Decadal-scale changes in the feeding ecology of Alaskan polar bears

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Introduction

- Sea ice loss is leading to changes in the foraging habitat of southern Beaufort Sea (SB) polar bears, particularly in the increased use of terrestrial habitats and possibly onshore food resources including subsistence-harvested bowhead whale carcasses and eggs/nestlings of colonial-nesting seabirds.[1,2]
- Estimates of prey resource use in SB polar bears have previously been determined by quantitative fatty acid signature analysis (QFASA).[3]
- Previous work using QFASA did not find significant diet temporal trends on feeding ecology changes show no temporal trends from 2004-2012, however, high inter-annual variability was found, and seabirds were not considered as potential prey. [4]
- Long-term monitoring is needed to more fully evaluate the use of onshore foods, including a broader suite of potential foods.

Objectives

1. Estimate proportions of onshore and marine prey considering a broad suite of potential food sources
2. Evaluate temporal trends in prey consumption (2004-2016)

Hypotheses

1. Onshore foods are an important component of SB diets.
2. Use of ice-obligate prey has declined and use of onshore food resources has increased over time.

Methods

1. Quantify fatty acid signatures for SB polar bears and potential prey species by established procedures.[5]
   - Polar Bear adipose (n = 573, collected Spring 2004-2016; **Fig. 1**)
   - Ringed seal blubber[6] (n = 89)
   - Bearded seal blubber[6] (n = 20)
   - Beluga whale blubber[6] (n = 29)
   - Bowhead whale blubber[7] (n = 64)
   - Seabirds** whole eggs and nestlings (n = 23)
2. Generate preliminary QFASA based diet estimates of SB polar bears, according to published approaches.[4]

** using black guillemot as representative colonial-nesting bird prey

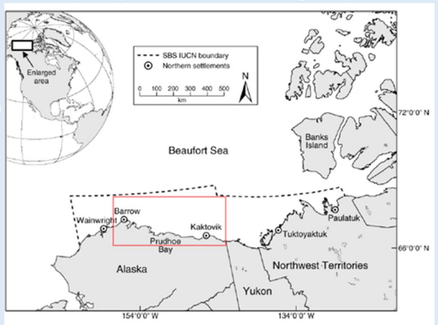

Fig 1. Map of study location. Area of sampling denoted by red box. Population boundary represented by dashed lines. (Adapted from Rode et al. 2010)[8]

Photo (left): SB polar bear attempting to prey on black guillemot nest on Cooper Island, AK. (Photo credit: G. Divoky)

Photo (Right): SB polar bear feeding on a bowhead whale carcass from the subsistence-harvest. (Photo credit: USFWS)

Results

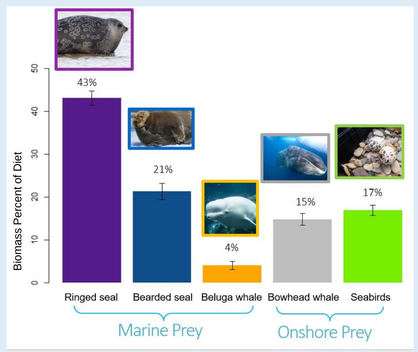

Fig 2. Mean proportion of diet (±SE) for five prey items of SB polar bears, 2004-2016.

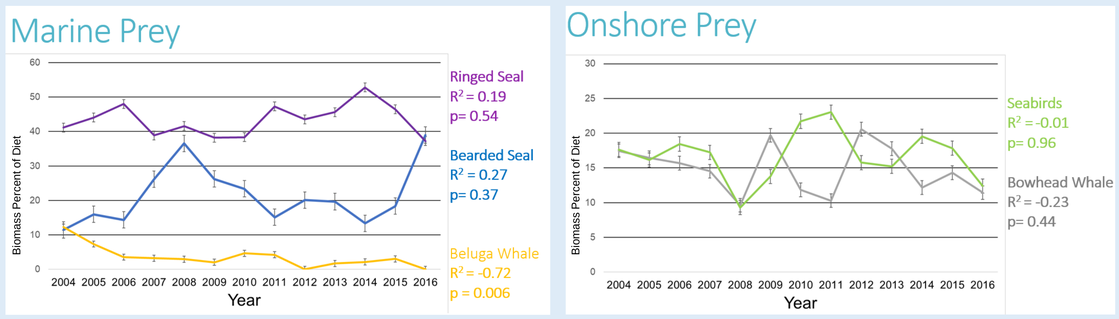

Fig 3. Temporal changes in the mean (±SE) proportion of prey items in the diet of SB polar bears from 2004-2016. Prey separated by location of foraging with marine prey (left) and onshore food sources (right).

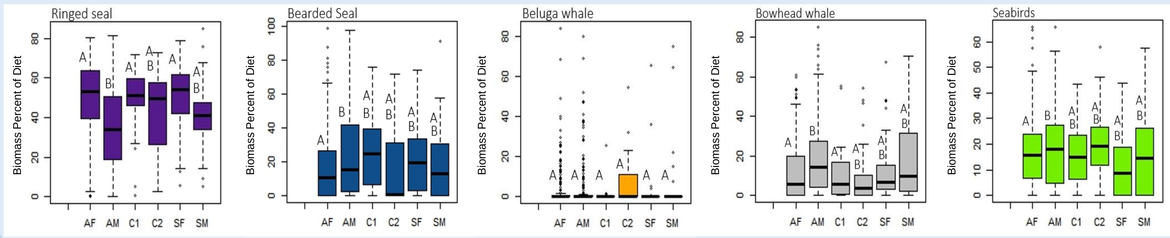

Fig 4. Box plots of the proportion of prey species in varying age/sex classes of SB polar bears. AF (adult female n = 205), AM (adult male n = 221), C1 (1 year old cub n = 38), C2 (2 year old cub n = 21), SF (sub-adult female n = 48), SM (sub-adult male n = 35). Age/sex classes in the same plot with the different letters indicate significant differences ($p < 0.05$).

Conclusions and Future Directions

1. Onshore foods, both bowhead whale and seabirds, appear to represent a substantive (up to 36% in some years) portion of SB polar bear diets throughout the time period of 2004-2016.
2. Consumption of traditional marine prey did not appear to have declined in preliminary results despite sea ice loss over the period (2004-2016) except for the minor prey, beluga whale.
3. Significant demographic variation was found with adult males having the most distinct diet.
4. Future work will further determine factors contributing to diet variation including prey abundance and ice.[9,10]

Acknowledgements: **Field sampling and sample coordination:** Kristin Simac, Anthony Pagano, George Durner, Karyn Rode, and Karen Oakley (USGS Alaska Science Center) References: [1.] Atwood TC, Peacock E, McKinney MA, Lillie K, Wilson R, Douglas DC, Miller S, Terletzky P (2016) Rapid Environmental Change Drives Increased Land Use by an Arctic Marine Predator. PLOS ONE 11:e0155932 [2.] Divoky GJ, Lukacs PM, Druckenmiller ML (2015) Effects of recent decreases in arctic sea ice on an ice-associated marine bird. Progress in Oceanography 136:151-161 [3.] Iverson SJ, Field C, Bowen WD, Blanchard W (2004) Quantitative Fatty Acid Signature Analysis: A New Method of Estimating Predator Diets. Ecological Monographs 74:211-235 [4.] McKinney MA, Atwood TC, Iverson SJ, Peacock E (2017) Temporal complexity of southern Beaufort Sea polar bear diets during a period of increasing land use. Ecosphere 8:e01633-e01 [5.] Budge SM, Iverson SJ, Koopman HN (2006) Studying trophic ecology in marine ecosystems using fatty acids: a primer on analysis and interpretation. Mar Mam Sci 22:759-801 [6.] Thiemann GW, Iverson SJ, Stirling I (2008) Polar Bear Diets and Arctic Marine Food Webs: Insights from Fatty Acid Analysis. Ecological Monographs 78:591-613 [7.] Budge SM, Springer AM, Iverson SJ, Sheffield G, Rosa C (2008) Blubber fatty acid composition of bowhead whales, *Balaena mysticetus*: Implications for diet assessment and ecosystem monitoring. Journal of Experimental Marine Biology and Ecology 359:40-46 [8.] Rode KD, Amstrup SC, Regehr EV (2010) Reduced body size and cub recruitment in polar bears associated with sea ice decline. Ecological Applications 20:768-782 [9.] Nguyen L, Pilfold NW, Derocher AE, Stirling I, Bohart AM, Richardson E (2017) Ringed seal (*Pusa hispida*) tooth annuli as an index of reproduction in the Beaufort Sea. Ecological Indicators 77:286-292 [10.] Rode KD, Wilson RR, Douglas DC, Muhlenbruch V, Atwood TC, Regehr EV, Richardson ES, Pilfold NW, Derocher AE, Durner GM, Stirling I, Amstrup SC, St.Martin M, Pagano AM, Simac K (2017) Spring fasting behavior in a marine apex predator provides an index of ecosystem productivity. Glob Change Biol 2017:1-14

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