Using AA $\delta^{15}\text{N}$ to Estimate Trophic Level

$$TP_{\text{Trophic-Source}} = \frac{\delta^{15}\text{N}_{\text{Trophic}} - \delta^{15}\text{N}_{\text{Source}} + \beta_{\text{Trophic-Source}}}{\text{TDF}_{\text{Trophic-Source}}} + 1$$

$eta_{x/y} = \text{TL}_1$ (primary producer)

$\delta^{15}\text{N}_{\text{Trophic}} - \delta^{15}\text{N}_{\text{Source}}$

TDF: $\Delta_x - \Delta_y$

$\beta$ and TDF are trophic-source pair specific
Some trophic-source pairs (Pro-Lys) show little change with [dietary protein], while others (Glu-Phe) show a significant decrease.

Whiteman et al. 2021
Variation in $TDF_{\text{Glu-Phe}}$

$$TP = \frac{\delta^{15}N_{\text{Trophic}} - \delta^{15}N_{\text{Source}} + \beta_{\text{Trophic-Source}}}{1}$$
Consumer–Diet $\Delta^{15}$N: Primary Consumers

- Aquatic, ammonia
- Aquatic, urea/uric acid
- Terrestrial, ammonia
- Terrestrial, urea/uric acid

McMahon and McCarthy 2016
Consumer–Diet $\Delta^{15}\text{N}$: Tertiary Consumers

$\Delta^{15}\text{N}_{C-D}$ (%)

Aquatic, ammonia
Aquatic, urea/uric acid
Terrestrial, ammonia
Terrestrial, urea/uric acid

Glu  Asp  Ala  Ile  Leu  Pro  Val  Gly  Ser  Phe  Lys  Met  Thr
Diet Quality and Excretion Mode Matter

\[ f(x) = -2.3x + 5.1 \]
\[ r^2 = 0.61, P < 0.01 \]
Patterns in Amino Acid $\delta^{15}N$: Proxy for Nitrogen Balance?

Marion Island, South Africa

Lubcker et al. 2016, 2017

Mirounga leonina
\( \delta^{15}N \) Values of Many Amino Acids are Higher During Fasting

- Ala
- Asp
- Glu
- Ile
- Leu
- Val
- Pro
- Gly
- Ser
- Phe
- Lys
- Tyr

Fasting (endogenous)
Independent (exogenous)

Lubcker et al. 2020
Gluconeogenesis: A Critical Pathway

Exogenous (dietary protein)

Endogenous (skeletal muscle)

\[ ^{15}\text{N}\text{-AAs (plasma)} \]

\[ ^{14}\text{N}\text{-Urea (pee)} \]

Lys (ketogenic)

\[ \delta^{15}\text{N} \]

Ala, Ser, Gly, Glu, Pro, Asp Phe, Tyr (glucogenic)
Ala  Asp  Glu  Ile  Leu  Val  Pro  Gly  Ser  Phe  Lys  Tyr

Fasting (endogenous)
Independent (exogenous)

Lubcker et al. 2020
Interorgan cycle that transports nitrogen from skeletal muscle to the liver using alanine as a carrier during nutritional stress (i.e., fasting).
No Change in Branch-Chained AAs and Glutamic Acid $\delta^{15}N$

- Fasting (endogenous)
- Independent (exogenous)

Lubcker et al. 2020
Significant (3-5%) decreases in $\delta^{15}N$ from early (yolk) to late (placenta) term pregnancy in nearly all AAs (except Phe)

Preliminary results suggest either (1) protein sparing (decrease in $\Delta^{15}N_{\text{consumer-diet}}$), and/or (2) nitrogen ($^{14}N$ urea) recycled for reproduction.
Developing a Pregnancy Test for a Whale

Dr. Geraldine Busquets Vass

Eubalaena australis

bulk - trophic

source

physiol.

$\delta^{15}$N

LD2 (34%)

LD1 (66%)

Cow

Calf

Adults

pregnant□
not pregnant□
Take Home Message(s): Amino Acid $\delta^{15}$N

For $\delta^{15}$N, amino acids are classified as source and trophic depending on their involvement in the central metabolic nitrogen pool.

$\delta^{15}$N analysis of source amino acids (Phe/Lys) provides a way of assessing baseline (primary producer) $\delta^{15}$N composition that is sensitive to environmental conditions by analyzing consumer tissues.

Comparison of trophic and source amino acids can provide an estimate of trophic position that only requires a single consumer tissue sample.

Amino acid $\delta^{15}$N is also a promising tool to study animal eco-physiology, specifically processes that impact nitrogen balance (reproduction).

At present, too few exist data to robustly assess taxon- and ecosystem-related variation in primary producer $\beta$ and AA-specific trophic discrimination factors* (especially true for terrestrial and freshwater aquatic ecosystems).

*IMO