Energy density of Steller sea lion prey in western Alaska: species, regional, and seasonal differences

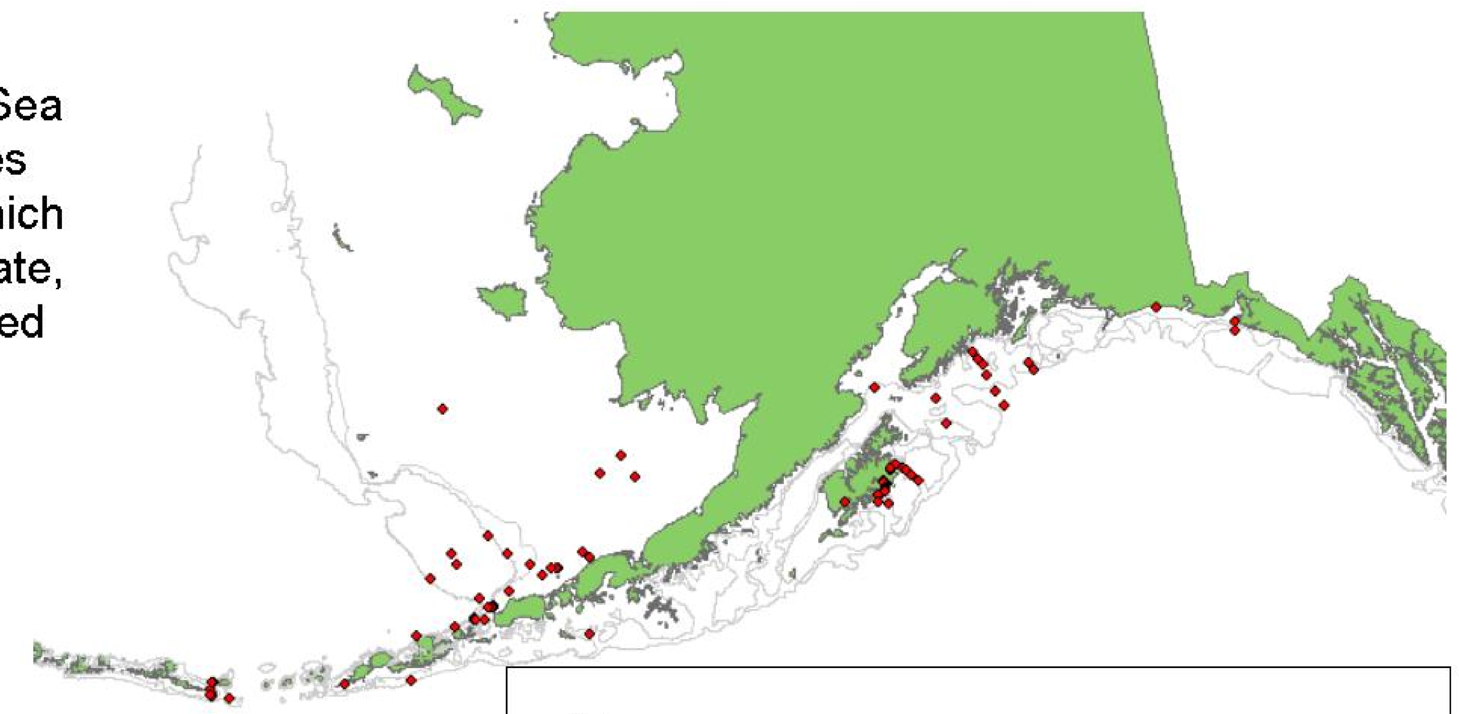
Elizabeth A. Logerwell[1] and Ruth A. Christiansen[2]*
[1]Alaska Fisheries Science Center, National Marine Fisheries Service, libby.logerwell@noaa.gov
[2]School of Marine Affairs, University of Washington, ruthc2@u.washington.edu
*presenter

Introduction

The energy density of prey fish is a necessary component of foraging models that show how changes in prey abundance or distribution (natural or fishery-related) might impact the feeding success of Steller sea lions. Although values of fish energy density can be found in the literature, data are not available for many species that sea lions eat. This is particularly true for specific geographic regions or seasons. The goal of this Fishery Interaction Team project was to fill these gaps by collecting fish that are common in sea lion diets, but for which energy density data is unavailable during the seasons and in the regions that sea lions eat them.

Methods

Fish were collected during AFSC research cruises in the Gulf of Alaska, Aleutian Islands and eastern Bering Sea during winter (December – April) and summer (May – September). Collections were restricted to fish species that occur in more than ~ 5% of sea lion stomachs (1990-1998, NMFS unpublished data). Fish species for which no previously published values of energy density existed were given top priority. The lipid, protein, carbohydrate, ash and water content of the collected fish was determined in the laboratory and energy density was calculated from the results.



SPECIES	Gulf of Alaska (n)	Aleutian Is. (n)	Bering Sea (n)
Skate sp.	26.27 +/- 1.34 (6)	29.41 +/- 2.56 (11) 7	18.97 +/- 2.73 (10)
Atka Mackerel	N/A	26.65 +/- 2.83 (28) 69	1
Rockfish sp.	23.02 +/- 0.78 [a] (5)	25.63 +/- 2.46 (6) 3	21.01 +/- 1.04 [a] (10)
Rock Sole sp.	18.23 +/- 1.19 (11) 1	24.01 +/- 2.40 (5) 4	16.94 +/- 2.16 (20)
Herring	29.33 +/- 1.91 (47)		24.41 +/- 2.44 (15) 3
Pollock	22.90 +/- 2.18 (49)	26.69 +/- 0.89 (24) 5	22.29 +/- 1.3 [a] (4)
Pollock, juvenile	21.07 +/- 5.28 (30)	5	20.83 +/- 1.38 (6) 4
Capelin	24.38 +/- 1.08 (22)		27.23 [b] (80)
Irish Lord sp.	22.16 +/- 1.68 (29)	11	21.02 (1)
Sandfish	22.34 +/- 1.07 (3)	5	23.45 [b] (4)
Sand Lance	20.6 +/- 0.07 [c] (242)		25.22 [b] (21)
Surf Smelt	18.8 +/- 0.69 [c] (7)		
Greenling	21.09 +/- 0 (2)		
Squid	25.03 [d]	1	27.96 [d]
Salmon sp.	22.10 +/- 0.77 (76) 5		1

units = kJ (per gram dry weight) +/- 1 SD n = number of specimens analyzed
colored numbers indicate number of specimens still to be analyzed

[a] Perez, M.A. 1994. Calorimetry measurements of energy value of some Alaskan fishes and squids. NOAA Tech. Memo. NMFS-AFSC-32
[b] Payne, S.A. et al. 1999. Proximate composition of some north-eastern Pacific forage fish species. Fish. Ocean. 8: 159-177
[c] Anthony, J.A. et al. 2000. Lipid content and energy density of forage fishes from the northern Gulf of Alaska. J. Exp. Mar. Biol. Ecol. 248: 53-78
[d] Davis, N.D. et al. 1998. Caloric value of high-seas salmon prey organisms and simulated salmon ocean growth and prey consumption. NPAFC Bull. No. 1: 146-162

SPECIES	Gulf of Alaska (n)	Aleutian Is. (n)	Bering Sea (n)
P. Cod			21.88 +/- 3.14 (3) 8
P. Cod, prespawn male	18.20 [a] (30)		24.33 (1) 4
P. Cod, ripe male			23.02 (1) 2
P. Cod, postspawn male			22.45 +/- 3.02 (5)
P. Cod, prespawn female	18.32 [a] (30)		22.56 +/- 2.42 (5)
P. Cod, ripe female			24.69 +/- 1 (4) 2
P. Cod, postspawn female			23.86 +/- 1.23 (4) 1
Herring	23.86 +/- 1.19 [b] (49)		29.89 +/- 1.39 (4)
Rock Sole sp.			19.32 +/- 1.99 (4) 9
Rockfish sp.			27.10 +/- 2.29 (15)
Pollock, juvenile			23.18 +/- 0.77 (4) 14
Pollock, prespawn female			25.08 +/- 1 (9)
Pollock, ripe female	18.83 [c]		25.35 +/- 0.76 (9) 1
Pollock, spent female	16.32 [c]		21.12 +/- 1.22 (2) 2
Pollock, ripe male	18.41 [c]		
Pollock, spent male	16.74 [c]		20.76 +/- 0.66 (2)
Irish Lord sp.			25.81 +/- 1.22 (15)
Snailfish			14.1 (1)
Squid	24.69 [d] (1)		18.63 +/- 0.84 (7)
Sandfish			23.54 (1)
Smooth Lumpsucker			21.12 +/- 3.78 (5)
Salmon sp.			4
Subadult Salmon sp.			23.97 (1)
Sandlance	15.91 +/- 1.35 [e] (13)		

units = kJ (per gram dry weight) +/- 1 SD n = number of specimens analyzed
colored numbers indicate specimens left to be analyzed

[a] Smith, R.L. et al. 1990. Seasonal changes in energy density and the energy cost of spawning in Gulf of Alaska Pacific cod. J. Fish. Biol. 36: 307-316
[b] Paul, A.J. and Paul, J.M. 1999. Energy content of whole body, ovaries, and ova from pre-spawning Pacific herring. AK Fish. Res. Bull. 6: 29-34
[c] Smith, R.L. et al. 1988. Aspects of energetics of adult walleye pollock from Alaska. J. Fish. Biol. 33:445-454
[d] Perez, M.A. 1994. Calorimetry measurements of energy value of some Alaskan fishes and squids. NOAA Tech. Memo. NMFS-AFSC-32
[e] Robards, M.D. et al. 1999. Changes in proximate composition and somatic energy content for Pacific sandlance from Kachemak Bay, Alaska relative to maturity and season. J. Exp. Mar. Biol. Ecol. 242: 245-258

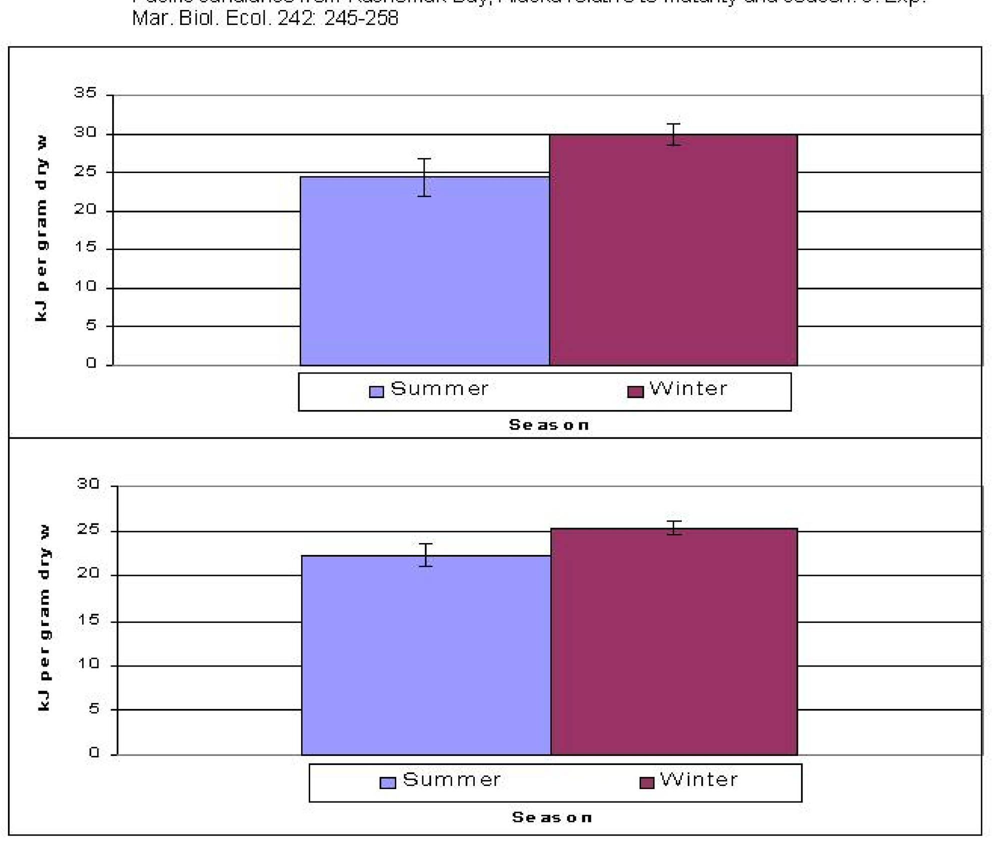


Figure 1. Seasonal variation in energy density (mean +/- SD). a. Bering sea herring, and b. Bering sea pollock, winter data are from ripe females, summer data are from fish of unkown sex and reproductive state.

Results

Tables 1 and 2 summarize the data on energy density from samples analyzed to date. Data from previously published studies is also included, with citations. These tables thus represent the current state of our knowledge of Steller sea lion prey energy density. Those interested in using these data in bioenergetic models should contact Libby Logerwell directly.

Figure 1 illustrates seasonal variation in enery density of Bering sea herring and pollock. The energy density of both species was higher during winter than summer.

Figure 2 compares the energy density of Gulf of Alaska pollock, capelin and herring during summer. Pollock energy density did not appear to be significantly lower than capelin energy density, contrary to conventional wisdom. Pollock energy density was lower than herring energy density, although not by a large amount.

Figure 3 shows several examples of regional variation in energy density. Data were not available in all regions for all species of interest. Herring energy density was higher in the Gulf of Alaska than in the Bering Sea (Fig. 3a). Skate and pollock energy density was highest in the Aleutian Islands during the summer (Fig. 3b and 3c). During winter pollock and Pacific cod energy densities were higher in the Bering Sea than in the Gulf of Alaska (Fig 3d and 3e).

Figure 4 shows how pollock energy density varies with reproductive state. Data are from female pollock collected during the winter. Not surprisingly, the energy density of post-spawn females was lower than pre-spawn and ripe females.

Discussion

In addition to providing modelers with data, our work shows that energy density varies not only with fish species, but with region, season and fish reproductive status. We thus caution against building a foraging model with prey energy density values that are not specific to the time and place the model represents.

Acknowledgements

We wish to thank all the NMFS RACE and REFM scientists that helped collect the specimens for this study. This work would not have been possible without their cooperation.

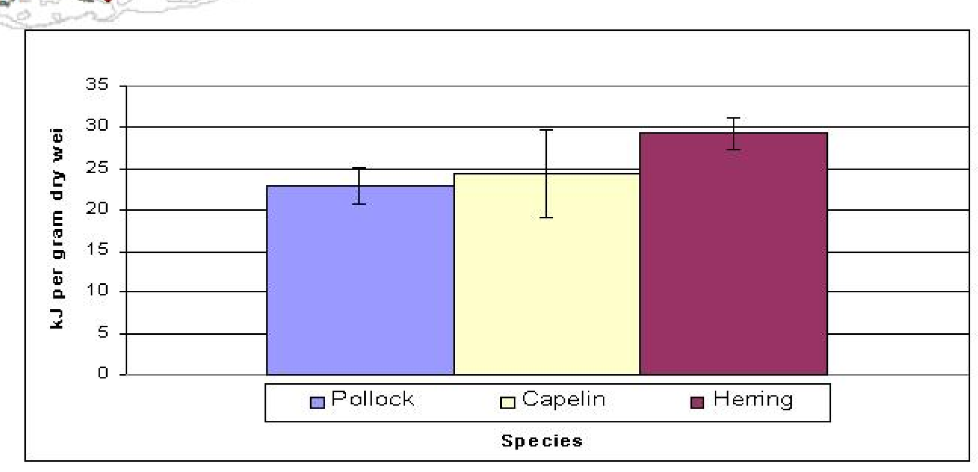


Figure 2. Energy density of pollock, capelin and herring (mean +/- SD). Samples collected during summer in the Gulf of Alaska.

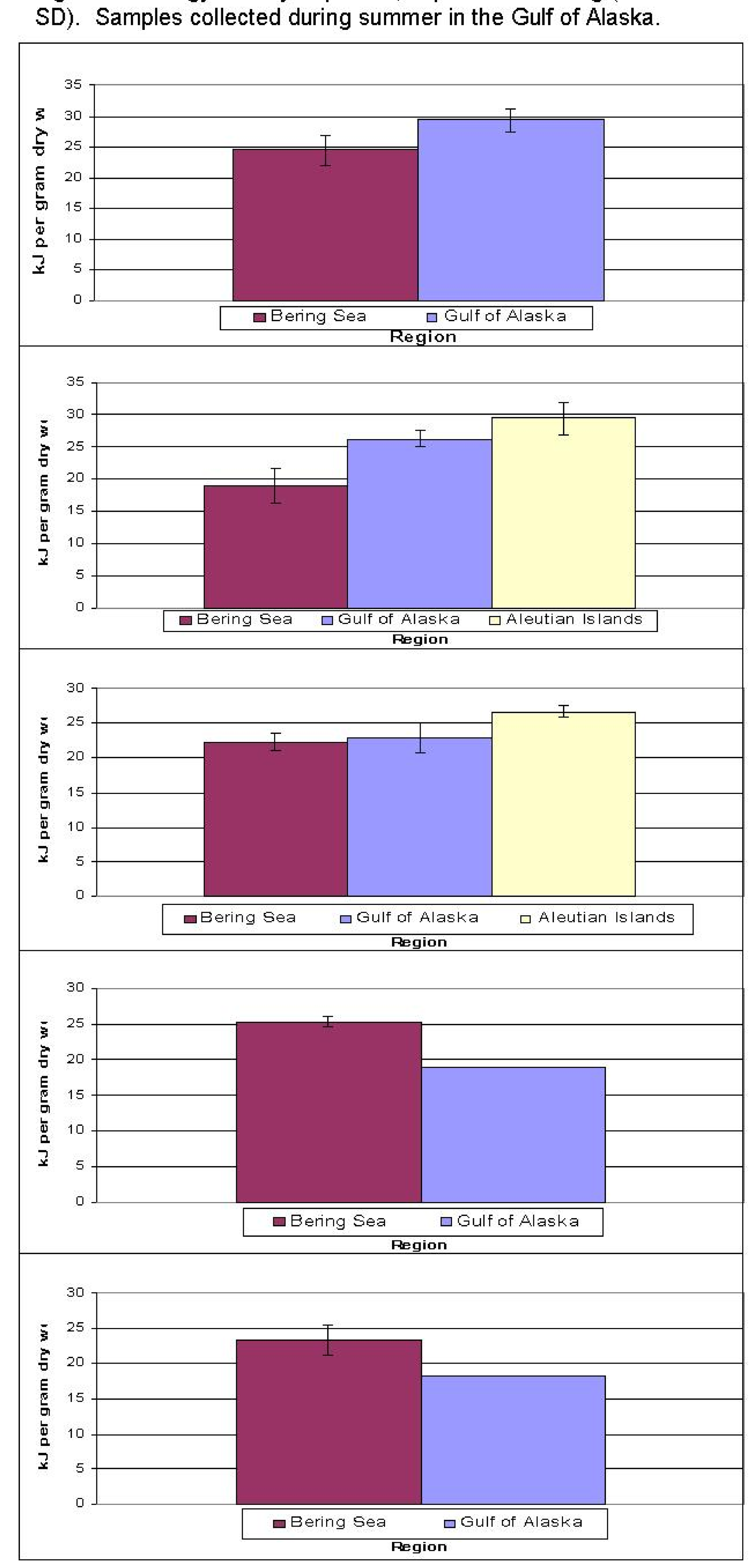


Figure 3. Regional variation in energy density (mean +/- SD). a. summer herring, b. summer skate, c. summer pollock, d. winter pollock (ripe females); Gulf of Alaska data from Smith, et al. (1988), and e. winter Pacific cod (averaged over sex and reproductive status); Gulf of Alaska data from Smith, et al. (1990).

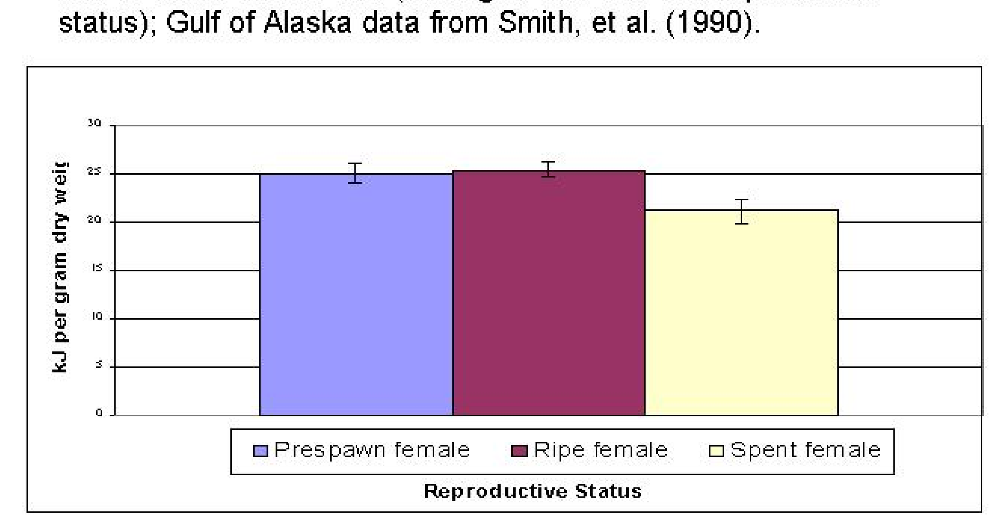


Figure 4. Variation in pollock energy density due to reproductive state (mean +/- SD). Samples collected during winter in the Bering Sea.