sided dolphin	No butterfish recorded in diet		
Common dolphin	No butterfish recorded in diet		

Annual Consumption by Marine Mammal Species:

$$C = Y*365*Abundance*Res_{adj}$$

- Y is the daily per capita consumed biomass (Smith et al. 2015)
- 365 days in a year
- *Abundance* is the most recent population estimate of the marine mammal species (Hayes et al. 2020)
- Res_{adj} is the residency ratio including the portion of the marine mammal population occupying the Northeast US shelf, reduced by the portion of feeding that occurs outside of the region due to migration (Smith et al. 2015)

Daily per capita consumption (Kleiber 1975):

$$Y = \alpha M^{\beta}$$

- Where Y is the ingestion, M is the individual body mass of predator, and α and β are consumption parameters (Smith)

Table 2. Estimates used to calculate annual butterfish consumption by marine mammals and the ratio of butterfish consumption to butterfish catch.

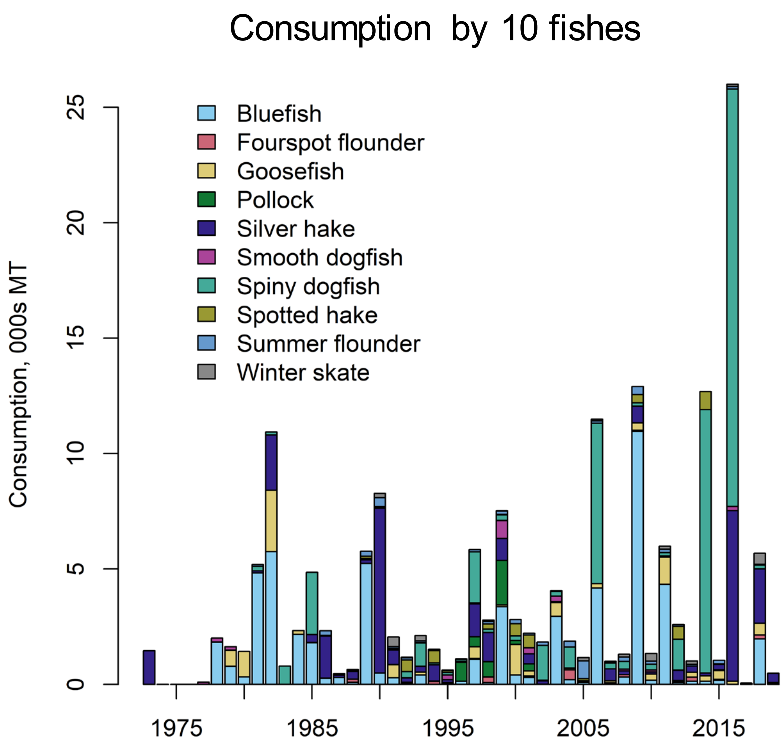
Predator	Population Estimate Year	Annual Consumption (mt)	Mean Proportion of Butterfish in Diet	Annual Butterfish Consumption (mt)	Annual Butterfish Catch during MM Assessment Year
Harbor seal	2012	83,038	0.00192	159.1	1636
Gray seal	2016	59,417	0.00056	33.1	2731

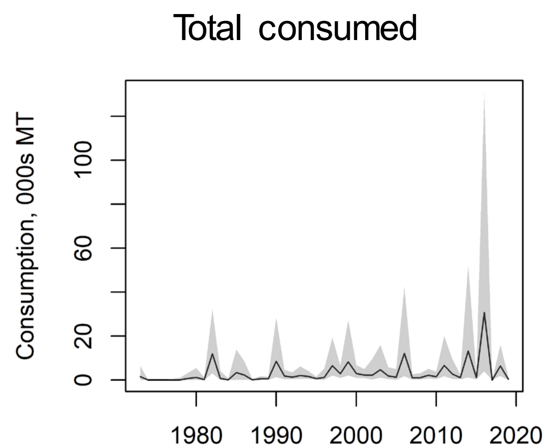
	Annual Butterfish Consumption by Marine Mammals (mt)	Ratio of Butterfish Consumption by Marine Mammals to Annual Catch
Total	192.2	0.088

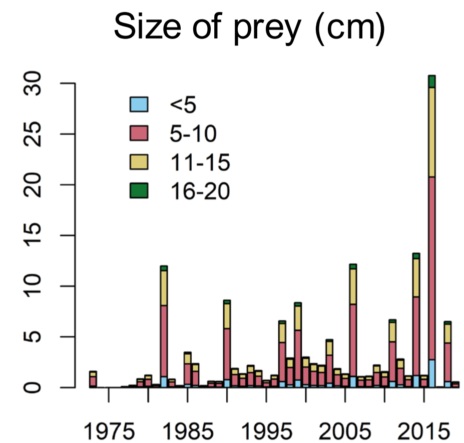
Conclusions:

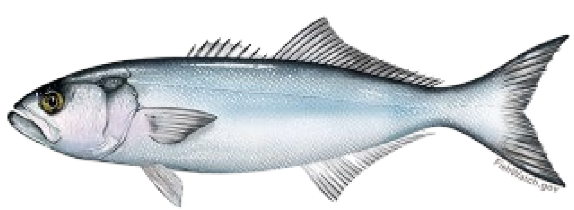
- Butterfish were 0.06-0.2% of gray and harbor seal diets
- ~190 mt of butterfish removals due to marine mammal predation per year
- ~9% of annual butterfish catch, ~0.09% butterfish *M* (2015)
- Possibly low estimate due to fast digestion, but butterfish not seen in fatty acid analysis (Beck et al. 2007)

Additional TOR 2: Evaluate consumptive removals of butterfish by fishes.









- Primary predators: bluefish, spiny dogfish, and silver hake.
- Variable predation: 0 to 30,000 MT, time series mean of 3,327 MT year^{-1}; relatively low compared to other forage fishes.
- Consumed butterfish were mostly 5-10 cm.
- Consumption estimated with evacuation rate models and scaled to fish community level (see working paper by Brian Smith).

Seabird Predation on Butterfish in the Gulf of Maine Region

A summary of available information

Rob Vincent MIT SEA GRANT COLLEGE PROGRAM
NOAA Butterfish Research Track Working Group Review Meeting
March 7, 2022

Four Sources of Information:

Represents current and long-term monitoring efforts in the Northeast

1. U.S. Fish and Wildlife Service and National Audubon Society Joint Seabird Restoration Program in the Gulf of Maine 30-year collaboration

2. Cornell Lab of Ornithology 2015-present

3. University of New Hampshire, Isle of Shoals Laboratory 1999-present

4. Atlantic Laboratory for Avian Research, University of New Brunswick 1995-2017

Seabird Predators

- The primary focus of these groups is to assess diet and success rates for nesting seabird populations over time
- These studies focused primarily on two types of nesting bird groups that nest on islands in the Gulf of Maine and Long Island Sound areas:
  - **Terns** (common, arctic, least, and roseate)
  - **<u>Alcids</u>** (razorbills, and Atlantic puffins),

Monitoring Methods

- **Visual observation** of nest feeding and discard
  - Provides estimate of predation, discard, size, proportion of diet, and mortality

- **DNA analysis** of chick fecal matter
  - Provides estimate of actual consumption
  - Estimates proportion of consumed diet contribution
  - Underestimates total predation and mortality (i.e., does not account for non-consumed butterfish discarded at the nest)

- Nest observations combined with fecal DNA analysis provides a more complete estimate of overall predation and mortality

Conclusions

1. Seabird predation on butterfish is occurring in the northeast region

2. Seabird predation on butterfish in the northeast region is minimal relative to the overall butterfish population and is not a large impact on butterfish population mortality

3. Butterfish predation appears to fluctuate over time and location with generally low contribution to seabird diet in Gulf of Maine seabird nest sites

4. Butterfish is generally too large for chicks to swallow, so the fish are mostly discarded at the nest (average size fed to chicks <10cm in length, but shape prohibits swallowing)

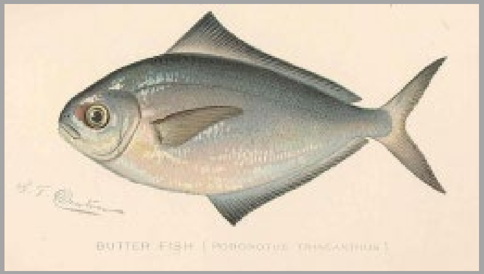
5. Seabird predation on butterfish has increased in recent years due to reduced availability of preferred higher quality prey species (i.e., Atlantic herring and silver hake)

Questions?

Rob Vincent, rvincent@mit.edu

MIT SEA GRANT
COLLEGE PROGRAM

Photos: Beckley Stearns



Butterfish Condition and Environmental Drivers

Butterfish Research Track Stock Assessment
March 7-11th, 2022

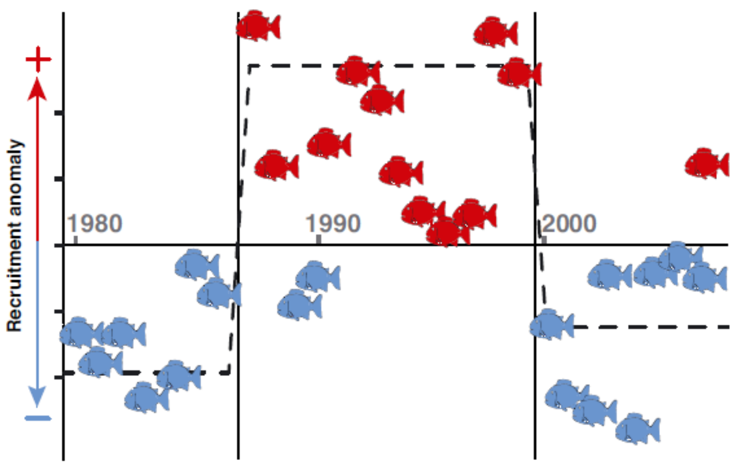
Laurel Smith

Additional TOR 1: 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.

Regime Shifts

Perretti et al. 2017

- Possible links in system from copepods to fish recruitment



Recruitment success regimes of fish on the Northeast US Continental Shelf.

Graphic: C. Perretti and S. Schüller

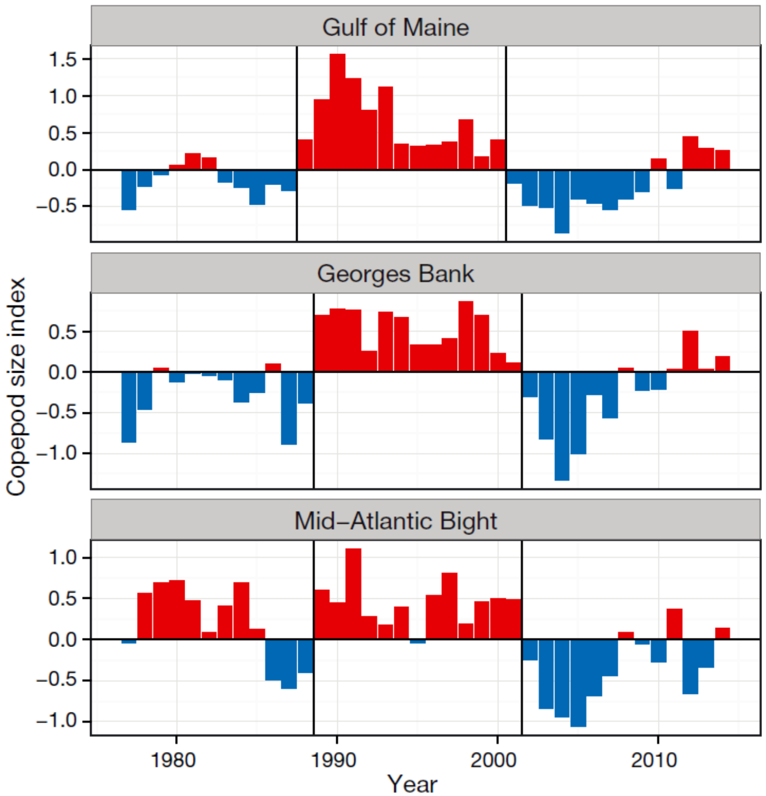
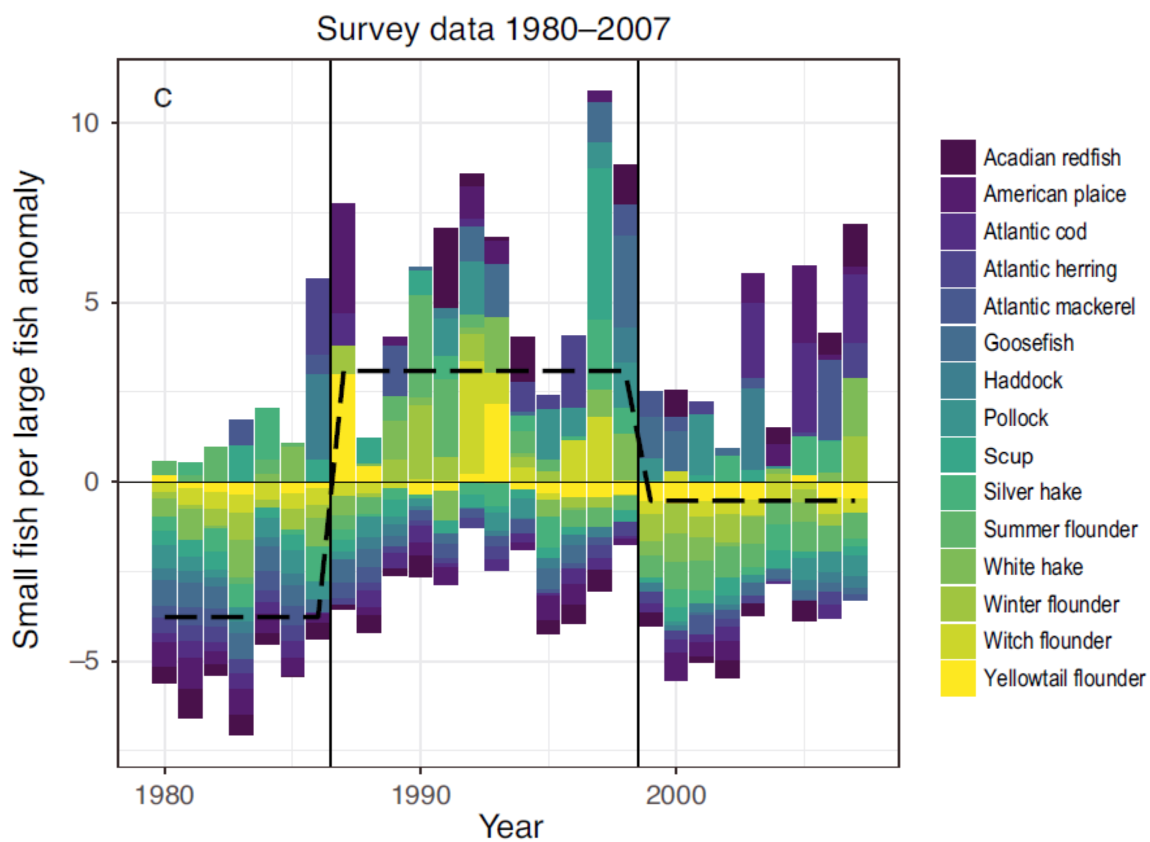


Fig. 4. Copepod size index (small copepod anomaly – large copepod anomaly) time series. Each bar represents the average annual anomaly, and vertical lines denote regime change points

Regime Shifts

Perretti et al. 2017

- Butterfish not included in recruitment analyses



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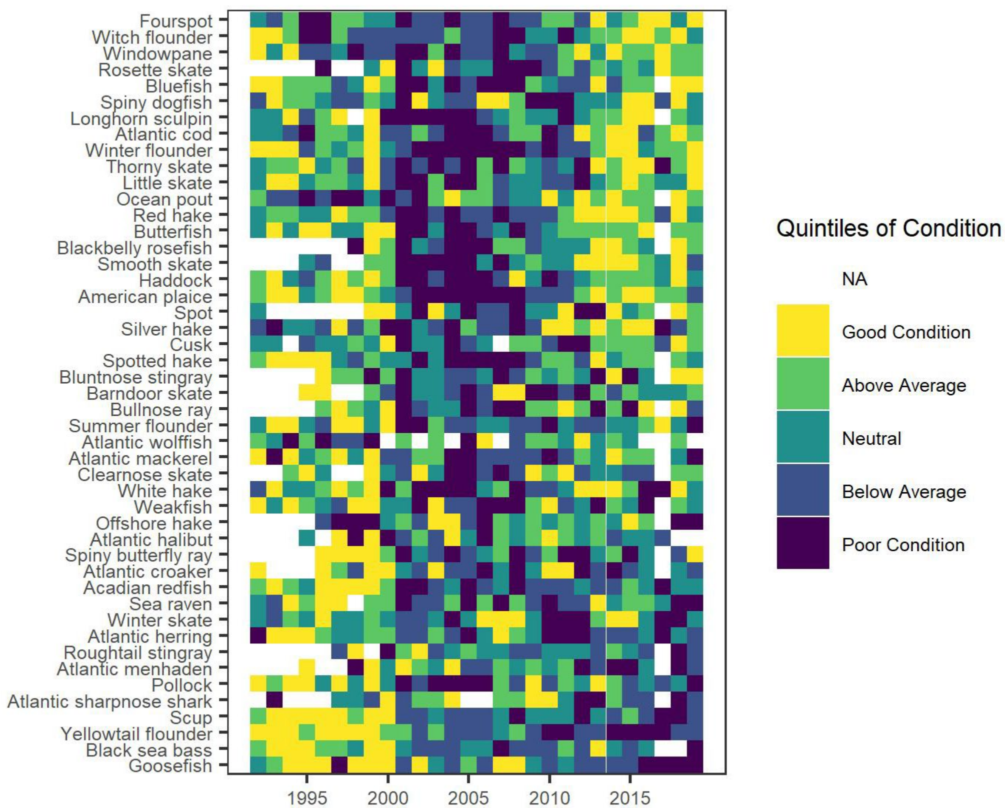
Fish Condition



Relative Condition (Kn)
from LeCren (1951)

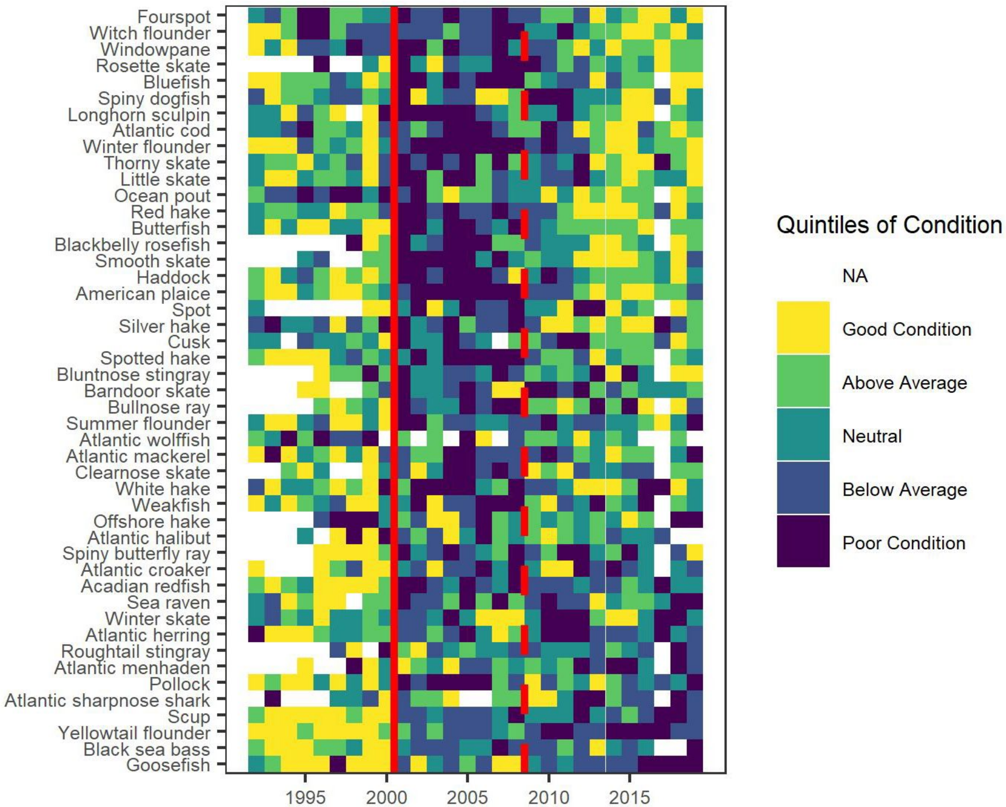
$$Kn = (W/W')$$

W = weight of an individual fish

W' = predicted length-specific mean weight for the fish in a given region (Wigley et al. 2003)

- Fall NEFSC bottom trawl data by species, strata

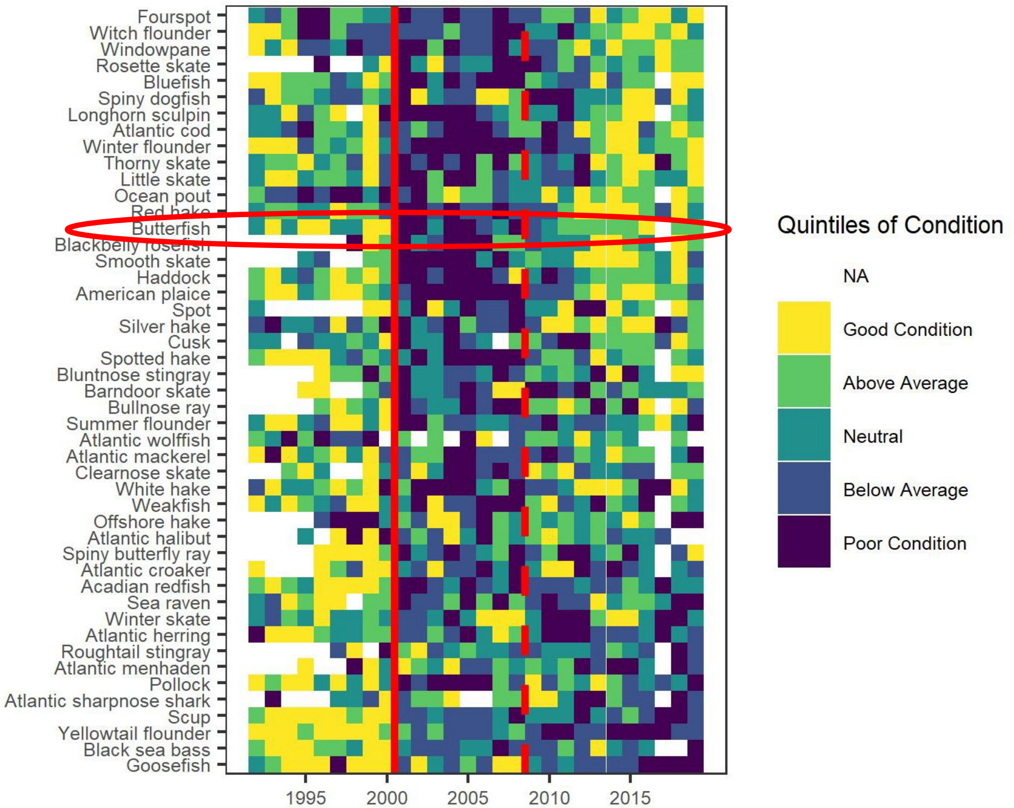
Fish Condition



Regime Shift(s)

- Chronological clustering using multivariate regression trees in rpart package in R
- Found same split in 2000 as Perretti et al. (2017): high condition/recruitment in 1990s, low condition/ recruitment in 2000s
- Less significant split in 2008 where some species are improving condition

Fish Condition



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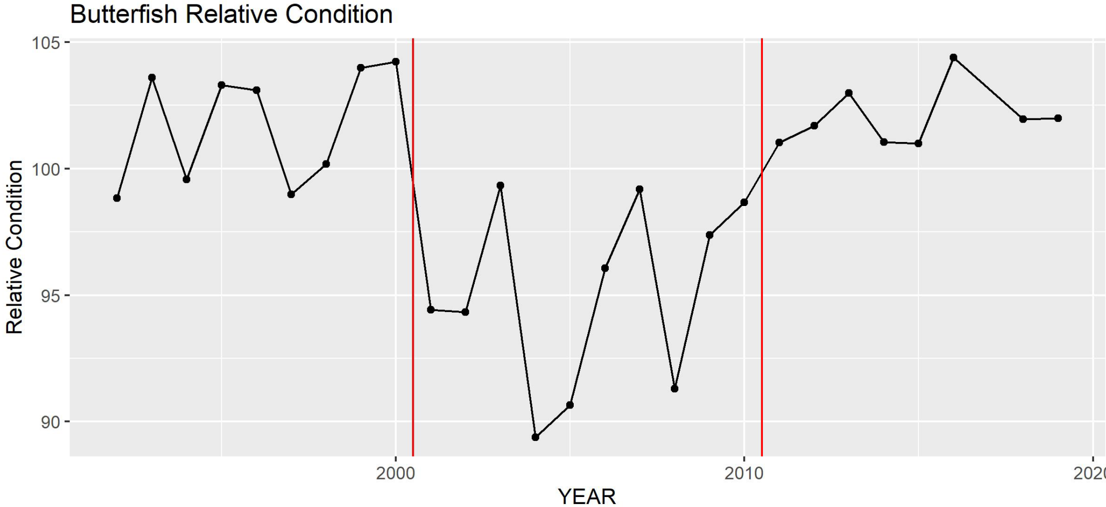
Butterfish Condition



Butterfish Regime Shifts

- Same split after 2000: high condition/recruitment in 1990s, low condition/ recruitment in 2000s
- Significant split after 2010: higher condition

Fish Condition Project

GAMs by Species (mgcv in R)

Kn ~ s(Local Environment)
+ s(Local Density)
+ s(Broad Environment)
+ s(Resource Quality)
+ s(Resource Availability)
+ s(Temporal Dependence)
+ s(Spatial Dependence)

Environmental Predictors

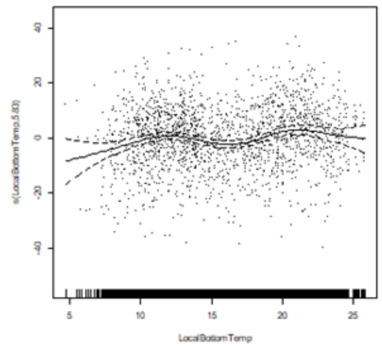
Local Environment

- Local bottom temperature by strata

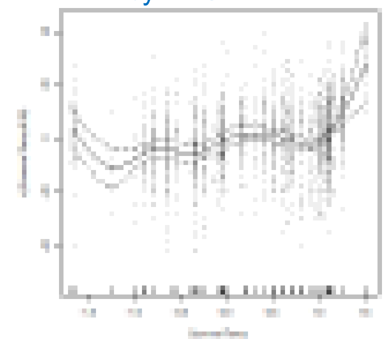
Broad Environment

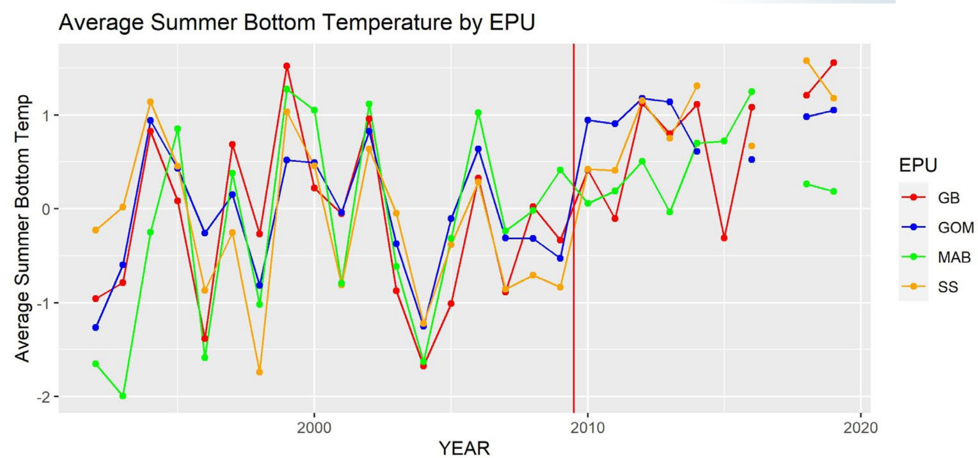
- Summer bottom temperature anomaly by EPU
- Possible improvements in condition with increasing temperatures
- Significant change point after 2009

Butterfish:
Local bottom temperature



Butterfish:
Summer temperature by EPU

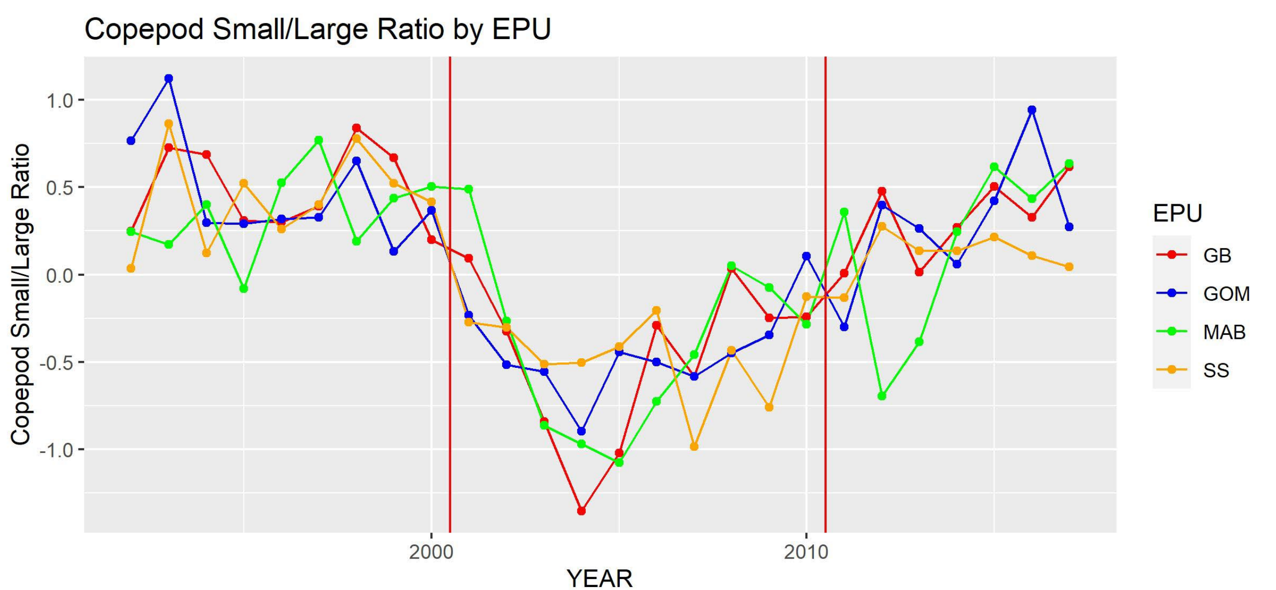




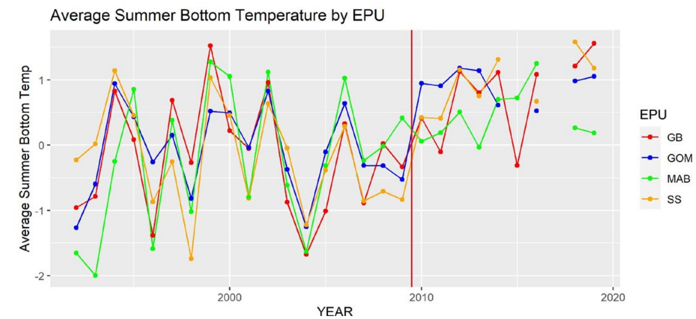
Environmental Predictors

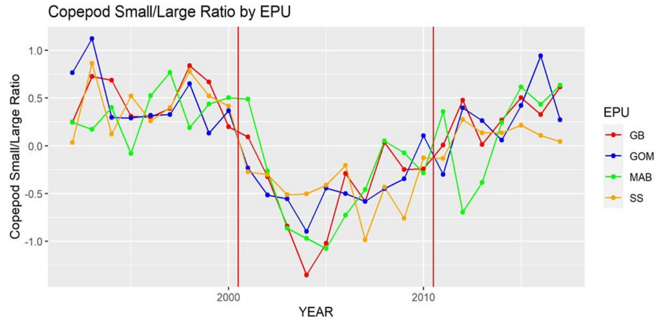
Resource Quality

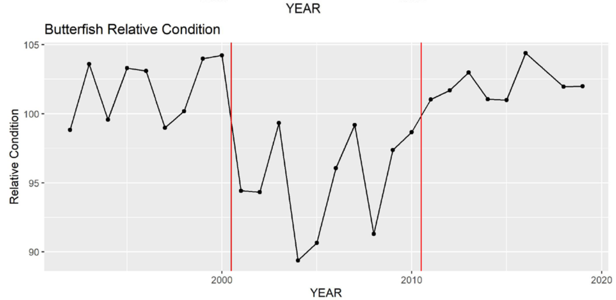
- Copepod small-large anomaly by EPU



Ecosystem Context: Butterfish Recruitment







Regime Shifts

- 2010 summer bottom water temperature increased
- 2011 copepod size structure shifted to small copepods
- 2011 butterfish condition improved

Ecosystem Considerations for Determining Recruitment Stanza

- 2011-2019 used as recruitment stanza for projections
- $F_{50\%}$ SPR and $B_{50\%}$ SPR

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Questions?