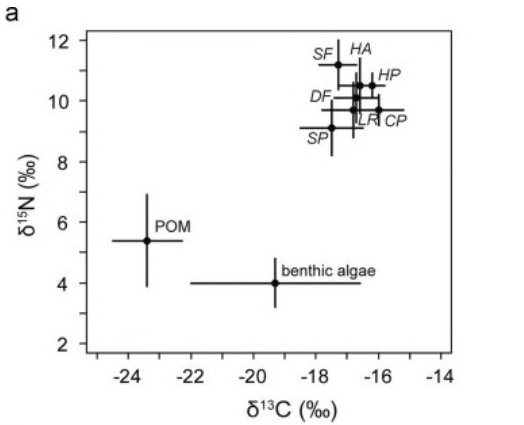
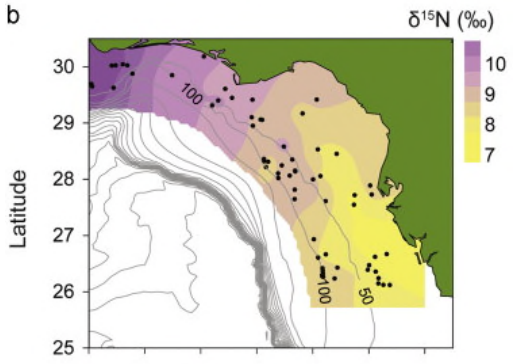
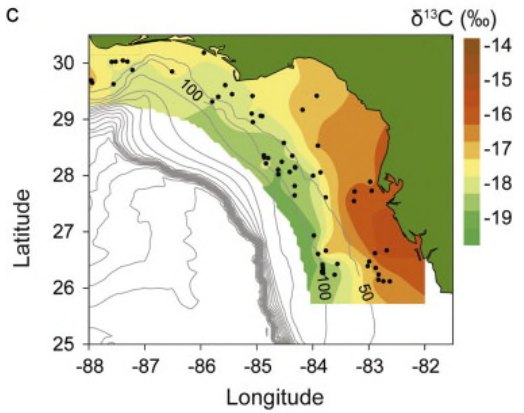
Comparison of Isotope-Based Biomass Pathways with Groundfish Community Structure in the Eastern Gulf Of Mexico

Sheri A. Huelster
and
Dr. Ernst Peebles

USF UNIVERSITY OF SOUTH FLORIDA
COLLEGE OF MARINE SCIENCE







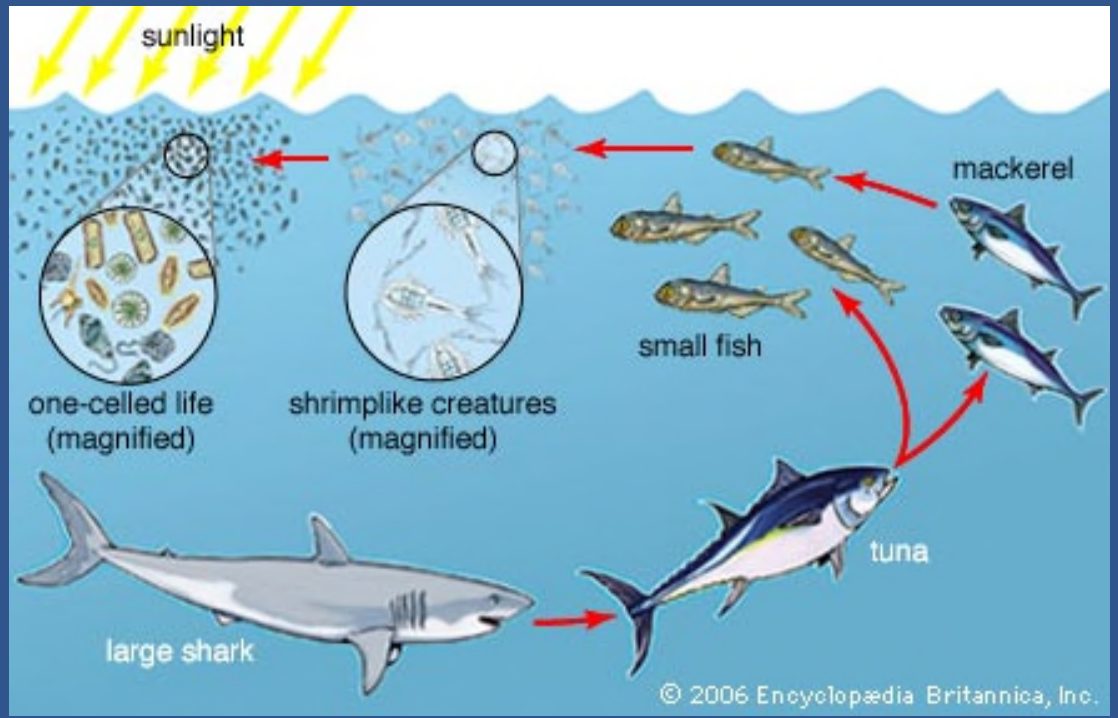
Questions Addressed Here:

- *What processes likely create the eastern GOM isoscapes (at left)?*
- *Is there spatial agreement between published isoscapes and fish community structure?*
- *Does "basal-resource dependence" (planktonic vs. benthic) play a role in community structure?*
- *Can we predict winners and losers if the eastern Gulf of Mexico becomes more eutrophic in the future?*

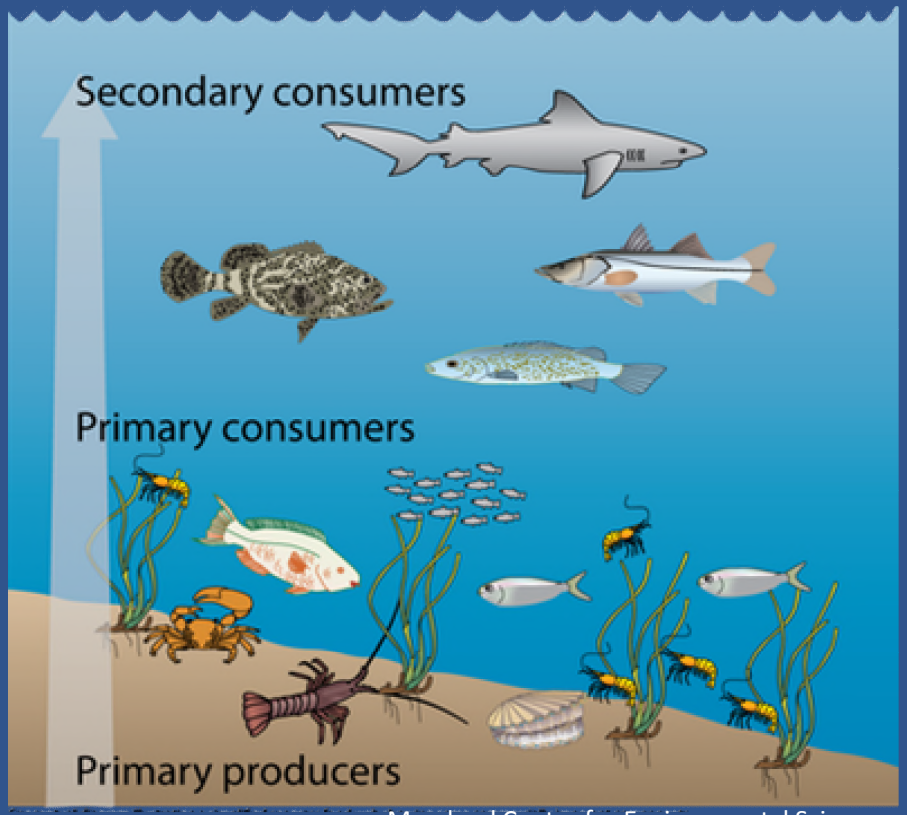
Radabaugh and Peebles (2014) Multiple regression models of $\delta^{13}C$ and $\delta^{15}N$ for fish populations in the eastern Gulf of Mexico. *Continental Shelf Research* 84: 158-168.

Trophic Pathways

Planktonic Basal Resource



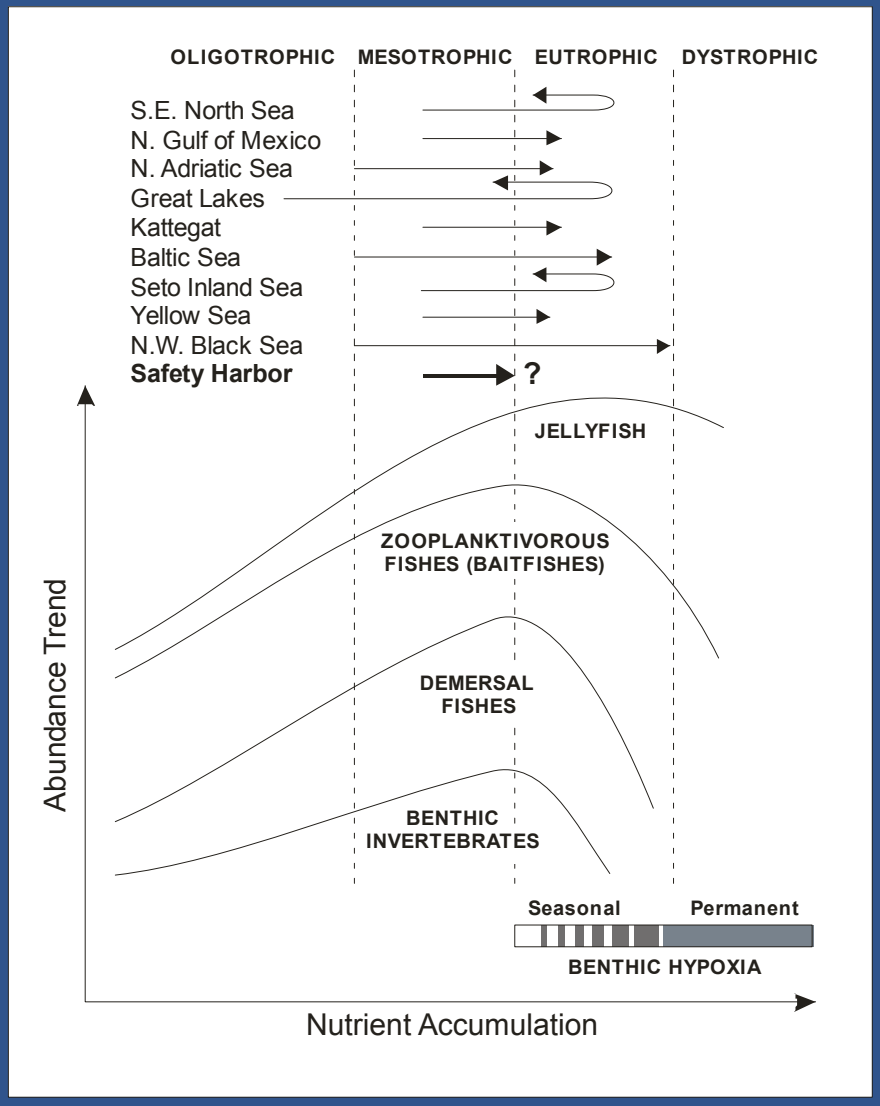
Benthic Basal Resource



Maryland Center for Environmental Science

Requires more light at depth; includes benthic algae

Changing Light Environment Affects Trophic Pathways

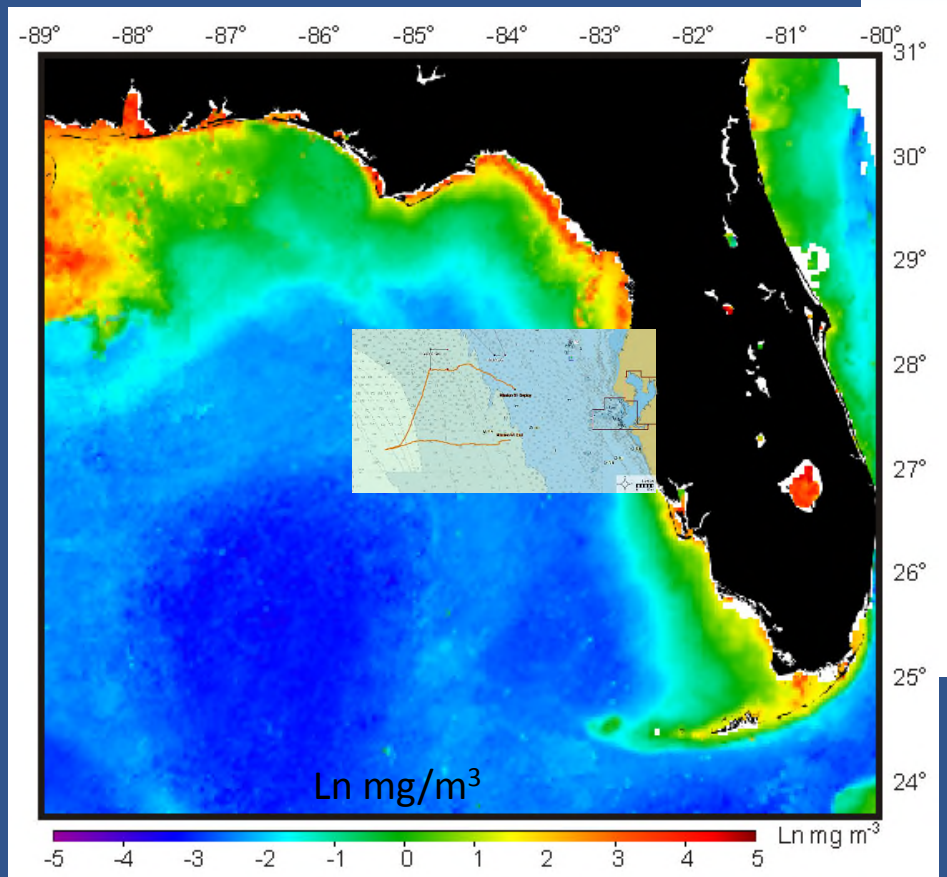


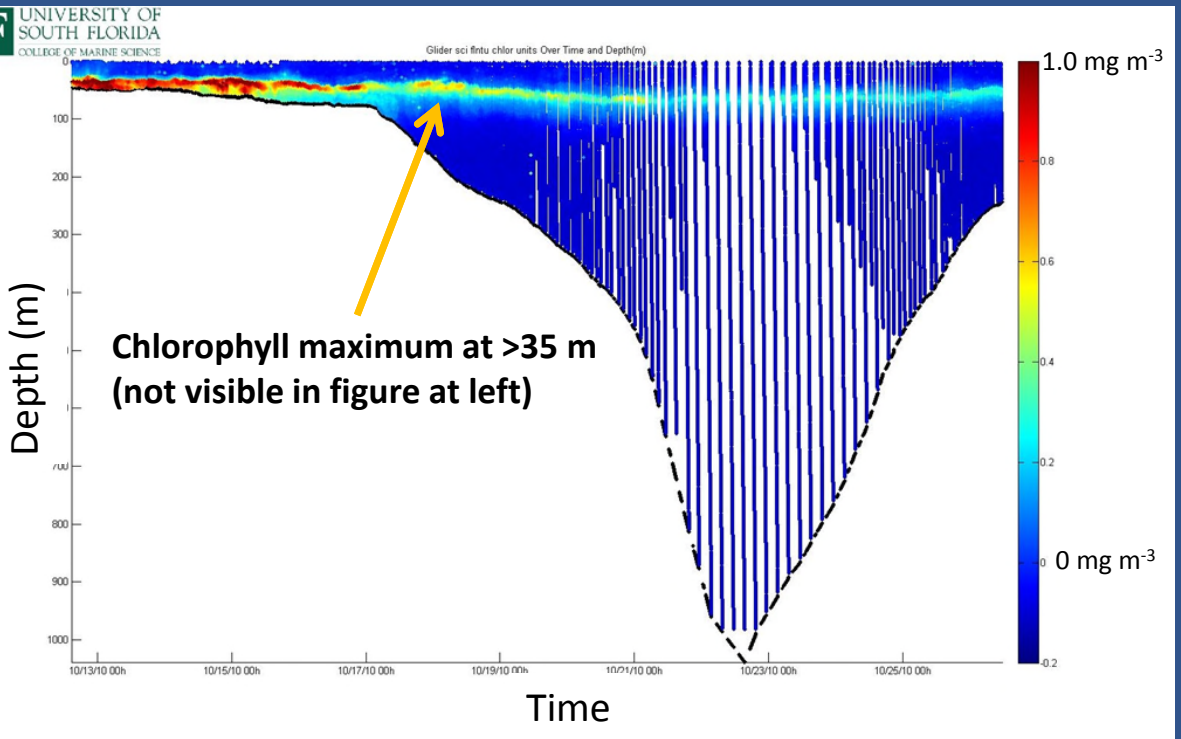
- Land Cover Changes
  - Deforestation/desertification
  - Agriculture
  - Urban growth
- Eutrophication (panel at left)
- Freshwater diversions and impoundments for water supply or hydroelectric power

All of the above alter coastal water quality and can lead to changes in the light environment

Chlorophyll in the Eastern Gulf of Mexico

Surface Phytoplankton (Aqua MODIS)



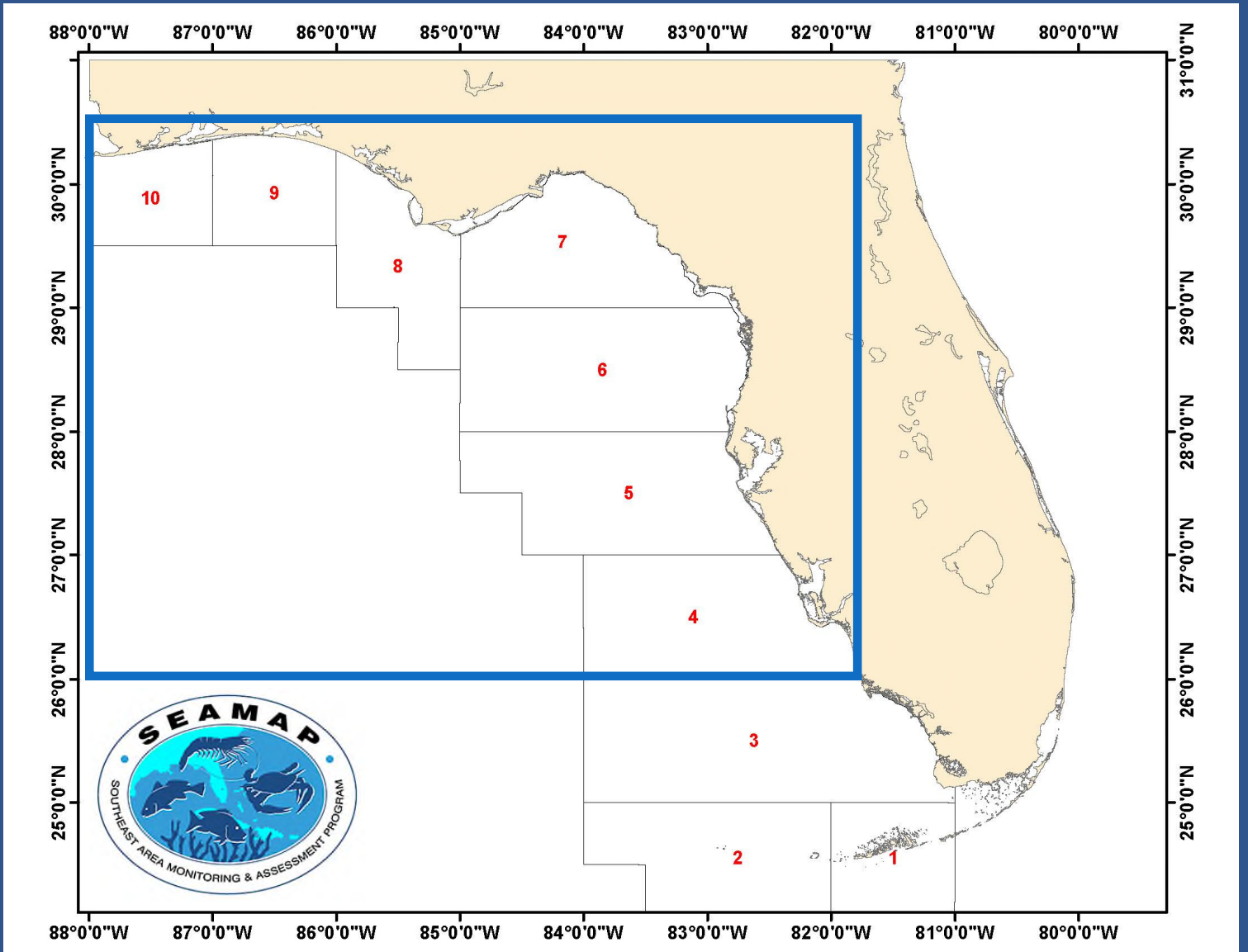


Deep Phytoplankton Maximum (USF 1000 m glider)

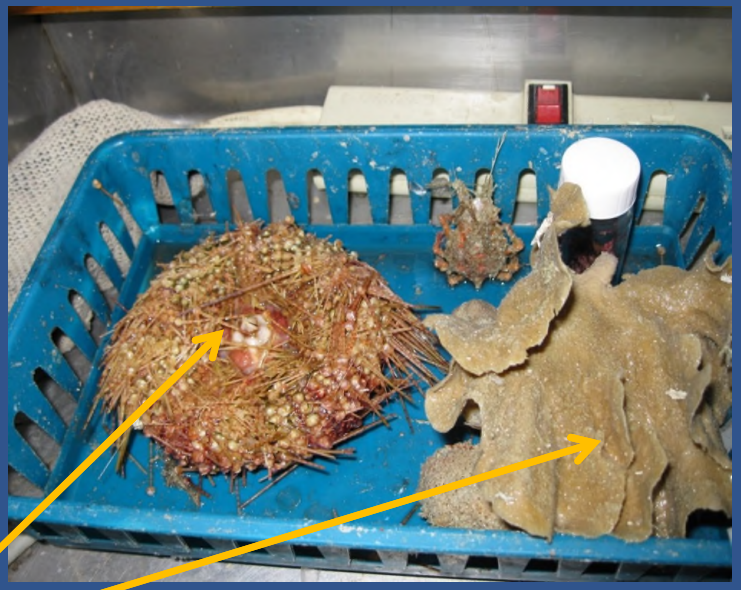
Aqua MODIS Level-2 chlorophyll concentration average for 14 d period centered on June 15, 2009.

Methods

- SEAMAP survey area & NMFS zones
  - Total of 10 NMFS statistical zones in the eastern GOM
  - During July 2009, 139 benthic trawls were deployed in NMFS zones 4-10



Fishes and invertebrate herbivores were sampled



Examples of invertebrate herbivores
(used to establish isotopic baselines)

Samples removed from fish for future lab analysis

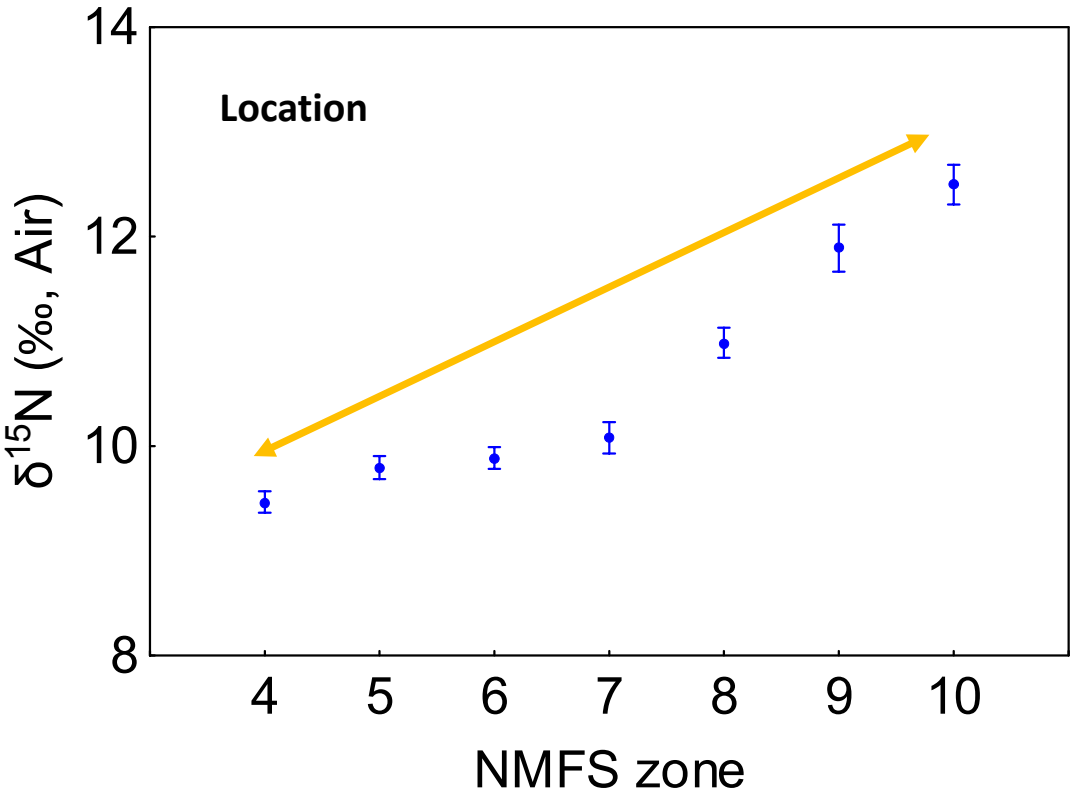
Isotope Analysis

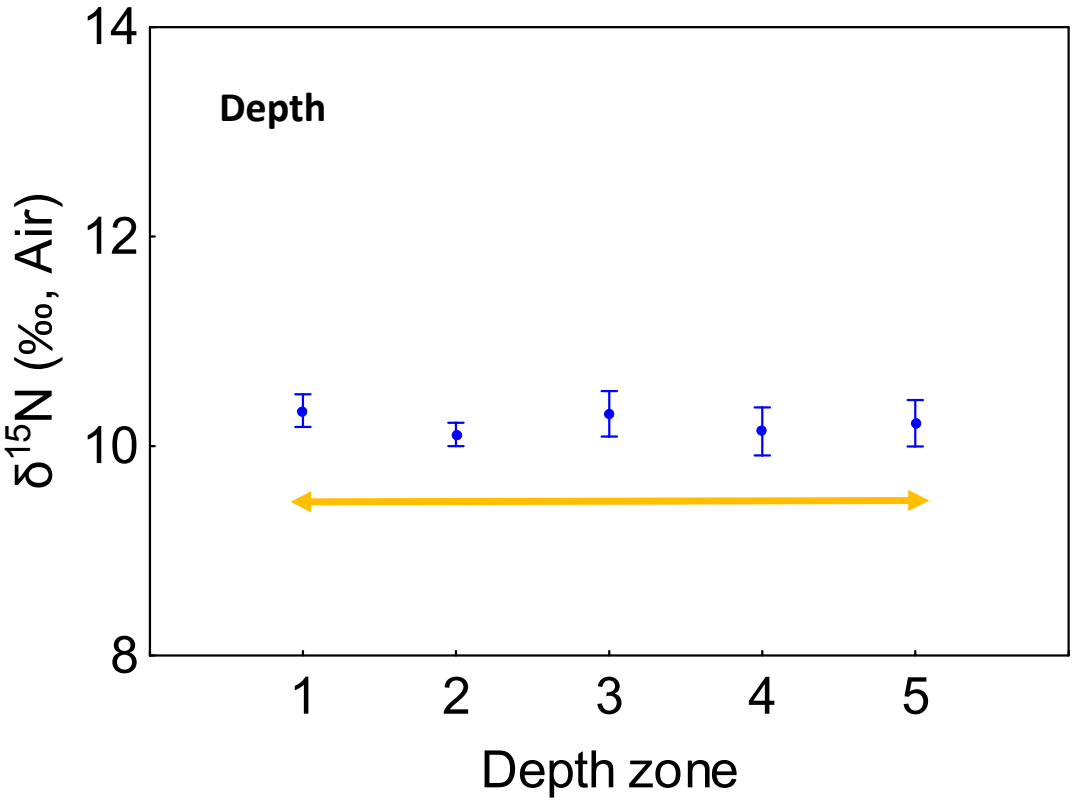
- Three representative muscle samples were collected from the 3-5 most abundant species per trawl
- All samples were frozen at -20°C at sea until later processing in August-September 2009
- 17 total fish species used in analysis
- $^{13}C/^{12}C$ and $^{15}N/^{14}N$ were measured at USF-CMS

Identifying Isoscape Processes

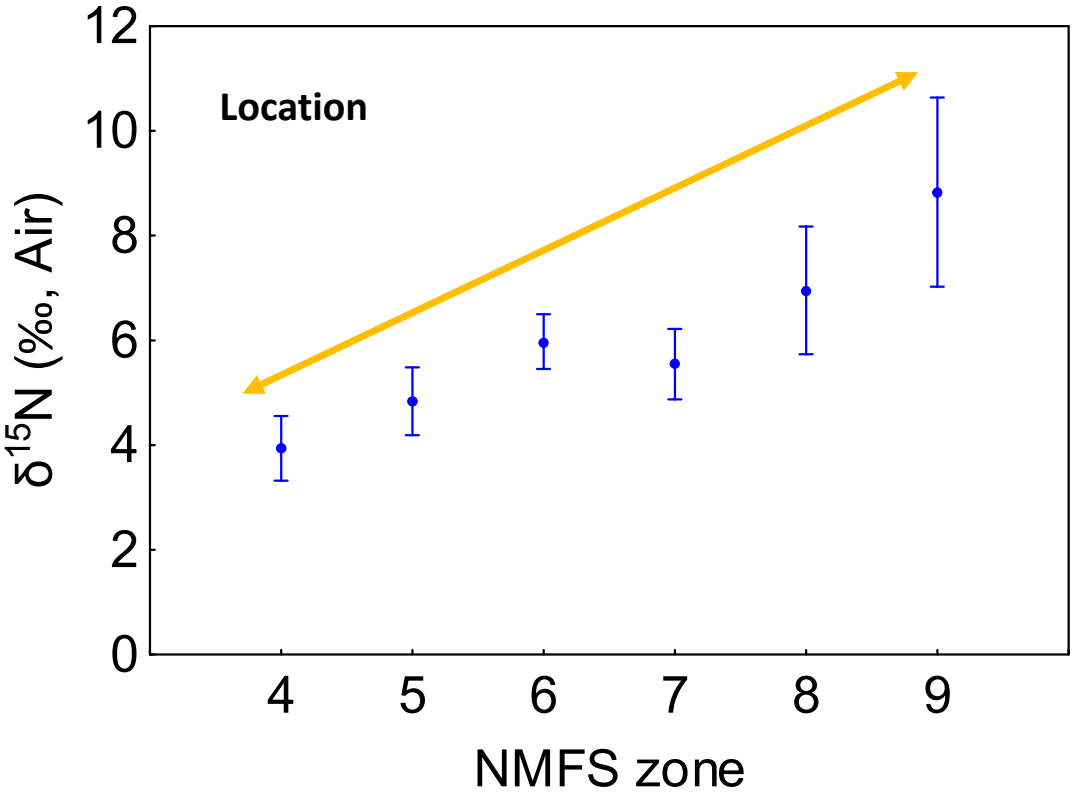
- $\delta^{15}N$ provides information on nutrient sources
- $\delta^{13}C$ is useful for basal resource detection
- If consistent spatial variation is observed in both herbivores and predators, then the cause of the spatial variation is baseline variation (i.e., isotopic variation in DIC or DIN)
- On the other hand, if herbivores and predator spatial trends differ, then the cause is basal-resource variation, where predators favor one trophic pathway (planktonic vs. benthic) over another

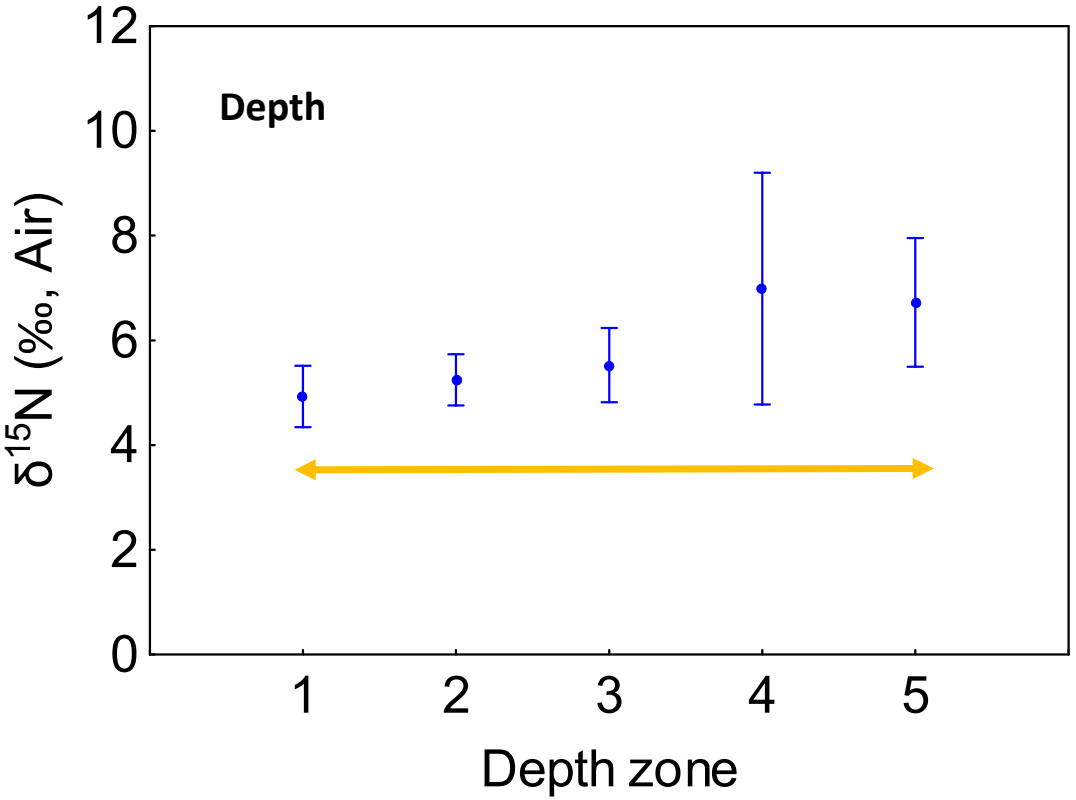
$\delta^{15}N$ Compared Among NMFS and Depth Zones
All Fish Combined





$\delta^{15}N$ Compared Among NMFS and Depth Zones
Invertebrate Herbivores





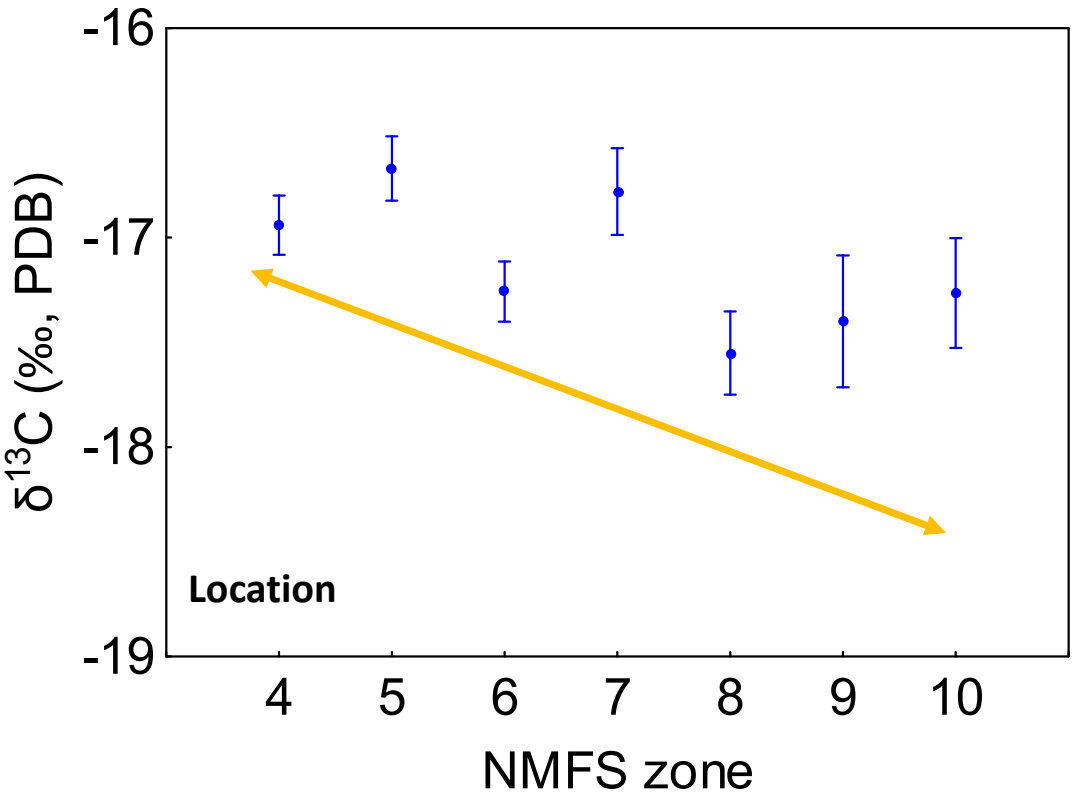
The northwest increase in $\delta^{15}N$ was observed for both fish and invertebrate herbivores

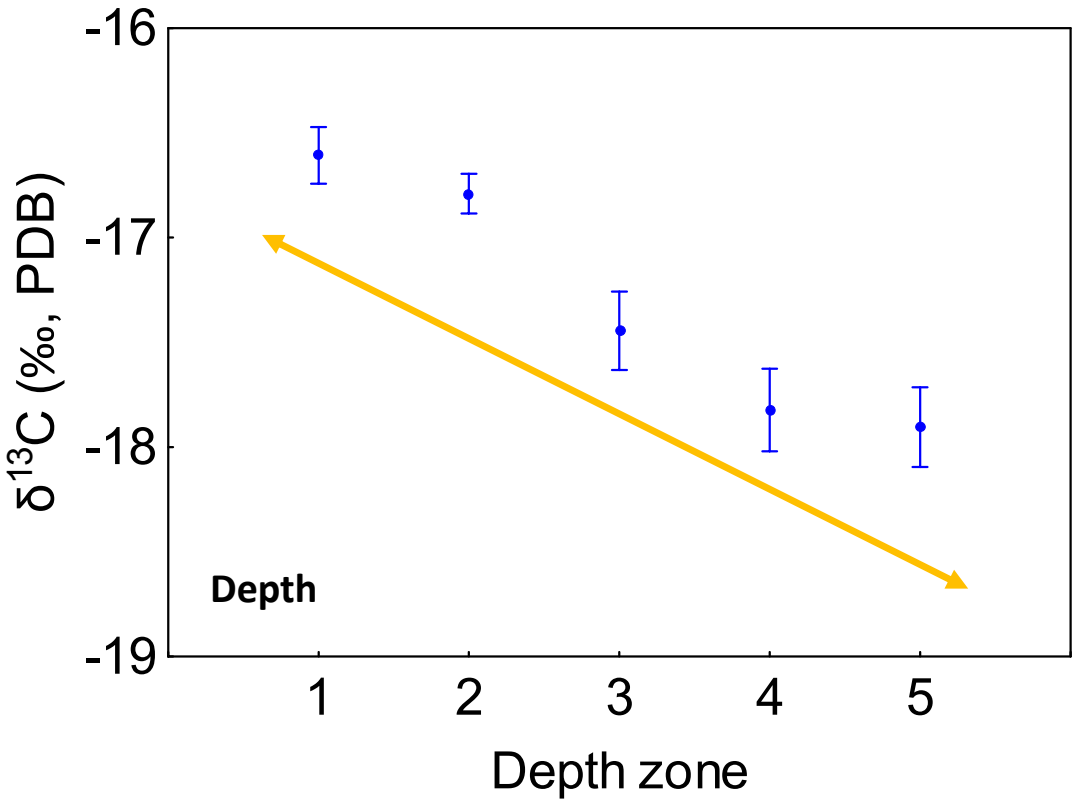
- 17 fish species
- All fish combined
- 3 invertebrate herbivore species
- All invertebrate herbivores combined

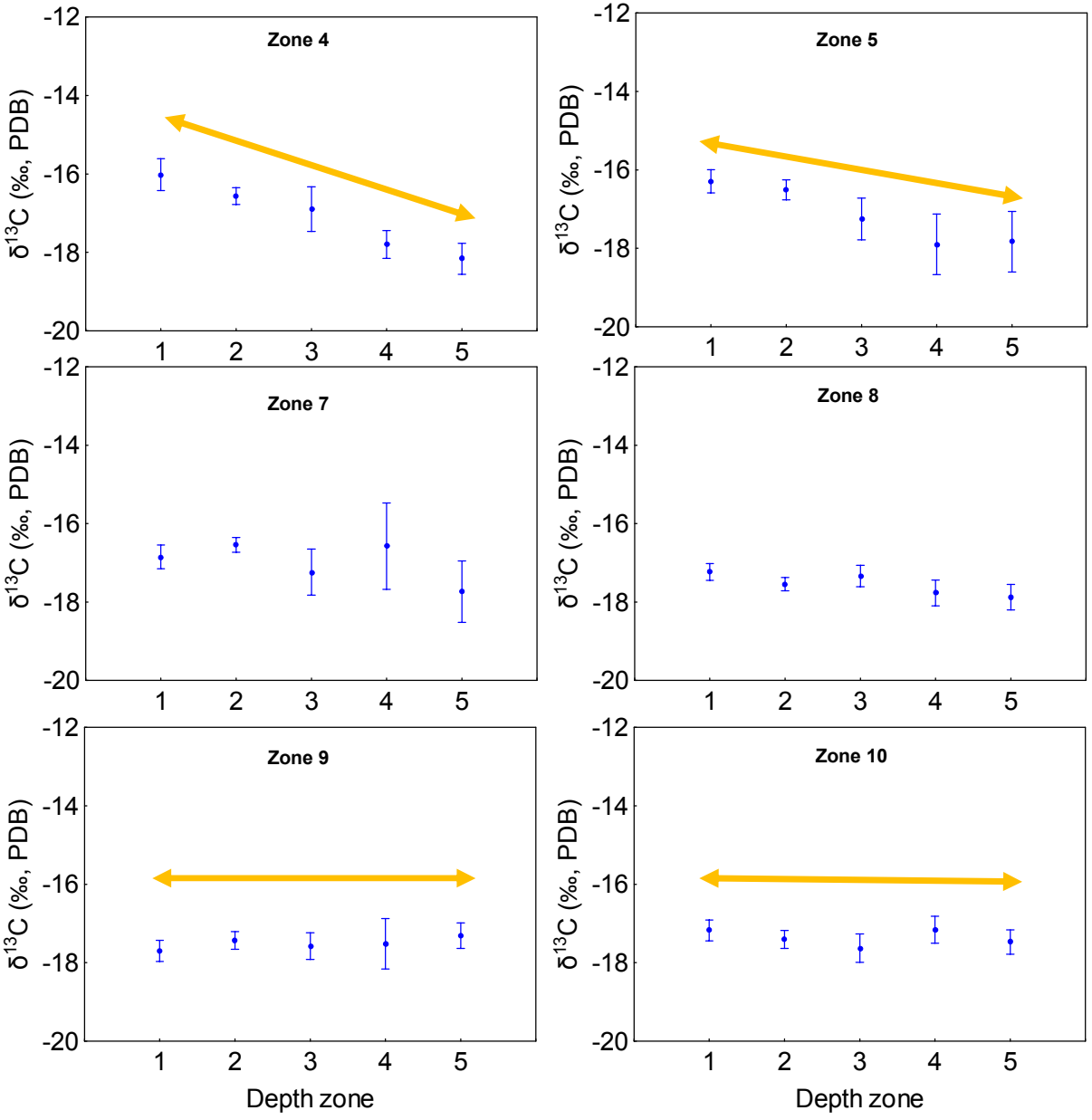
This agreement suggests the $\delta^{15}N$ trend is caused by a baseline trend in DIN $\delta^{15}N$

- Relatively high $\delta^{15}N$ in river discharge to northwest mixes with relatively low $\delta^{15}N$ associated with nitrogen fixation in oligotrophic waters to the southeast

$\delta^{13}C$ Compared Among NMFS and Depth Zones All Fish Combined



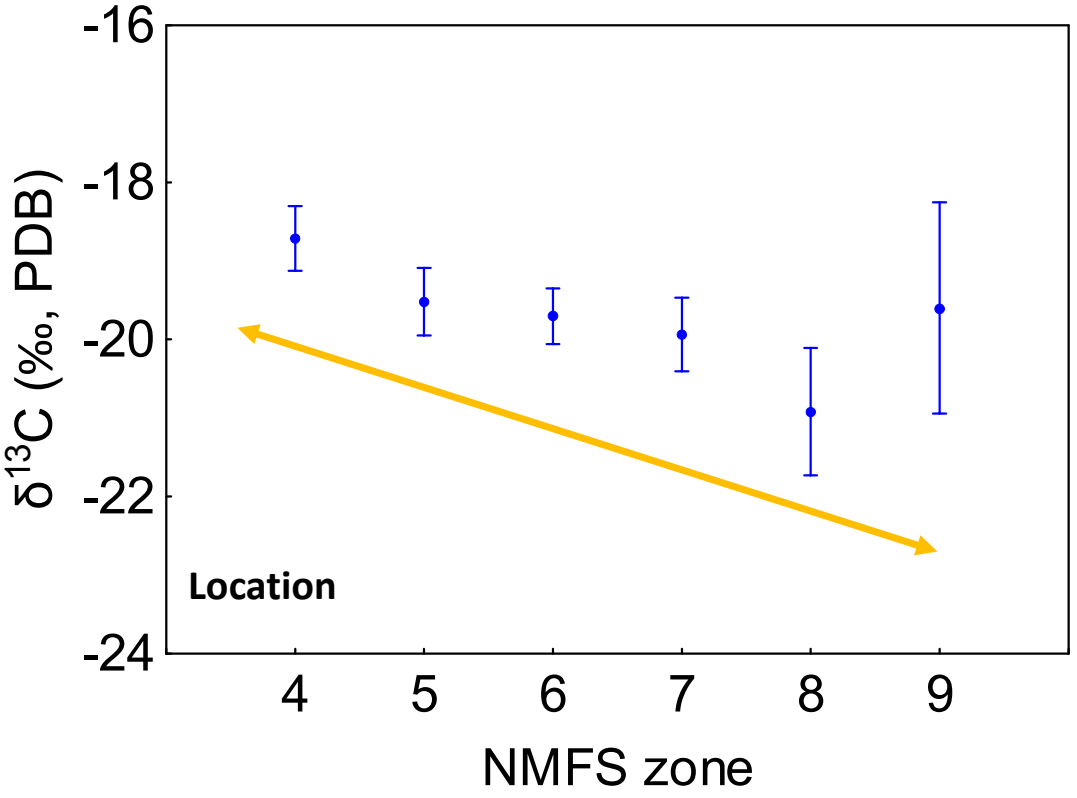


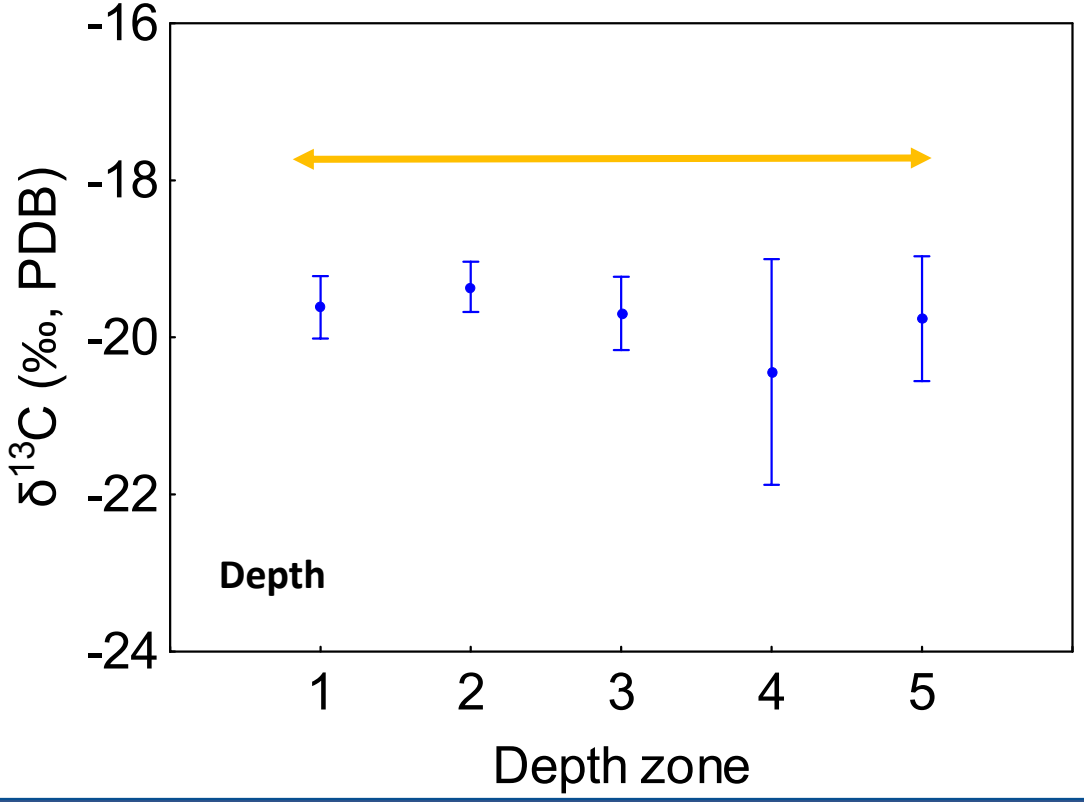


For all fish combined, the depth trend in $\delta^{13}C$ gradually disappeared towards the northwest (from zone 4 to zone 10)

$\delta^{13}C$ Compared Among NMFS and Depth Zones

Invertebrate Herbivores





Invertebrate herbivores did not have the same spatial trends as fish

For $\delta^{13}C$, invertebrate herbivores did not have the same spatial trends as fish

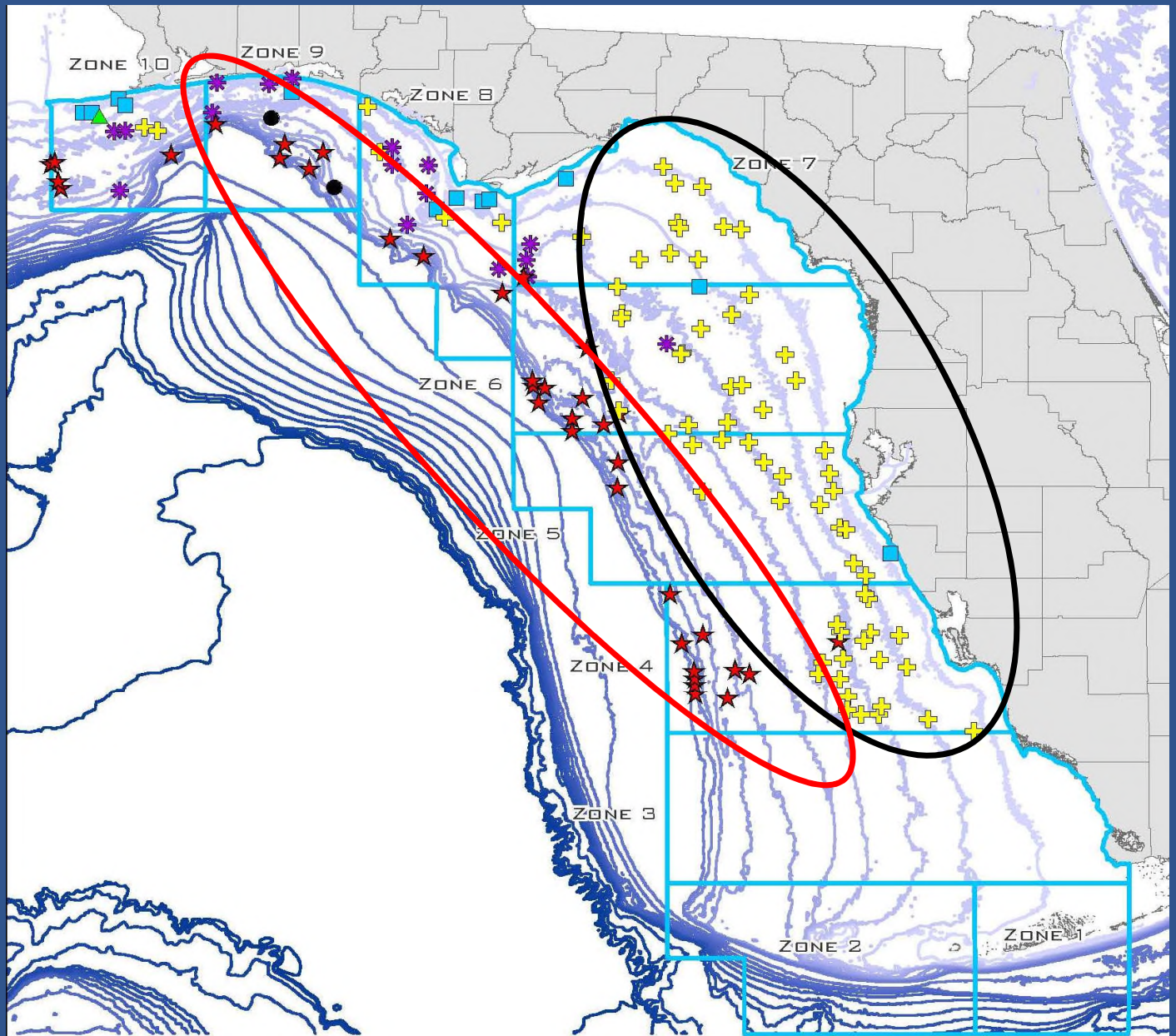
- 4 fish species had higher values in shallows
- Trend was limited to the southeast
- Invertebrate herbivores did not have these trends when considered together or as individual species

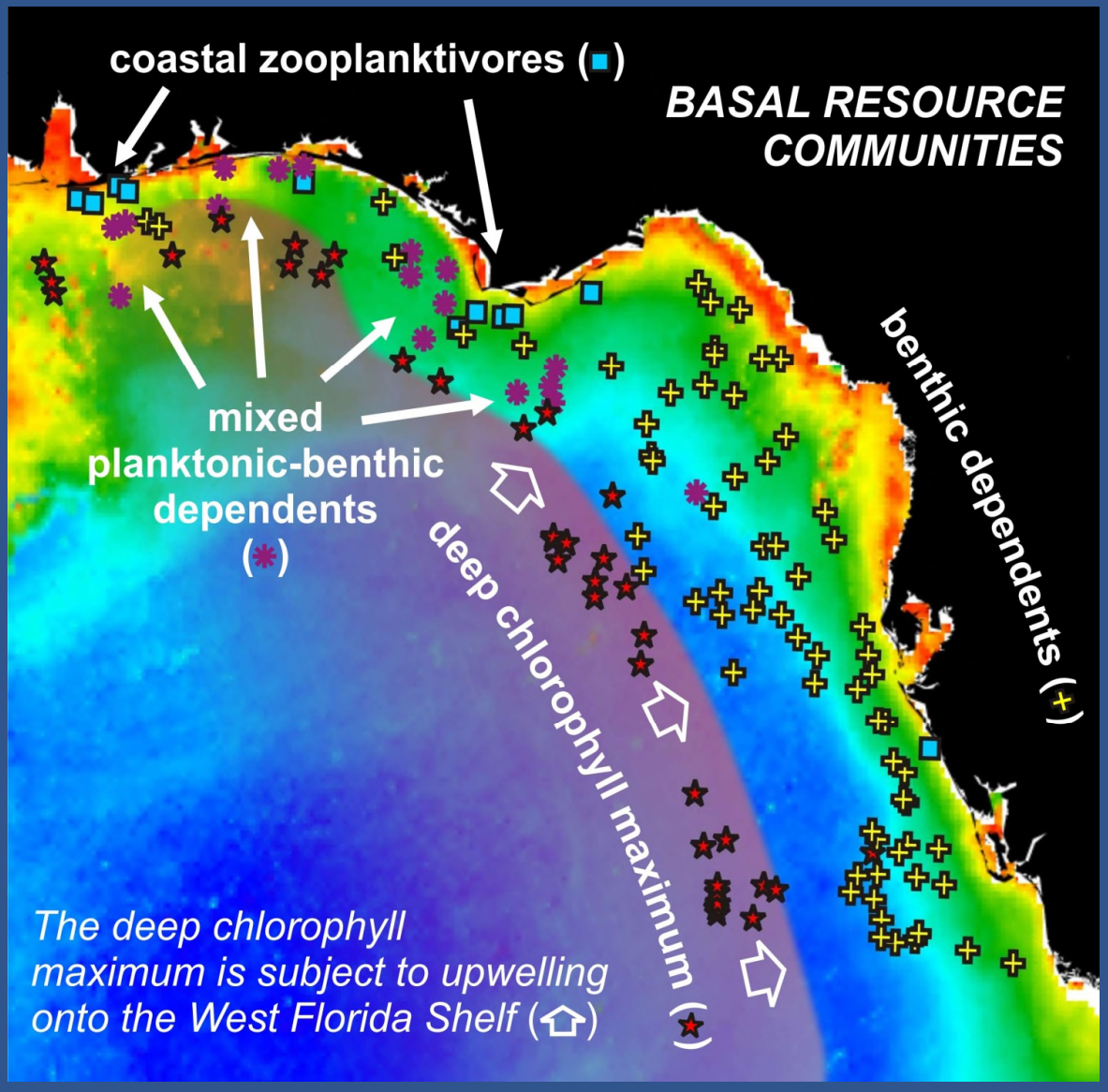
This disagreement suggests the $\delta^{13}C$ trend is caused by basal-resource variation

- Higher dependence on benthic basal resources (high $\delta^{13}C$) in the shallow, clear waters of the southeastern study area

Fish Community Analysis

- Abundances (individuals per standardized trawl) were obtained for 237 fish species in 139 trawl deployments
- Abundance data were analyzed using PRIMER 7
- Cluster Analysis (CA) was followed by Similarity Profile Analysis (SIMPROF)
  - SIMPROF analyses were used to define statistically significant groups within the CA


ZONE 10
ZONE 9
ZONE 8
ZONE 7
ZONE 6
ZONE 5
ZONE 4
ZONE 3
ZONE 2
ZONE 1

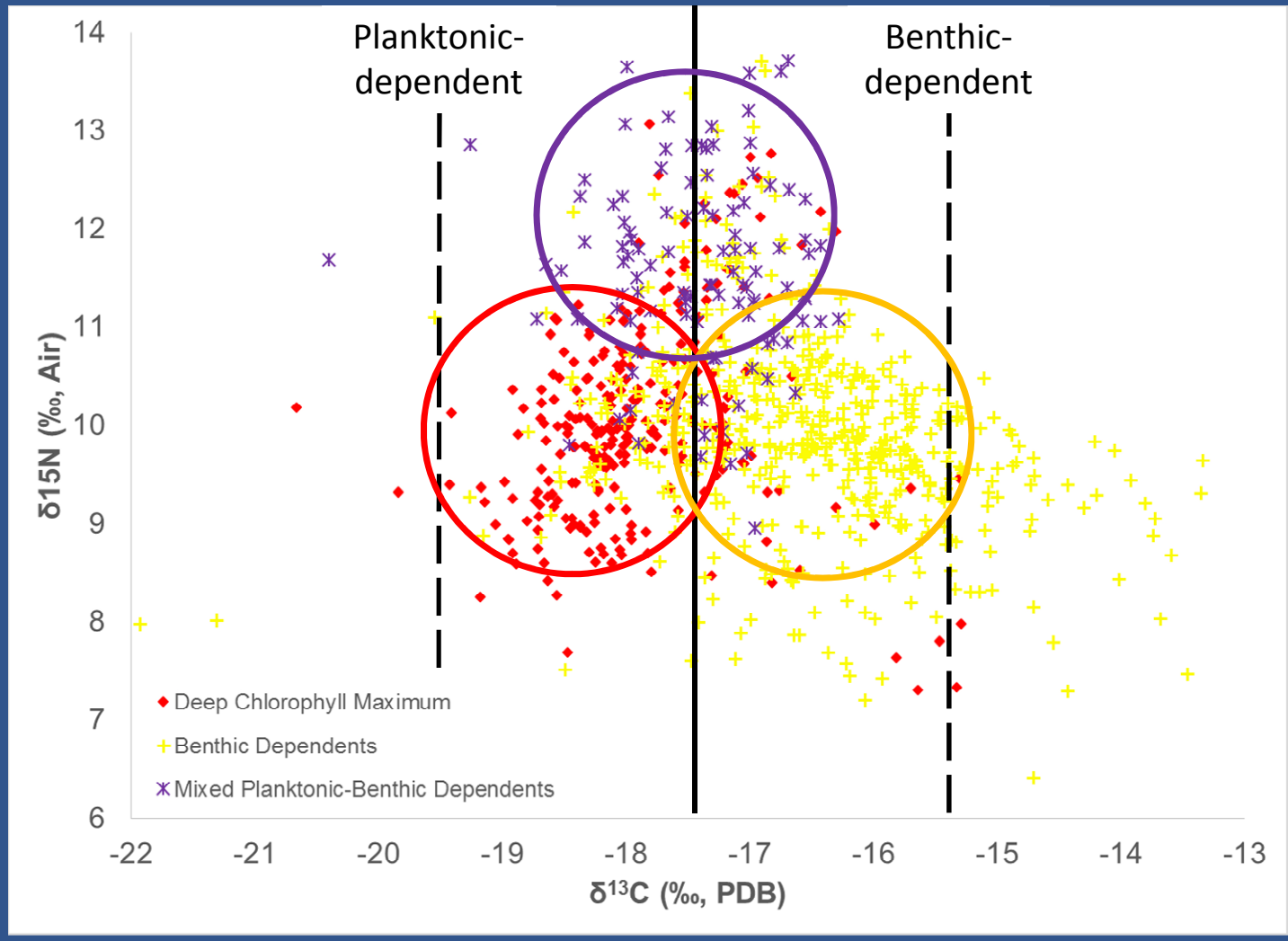


Basal Resource Communities

- Benthic-dependent (✚)
- Coastal zooplanktivores (■)
- Mixed planktonic-benthic dependents (✱)
- Deep chlorophyll maximum dependents (★)

Isotope Variation Among the Three Largest Communities

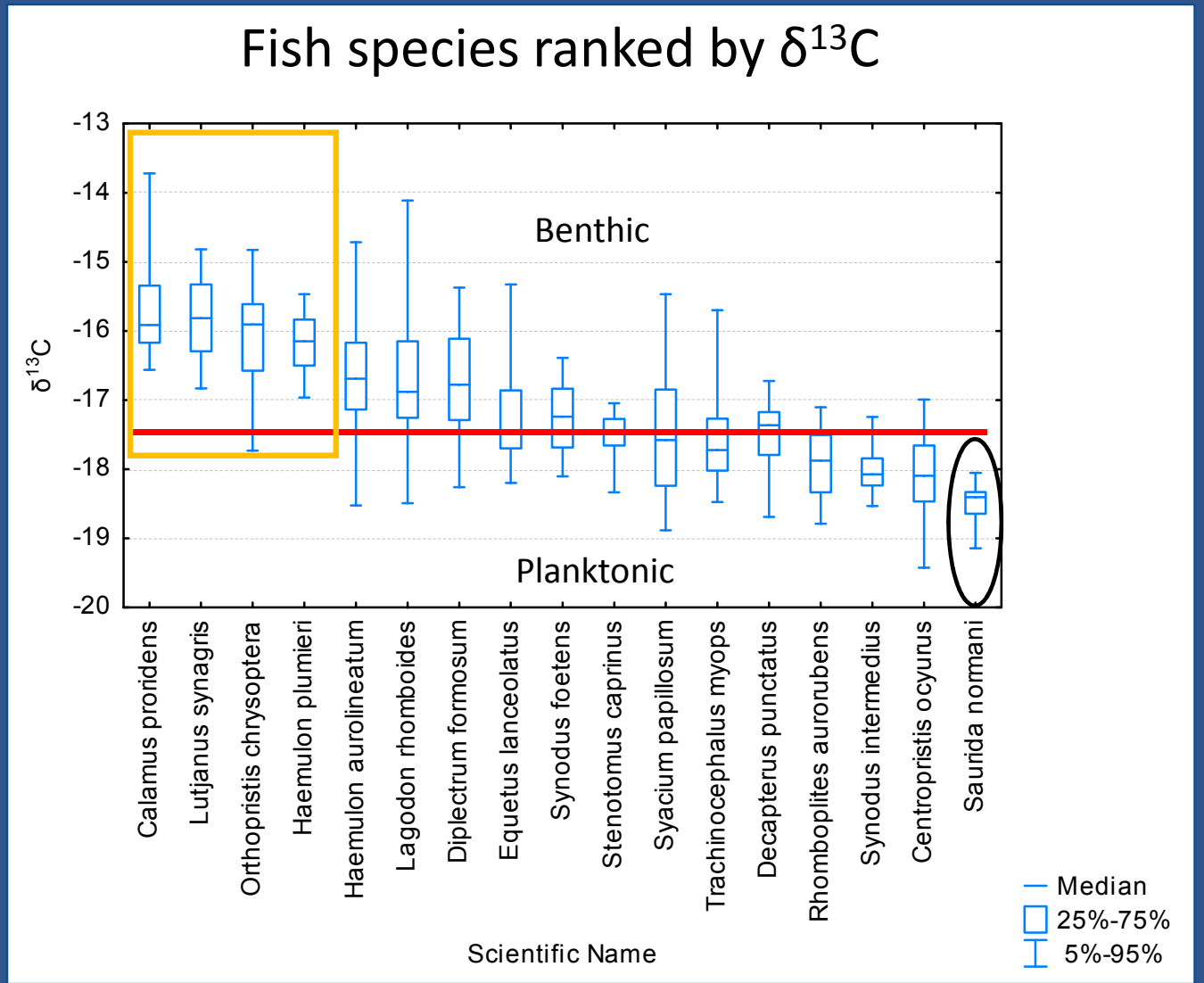
- Benthic-dependent individuals generally had **high $\delta^{13}C$** values and **low $\delta^{15}N$**
- Mixed planktonic-benthic dependents had **intermediate $\delta^{13}C$** and **high $\delta^{15}N$**
- The deep-chlorophyll maximum dependents had **low $\delta^{13}C$** and **low $\delta^{15}N$**
- In all communities, $\delta^{15}N$ varied with location along the FL coastline



There is spatial agreement between these isoscapes and variations in fish community structure.

$\delta^{13}C$ Basal-Resource Dependence for Individual Species

- Majority of species are facultative, but have varying dependence on benthic basal resources
- Few species utilize either basal resource exclusively
- **Species to the left of the figure can be expected to be impacted most by eutrophication**

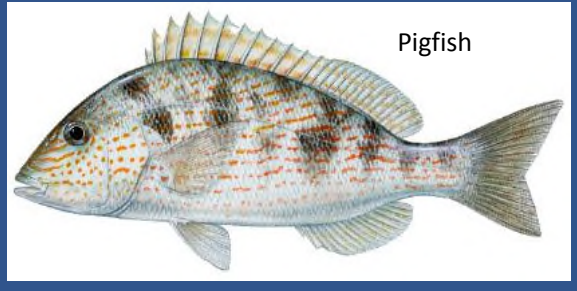


Implications for Fish Community

- **If eutrophication or other light-reducing processes expand east and south in the eastern GOM** (Rabalais et al. 2009), then benthic productivity will be reduced and the species identified as benthically dependent will likely be affected – **there will be winners and losers**

- The above would be reflected as a shift in fisheries landings towards more pelagic species; this would reflect the change from oligotrophic to eutrophic conditions (Caddy 2000)

- We are not sure if changes are currently happening in the eastern GOM



Acknowledgements

- Ernst Peebles, David Hollander, and Lori McRae
- FWC - especially Bob McMichael, Jr., Jenna Tortarelli-Tanis, and Amanda Tyler-Jedlund
- USF staff and students that helped with data collection/processing/review
  - Kara Radabaugh, Kristen Murphy, Ethan Goddard, Greg Ellis, Elon Malkin, and Ralph Kitzmiller, Ori Tzadik, Josh Kilborn, Brianna Michaud, Jeremy Browning, Amy Wallace
- Captain and Crew of R/V *Tommy Munro*
- Adam Bausch and other Cardno co-workers
- Family and Friends