Compound Specific Stable Nitrogen Isotope Analysis of Amino Acids: What can this Novel Technique tell us about the Ecology of a Highly Migratory Marine Turtle?

Karen Arthur¹
Brian Popp¹, Scott Benson², Jeff Seminoff²

¹Department of Geology and Geophysics, University of Hawaii
²Southwest Fisheries Science Center, NOAA
The challenge: Modeling marine ecosystems

Based on Olson & Watters 2003

Important ways we model marine ecosystem is through trophic models, but relationships often complex and dynamic
Current tools: Trophic position (TP)

- **Stomach content analysis**
  - Challenges: Time consuming, expensive, snap shot & miss cryptic items

- **Bulk tissue nitrogen isotope analysis**
  - Challenges: Source $\delta^{15}\text{N}$, enrichment, tissue type

![Trophic enrichment diagram](image)

- Source $\delta^{15}\text{N}$
- $\sim 3\%$
 Novel tool: Compound specific nitrogen isotope analysis of amino acids (AA-CSIA)

“Trophic” Amino Acids
- Carbon/ nitrogen bond cleaved causing enrichment of $^{15}$N during metabolism
- These AA enriched in $^{15}$N through food web
- Eg: Glutamic acid, alanine, aspartic acid

“Source” Amino Acids
- Do not undergo transamination reactions during metabolism
- Retain $\delta^{15}$N composition of base food web
- Eg: Phenylalanine, lysine, threonine.

McClelland and Montoya (2002), Chikaraishi et al. (2007), Popp et al. (2007)
Novel tool: AA-CSIA for calculating TP

\[ TP_{\text{Glu-Phe}} = \left( \delta^{15}\text{N}_{\text{Glu}} - \delta^{15}\text{N}_{\text{Phe}} - 3.4 \right) / 7.6 + 1 \]

We can obtain nitrogen isotopic source & trophic information from just the consumer tissue

Re-drawn from Chikaraishi et al 2009 L&O Methods
Leatherbacks (*Dermochelys coriacea*)

- Nest in tropical beaches
- Display natal beach homing
- Forage over vast areas at high latitudes
- Exclusively feed on gelatinous prey

[Map of Leatherback Sea Turtle Range](http://www.nmfs.noaa.gov/pr/pdfs/rangemaps/leatherback_turtle.pdf)
Challenge of bulk isotopes: Leatherbacks in Pacific

Interpretations:
1. Two feeding populations feeding at different trophic levels (~3‰ difference)
2. Two feeding populations feeding in areas with different nitrogen cycling regimes

THIS IS A JOB FOR AA-CSIA!
Application of AA-CSIA: Leatherbacks in Pacific

Skin samples: 

Source AA: phe = 4.2 ± 0.7 ‰ 
Trophic AA: glu = 17.7 ± 0.4 ‰ 

Source AA: phe = 7.2 ± 0.3 ‰ 
Trophic AA: glu = 21.0 ± 0.1 ‰ 

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

Trophic Position (AA) = 2.33 ± 0.1 

Trophic Position (AA) = 2.36 ± 0.1
Application of AA-CSIA: Trace different sources of N

N* is a Redfield N:P ratio derived such that:

N* > 1 nitrogen fixation dominates ($\delta^{15}N < 5 \, \text{‰}$)

N* < 1 denitrification dominates ($\delta^{15}N \approx 5-15 \, \text{‰}$)

From: Pennington et al 2006

Source AA: phe = 4.2

Source AA: phe = 7.2
Summary:

- We were able to explain bulk isotope data for leatherbacks
- Management perspective – clearly describes two feeding populations
- Powerful tool esp. in conjunction with multiple approaches: stomach, bulk, telemetry
- More to learn...
A novel tool for validating trophic position estimates in ecosystem-based fisheries models

Brian Popp (UH), Jeffrey Drazen (UH), Michael Landry (Scripps), Carolyn Holl (Oceanic Institute), Bob Olson (Inter-American Tropical Tuna Commission)

Goals:
1. To validate the application of AA-CSIA across multiple marine phyla under differing physiological conditions.
2. To compare the application of AA-CSIA across systems with contrasting biogeochemical cycling regimes.
3. To develop the use of AA-CSIA TP estimates for validating trophic models of exploited ecosystems – past and present.

http://cameo.noaa.gov/pres_bpopp.html

arthur4@hawaii.edu
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Questions?