How Well Do Stable Isotopes Represent Bearded Seal Diet?

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Introduction

A common way to study animal diet is to examine stable isotope ratios in tissues. Stable isotopes represent a mixture of prey consumed over a tissue-specific timeframe and can be used to detect large scale changes in prey consumption, but has limited taxonomic resolution. Mixing models have been developed to increase the resolution of data, but are restricted in the number of prey categories that can be included in the analysis. To quantify these limitations, we analyzed stable isotope ratios in muscle of 36 bearded seals (*Erignathus barbatus*), which are benthic generalists, and compared them to stomach contents.

Figure 1. *Map of Alaska including communities where seal tissues were collected.*

Methods

Field Collections

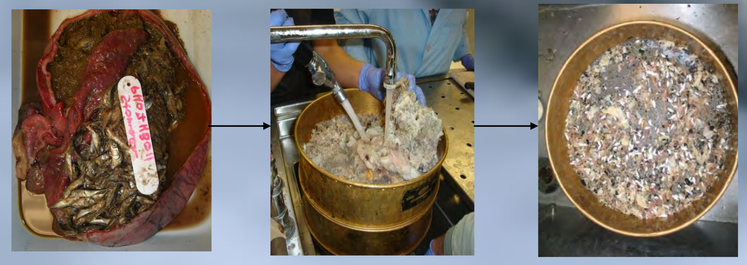
Stomach contents and muscle samples were collected from 36 (20 female, 16 male) adult (>5 years) bearded seals harvested for subsistence use in the spring near Little Diomede and Point Hope, Alaska between 2004 and 2009 (Figure 1). Samples were frozen at -20°F until analyzed. In addition, the Alaska Department of Fish and Game (ADF&G) has stomach content data for 298 bearded seals collected near various communities through the Bering and Chukchi sea regions since 2000 (including the 36 above) that were used to identify common prey taxa.

Analysis

- ***Stomach contents*** were rinsed with freshwater through two sieves and prey items were identified to the lowest possible taxonomic level (Table 1). Relative occurrence (RO) was calculated for major prey items. RO is the number of stomachs that contain a prey category divided by the cumulative number of taxa identified in all stomachs.
- Muscle was freeze-dried and analyzed for ***stable isotopes***, $\delta^{13}C$ and $\delta^{15}N$, at the Alaska Stable Isotope Facility at University of Alaska Fairbanks on an IRMS-EA following the methods described in Dehn et al. (2007).
- ***Stable isotopes*** **in** muscle represent diet over at least several months, and therefore our muscle samples likely represent winter diet. We then compared proportions from a stable isotope mixing model (SIAR) with those derived from ***Stomach contents.***

Results

ADF&G has identified 186 different prey taxa in bearded seal ***stomach contents*** since 2000 (Quakenbush et al. 2011). Of these, 8 taxa of fish (at least 12 species) and 8 taxa of invertebrates (at least 16 species) were identified from the 36 seals in this study (Table 1). These prey taxa were used to create the trophic guilds for the stable isotope mixing model.



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Background Photo: NOAA

Trophic guild	Taxon	Relative occurrence (RO) All seasons (*n*=298)	Winter season (*n*=61)	This study (*n*=29)
1	Cod (Gadidae)	10%	11%	13%
	Pacific sand lance (*Ammodytes hexapterus*)	3%	2%	7%
2	Echiuridae	6%	5%	10%
	Polychaeta	3%	2%	2%
3	Clam (Bivalve)	8%	8%	5%
4	Crab	14%	10%	14%
	Flatfish (Pleuronectidae)	10%	15%	10%
5	Pricklebacks (Stichaeidae)	5%	4%	3%
	Sculpin (Cottidae)	14%	15%	17%
	Shrimp (Decapod)	16%	19%	16%
	Snail (Gastropoda)	5%	1%	2%
6	Amphipod	2%	5%	-
1 & 2	Cephalopoda	2%	2%	1%

Table 1. *Relative occurrence of 12 common prey taxa found in bearded seal* ***stomach contents*** *since 2000* (Quakenbush et al. 2011). *Eleven were found in 29 (7 empty) of the seals used for stable isotopes. Winter diet has been isolated to compare against the stable isotope results. Row colors match the color scheme of prey highlighted in Figures 2 and 3 and Table 2.*

Stable isotope ratios in muscle ranged from 14.1 to 18.5 ‰ $\delta^{15}N$ and indicate foraging on mid to high trophic levels. The range of $\delta^{13}C$ was more variable likely due to factors including feeding on both benthic and pelagic species and feeding over a wide geographic range and habitat types (Figure 2). (*Note*: the samples with <-20 ‰ $\delta^{13}C$ values were contaminated with oils; lipid extraction would likely correct these values, but may impact $\delta^{15}N$)

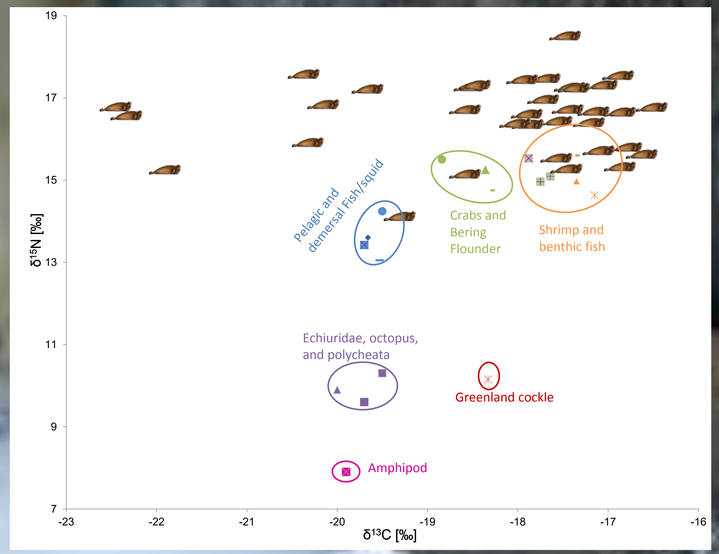

Figure 2. ***Stable isotope ratios*** *for bearded seal muscle from this study and some representative prey species from the literature (Dehn et al. 2007, Iken et al. 2010, and Carroll et al. in review). Prey isotope values have not been adjusted for tissue fractionation. Colored circles identify the trophic guilds used in the mixing model (Table 2 and Figure 3).*

To apply a ***stable isotope mixing model*** we grouped 22 prey items into 6 trophic guilds (based on similar isotope values) because of model constraints. In addition, region specific isotopic information does not exist for all prey. No tissue fractionation rates exist for bearded seal muscle so harp seal (*Pagophilus groenlandicus*) muscle values were used (Hobson et al. 1996).

Trophic guild		Percentage
1	Pelagic and demersal fish/squid	35% (17-55%)
2	Echiuridae/octopus/polychaeta	7% (0-19%)
3	Greenland cockle	7% (<1-16%)
4	Crabs/Bering flounder (flatfish)	23% (1-42%)
5	Shrimp/whelk/benthic fish	22% (5-41%)
6	Amphipod	5% (0-13%)

Table 2. *Results from the* ***Mixing Model*** *for the 36 seals. The proportions of each trophic guild consumed are presented by the mean and 95% credibility intervals for all seals.*

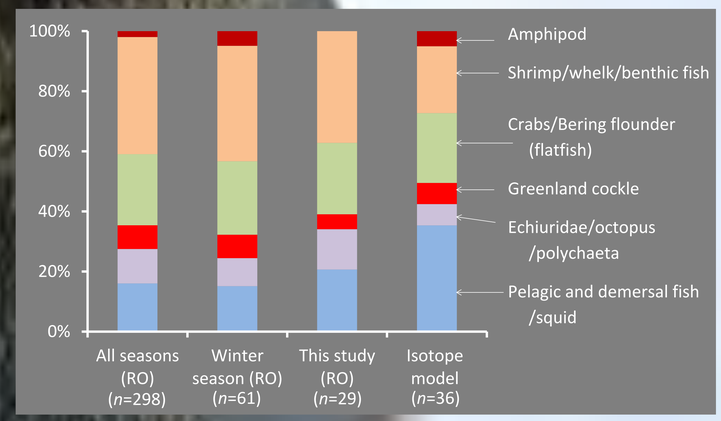

Figure 3. *Total Relative Occurrence from* ***stomach contents*** *for all items in each trophic guild and average proportions from the* ***stable isotope mixing model.***

Why don't they match?

- Trophic guilds overlap in isotopic space
- Not all taxa in the stable isotope prey library are exact matches to species found in stomach contents
- Location and year of collection are not the same for all taxa in the library
- Some taxa in the library are lipid extracted while others are not
- Stable isotopes reflect assimilated diet which may differ from ingested diet

Conclusions

- The mixing model did not represent the complexity of bearded seal diet but the major prey categories were represented.
- Dietary proportions differ between the stable isotope mixing model and stomach contents.

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