Do Stomach Contents, Fatty Acids, and Stable Isotopes Yield the Same Dietary Results?

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Introduction

Stomach contents, stable isotopes, and fatty acids are commonly used to infer diet of marine mammals. How the results of these methods compare is poorly understood. We applied all three techniques to a sample of 36 bearded seals (*Erignathus barbatus*). Bearded seals are ice-associated pinnipeds in the circumpolar Arctic and are known to have a mixed diet including both benthic and pelagic species. We also reconstructed the diet of an individual bearded seal using each of the three methods.

Figure 1. *Map of Alaska including Little Diomede and Point Hope; seal tissue collection locations.*

Methods

Field Collections

Stomach contents, muscle, and blubber samples were collected from 36 (20 female, 16 male) adult (>5 years) bearded seals harvested for subsistence use in Little Diomede and Point Hope, Alaska between 2004 and 2009 (Figure 1). Samples were frozen at -20°F until analyzed.

Analysis

- ***Stomach contents*** were rinsed with freshwater through two sieves and prey items were identified to the lowest possible taxonomic level (Table 1).
- 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).
- Lipids were extracted from full thickness blubber for ***fatty acids*** and analyzed following the methods described in Budge et al. (2006). Dietary fatty acids were normalized and then log transformed (Budge et al. 2006).

Results

Stomach contents identified 8 taxa of fish (at least 12 species) and 8 taxa of invertebrates (at least 16 species) as prey items (Table 1).

Taxon	Frequency of occurrence	Relative occurrence
Saffron cod (*Eleginus glacialis*)	45%	12%
Pacific sand lance (*Ammodytes hexapterus*)	31%	8%
Arctic cod (*Boreogadus saida*)	31%	8%
Echiuridae	41%	11%
Polychaeta	10%	3%
Clam (Bivalve)	24%	6%
Crab	59%	15%
Flatfish (Pleuronectidae)	7%	2%
Shrimp	55%	15%
Sculpin (Cottidae)	31%	8%
Pricklebacks (Stichaeidae)	7%	2%
Snail (Gastropoda)	7%	2%
Porifera	21%	5%
Bryozoa	3%	1%
Capelin (*Mallotus villosus*)	3%	1%
Cephalopoda	3%	1%

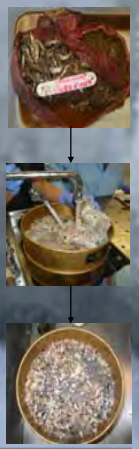


Table 1. *Sixteen prey taxa found in stomach contents from 29 bearded seals (7 empty). Frequency of occurrence is the number of stomachs that contain a particular prey taxa divided by the number of total stomachs with prey. Relative occurrence is the number of stomachs that contain a prey category divided by the cumulative number of taxa identified in all stomachs. Row colors match the color scheme of prey highlighted in Figure 2.*

Stable isotopes in muscle ranged from 14.11 to 18.51 $\delta^{15}N$ ‰ 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 carbon values were contaminated with oils; lipid extraction would likely correct these values, but may impact $\delta^{15}N$.)

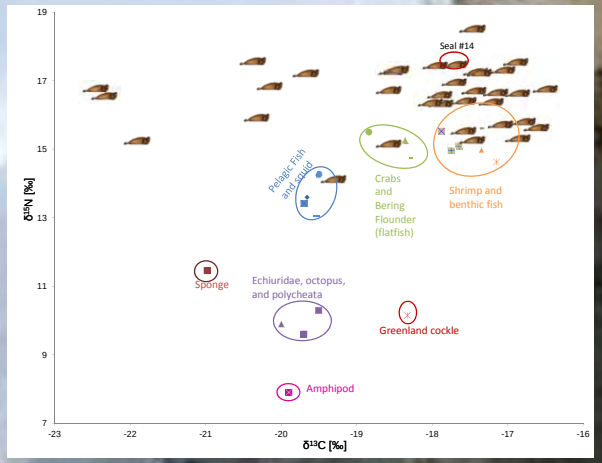
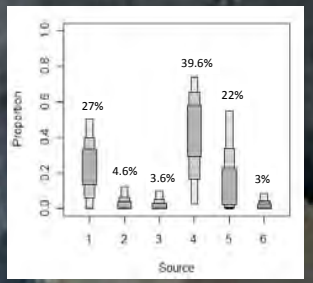


Figure 2. *Stable isotopes for bearded seal muscle from this study and some representative prey species from the literature (Dehn et al. 2007, Iken et al. 2010, and Carroll et al. in review). Prey isotope values have not been adjusted for tissue fractionation. Colored circles identify the trophic guilds used in the mixing model (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 muscle values were used (Hobson et al. 1996).

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

Figure 3 A. *Results from the Bayesian Mixing Model SIAR for the 36 seals. The proportions of each trophic guild consumed are presented by the mean and 95% credibility intervals for all seals.*



B. *Dietary composition for seal #14, an adult female bearded seal. The bars represent the 95, 75, and 25% credibility intervals; the darkest bar is 25%. Mean proportions are above the bars.*

Modeling of ***fatty acids*** **(e.g., QFASA)** was not possible because a fatty acid prey library does not exist for the Bering/Chukchi seas. Fatty acids found in shrimp, sculpin, pelagic fishes, and benthic invertebrates were part of the seal signatures and therefore likely part of the diet. A Principle Component Analysis of 34 dietary fatty acids produced 5 eigenvalues >1.0 and PC1 and PC2 explained 73.8% of the variability. PC values indicate there are differences in the diets of these seals (particularly the 8 highlighted in Figure 4).

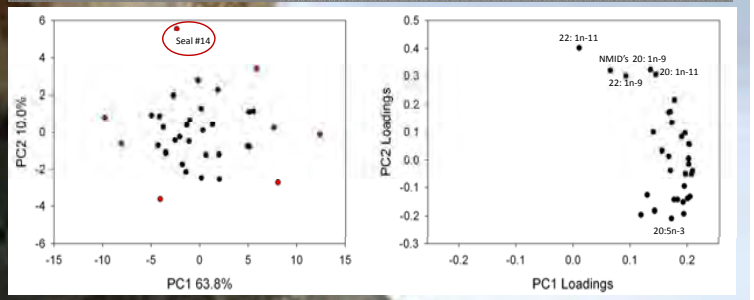


Figure 4. *Principle Component Analysis of 34 dietary fatty acids in 35 bearded seals (one seal was removed as an outlier). Seal #14 is circled in red.*

Dietary reconstruction of an individual bearded seal (# 14)

Using stomach contents, diet included:

- **Pacific sand lance, saffron cod, sculpin (Arctic staghorn sculpin and *Myoxocephalus* spp.), flatfish (longhead dab), bivalve (*Mya* spp.), shrimp (*Argis lar*), and crab (*Telmessus cheiragonus*, *Hyas lyratus*, and *Chionoecetes opilio*)**

Using stable isotopes, diet included:

- **Lower than average amount of pelagic fishes/squid (trophic guild 1) compared to other bearded seals**
- **Higher than average amount of shrimp/whelk/benthic fishes (trophic guild 5)**
- **Average amounts of trophic guilds 2,3,4, and 6 (Figure 3)**

Using fatty acids, diet included:

- **Higher levels of 22:1n-11, which may indicate a diet higher in pelagic fishes compared to other bearded seals; but bivalves and gastropods were likely also contributing prey.**

The three methods do not agree on the proportions of prey in the diet of seal # 14, but all known prey categories were represented by all three methods.

Conclusions

- All known prey categories were represented by the three methods, however, the detail of the dietary information varied.
- For general questions or comparisons stable isotopes and fatty acid methods may be useful, but until prey libraries, tissue fractionation, and fatty acid metabolism and distribution within seals are better understood, stomach content analysis is the only method that provides identification of specific prey in bearded seal diet in Alaska.

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Background Photo: NOAA

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