Forage indicators and consumption profiles for Chesapeake Bay fishes

Andre Buchheister

Ed Houde

Carlos Lozano

Presentation to Fisheries GIT

Dec 14, 2015

University of Maryland
CENTER FOR ENVIRONMENTAL SCIENCE
CHESAPEAKE BIOLOGICAL LABORATORY

Outline

- Background & Objectives
- Result Highlights
- Discussion
  - Important findings
  - Main conclusions
    - Long-term, correlated shifts in prey abundances
    - Decline in total predatory demand from 2002-2014
    - Suite of forage indicators recommended
  - Utility for managers
    - Basic information that was requested
    - Help prioritize prey groups
    - Foundation for future forage targets
    - Identify some challenges
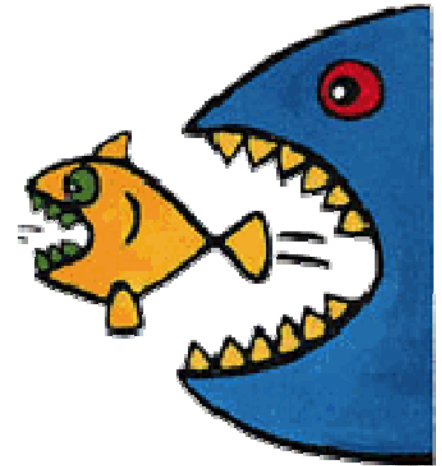
2014 CBP Watershed Agreement & Forage Workshop

Includes invertebrates

- Forage fish outcome:
  - "By 2016, develop a strategy for assessing the forage fish base available as food for predatory species in the Chesapeake Bay."

- Priority research needs from Forage Workshop (Nov 2014)
  - Coordinated analysis of currently available data to develop forage metrics
  - Development of a suite of indicators useful for decision-making
  - Increased shallow water monitoring of forage and habitats

Ihde et al. 2015

Project Objectives

1. Develop a suite of forage indicators of key prey species in Ches. Bay
   - Track status of 14 forage groups through time

2. Evaluate population-scale consumption by six dominant predatory fishes
   - Identify temporal changes (2002-2014)
   - Compare relative importance of prey
   - Compare effects of different predators

Objective 1. Develop forage indicators

	Forage indicators	Description/justification	Methodology	
1.	Relative prey abundance or biomass	• Synthesis of survey-based indices • Metric of prey standing stock	<u>Indices</u>: geometric mean or delta-GLM <u>Pooled indices</u>: hierarchical analysis[1]	
2.	Diet-based indices	• Predators as prey "samplers". • Index of relative prey importance and availability from diets. • Good for poorly sampled prey.	Delta-GAMM[2]	**"Case Study" with ChesMMAP Data**
3.	Prey-predator ratios (PPR)	• Ratio of prey to predator indices. • Index of relative prey availability. • Accounting for density dependence.	$\dfrac{\text{Prey Index}}{\text{Predator Index}}$	
4.	Consumption-prey ratios (CPR)	• Ratio of population-scaled consumption to prey index. • Index of predation intensity.	$\dfrac{\text{Consumption Index}}{\text{Prey Index}}$	

[1]Conn 2010, [2]Buchheister and Latour In Press

Summary of indices and data sources

Benthic Inverts

Pelagic Fishes

Demersal Fishes

Index type		Survey	Location	Fishes								Crust.			Other			No. Years
				bay anchovy	menhaden, YOY	weakfish, YOY	spot, YOY	croaker, YOY	alewife	blueback	silverside	mysids	mantis	sand shrimp	polychaetes	bivalves	Macoma	
1. Abundance	1	MDDNR Seine	MD Tribs	X	X		X		X	X	X							60
	2	MDDNR Sum. Trawl	MD Tribs, bays		X					X								38
	3	VIMS Juv Trawl	VA Tribs, mainstem	X	X	X	X	X										26
	4	VIMS Seine	VA Tribs	X	X		X											48
	5	CBP Benthos	Tribs, mainstem												X	X	X	27
	6	TIES/CHESFIMS	Mainstem	X	X	X	X	X	X	X	X							13
2. Diet-based		ChesMMAP	Mainstem	X								X	X	X	X	X		13
3. Prey-Predator		ChesMMAP	Mainstem			X	X	X										13
4. Consumption		ChesMMAP	Mainstem			X	X	X										13

Example of Abundance Indicator Calculation

Survey Index — Species Index — Prey Group Index

Survey 1, Survey 2, Survey 3 → Anchovy, Menhaden → Pelagic Forage Fish

Conn method   *Biomass weighting*
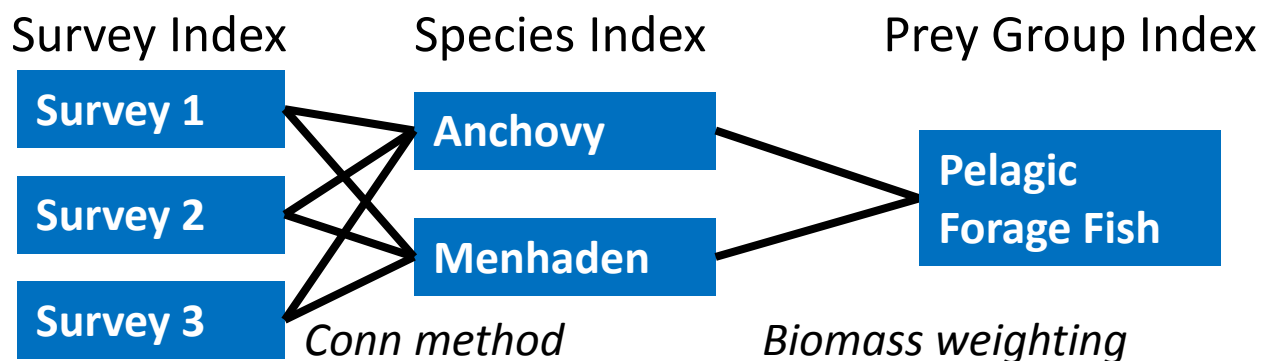
Objective 2 – Develop consumption profile

- Calculate annual, bay-wide consumption of 10 key prey by 6 dominant predators

Key Predators
(~80% of CM catch[1])

Piscivores	Benthivores
Striped bass	Atlantic croaker
Summer flounder	White perch
Weakfish	Spot

Prey
- Polychaete
- Bivalve
- Other
- Crustacean
- Mysid
- Weakfish
- Spot
- Croaker
- Menhaden
- Anchovy
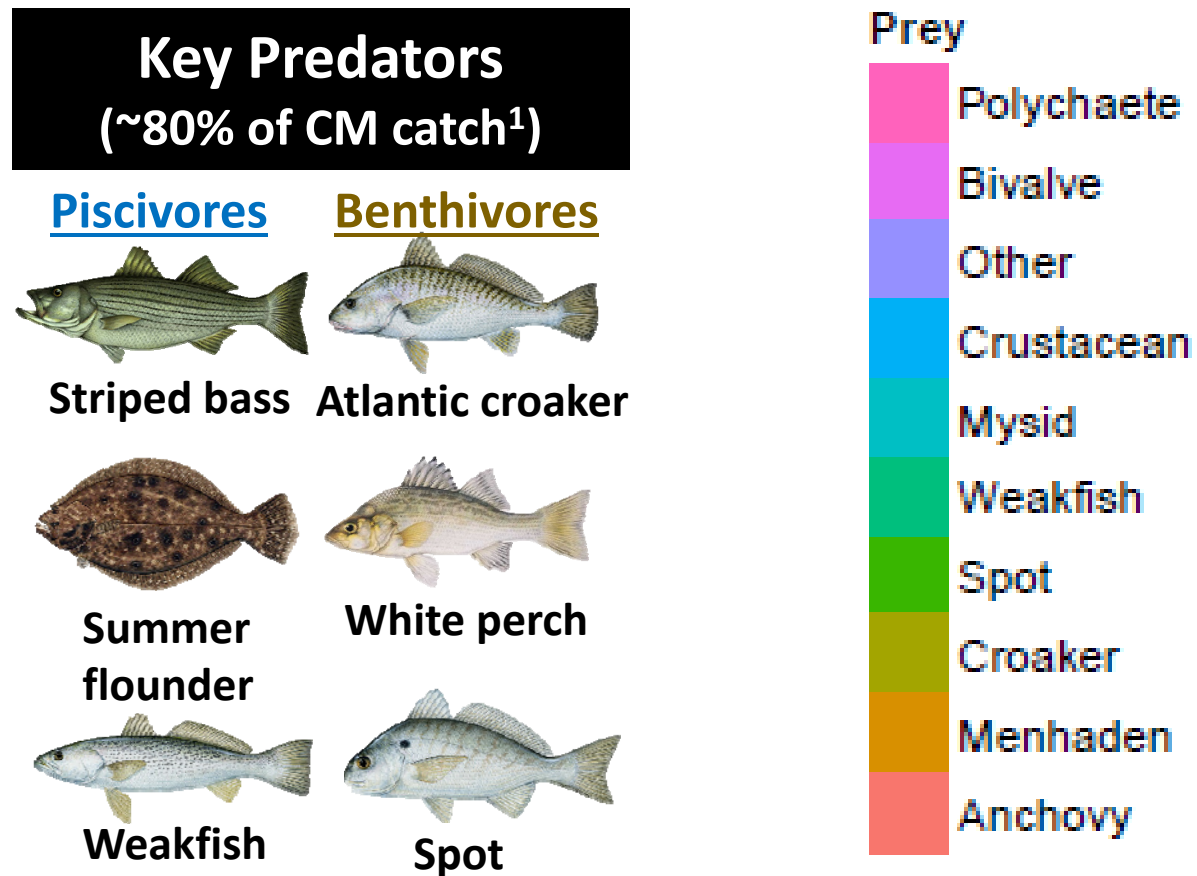
[1]Buchheister et al. 2013

Objective 2 – Develop consumption profile*

Annual consumption by predator (C)

$$= \sum_{Size} \sum_{time} \text{Per capita, daily consumption (c)} \times \text{Predator abundance (N)} \times \text{Time period (t)} \times \text{Diet proportion (D)}$$

Evacuation rate model
Data inputs:
- Avg. stom. contents
- Water temp.

Area-swept estimates
– No efficiency, selectivity
– Conservative estimates

6-month seasons
Index (higher abund.)
Non-Index

Gut contents

Predator-specific size classes

S: <30 cm

M: 30-50 cm

L: >50 cm

Approach accounts for:
- Predator size
- Diet shifts
- "Seasons" (e.g., migration)
- Temperature

E.g., Link and Sosebee 2008, Overholtz and Link 2007   *All data from the ChesMMAP survey

Objective 1 Results
Forage Indicators

1. Abundance indices – Fish species

Pelagic Fishes Demersal Fishes
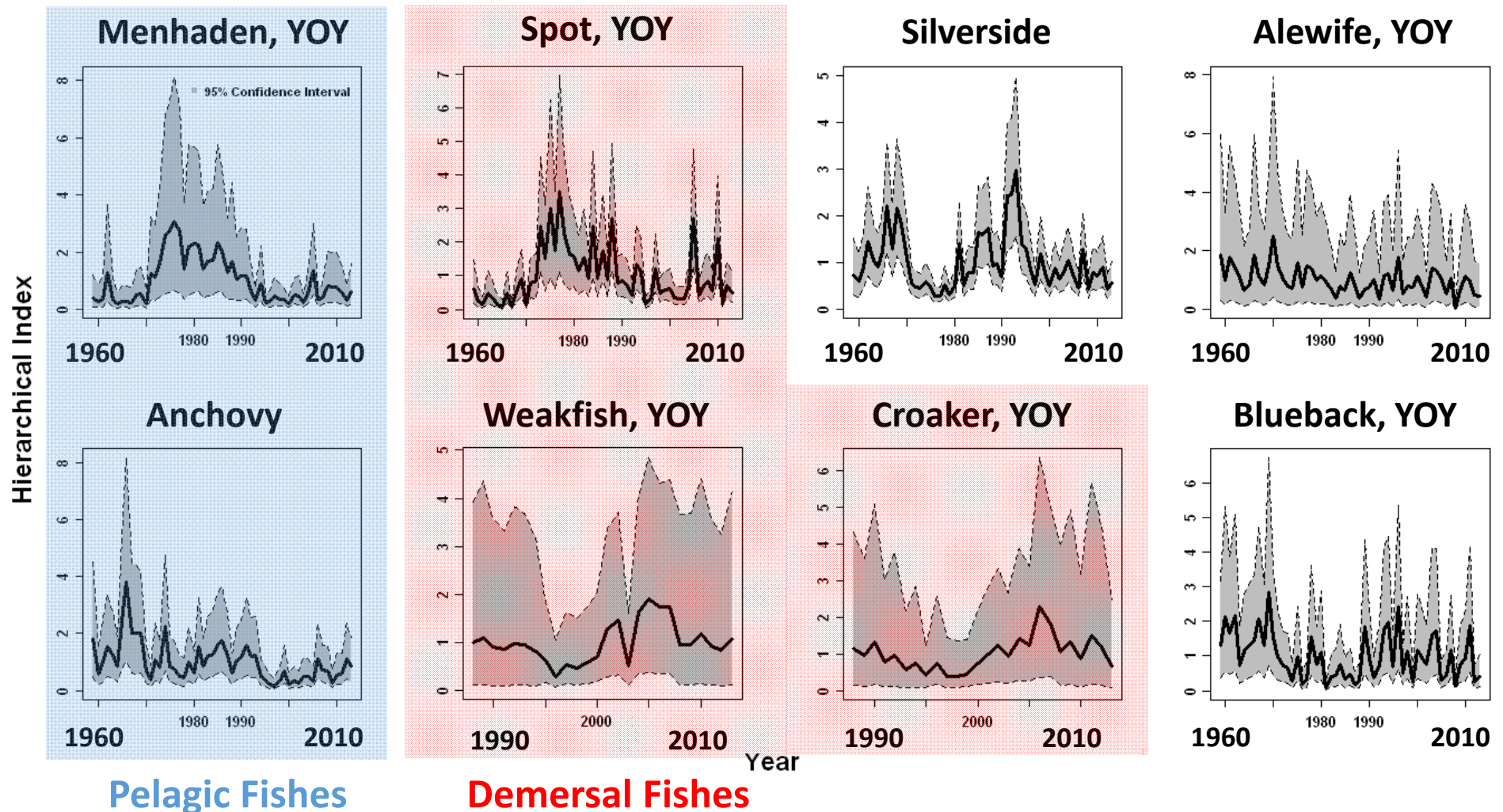
- Low-frequency, correlated patterns for some (menhaden, spot, silversides; weakfish & croaker)

1. Biomass indices – Invertebrate groups

- Both relatively stable
- Greater biomass of bivalves than worms
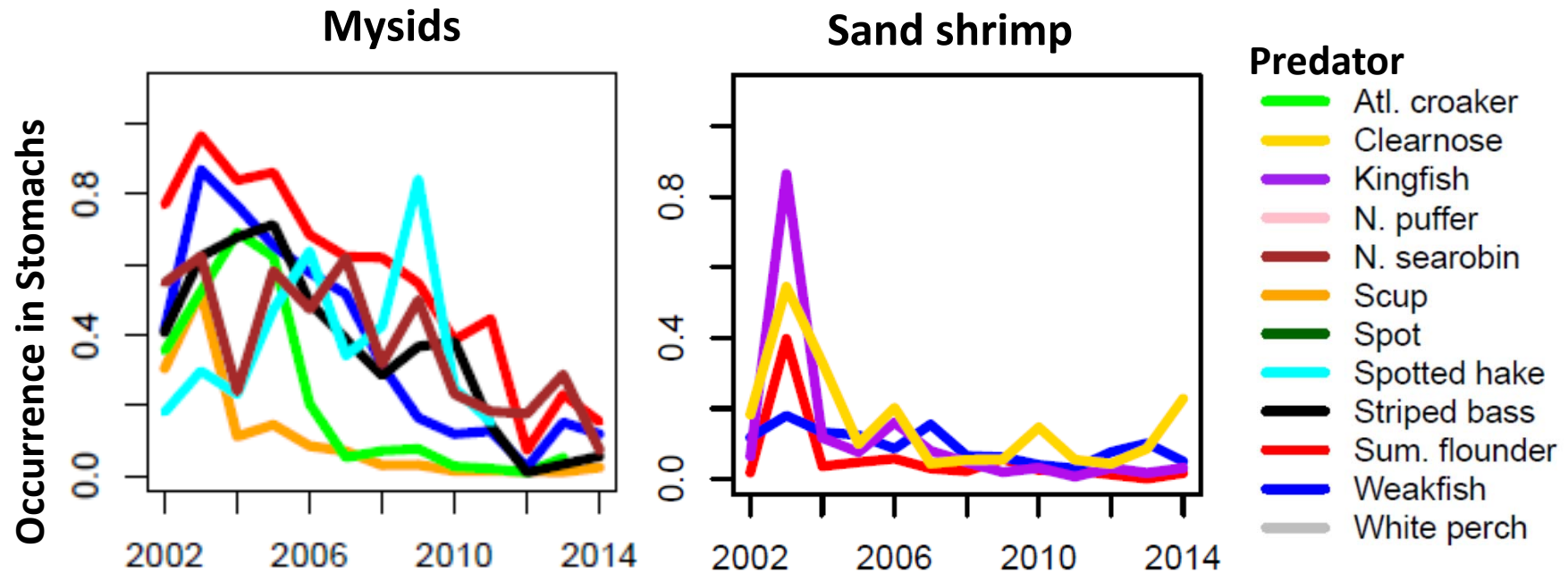- More bivalves in upper bay
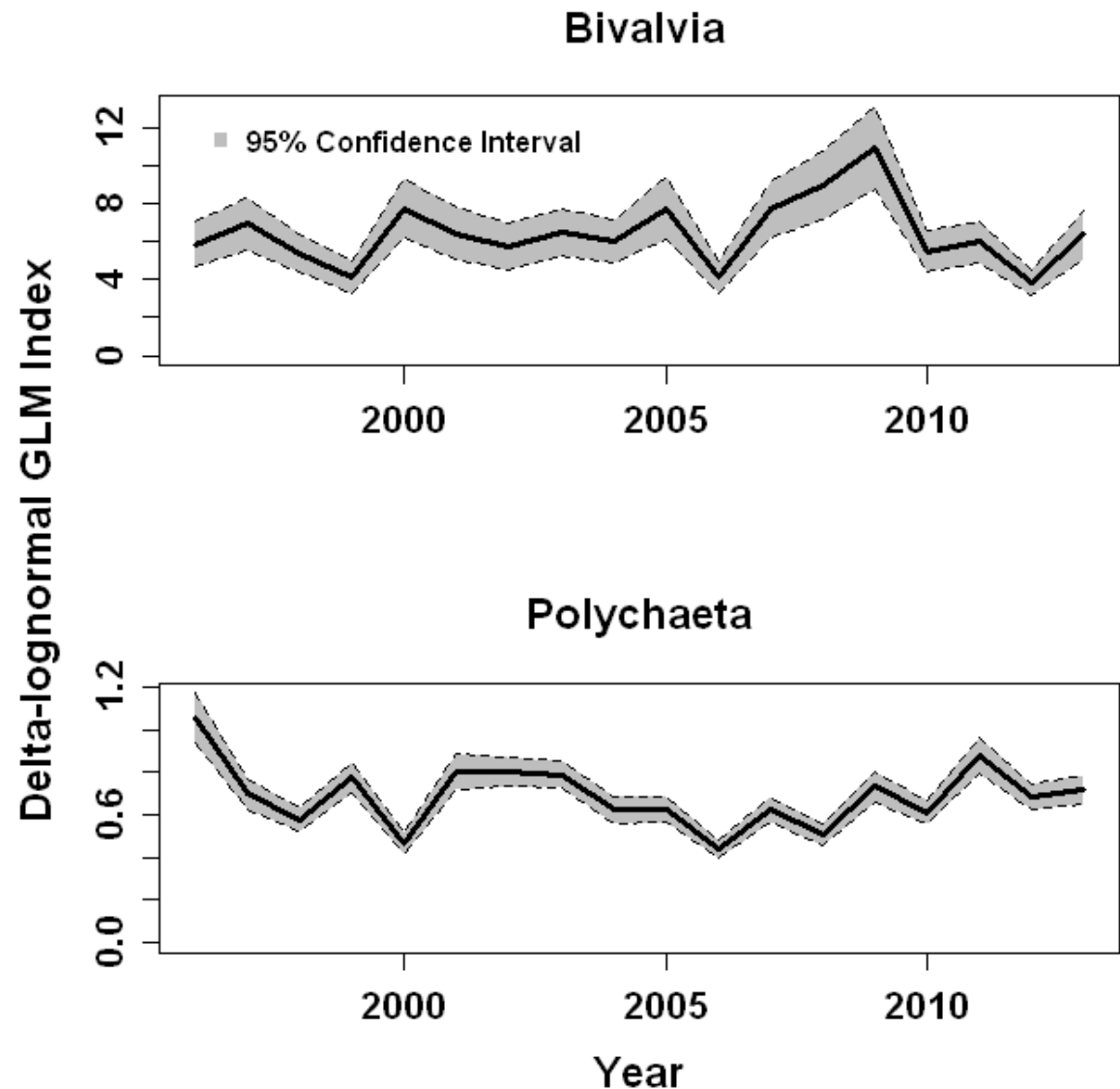
1. Pooled Biomass Indices – By prey groups

**Pelagic Fish Index
(Menh, anchovy)**

**Demersal Fish Index
(YOY croaker, spot, weakfish)**

**Benthic Invertebrate Index
(polychaetes, bivalves)**
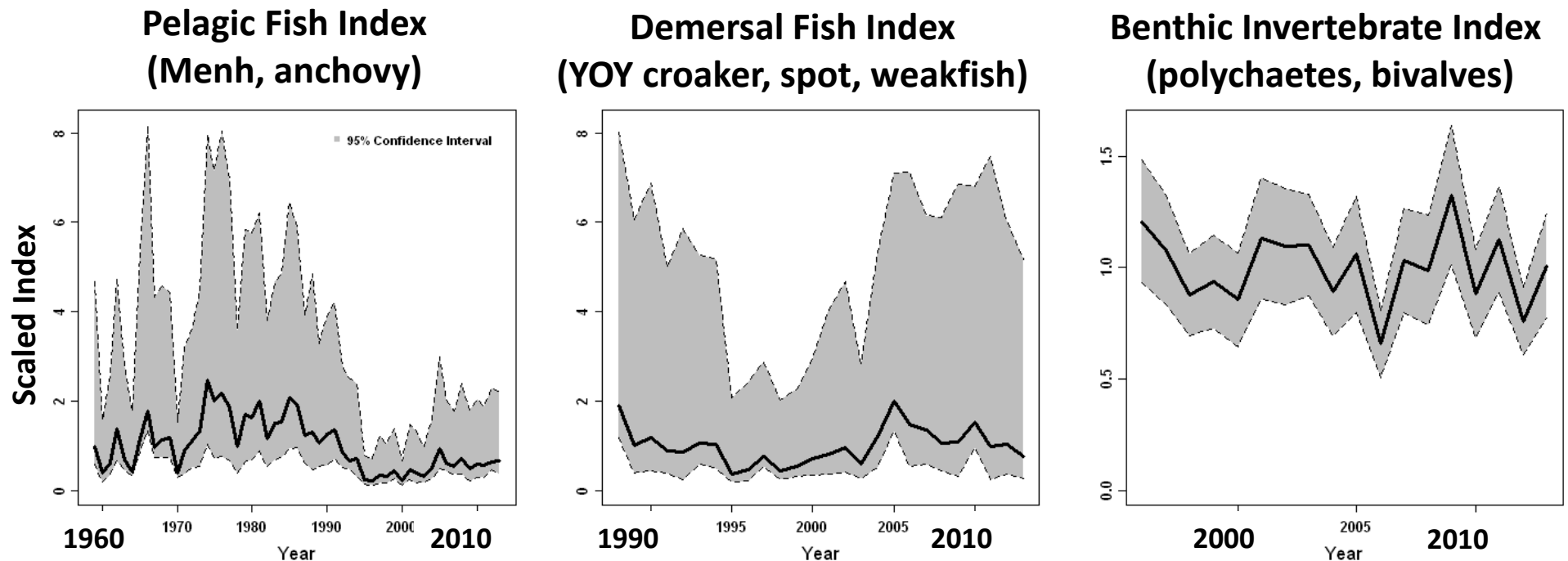
- Biomass-weighted estimates for each general prey group
- Pelagic fish index lower since mid 1990s; little trend in others

2. Diet-based indices (Examples)

- Substantial decline in mysids
- Evidence of "pulses" in some years (e.g., sand shrimp)

3. Prey-Predator Ratios (Striped bass example)
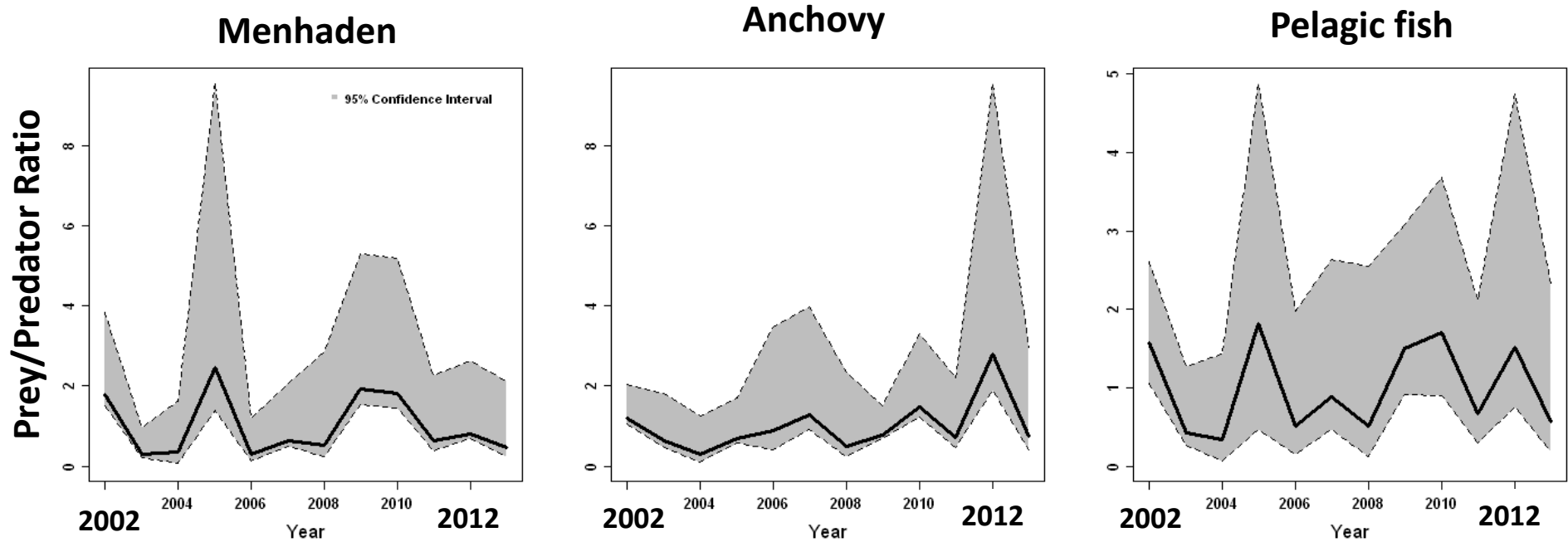
- Weak or no patterns (due to short time series)
- But, detected "pulse" years of relatively higher prey
- More informative at longer time scales[1]
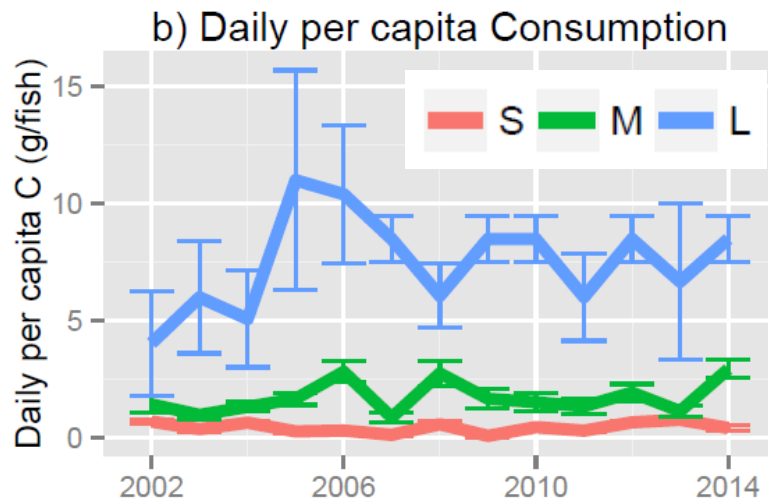
[1]Uphoff et al. 2015 – MD DNR Report

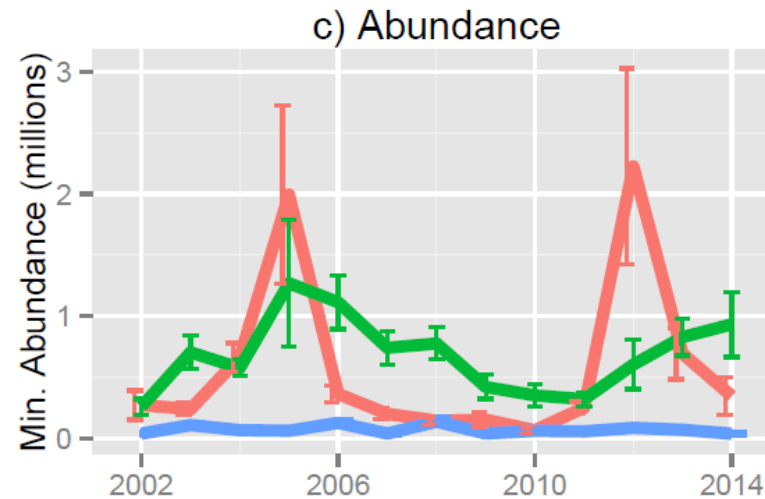# 4. Consumption-Prey Ratios = $\frac{\text{Total Prey Consumption}}{\text{Prey Abund. Index}}$

Bivalve
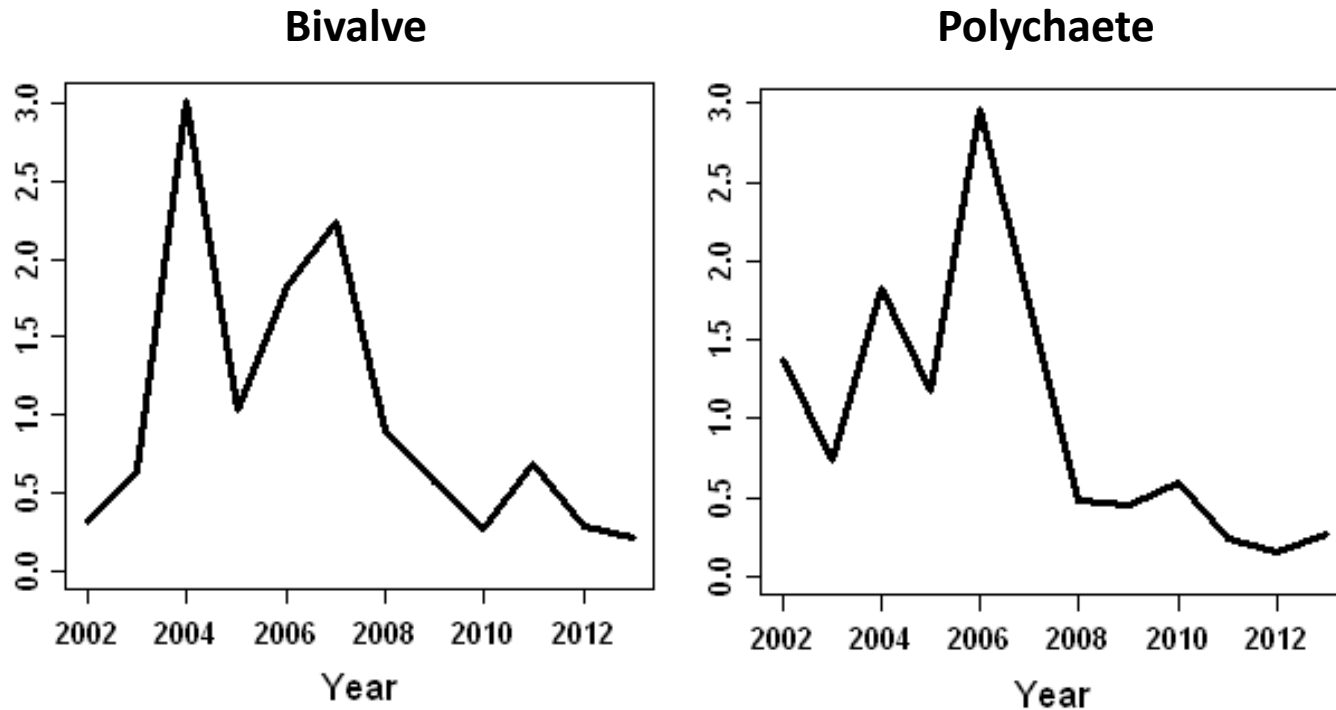
Polychaete

- Decline in bivalves & polychaetes, due mostly to croaker (see Obj. 2)

Objective 2 Results
Consumption Profiles

Calculation Example (Stripers, 6-mo. Index period)

b) Daily per capita Consumption

c) Abundance

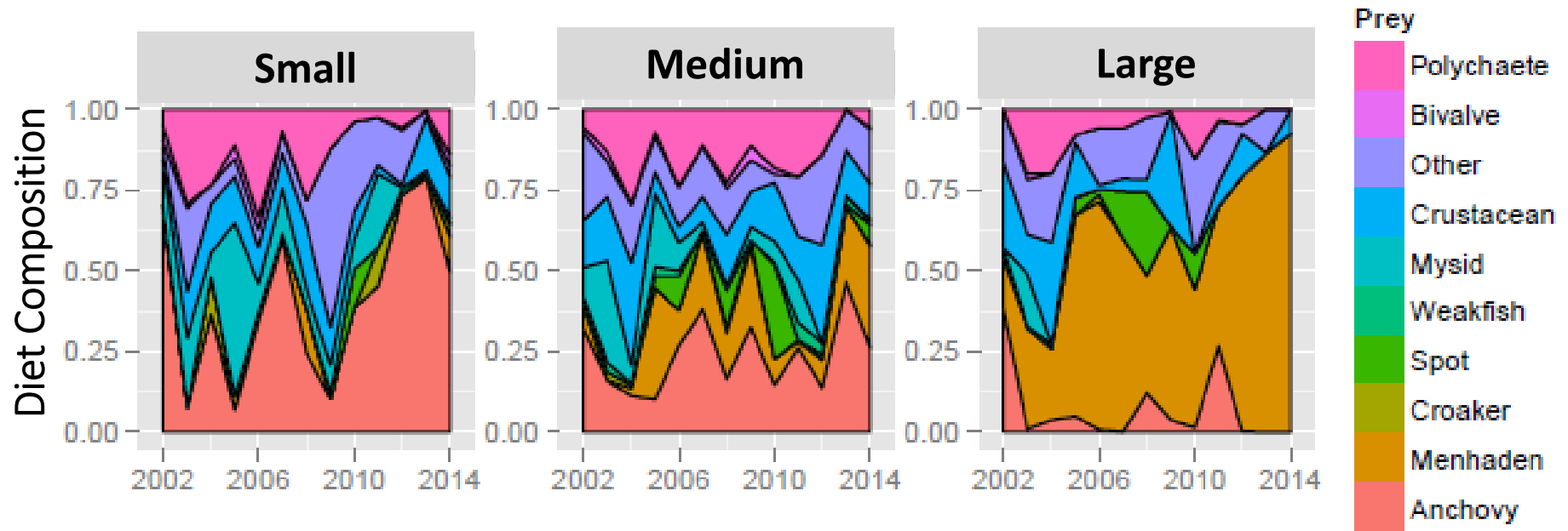d) Scaled Consumption

X

X 6 mo.

=
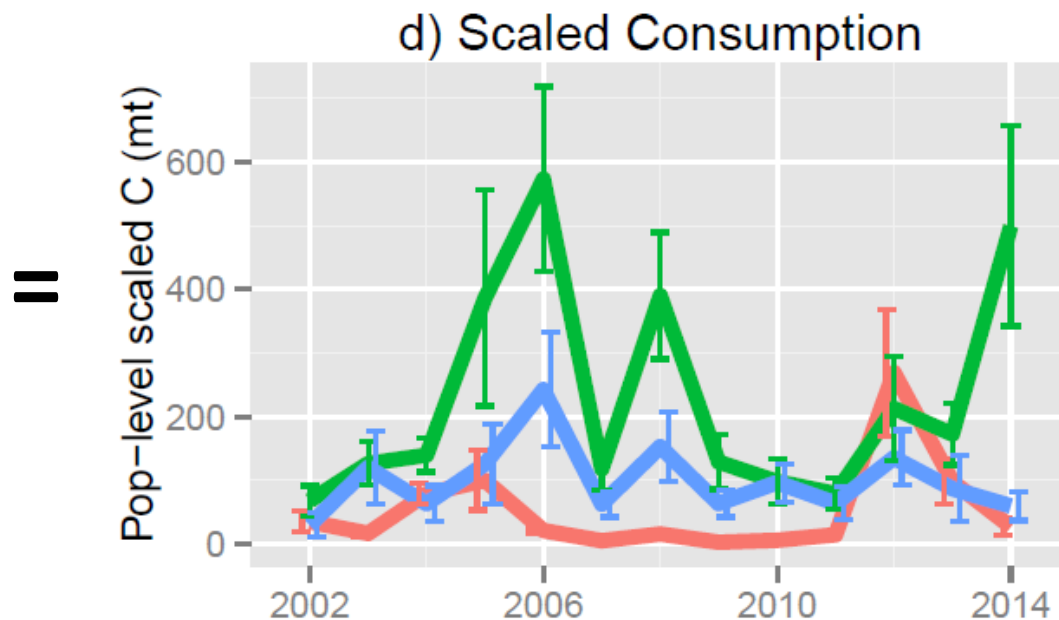
- Importance of accounting for size:
  - High per capita consumption
  - Low abundance
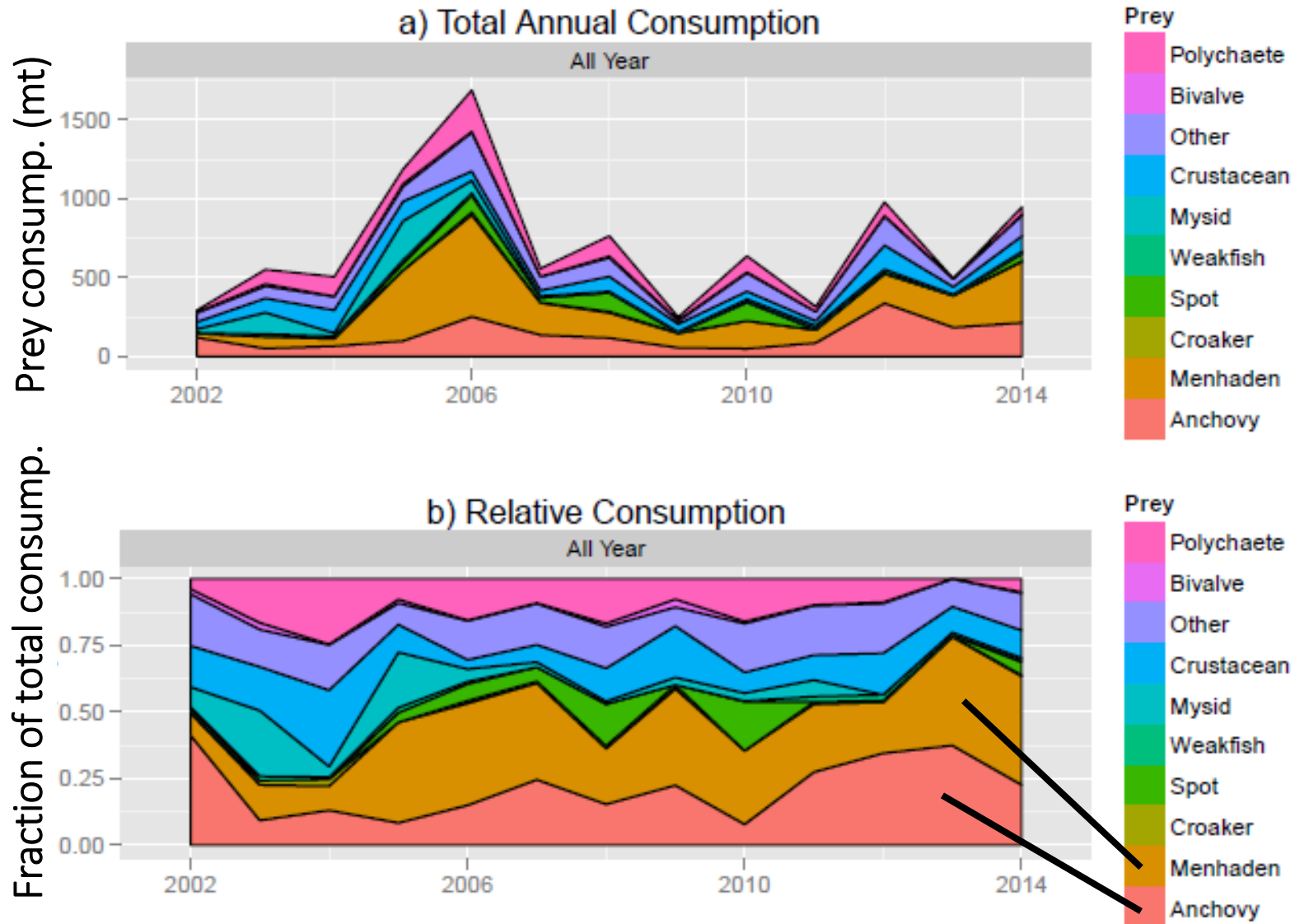 - Also, diet shifts...

Error bars = SE

Calculation Example (Stripers, 6-mo. Index period)
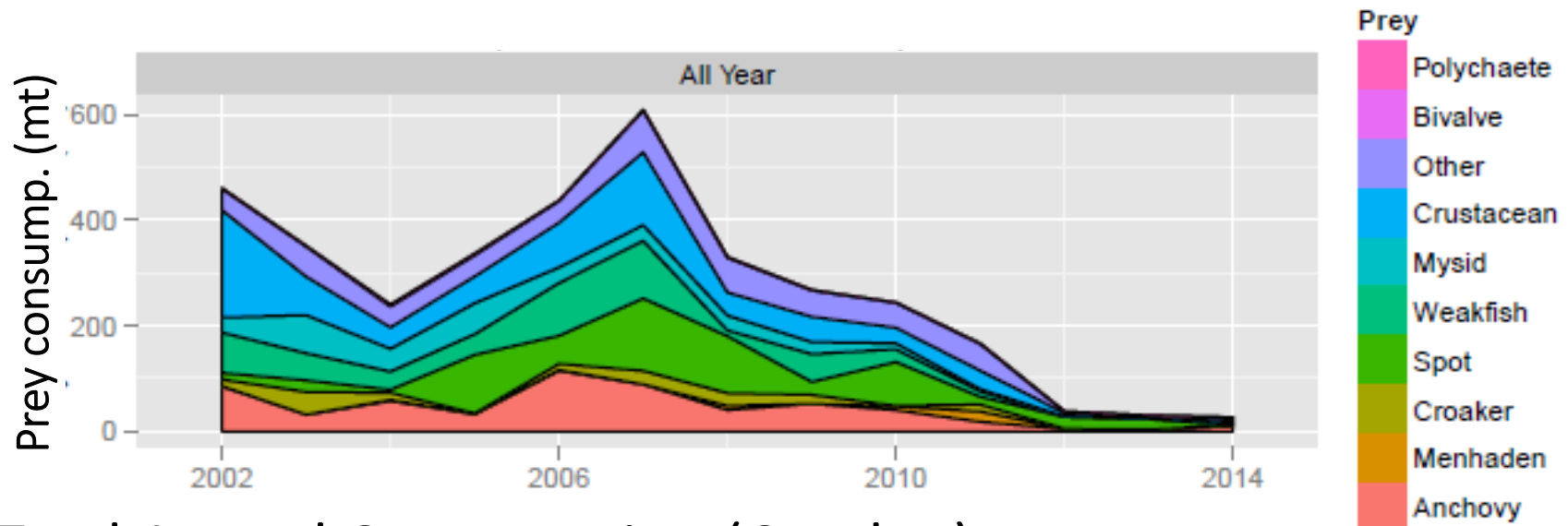
Apportion consumption based on diet:

- Account for dietary changes with size and by year
- E.g., Striper switch to menhaden from anchovy.

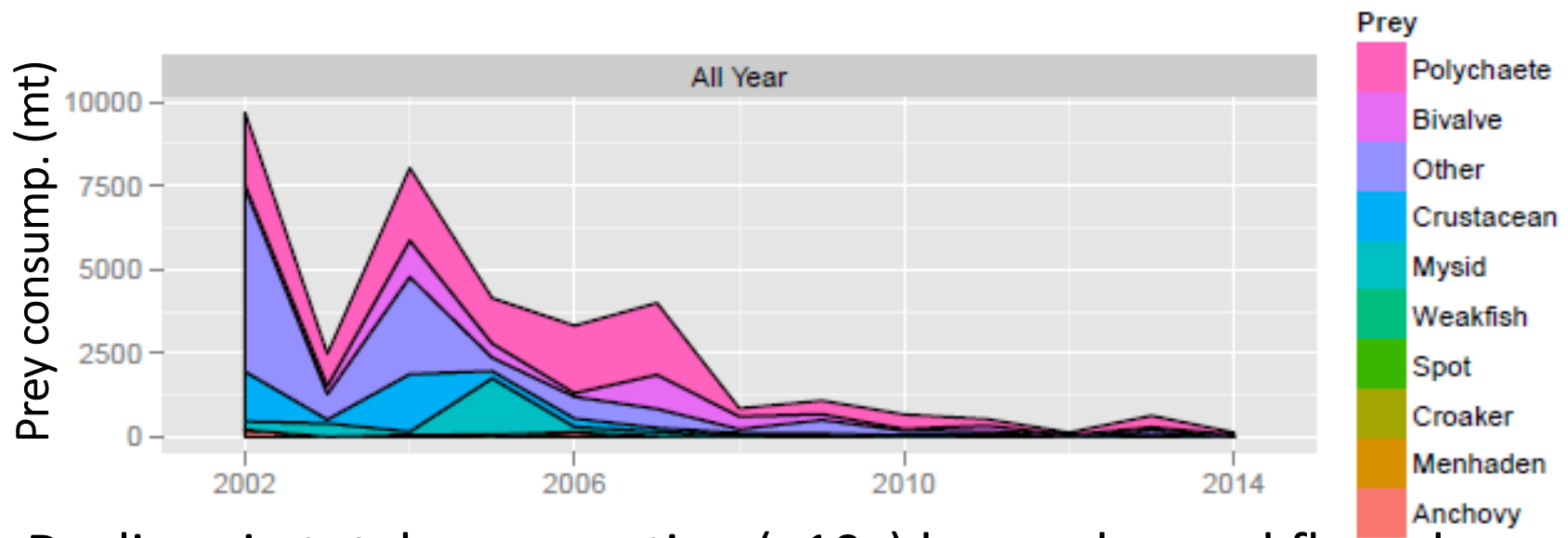# Total Annual consumption (Striped bass)

- Relatively stable consumption and prey contributions
- >50% anchovy and menhaden
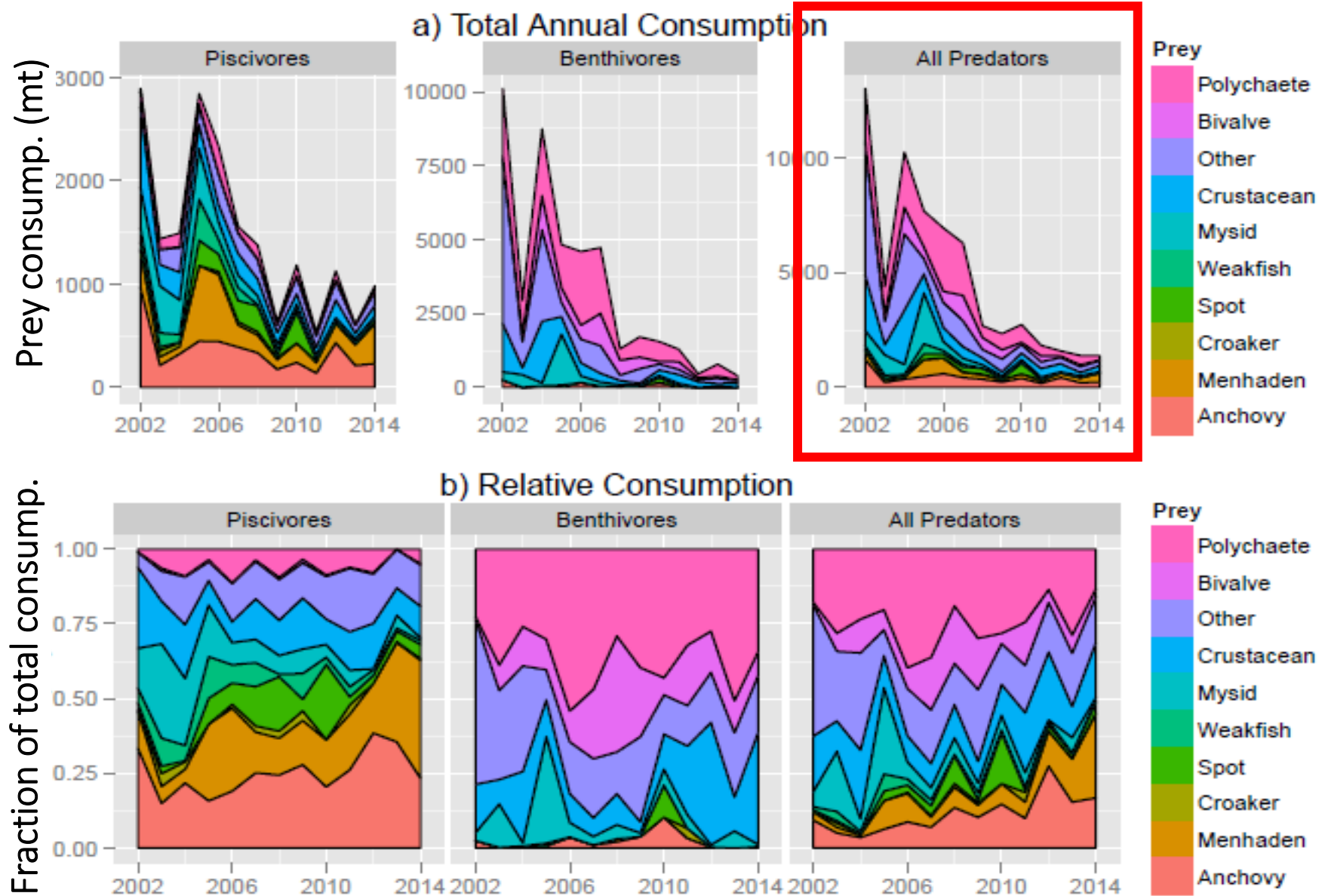
Total Annual Consumption (Summer flounder)

Total Annual Consumption (Croaker)

- Declines in total consumption (>10x) by croaker and flounder

Consumption by predator guilds

a) Total Annual Consumption

b) Relative Consumption

- Declines in total C; importance of benthos for all preds

Which predators are consuming the most?

b) Relative contributions
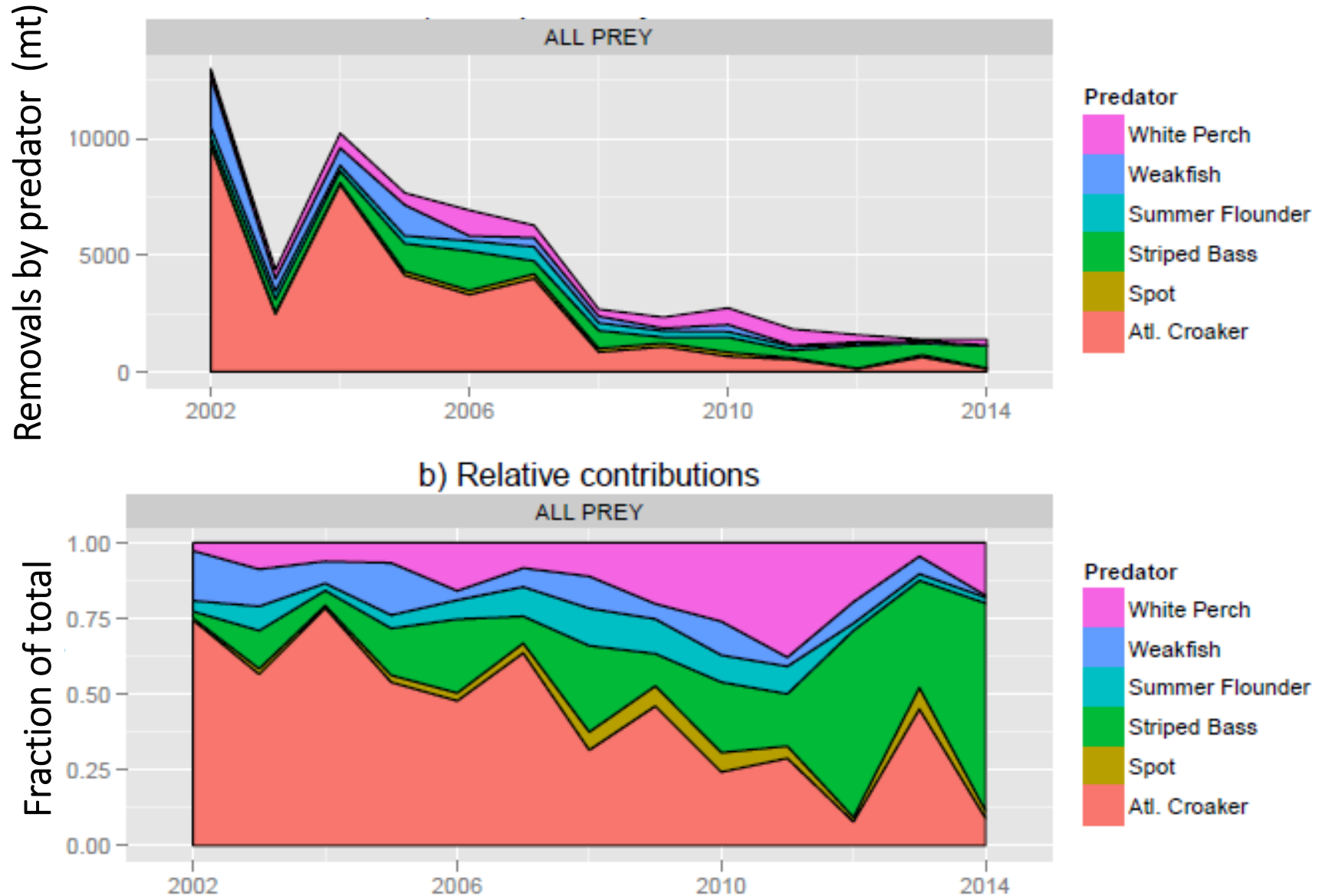
- Declines in total C (esp. croaker); relative increase in stripers

Main Conclusions

Important findings

1. Lower pelagic fish biomass index since mid 1990s
2. Interannual variability in abundance
3. "Pulses" in forage consumption
4. Mysid decline in recent years
5. Prey groups ranked most important in a given year:
   - Polychaetes
   - Anchovy
   - Menhaden
   - Mysids

Main Conclusions

1. **Long-term, correlated shifts in prey abundances (e.g., menhaden, spot, silversides)**
    - Links to climate and environment (AMO, temp, precipitation)[1]
    - Possibly different ecosystem states affecting groups of fishes

2. **Decline in total predatory demand from 2002-2014 (croaker, flounder, weakfish, spot)**
    - Driven by lower predator abundances, particularly croaker
    - Does not appear to be prey-driven
    - Possible ties to climate/environment/habitat[2]

3. **Suite of forage indicators recommended**
    - Needed for complementary perspectives on complex dynamics
        - E.g., changes in prey & pred abundance, changes in consumption, cryptic prey
    - Abundance (or biomass) indicators insufficient
    - Longer time-series ideal

1: Wood and Austin 2009; Buchheister et al. In Press;   2: Wood Hare and Able 2007

Utility for managers

1. **Information** on interannual changes in the relative abundance, availability, importance, and predation intensity for key groups

2. **Help prioritize prey groups** based on mgmt. goals

3. **Foundation** for identifying possible target values for selected forage indicators

4. **Concerns/challenges**
    - State shifts in the system can affect baselines and attainable forage conditions
    - Need to understand the drivers of forage changes & links to predators
    - System is complex and predators are generalists; ideal forage conditions likely dynamic

Acknowledgements

- Funding: Chesapeake Bay Trust and EPA

- Survey managers and personnel
  - MDDNR Seine (Eric Durrell)
  - MDDNR Summer Trawl (Chris Walstrum)
  - VIMS Juvenile Trawl (Mary Fabrizio, Troy Tuckey)
  - VIMS Seine (Mary Fabrizio, Troy Tuckey)
  - CBP Benthos (Mike Lane)
  - TIES/CHESFIMS (Tom Miller)
  - ChesMMAP (Chris Bonzek, Rob Latour, Jim Gartland)

- Assistance
  - Other survey managers contacted for information
  - Tom Ihde
  - Jim Uphoff