AA-CSIA-derived Regional Comparison of the Trophic Positions of Midwater Fishes

Anela Choy
(cachoy@hawaii.edu)
Brian N. Popp
Jeffrey C. Drazen
Elizabeth Gier, Peter Davidson, Adrian Flynn, Joel Hoffman, Jennifer McClain, Todd Miller, Steve Ross, Tracey Sutton

© MBARI
What is the AA-CSIA method?

Compound-specific isotope analysis of INDIVIDUAL Amino Acids

McClelland and Montoya 2002

TROPHIC AMINO ACIDS
Undergo transamination.
Undergo deamination.
Are kinetically fractionated.
Eg. Glutamic Acid (Glu)

SOURCE AAs
Directly transferred fr prey to consumer.
Record food web base $\delta^{15}$N.
Little $^{15}$N enrichment.
Eg. Phenylalanine (Phe)
One of the main outputs of AA-CSIA is an integrated trophic position.

- TP may not represent complex trophic interactions inferred by stomach contents, modeling, etc.
- TP can provide some clarity to ecological structure within a diverse (pelagic) food web, esp. when used alongside biochemical markers, etc.
- Temporal, spatial, within/between species variability in TP is useful information for ecosystem-based managers/modelers ??

Olson and Watters 2003
Isotopically, you are what you eat.

\[ \delta^{15}\text{N of Predator} = \delta^{15}\text{N of Prey} + \sim 3\% \]

Lighter isotopes are preferentially excreted in waste processing.
Phytoplankton in upwelling regions (5 ‰)

Forage Fish (6 ‰)

Top Predators (9 ‰)

Crustaceans (3 ‰)

N₂ Fixing Phytoplankton (0 ‰)

after Graham et al. 2007
Spatial variation in consumer bulk signatures.

Graham et al. 2008
Time-series contour plot of $\delta^{15}$N-suspended PN with depth at St. Aloha demonstrates a shifting isotopic food web base.

Dore et al. 2002
Alternate Title:
Lanternfishes and dragonfishes –
What the heck is the difference??
Study Rationale

Problem
Bulk isotope variation between/within species, across regions, etc. is great. This makes ecological interpretation of widespread bulk data difficult. Before we can do regional comparisons of food webs we need to understand what mechanism is responsible for this variation.

Approach
Select two species spanning two trophic levels (3 and 4) from different regions with different biogeochemistries. Diets are known from independent stomach content work.

Analyze for bulk and compound-specific isotope values. Compare resulting TLs with diet work across regions. Are these “real” ecological food web differences? Is it something procedural? Can differences be explained by differing biogeochemistries?

\[ TP_{Glu-Phe} = \frac{\delta^{15}N_{Glu} - \delta^{15}N_{Phe} - 3.4}{7.6} + 1 \]

[Chikaraishi et al. 2009]
Trophic Level 3 = Zooplanktivorous Myctophid
- Most are diel vertical migrators
- Size range across regions was 19-101mm
- Relatively faster-growing/reproducing

Trophic Level 4 = Piscivorous Dragonfish
- Mostly non-migratory
- Size range across regions was 27-318mm
- Relatively slower-growing/reproducing
1. Hawaii (HI) – oligotrophic central gyre with long, microbial-based pelagic food webs
2. CA Current (CA) – eutrophic upwelling system with shorter food webs, seasonally diatom-based
3. Gulf of Mexico (GOM) – semi-enclosed, loop current upwelling, riverine inputs
4. Mid-Atlantic Ridge (MAR) – bathymetric topography, low offshore surface production, seasonality
5. Tasman Sea (AUS) – roaring forties, high energy, marked seasonality
Bulk Isotope Values for Various Mid-water Fishes

- Mid-Atlantic Ridge TL-3
- Mid-Atlantic Ridge TL-4
- Hawaii TL-3
- Hawaii TL-4
- CA current TL-3
- CA current TL-4
- Gulf of Mexico TL-3
- Gulf of Mexico TL-4
- Tasman Sea TL-3
- Tasman Sea TL-4

Trophic Level 3 = Zooplanktivorous Myctophid
Trophic Level 4 = Piscivorous Dragonfish
Trophic Positions for Zooplanktivorous Lanternfishes

- Tasman Sea
- CA Current
- Gulf of Mexico
- Hawaii
- Mid-Atlantic Ridge
Trophic Positions for Piscivorous Dragonfishes

- Tasman Sea
- CA Current
- Gulf of Mexico
- Hawaii
- Mid-Atlantic Ridge
No statistical difference between lanternfishes and dragonfishes CSIA-TP by region [Paired t-test, p=0.53]
Summary

- AA-CSIA method produces remarkably consistent TPs across five distinct oceanographic basins for both fishes.

- AA-CSIA Dragonfish TP is drastically lower than estimated from stomach content analysis.
  - Does SCA miss smaller, lower-TL prey?
  - Is there something distinct in the life histories, etc. of the two groups that would require application of different TEFs?

- Surprisingly little difference in TP between the two groups.

- Technique offers integrated independent ecological insight when used in conjunction with [snapshot] stomach contents, bulk isotopes, etc.
Acknowledgement(s)

[Pelagic Fisheries Research Program for Funding and Research Support]
[University of Hawaii, Dept. of Oceanography]
[UH Isotope Biogeochemistry Laboratory]
[Collaborators]