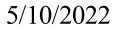


# Butterfish Environmental Drivers, Consumptive Removals and Condition

Laurel Smith<sup>1</sup>, Tori Kentner<sup>1,2</sup>, Brian Smith<sup>1</sup> and Robert Vincent<sup>3</sup>

<sup>1</sup>NOAA NMFS Northeast Fisheries Science Center <sup>2</sup>Mid-Atlantic & New England Fishery Management Councils <sup>3</sup>MIT Sea Grant



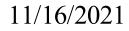


SHERIES

# Butterfish Historic Distributions & Climate Predictions

Tori Kentner

NOAA NMFS Northeast Fisheries Science Center Mid-Atlantic & New England Fishery Management Councils



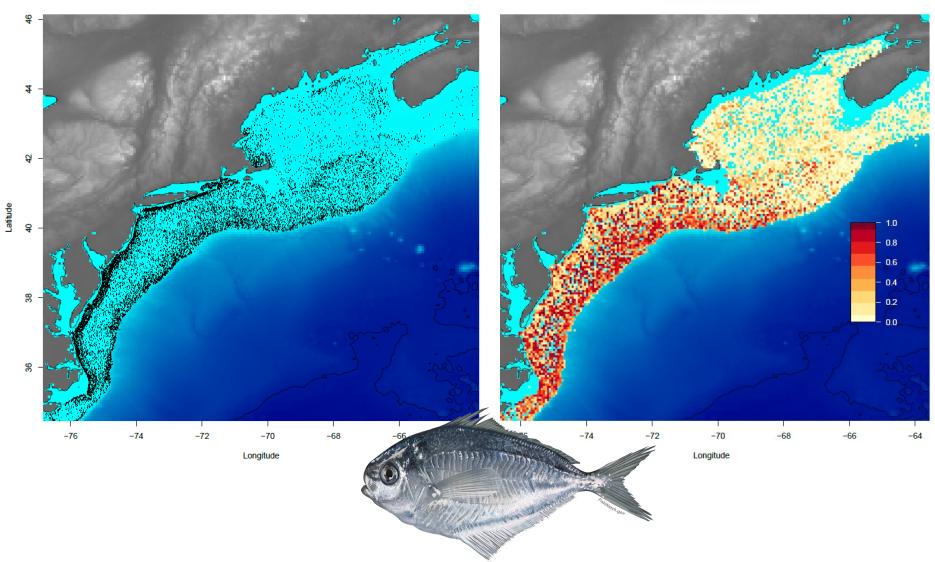
Northeast Regional Habitat Assessment: **To describe and characterize estuarine, coastal, and offshore fish** habitat distribution, abundance, and quality in the Northeast.

#### **Historical Catch Locations**

All catch for peprilus triacanthus

#### Predicted species distribution

butterfish 1965-2019



#### **Decadal Butterfish Distributions**

1965-1969

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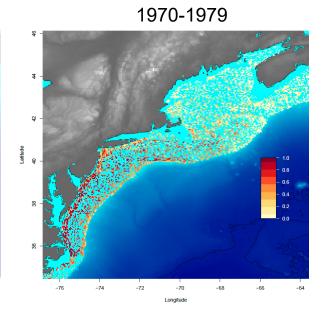
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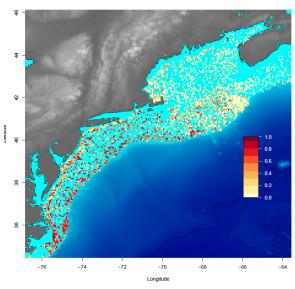
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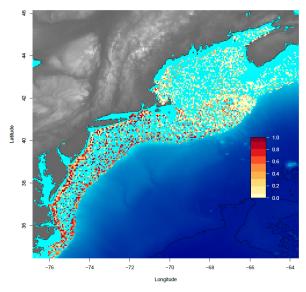


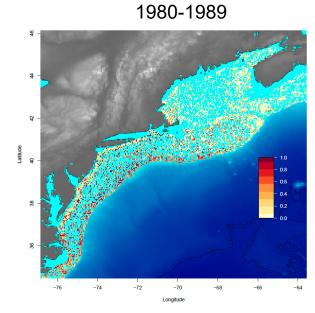
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Longitude

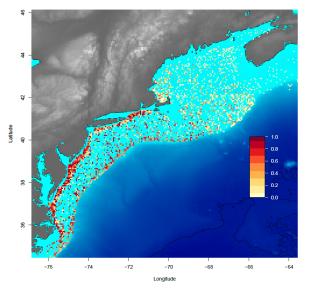


2000-2009





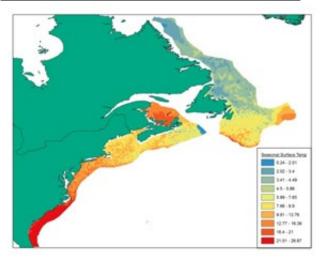
2010-2019



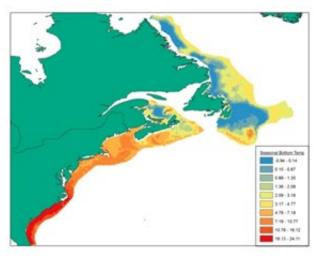
### **Environmental Variables**

Ocean water temperature data obtained from Simple Ocean Data Assimilation Resolution: 0.25 deg (~28 km)

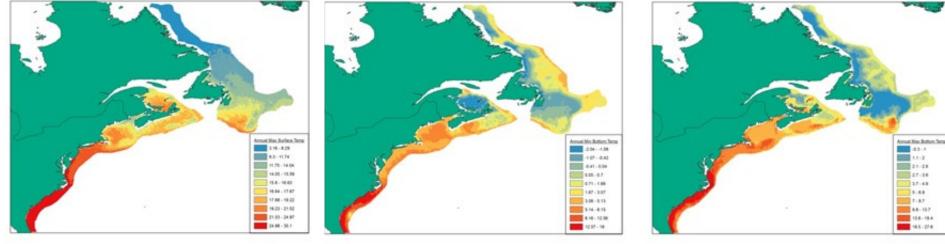
Seasonal Surface Temperature



Seasonal Bottom Temperature

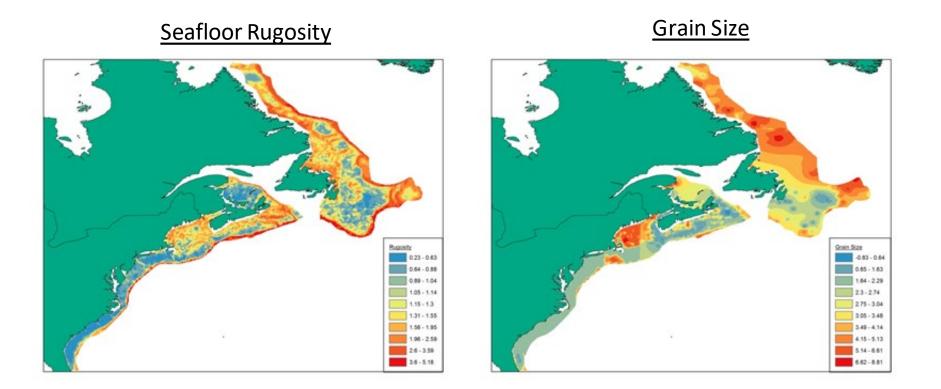


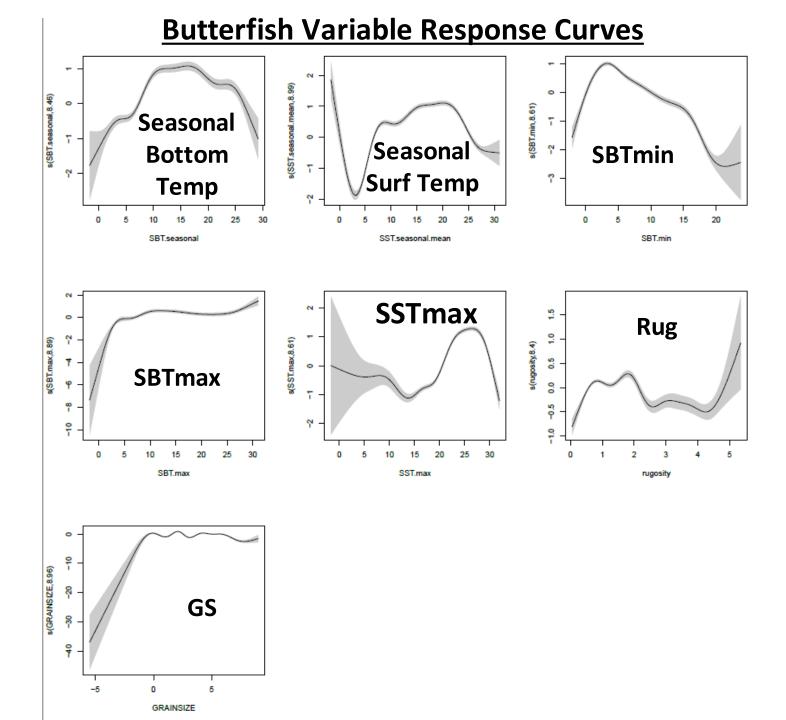
Maximum Surface Temperature Minimum Surface Temperature Maximum Bottom Temperature



### 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





# <u>Two climate scenarios of</u> <u>greenhouse emission effects</u>

### RCP 2.6 – high mitigation

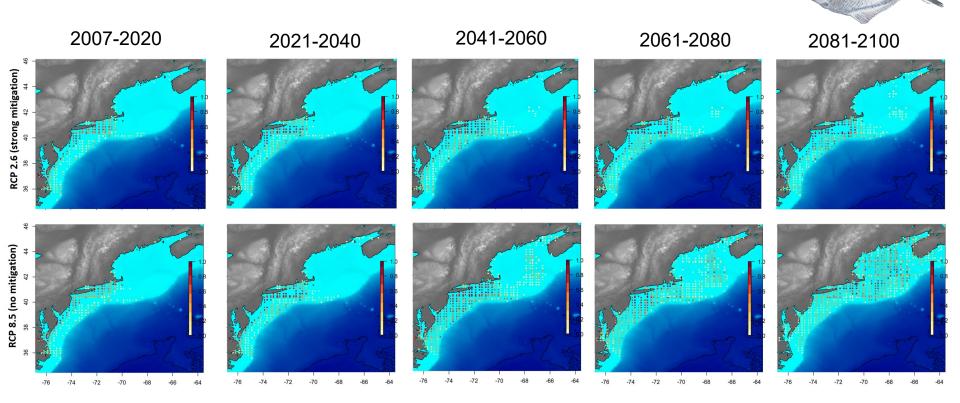


### RCP 8.5 - business as usual



### 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.









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

LAUREL A. SMITH,<sup>1,3</sup> JASON S. LINK,<sup>1</sup> STEVEN X. CADRIN,<sup>2</sup> AND DEBRA L. PALKA<sup>1</sup>

<sup>1</sup>NOAA/Northeast Fisheries Science Center, 166 Water Street, Woods Hole, Massachusetts 02540 USA <sup>2</sup>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 Fairhaven, MA USA



<sup>2</sup>NOAA/Northeast Fisheries Science Center Woods Hole, MA USA



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| Norway pout     |  |  |   |  
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| poor cod        |  |  |   |  
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| cod             |  |  | 0.04  | 0.08   
   | 0.03  
   | 0.06277   | 0.01028   
   
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| redfish         |  |  |   |  
   | 0.03  
   | 0.12872   | 0.07969   
   
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| silver hake     |  |  |   |  
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   | 0.69362   | 0.58548   
   
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| pollock         |  |  |   |  
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| red/white hake  |  |  |   |  
   | 0.12  
   | 0.03511   | 0.06877   
   
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| walleye pollock |  |  |   |  
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| Pleuronectidae  |  |  |   |  
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   | 0.08  
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| ocean pout      |  |  |   |  
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0.00745

Diet Comp\_harborseal

0.01064 0.00707

39 butterfish 40 invertebrates

41 fourbeard rockling ....

Diet Comp\_grayseal

Butterfish in Diet

Diet Items

 $\oplus$ 

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

#### Predator

Harbor seal Gray seal Harbor porpoise Humpback whale Fin whale Sei whale Minke whale Right whale Pilot whales Bottlenose dolphin Atlantic white-sided dolphin Common dolphin

### Butterfish as Proportion of Diet Composition:

Min	Mean	Max
0	0.00192	0.011
0	0.00056	0.016

No butterfish recorded in diet 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<sub>adj</sub> 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.

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

Total





AnnualRatio ofButterfishButterfishConsumption by<br/>MarineConsumption by<br/>Marine MammalsMammals (mt)to Annual Catch192.20.088

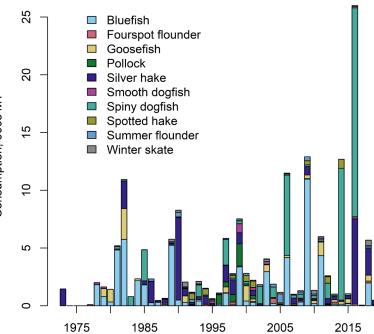
### **Conclusions:**

Butterfish were 0.06-0.2% of gray and harbor seal diets

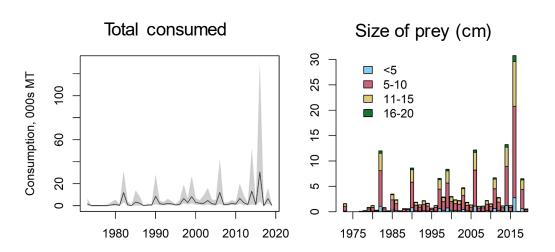
- ~190 mt of butterfish removals due to marine mammal predation per year
- ~9% of annual butterfish catch, ~0.09% butterfish M (2015)
- Possibly low estimate due to fast digestion, but butterfish not seen in fatty acid analysis (Beck et al. 2007)

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

Consumption by 10 fishes







- Primary predators: bluefish, spiny dogfish, and silver hake.
- Variable predation: 0 to 30,000 MT, time series mean of 3,327 MT year<sup>-1</sup>; 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

- 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**

- **<u>Visual observation</u>** 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, <u>rvincent@mit.edu</u>

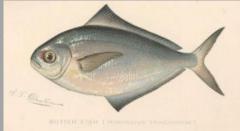






Photos: Beckley Stearns





### Butterfish Condition and Environmental Drivers

Butterfish Research Track Stock Assessment March 7-11<sup>th</sup>, 2022

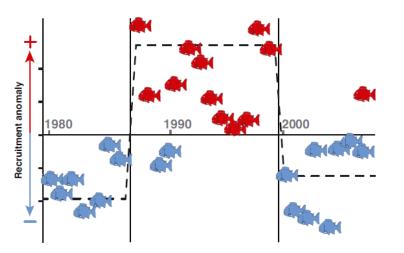
Laurel Smith

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.



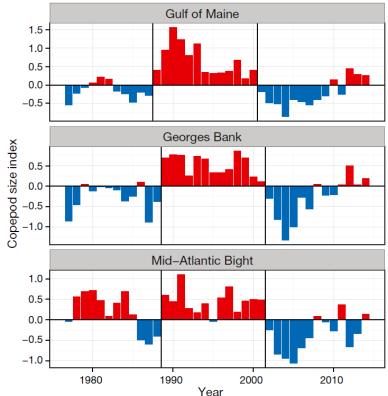


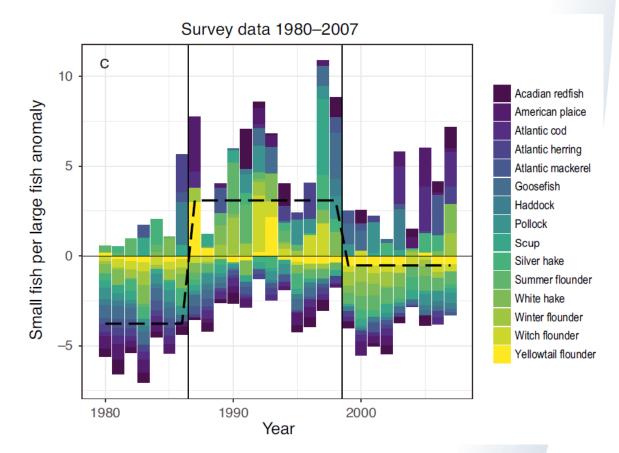
Fig. 4. Copepod size index (small copepod anomaly – large copepod anomaly) time series. Each bar represents the average annual anomaly, and vertical lines denote regime change points



# **Regime Shifts**

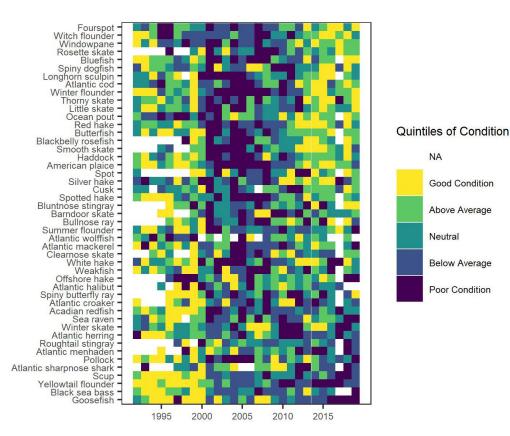
Perretti et al. 2017

 Butterfish not included in recruitment analyses





### **Fish Condition**



NA

Good Condition

Above Average

**Below Average** 

Poor Condition

Neutral

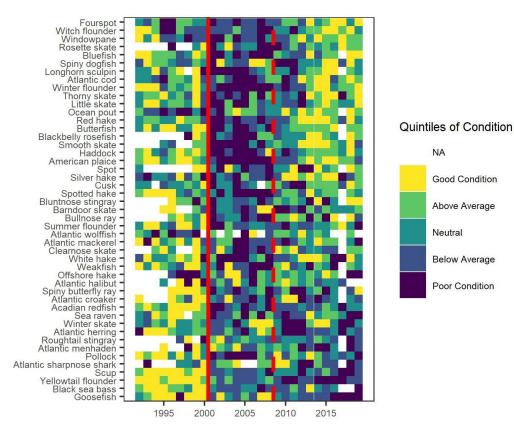
**Relative Condition (Kn)** from LeCren (1951)

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







#### **Regime Shift(s)**

NA

Good Condition

Above Average

**Below Average** 

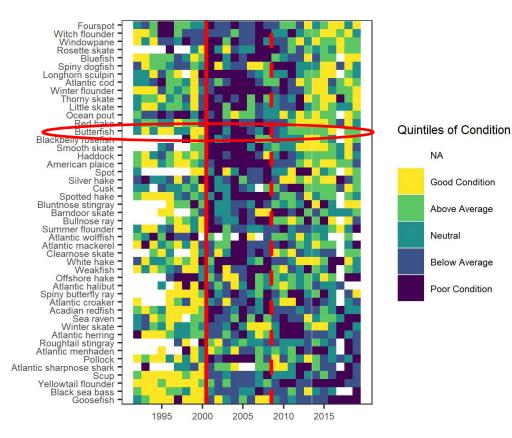
Poor Condition

Neutral

- 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**



#### **Regime Shift(s)**

NA

Good Condition

Above Average

**Below Average** 

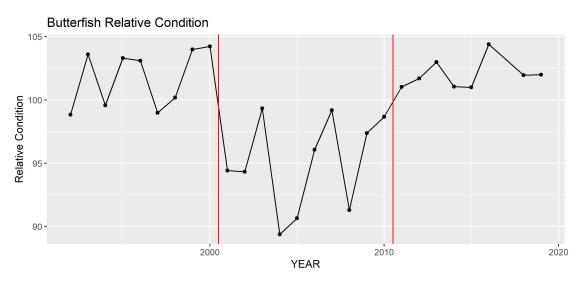
Poor Condition

Neutral

- 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 2009 where some species are improving condition



# **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

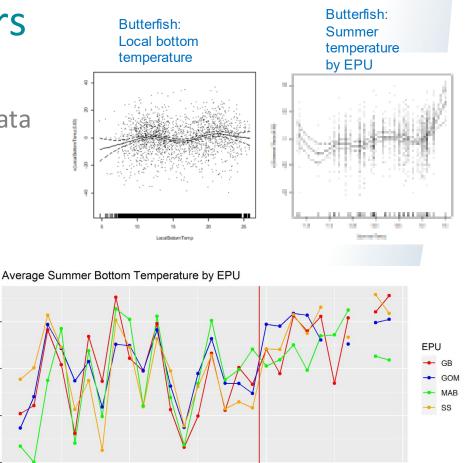
• Local bottom temperature by strata

#### **Broad Environment**

• Summer bottom temperature anomaly by EPU

Average Summer Bottom Temp

- Possible improvements in condition with increasing temperatures
- Significant change point after 2009



2010

YEAR

2000

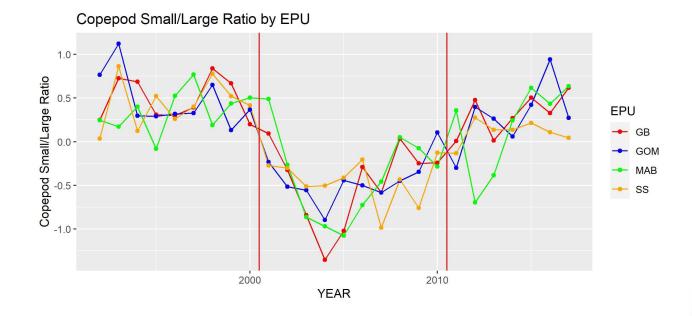


2020

# **Environmental Predictors**

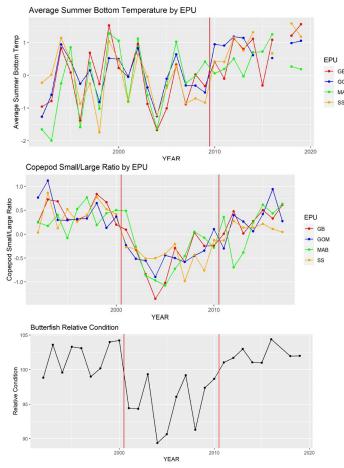
#### **Resource Quality**

• 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<sub>50%</sub> SPR and B<sub>50%</sub> SPR



### **Questions?**

