What's Really For Dinner: Pacific Walrus Trophic Level Feeding Ecology in Relation to Location and Sex

J. Seymour [1], L.A.-Dehn [1], M. Wooller [1]
[1] School of Fisheries and Ocean Sciences, University of Alaska Fairbanks, Fairbanks, Alaska

Photo Credit: J. Seymour

Introduction and Background

Pacific walruses (*Odobenus rosmarus divergens*) are currently under review for U.S. Federal Endangered Species Act (ESA) listing. Sea ice provides a vital resting platform for walruses between foraging trips, however the Arctic's changing environment may prompt the walruses to adopt alternative foraging strategies (Rausch et al. 2007; Fischbach & Jay 2008). These may take the form of direct changes, such as altered feeding behavior, or indirect changes in the form of differences in food web dynamics, decreased biomass input to the benthos, and decreases in prey quality (Grebmeier et al. 2006). Walruses may feed opportunistically on available resources and Fay (1960) suggested that in during times of nutritional stress or unfavorable ice conditions walruses may prey on seals. The use of centralized terrestrial haulouts in the absence of sea ice could also lead to localized prey depletion and/or create energetically costly increases in travel distances to foraging grounds (Sheffield & Grebmeier 2009). Seal-eating and carcass scavenging by walruses is not a novel behavior, although the incidence of this foraging strategy appears to be increasing (Fay 1960; Lowry & Fay 1984; Wolkers et al. 2006).

Dramatic prey shifts (e.g., seal-eating) can in turn change host-parasite dynamics and result in declining body condition and fecundity, increased disease susceptibility, decreased offspring survival, and changes in contaminant exposure; all of which can then lead to population declines. Additionally, predation upon pagophilic seals may have consequences on population dynamics of these seal species, several of which have been proposed for listing under the ESA. Historically, gut content studies have been used to determine prey choice and diversity in walrus diet. However, such studies may be biased towards hard-bodied dietary items that have long digestive retention times or are indigestible, therefore underestimating the contribution of soft-tissue prey. The ability to quantify seal consumption in Pacific walruses as well as determine potential correlations among proportional contribution of different trophic level prey, sex, and location is vital to marine mammal species management and the construction of models of climatic impacts on Arctic marine ecosystems.

Methods

Walrus lumbar muscle (*n*=161), tongue muscle (*n*=7), liver (*n*= *109*), and skin (*n*=*2*) samples from a total of 279 animals were analyzed for stable carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) isotopes at the University of Alaska Fairbanks (UAF) Stable Isotope Facility. The resulting values were then compared to previously published mean stable carbon and nitrogen isotope signatures for both invertebrate prey and ice seals (ringed (*Pusa hispida*) and bearded seal (*Erignathus barbatus*)) from the Chukchi and Bering seas in efforts to quantify predation on seals by Pacific walruses (Dehn et al., 2007; Personal communication with Dr. K. Iken, UAF, School of Fisheries and Ocean Sciences). Isotopic data were analyzed using SIAR mixing model software to determine proportional contribution of benthic invertebrate and higher trophic level prey to walrus diet and establish any existing (if any) correlations among diet, sex, and location.

All Pacific walrus samples used in this study were obtained through the USFWS as allowed under 50 CFR 18.23(a)(3)(b)(1). Samples were taken from Pacific walruses harvested for subsistence purposes by Alaska Natives, obtained from natural mortality events, or provided from tissue archives courtesy of Dr. L. Dehn and the UAF Museum of the North Frozen Tissue Collections.

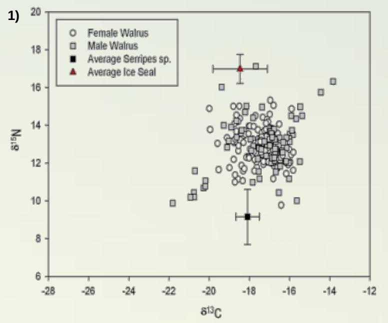


Figure 1: Female (white circles) and male (gray squares) walrus stable carbon and nitrogen isotope signatures. Mean and standard deviations of ringed and bearded seal muscle are included from the Bering and Chukchi seas (red triangle, Dehn et al., 2007) and for typical bivalve prey from the Chukchi Sea (*Serripes* sp., black square, unpublished data used with permission, Dr. K. Iken, UAF, SFOS).

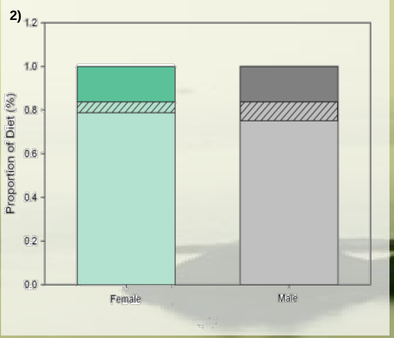


Figure 2: Low (solid) and high (shaded) estimates (95% CI) of proportional contributions of *Serripes* sp. (light layer) and ice seal (dark layer) to female (cyan) and male (gray) walrus diets.

Results

- Using SIAR mixing models, mean proportion of higher trophic level prey (e.g., ice seals) to female walrus diet is 18.78% (95% confidence interval (CI) 16.50% to 21.04%)
- Mean higher trophic level prey to the diet of male walruses is 20.61% (95% CI 16.18% to 25.00%)
- Mean proportion of higher trophic level prey among animals with "seal-eater" isotope signatures (6% of individuals, n=16) was 59.8%
- Bering Sea: mean proportion of higher trophic level prey is 18.82%
- Bristol Bay: mean proportional contribution of higher trophic level prey is 19.60%
- Chukchi Sea: mean proportion of higher trophic level prey is 25.18%
- Chukotka Region: mean proportional contribution of higher trophic level prey is 21.83%

Discussion

Higher trophic level prey contributes approximately 20% to Pacific walrus diet. There appears to be some geographical and sex influences on diet (*Figures 1, 3*), likely interdependent due to sexual segregation of the population during the summer season. However, the effect on diet of both variables was not statistically significant (p> 0.05, SIAR Mixing Model, *Figures 2, 4*).

Walruses with the highest $\delta^{15}N$ values (indicative of higher trophic level feeding) were all males, and is consistent with Alaskan coastal Native traditional ecological knowledge.

The fairly narrow range in proportional dietary **contribution of higher trophic level prey (~20%)** suggests that most walruses feed opportunistically upon seals or similar species when and where available. This proportional contribution of seals to walrus diet is higher than the historical 10% and could suggest climatic impacts on walrus foraging brought on by changes in sea ice quality and extent (Lowry and Fay 1984; Wolkers et al. 2006). However, historical analyses by Lowry and Fay were based on gut content, a method which provides information only on the most recent meal consumed and is biased towards hard-bodied prey items. Thus, **historical data may underestimate the past significance of ice seals as walrus prey species**, particularly if higher trophic level predation occurs opportunistically.

Subsistence hunters identify **seal-eating walruses based on external characteristics and avoid harvesting these animals, leading to potential biases** if analysis is limited solely to samples from subsistence harvest. The most unbiased results will come from analysis of biopsy samples of an equal number of females and males, however such sex-equalized sample pools do not currently exist.

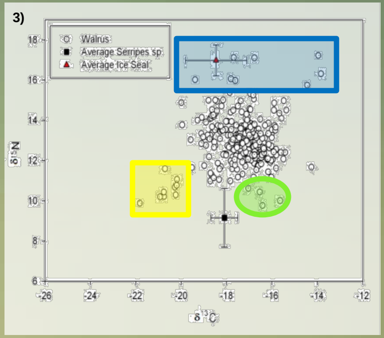


Figure 3: Walrus stable carbon and nitrogen isotope signatures including potential prey isotope signatures. Average and standard deviations of ringed and bearded seal are given from the Bering and Chukchi seas (red triangle, Dehn et al., 2007) and for typical bivalve prey from the Chukchi Sea (*Serripes* sp., black square, unpublished data used with permission, Dr. K. Iken, UAF, SFOS). Shaded areas indicate isotopically segregated clusters by location, suggesting possible geographic influence on diet or potential differences in stock structure.

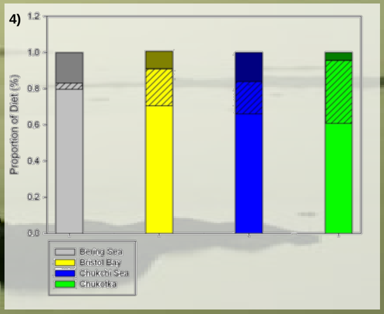
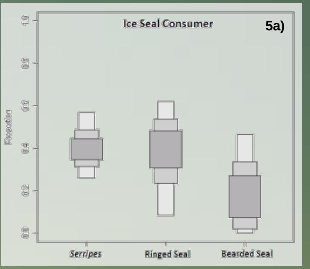


Figure 4: Low (solid) and high (shaded) estimates (95% CI) of proportional contributions of *Serripes* sp. (light layer) and ice seals (dark layer) to walrus diets based on location (Bering Sea, gray (*n*=*240*); Bristol Bay, yellow (*n*=*22*); Chukchi Sea, blue (*n*=*9*); Chukotka, green (*n*=*11*). Samples span 1991-2010.



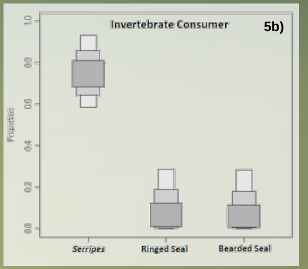


Figure 5: Differences in proportions of prey sources between a "seal-eating" walrus (*Fig. 5a*) and benthic invertebrate consuming walrus (*Fig. 5b*).

Photo Credit: Birder's World 2008

SIDE NOTE: What about Eiders?

Lovvorn et al. (2010) observed and documented walruses attempting to attack spectacled eiders (*Somateria fischeri*) in the Bering Sea pack ice. Successful walrus attacks on murres (*Uria lomvia*) have been observed in the Canadian Arctic (Mallory et al. 2004). Stable carbon and nitrogen isotopic signatures for spectacled eider muscle tissue are not currently available, however SIA data is expected in early 2011 and with the generous permission of Dr. Lovvorn and colleagues will be incorporated into the existing walrus diet mixing model.

References

Dehn, L.-A., G.G. Sheffield, E.H. Follmann, L.K. Duffy, D.L. Thomas et al. 2007. Polar Bio. 30: 167-181.
Fay, F.H. 1960. Arctic 13: 111–122.
Fay, F.H. 1982. North American Fauna 74, United States Department of the Interior, Washington, DC.
Fischbach, A.S. and Jay, C.V.. 2008. U.S.G.S. Fact Sheet 2008-3041
Grebmeier, J.M., J.E. Overland, S.E. Moore, E.V. Farley, E.C. Carmack et al. 2006. Science 311(5766): 1461-1564.
Lovvorn, J.R., J.J. Wilson, D. McKay, J.K. Bump, L.E. Cooper et al. 2010.. Arctic 63(1):53-56.
Lowry, L.F., F.H. Fay. 1984. Polar Bio. 3: 11–18.
Mallory, M.K., K. Woo, A.J. Gaston, W.E. Davies, P. Mineau. 2004. Polar Res 23(1): 111-114.
Muir, D.C.G., M.D. Segstro, K.A. Hobson, C.A. Ford, R.E.A. Stewart, et al. 1995.. Environ Pollut. 90: 335–348.
Sheffield, G., J.M. Grebmeier. 2009. Mar. Mam. Sci. 25(4): 761-777.
Wolkers, H., B. van Bavel, I. Ericson, E. Skoglund, K.M. Kovacs et al. 2006.. Sci.Total Environ. 370: 70-79.

Additional Thanks to: The Native subsistence communities and hunters of Barrow, Gambell, Little Diomede, Savoonga, and Wainwright, UAF-Museum of the North Tissue Collections, Jonathan Snyder (USFWS), Joel Garlich-Miller (USFWS), Dr. Katrin Iken (UAF), Cyd Hanns (NSB-DWM), Gay Sheffield (ADFG), Dr. Shannon Atkinson (UAF), Dr. Cheryl Rosa, Sara Carroll and Greta Krafsur

Financial and/or Logistical support provided by: Dr. Lara Dehn, University of Alaska Fairbanks, and the following: