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Calorimetry Measurements of Energy Value of Some Alaskan Fishes and Squids

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Michael A. Perez

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
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ABSTRACT

Food habits studies of marine mammals increase our understanding of the trophodynamic interrelationships of these predators within their ecosystem. In order to determine the energetic importance of specific prey in the diet and physiology of marine mammals, it is necessary to know the caloric density of these prey. Few data exist in the literature concerning the energy content of complete fish and squid bodies, especially noncommercial species which are usually eaten whole by Alaskan pinnipeds. In 1984, the National Marine Mammal Laboratory conducted a short-term study to obtain additional data on the total energy content of entire specimens of known and probable prey species. A total of 278 fish and squid specimens representing 20 species were collected in the Bering Sea and Gulf of Alaska during routine assessment surveys by the Alaska Fisheries Science Center. In addition, 10 squid specimens of three additional species caught in the North Pacific Ocean during 1981 and 1982 were included in this study. Total energy content of the entire fish or squid body was determined by bomb calorimetry after the specimens were thawed and weighed. Percent moisture and ash were also determined for each specimen. Energy values of dry mass, ash-free dry mass, and wet mass were calculated. Based on the energy content of ash-free dry mass, the fish and squid species analyzed in this study comprised five groups: 1) very high energy (x = 7.7 kcal/g) species such as eulachon, *Thaleichthys pacificus;* 2) high energy (x = 6.6 kcal/g) species such as Pacific herring, Clupea pallasi, capelin, Mallotus villosus, and magistrate armhook squid, Berryteuthis magister; 3) medium energy content (x = 6.1 kcal/g) species such as northern rockfish, Sebastes polyspinis, and boreal clubhook squid, Onychoteuthis borealijaponica; 4) low energy density (x = 5.8 kcal/g) species such as walleye pollock, Theragra chalcogramma, and arrowtooth flounder, Atheresthes stomias; and 5) very low caloric density (x = 5.4 kcal/g) species such as Pacific cod, Gadus macrocephalus, and armorhead sculpin, Gymnocanthus galeatus.

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INTRODUCTION

Food habits studies of marine mammals increase our understanding of the trophodynamic interrelationships of predators within their ecosystem. In order to determine the importance of specific prey in the diet and physiology of marine mammals, it is necessary to know the energy value of these prey. Few data exist in the literature concerning the energy content of complete fish and squid bodies, especially noncommercial species which are usually eaten whole by Alaskan pinnipeds.

Because of the constant summation of heat in biological systems, the measurement of chemical energy as the heat of combustion is frequently used to evaluate animal energetics (Robbins 1983). Differences in the chemical or gross energies of either plants or animals are due to the energy contents of the specific chemical compounds and their relative proportions. The bomb calorimeter measures the amount of heat released when a sample of plant or animal tissue is completely oxidized (Robbins 1983). The sample is placed in a combustion chamber containing excess oxygen, which is then immersed in an insulated water jacket and ignited. The temperature rise in the surrounding water is proportional to the sample's chemical energy content. For instance, when a 1 g sample is ignited and produces a temperature rise of 4°C in 1,000 g of water, the chemical energy content of the sample is 4 kcal.

Watt and Merrill (1963), Kizevetter et al. (1965), Kizevetter (1971), Sidwell (198 1), Croxall and Prince (1982), Vlieg (1984a, 1984b), Krzynowek and Murphy (1987), Gooch et al. (1987) have provided lists of energy values for many fish and cephalopod species. These reference sources provide energy density data based on proximate composition methodology where the percentages of protein, fat, and carbohydrate in a sample of body tissue are determined, and the energy density (kcal/g) of that tissue is calculated using standard constant conversion factors for each nutrient. One limitation of the data provided in much of the literature is that the published energy values often refer to edible portions of the food source in terms of human consumption and their commercial value. However, pinnipeds often consume their prey whole in the wild and eat significant quantities of noncommercial fish and squid species. Miller (1978) provided energy values based on heats of combustion from bomb calorimetry for four fish and squid species eaten by northern fur seals, *Callorhinus ursinus.*

In 1983-85 the National Marine Mammal Laboratory (NMML), Alaska Fisheries Science Center (AFSC), conducted a study using bomb calorimetry procedures to obtain additional data on the total energy content of entire specimens of known and probable prey species. A total of 267 fish and 11 squid specimens were collected in the Bering Sea and Gulf of Alaska during routine assessment surveys conducted by the AFSC during 1984. In addition, 10 squid specimens collected on marine mammal-fisheries interactions research cruises in the North Pacific Ocean during 1981 and 1982 were also included in this study. A total of 18 fish and 5 squid species were analyzed in the study (Table 1). The results of the study are reported in this paper.

METHODS

During 1984, specimens collected for this study were taken opportunistically from the discards of groundfish trawl survey catches in the Bering Sea and Gulf of Alaska (Fig. 1) by research scientists of the Resource Assessment and Conservation Engineering Division (RACE), AFSC. Ten additional squid specimens were made available for the study from collections taken by NMML research scientists in 1981-82 aboard Japanese research cruises in the North Pacific Ocean. The dates, vessels, and locations of collection of samples in this study are listed in Appendix Table A-1. With the exception of collection group number 5 (Appendix Table A-l), the haul number was recorded for each specimen. Date, position, and depth (in fathoms) of collection for each trawl haul were obtained later from RACE data records.

Specimens were placed in ship storage freezers immediately after collection. With the exception of the squids collected during 1981-82, all specimens were kept frozen until they were shipped to an analytical laboratory for bomb calorimetry (shipment dates are listed in Appendix Table A-l). Fishes and squids were retained in storage freezers on board the vessel or at the

Table 1 .--List of species of fishes and squids which were analyzed for energy value by bomb calorimetry measurements in this study.

Common Name [a]	Scientific Name
Fishes	
Pacific herring	*Clupea pallasi*
Capelin	*Mallotus villosus*
Eulachon	*Thaleichthys pacificus*
Pacific cod	*Gadus macrocephalus*
Walleye pollock	*Theragra chalcogramma*
Pacific ocean perch	*Sebastes alutus*
Dusky rockfish	*Sebastes ciliatus*
Northern rockfish	*Sebastes polyspinis*
Rockfish (unidentified) [b]	*Sebastes* sp.
Sablefish	*Anoplopoma fimbria*
Armorhead sculpin	*Gymnocanthus galeatus*
Blackfin sculpin	*Malacocottus kincaidi*
Sculpin [c]	*Triglops* sp.
Sculpin (unidentified) [d]	Cottidae
Snailfish	*Liparis* sp.
Searcher	*Bathymaster signatus*
Pacific sandfish	*Trichodon trichodon*
Arrowtooth flounder	*Atheresthes stomias*
Squids	
Magistrate armhook squid [e]	*Berryteuthis magister*
Gonate squid (unidentified) [f]	*Berryteuthis* sp.
Boreopacific gonate squid	*Gonatopsis borealis*
Boreal clubhook squid	*Onychoteuthis borealijaponica*
Neon flying squid	*Ommastrephes bartrami*

[a] References for common names: Roper et al. (1984); Turgeon et al. (1988); and Robins et al. (1991).
[b] All specimens of this unidentified rockfish group in this study belong to a fourth species of the genus *Sebastes*.
[c] All specimens of this fish group in this study belong to the same species of the genus *Triglops*.
[d] All specimens of this unidentified fish group in this study belong to a fourth sculpin species, which may be assigned to any genus of the family Cottidae.
[e] Also known as schoolmaster gonate squid.
[f] This unidentified squid group belongs to a second species of the genus *Berryteuthis*.

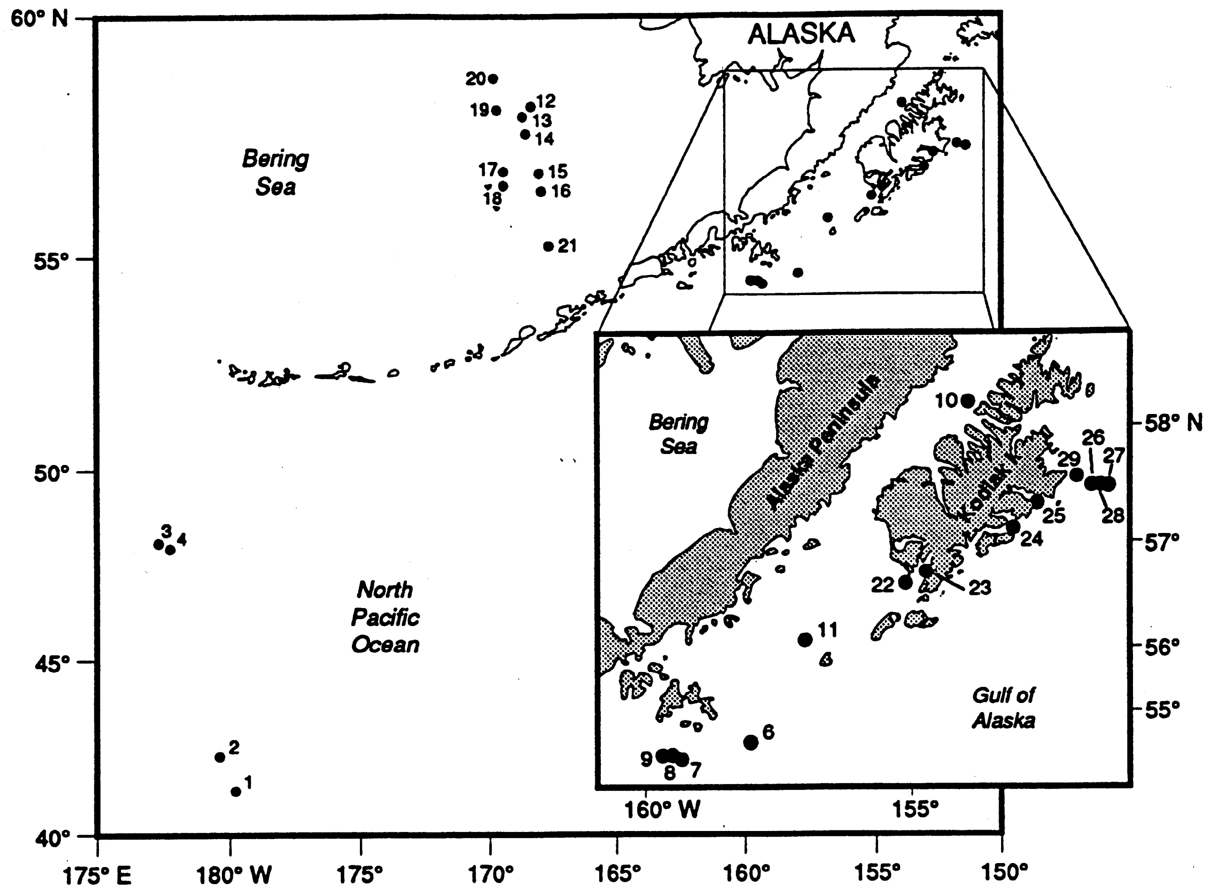

Figure 1.--Locations in the Bering Sea and North Pacific Ocean where the fishes and squids analyzed in this study were collected.* Locations in the Gulf of Alaska are shown in the inset. The numbers shown in the figure indicate the collection groups enumerated in Appendix Table A-l.

Kodiak, Alaska, Laboratory (RACE) until they could be sent to Seattle in containers packed with dry ice. Upon delivery to NMML, specimens were promptly placed in the freezer. Samples were Subsequently shipped to the contract calorimetry analytical laboratory within 24 hours after receipt by NMML. All specimens were shipped by overnight air freight express in freeze-safe containers containing blue-ice packs. Bomb calorimetry analyses were conducted after specimens thawed, and data results were sent to NMML within 30 days.

The 10 squid specimens collected during 1981-82 (collection groups 1-4; Appendix Table A-l) had been collected for different research purposes and had been previously thawed. Rather than simply being discarded, the specimens were also included in this calorimetry study because of the limited information on squids. Five of the squids were incomplete, with a tentacle or other body part missing (Appendix Table A-2).

Measurements of wet mass were not recorded by shipboard personnel at the time of collection, but only after thawing when specimens were received for calorimetry operations. The wet mass (g) of each specimen is given in Appendix Table A-2. Sex and length were not recorded for most of the 288 specimens in Appendix Table A-2. However, this information is given in Appendix Table A-3 for those specimens with available data. Standard length measurements (cm) were recorded for fish and dorsal mantle length (cm) for some squid specimens.

Except for the 5 incomplete squid specimens collected during 1981-82, measurements were made of the total energy content of each whole fish and squid specimen. Total energy content was determined using a Parr adiabatic bomb calorimeter by Woodson-Tenet Laboratories in Memphis, Tennessee, who made all of the bomb calorimetry and body mass measurements. Percent moisture and ash were also determined for each specimen. Energy values of dry mass, ash-free dry mass, and wet mass were calculated from these data. General accounts of the instrumentation and procedures used in bomb calorimetry are provided by Grodzinski et al. (1975) and Robbins (1983).

An analysis of variance (ANOVA) was performed on the means of caloric density of ash-free dry mass and wet mass of each of 17 of the 23 species of fish and squid in Table 1 (no unidentified species and N>l for each species) to test the null multisample hypothesis of equal means. For the ANOVA, the following species groups listed in Table 1 were excluded: rockfish (unidentified), *Sebastes* sp.; sculpin (unidentified), Cottidae; gonate squid (unidentified), *Berryteuthis* sp.; boreopacific gonate squid, *Gonatopsis borealis;* neon flying squid, *Ommastrephes bartrami.* A Student-Newman-Keuls test (Zar 1984) was used to perform multiple-comparison tests to determine which of the 17 species had significantly different energy values from each other. Species which did not have significantly different means of caloric density were grouped (group names were arbitrarily assigned) together, and pooled means and standard errors were calculated for energy content of ash-free dry mass and wet mass.

A paired t-test with an assumption of unequal variance was used to compare energy values of ash-free dry mass of species, with sample sizes >10, collected in different seasons or geographical areas. Specimens taken during February and March (Appendix Table A-l) were pooled to comprise the winter collections.

RESULTS AND DISCUSSION

Measurements of dry mass energy values for the 288 fish and squid specimens from 18 fish and 5 squid species analyzed in this study ranged from a minimum of 3.0 kcal/g for walleye pollock, *Theragra chalcogramma,* to a maximum of 7.7 kcal/g for eulachon, *Thaleichthys pacificus*, (Appendix Table A-2). Among the fishes, mean moisture content was lowest for eulachon (64%) and highest for blackfin sculpin, *Malacocottus kincaidi*, (80%) (Fig. 2). The mean moisture content of the squid species was between 74% and 82% (Table 2). Mean ash content (as a percentage of dry mass) was lowest for eulachon (4%) (ignoring the solitary snailfish specimen with zero measurable ash content) and highest for armorhead sculpin, *Gymnocanthus galeatus*, (24%) (Table 2). Squid species had a lower mean ash content (<9%) than several fish species, e.g., walleye pollock (13%) and armorhead sculpin (24%) (Table 2). Mean and standard

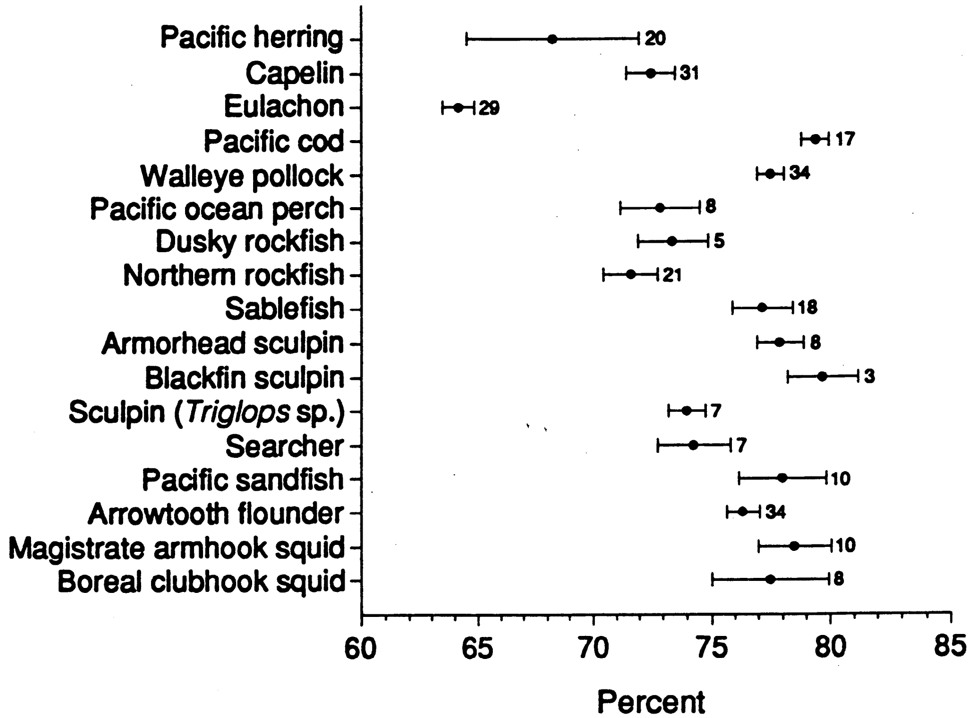

Figure 2.--Moisture content (percent; mean + 95% confidence intervals) of whole specimens of 17 fish and squid species analyzed in this study. The sample size is shown to the right of each confidence interval.

Table 2.--Mean and standard deviation of percent moisture, percent ash, and energy value of some whole fish and squid species of the Bering Sea and North Pacific Ocean[a]

		Percent moisture		Percent ash (dry mass)		Energy value (kcal/g): Dry mass		Ash-free dry-mass		Wet mass (estimate)	
	n	$\bar{x}$	*SD*	$\bar{x}$	*SD*	$\bar{x}$	*SD*	$\bar{x}$	*SD*	$\bar{x}$	*SD*
Fishes											
Pacific herring	20	68.3	7.9	8.76	3.08	6.21	1.07	6.79	0.96	2.05	0.83
Capelin	31	72.5	2.7	7.49	2.92	6.06	0.57	6.55	0.51	1.68	0.29
Eulachon	29	64.2	1.7	4.11	0.58	7.35	0.19	7.66	0.20	2.63	0.13
Pacific cod	17	79.4	1.0	16.90	2.43	4.54	0.18	5.47	0.28	0.94	0.04
Walleye pollock	34	77.5	1.4	13.38	2.13	4.94	0.55	5.70	0.63	1.11	0.15
Pacific ocean perch	8	72.9	2.0	15.99	1.85	5.41	0.32	6.43	0.32	1.47	0.13
Dusky rockfish	5	73.4	1.1	16.02	0.88	5.50	0.19	6.55	0.16	1.46	0.07
Northern rockfish	21	71.6	2.5	14.85	2.35	5.23	0.28	6.14	0.27	1.49	0.20
Rockfish (unidentified)	9	73.8	4.5	16.62	1.89	5.22	0.45	6.26	0.54	1.38	0.31
Sablefish	18	77.2	2.5	9.85	1.66	5.64	0.40	6.26	0.39	1.30	0.23
Armorhead sculpin	8	77.9	1.1	23.58	3.56	4.13	0.31	5.40	0.30	0.91	0.09
Blackfin sculpin	3	79.7	0.6	23.13	1.27	4.10	0.20	5.36	0.31	0.84	0.02
Sculpin (*Triglops* sp.)	7	74.0	0.8	14.60	6.68	4.76	0.21	5.61	0.37	1.24	0.08
Sculpin (unidentified)	5	77.0	1.0	17.22	1.67	4.84	0.17	5.85	0.15	1.11	0.08
Snailfish (unidentified)	1	78.0	-	0.00	-	4.10	-	4.10	-	0.91	-
Searcher	7	74.3	1.6	13.50	1.16	5.13	0.15	5.93	0.20	1.32	0.08
Pacific sandfish	10	78.0	2.5	13.03	1.34	5.28	0.32	6.07	0.32	1.17	0.19
Arrowtooth flounder	34	76.3	1.8	11.37	1.83	5.17	0.36	5.83	0.32	1.23	0.18
Squids											
Magistrate armhook squid	10	78.5	2.1	7.33	0.94	6.12	0.40	6.61	0.39	1.32	0.19
Gonate squid (*Berryteuthis* sp.)	1	82.0	-	8.30	-	5.10	-	5.56	-	0.92	-
Boreopacific gonate squid	1	82.0	-	5.00	-	6.20	-	6.52	-	1.12	-
Boreal clubhook squid	8	77.5	2.9	5.30	0.74	5.73	0.18	6.04	0.20	1.29	0.19
Neon flying squid	1	74.0	-	6.20	-	6.00	-	6.38	-	1.56	-

[a] Based on the data in Appendix Table A-2.

deviation values for energy content of dry mass, ash-free dry mass, and wet mass of the 18 fish species and 5 squid species in this study are given in Table 2.

Based on the mean caloric density of ash-free dry mass, the fish and squid species analyzed in this study appeared to align themselves into five groups (Fig. 3): 1) very high energy ($\bar{x}$ = 7.7 kcal/g, *SE* = 0.04 kcal/g) species such as eulachon; 2) high energy ($\bar{x}$ = 6.6 kcal/g, *SE* = 0.07 kcal/g) species such as Pacific herring, *Clupea pallasi*, capelin, *Mallotus villosus*, Pacific ocean perch, *Sebastes alutus*, dusky rockfish, *Sebastes ciliatus*, and magistrate armhook squid, *Berryteuthis* magister; 3) medium energy content, ($\bar{x}$ = 6.1 kcal/g, *SE = 0.04* kcal/g) species such as northern rockfish, *Sebastes polyspinis*, sablefish, *Anoplopoma fimbria*, searcher, *Bathymaster signatus*, Pacific sandfish, *Trichodon trichodon*, and boreal clubhook squid, *Onychoteuthis borealijaponica;* 4) low energy density ($\bar{x}$ = 5.8, kcal/g, *SE = 0.06* kcal/g) species such as walleye pollock, sculpins belonging to *Triglops* sp., and arrowtooth flounder, *Atheresthes stomias;* and 5) very low caloric density ($\bar{x}$ = 5.4 kcal/g, *SE* = 0.05 kcal/g) species such as Pacific cod, *Gadus macrocephalus*, armorhead sculpin, and blackfin sculpin. Energy values for wet mass generally showed similar groupings of energy content among species (Fig. 4). However, comparison of the mean caloric density. of wet mass of the 17 species examined indicated that there was a wider distribution of medium to high energy species comprising a total of six distinct groups: 1) extremely high energy ($\bar{x}$ = 2.6 kcal/g, *SE* = 0.02 kcal/g) species such as eulachon; 2) very high energy ($\bar{x}$ = 2.0 kcal/g, *SE* = 0.18 kcal/g) species such as Pacific herring; 3) high energy ($\bar{x}$ = 1.7 kcal/g, *SE* = 0.05 kcal/g) species such as capelin; 4) medium energy content ($\bar{x}$ = 1.4 kcal/g, *SE* = 0.02 kcal/g) species such as northern rockfish and magistrate armhook squid; 5) low energy density ($\bar{x}$ = 1.2 kcal/g, *SE* = 0.02 kcal/g) species such as walleye pollock and arrowtooth flounder; and 6) very low caloric density ($\bar{x}$ = 0.9 kcal/g, *SE* = 0.01 kcal/g) species such as Pacific cod and armorhead sculpin (Fig. 4).

The ash-free dry mass energy value of eulachon caught in March (7.8 kcal/g) in the Gulf of Alaska was significantly greater ($P<0.05$) than that of eulachon specimens taken in August (7.5 kcal/g) in the Gulf of Alaska (Table 3). However, there was no significant difference in

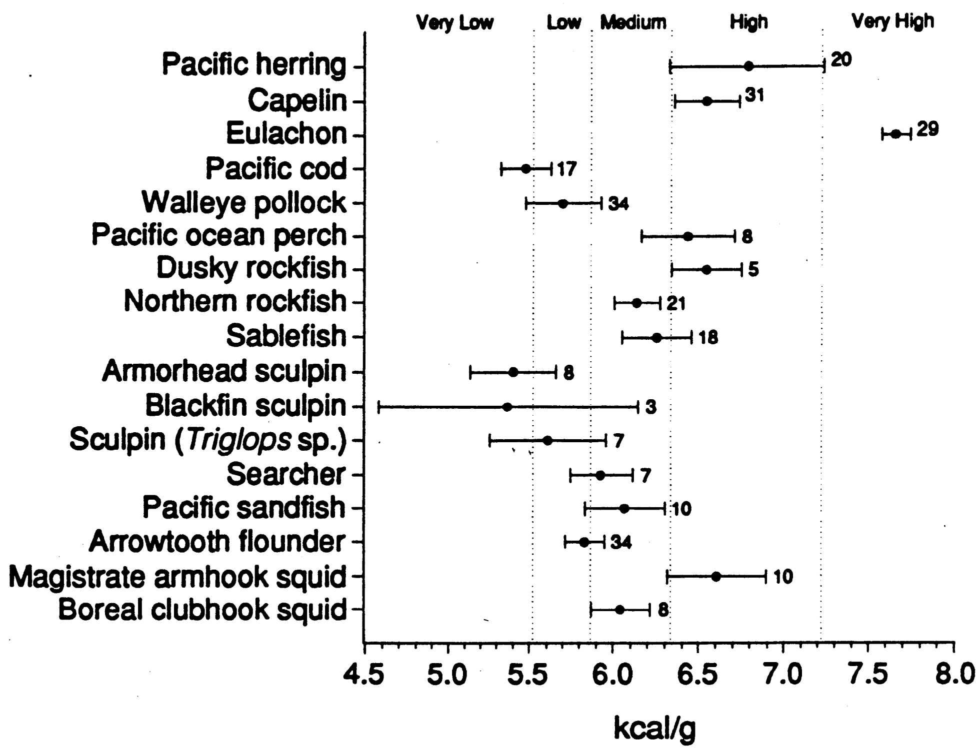

Figure 3.--Energetic density (kcal/g; mean + 95% confidence intervals) of ash-free dry mass of 17 fish and squid species analyzed in this study. The sample size is shown to the right of each confidence interval. The reference lines separate the species into five groups which have significantly different levels of caloric density.

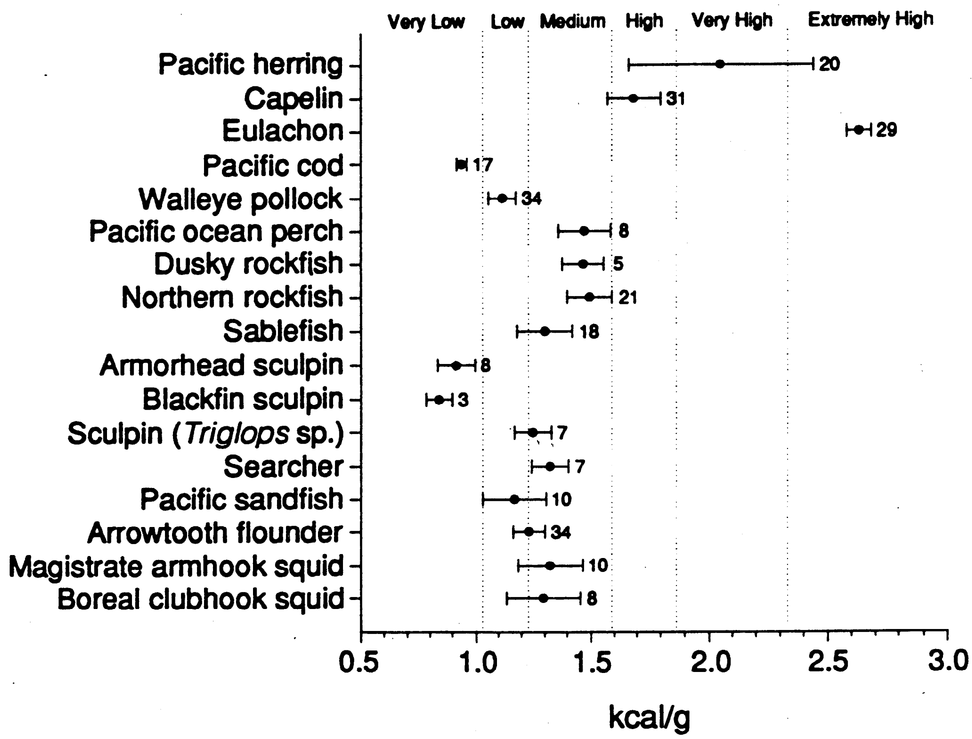

Figure 4.--Estimated energetic density (kcal/g; mean + 95% confidence intervals) of wet mass (whole bodies) of 17 fish and squid species analyzed in this study. The sample size is shown to the right of each confidence interval. The reference lines separate the species into six groups which have significantly different levels of caloric density.

Table L-Two-tailed t-test probabilities (P), based on an assumption of unequal variance, for comparisons of energy values of ash-free dry mass of fish specimens caught in different seasons or areas.

Species	Comparison group	*n*	Energy value (kcal/g) $\bar{x}$	*SD*	95% *CI*	*P*	
			Gulf of Alaska				
Eulachon	Winter	19	7.77	0.113	7.71 - 7.82	0.0002	*
	Summer	10	7.46	0.169	7.35 - 7.58		
Walleye pollock	Winter	10	5.69	0.164	5.58 - 5.79	0.8301	
	Summer	20	5.64	0.798	5.28 - 6.02		
Arrowtooth flounder	Winter	13	5.92	0.225	5.79 - 6.06	0.4965	
	Summer	11	5.82	0.442	5.54 - 6.11		
			Summer				
Herring	Bering Sea	10	5.92	0.380	5.66 - 6.17	<0.0001	*
	Gulf of Alaska	10	7.66	0.312	7.45 - 7.87		
Capelin	Bering Sea	16	6.51	0.426	6.29 - 6.73	0.6871	
	Gulf of Alaska	15	6.59	0.598	6.27 - 6.91		
Arrowtooth flounder	Bering Sea	10	5.71	0.260	5.54 - 5.88	0.4917	
	Gulf of Alaska	11	5.82	0.442	5.54 - 6.10		
			Different area and season				
Northern rockfish	Bering Sea (Summer)	11	6.27	0.185	6.15 - 6.39	0.0180	*
	Gulf of Alaska (Winter)	10	5.99	0.281	5.80 - 6.18		

* = Significant difference

energy values of ash-free dry mass between winter and summer catches of both walleye pollock and arrowtooth flounder in the Gulf of Alaska (Table 3). The ash-free dry mass energy value of Pacific herring (Table 3) caught in summer in the Bering Sea (5.9 kcal/g) was significantly less ($P<0.05$) than that of herring specimens taken at approximately the same time in the Gulf of Alaska (7.7 kcal/g). Conversely, northern rockfish specimens taken in the Bering Sea in summer (6.3 kcal/g) had a significantly greater ($P<0.05$) energy value than that of specimens taken in the Gulf of Alaska in winter (6.0 kcal/g) (Table 3). But there was no significant difference in energy value of ash-free dry mass of capelin or arrowtooth flounder between catches in summer from the Bering Sea and from the Gulf of Alaska (Table 3).

The content of fat in the flesh and other parts of the body of some fish species (e.g., Pacific herring; capelin; rockfishes, Scorpaenidae) changes significantly during the year between spawning (summer) and foraging (winter) periods (Kizevetter 1971; Jangaard 1974; Bigg et al. 1978). The spawning period for eulachon is May and June in the eastern Bering Sea and May in southeast Alaska and on the Alaskan Peninsula (Macy et al. 1978; Wespestad 1987). The difference in energy density of eulachon between winter (March; 7.8 kcal/g) and summer (August; 7.5 kcal/g) in the Gulf of Alaska (Table 3) probably reflects changes in caloric density due to spawning times. Likewise, the difference in energy content of Pacific herring between areas during summer is also due to regional differences in spawning times since spawning occurs during March-April in the Gulf of Alaska and May-July in the southeast Bering Sea (Niggol 1982). Fat content also varies by age, body mass, or stage of migration of the fish (e.g., salmon, Oncorhynchus spp.; sablefish) (Kizevetter 1971). For many other fishes (e.g., walleye pollock, other gadids, sculpins, Cottidae) the fat content of the body does not vary appreciably during the year (Kizevetter 1971). However, Troy Buckley (Resource Ecology and Fisheries Management Division, Alaska Fisheries Science Center, 7600 Sand Point Way N.E., Seattle, WA 98115, pers. comm.) has compiled a list of recent unpublished data showing that the energetic density of walleye pollock may vary by locality and time of year.

The energy values for dry mass and ash-free dry mass are measurements taken from combustion of the specimen material using bomb calorimetry methods accounting for the measurable mass of the material and percent moisture and ash content. In contrast, the wet mass energy values based on these data are only estimates of the true wet mass energy values because the original wet mass of the specimens was not measured at the time of collection. However, 10 of the squid specimens had been previously measured and weighed and provide an indication of the relative difference between the estimates reported in this study and the true energy values for wet mass. Table 4 presents a comparison of calculations based on two sets of wet mass measurements taken approximately 4 months apart and using the same sample measurements of total specimen energy content from bomb calorimetry. The first set of wet mass measurements were all recorded at the time of bomb calorimetry after thawing of the specimens during and after shipment to the analytical laboratory. The second set of measurements had been recorded previously during biological examination of the specimens after thawing and draining of the squid specimens to remove excess water from the body cavity. (This second set of measurements is more likely to indicate the actual living weight of the squid.) The two sets of calculations of energy content values for wet mass (Table 4) suggest that the estimates in Table 2, Appendix Table A-2 and Figure 4 are approximately 10% lower than the probable values for wet mass energy content from freshly caught squid. This is presumably true for the fish species as well.

The quality of frozen fish is influenced by many different considerations. Among the most important are composition of fish, pre-freezing handling and treatment, method of freezing, and the environment during storage and handling (Stansby 1963). Therefore, the energy density values reported in this study may be somewhat less than values which might be obtained directly from freshly caught specimens. The effect of energy loss due to freezing and shipment in this study is unknown. However, because the methods used in this study were consistent among samples, it is unlikely that any loss due to freezing processes and storage times affected the relative relationship (Fig. 3) of energy value measurements among species in any significant way.

Table 4.--Comparison of wet mass measurements and their estimated energy value for squid specimens collected in the North Pacific Ocean that were refrozen and thawed for caloric content analyses (A) following a previous period of freezing and thawing for biological measurements (B) several months earlier?

		Total specimen		Energy value			
Species/ Sample number [b]	Collection group [c]	(A) Wet mass (g) [d]	(B) Wet mass (g)	Total sample (kcal) [d]	(A) Wet mass (estimate) (kcal/g)	(B) Wet mass (estimate) (kcal/g)	Ratio (B/A) (%)
Boreopacific gonate squid							
279	3	783	678	873	1.12	1.29	115
Boreal clubhook squid							
280	1	362	331	565	1.56	1.71	109
281	1	242	209	386	1.60	1.85	116
282	2	785	700	923	1.18	1.32	112
283	2	714	641	855	1.20	1.33	111
284	2	800	713	957	1.20	1.34	112
285	2	864	789	1,100	1.27	1.39	110
286	2	687	576	742	1.08	1.29	119
287	4	715	671	886	1.24	1.32	107
Neon flying squid							
288	1	1,721	1,674	2,680	1.56	1.60	103

[a] All specimens were immediately frozen after collection. Total wet mass for (A) was measured upon receipt by the analytical laboratory. Total wet mass for (B) was previously measured following a period of initial thawing for biological measurements and species identification before refreezing.

[b] Identical to the samples listed in Appendix Table A-2.

[c] The date and location of each collection group are given in Appendix Table A-1. Each of the squid samples collected and frozen in 1981 and 1982 were originally thawed and measured in July 1983, and subsequently refrozen for energy content analyses in November 1983.

[d] From Appendix Table A-2.

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CITATIONS

Bigg, M. A., I. B. MacAskie,. and G. Ellis. 1978. Studies on captive fur seals. Progress Rep. No. 2. Can. Fish. Mar. Serv., Manuscr. Rep. 1471, 21 p.

Croxall, J. P., and P. A. Prince. 1982. Calorific content of squid (Mollusca: Cephalopoda).. Br. Antarct. Surv. Bull. 55:27-31.

Gooch, J. A., M. B. Hale, T. Brown, Jr., J. C. Bonnet, C. G. Brand, and L. W. Regier. 1987. Proximate and fatty acid composition of 40 southeastern U.S. finfish species. U.S. Dep. Commer., NOAA Tech. Rep. NMFS 54,23 p.

Grodzinski, W., R.Z. Klekowski, and A. Duncan. 1975. Methods for ecological bioenergetics. IBP Handbook No. 24. Blackwell Scientific Publ., Oxford, UK, 367 p.

Jangaard, P. M. 1974. The capelin *(Mallotus* villosus): Biology, distribution, exploitation, utilization and composition. Fish. Res. Board Can. Bull. 186.

Kizevetter, I. V. 1971. Tekhnologicheskaya i khimicheskaya kharakteristika promyslovykh ryb tikhookeanskogo basseina. [Chemistry and technology of Pacific fish.] Izd. "Dal'izdat", Vladivostok, 297 p. [Transl. from Russian by Israel Program Sci. Transl., 1973, 304 p.] (Available from Natl. Tech. Inf Serv., Springfield, VA, as TT72-50019.)

Kizevetter, I. V., E. F. Kleie, A. A. Kirillova, O. M. Mel'nikova, V. M. Myasoedova, and L. Ya. Ertel'. 1965. Tekhnologicheskaya kharakteristika Beringovomorskikh ryb. [Technological characteristics of Bering Sea fishes.] Tr. Vses. Nauchno-issled. Inst. Morsk. Rybn. Khoz. Okeanogr. (VNIRO) 58 [Izv. Tikhookean. Nauchno-issled. Inst. Morsk. Rybn. Khoz. Okeanogr. (TINRO) 53]:201-272. [Transl. from Russian by Israel Program Sci. Transl., 1968, p. 191-258 In P. A. Moiseev (editor), Soviet fisheries investigations in the northeast Pacific, Pt. 4.] (Available from Natl. Tech. Inf Serv., Springfield, VA, as TT67-51206.)

Krzynowek, J., and J. Murphy. 1987. Proximate composition, energy, fatty acid, sodium, and cholesterol content of finfish, shellfish, and their products. U.S. Dep. Commer., NOAA Tech. Rep. NMFS 55, 53 p.

Macy, P. T., J. M. Wall, N. D. Lampsakis, J. E. Mason. 1978. Resources of non-salmonid pelagic fishes of the Gulf of Alaska and eastern Bering Sea, Part l--Introduction, general fish resources and fisheries, review of literature on non-salmonid pelagic fish resources. Unpubl. final rep., Task A-7, Outer Continental Shelf Environmental Assessment Program RU 64/354, 356 p. (Available from Natl. Mar. Mammal Lab. Library, Alaska Fish. Sci. Cent., 7600 Sand Point Way N.E., Seattle, WA 98115-0070.)

Miller, L. K. 1978. Energetics of the northern fur seal in relation to climate and food resources of the Bering Sea. U.S. Marine Mammal Comm. Rep. MMC-75/08, 27 p. (Available from Natl. Tech. Inf Serv., Springfield, VA, as PB-275296.)

Niggol, K. 1982. Data on fish species from Bering Sea and Gulf of Alaska. U.S. Dep. Commer., NOAA Tech. Memo. NMFS F/NWC-29, 125 p.

Robbins, C. T. 1983. Wildlife feeding and nutrition. Academic Press, New York, NY, 343 p.

Robins, C. R., R. M. Bailey, C. E. Bond, J. R. Brooker, E. A. Lachner, R. N. Lea, and W. B. Scott. 1991. Common and scientific names of fishes from the United States and Canada. 5th ed. Am. Fish. Soc. Spec. Publ. 20, 183 p.

Roper, C. F. E., M. J. Sweeney, and C. E. Nauen. 1984. FAO species catalogue, Vol. 3: Cephalopods of the world. FAO Fish. Synop. 125 (Vol. 3), 277 p.

Sidwell, V. D. 1981. Chemical and nutritional composition of finfishes, whales, crustaceans, mollusks, and their products. U.S. Dep. Commer., NOAA Tech. Memo. NMFS F/SEC-11,432 p.

Stansby, M.E. 1963. Industrial fishery technology. Reinhold Publ. Corp., New York, 393 p.

Turgeon, D. D., A. E. Bogan, E. V. Coan, W. K. Emerson, W. G. Lyons, W. L. Pratt, C. F. E. Roper, A. Scheltema, F. G. Thompson, and J. D. Williams. 1988. Common and scientific names of aquatic invertebrates from the United States and Canada: mollusks. Am. Fish. Soc. Spec. Publ. 16, 277 p.

Vlieg, P. 1984a. Proximate analysis of commercial New Zealand fish species. 2. N. Z. J. Sci. 27:427-433.

Vlieg, P. 1984b. Proximate composition of New Zealand squid species. N. Z. J. Sci. 27:145-150.

Watt, B. K., and A. L. Merrill. 1963. Composition of foods...raw, processed, prepared. U.S.. Dep. Agric., Agric. Handb. 8, 190 p.

Wespestad, V. G. 1987. Population dynamics of Pacific herring *(Clupea pallasii)*, capelin *(Mallotus villosus)*, and other coastal pelagic fishes in the eastern Bering Sea, p. 55-60 In MBC Applied Environmental Sciences (compilers), Forage fishes of the southeastern Bering Sea, Proceedings of a conference, 4-5 November, 1986, Anchorage AK. OCS Study MMS 87-0017. U.S. Dep. Interior, Minerals Manage. Serv., Alaska OCS Region, Anchorage, AK 99508-4302.

Zar, J. H. 1984. Biostatistical analysis. 2nd. ed. Prentice-Hall, Englewood Cliffs, NJ, 718 p.

APPENDIX

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Appendix Table A-L-Date, location, and depth of sample collection and date of shipment for calorimetry analysis of samples collected for this study.

Collection group	Sample collection information: Vessel	Date	Latitude	Longitude	Trawl depth (fathoms)	Calorimetry analysis shipment date	
1	Japanese RV *Oshoro Maru*	14 June 1981	41°07' N	179°59' W	Surface gillnet	21 November 1983	*a*
2	Japanese RV *Oshoro Maru*	16 June 1981	42°03' N	179°53' E	Surface gillnet	21 November 1983	*a*
3	Japanese RV *Kumamoto Maru*	24 June 1982	47°55' N	177°39' E	Surface gillnet	21 November 1983	*b*
4	Japanese RV *Kumamoto Maru*	20 July 1982	47°58' N	177°31' E	Surface gillnet	21 November 1983	*b*
5	NOAA RV *Miller Freeman*	February 1984	Western Gulf of Alaska		Unknown	22 May 1984	
6	NOAA RV *Miller Freeman*	18 February 1984	54°32' N	158°54' W	164	28 June 1984	
7	NOAA RV *Miller Freeman*	23 February 1984	54°23' N	160°08' W	90	28 June 1984	
8	NOAA RV *Miller Freeman*	23 February 1984	54°24' N	160°13' W	85	28 June 1984	
9	NOAA RV *Miller Freeman*	24 February 1984	54°24' N	160°18' W	86	28 June 1984	
10	NOAA RV *Miller Freeman*	3 March 1984	58°06' N	153°34' W	99	18 April 1984	
11	NOAA RV *Miller Freeman*	9 March 1984	56°10' N	156°09' W	128	18 April 1984	
12	NOAA RV *Chapman*	3 July 1984	58°01' N	168°25' W	40	24 October 1984	
13	NOAA RV *Chapman*	3 July 1984	57°50' N	168°40' W	40	24 October 1984	
14	NOAA RV *Chapman*	4 July 1984	57°30' N	168°38' W	40	24 October 1984	
15	NOAA RV *Chapman*	5 July 1984	56°40' N	168°17' W	60	24 October 1984	
16	NOAA RV *Chapman*	5 July 1984	56°20' N	168°14' W	87	24 October 1984	
17	NOAA RV *Chapman*	6 July 1984	56°39' N	169°28' W	40	24 October 1984	
18	NOAA RV *Chapman*	6 July 1984	56°22' N	169°28' W	75	24 October 1984	
19	NOAA RV *Chapman*	8 July 1984	58°00' N	169°41' W	40	24 October 1984	
20	NOAA RV *Chapman*	8 July 1984	58°40' N	169°47' W	38	24 October 1984	
21	NOAA RV *Chapman*	15 July 1984	55°05' N	167°39' W	187	24 October 1984	
22	FV *Ocean Spray*	1 August 1984	56°46' N	154°26' W	35	4 February 1985	
23	FV *Ocean Spray*	1 August 1984	56°55' N	154°05' W	43	4 February 1985	
24	FV *Ocean Spray*	3 August 1984	57°18' N	152°56' W	49	4 February 1985	
25	FV *Ocean Spray*	4 August 1984	57°28' N	152°46' W	49	4 February 1985	
26	FV *Ocean Spray*	4 August 1984	57°30' N	151°50' W	47	4 February 1985	
27	FV *Ocean Spray*	4 August 1984	57°30' N	151°48' W	48	4 February 1985	
28	FV *Ocean Spray*	5 August 1984	57°30' N	151°49' W	49	4 February 1985	
29	FV *Ocean Spray*	5 August 1984	57°31' N	151°56' W	46	4 February 1985	

FV = fishing vessel
NOAA = National Oceanic and Atmospheric Administration
RV = research vessel

[a] Specimens were frozen at the time of collection, but thawed, drained, identified and measured on 14 July 1983. They were subsequently refrozen and saved for calorimetry analysis later that year.

[b] Specimens were frozen at the time of collection, but thawed, drained, identified and measured on 20 July 1983. They were subsequently refrozen and saved for calorimetry analysis later that year.

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Appendix Table A-2.--Sample number, collection group, sex, total mass (wet and dry), percent moisture, percent ash, ash-free dry mass, and energy value of whole bodies of fishes and squids collected in the Bering Sea and North Pacific Ocean.

		Whole body					Energy value			
Species/ Sample number	Collection group [a]	Wet mass (g) [b]	Percent moisture	Dry mass (g)	Percent ash [c]	Ash-free dry mass (g)	Total sample (kcal)	Dry mass (kcal/g)	Ash-free dry mass (kcal/g)	Wet mass (estimate) (kcal/g)
Pacific herring										
1	20	28.5	73	7.7	9.3	7.0	45	5.8	6.4	1.6
2	20	30.9	76	7.4	15.8	6.2	39	5.2	6.2	1.3
3	20	43.7	73	11.8	9.6	10.7	66	5.6	6.2	1.5
4	20	28.7	76	6.9	10.4	6.2	37	5.4	6.0	1.3
5	20	29.3	78	6.4	12.7	5.6	31	4.8	5.5	1.1
6	20	32.6	74	8.5	9.6	7.7	44	5.2	5.7	1.3
7	20	39.7	73	10.7	10.4	9.6	60	5.6	6.2	1.5
8	20	33.3	78	7.3	11.8	6.5	37	5.0	5.7	1.1
9	20	29.0	75	7.2	10.4	6.5	38	5.2	5.8	1.3
10	20	34.3	78	7.5	13.6	6.5	34	4.5	5.2	1.0
11	22	162.4	67	53.6	6.7	50.0	381	7.1	7.6	2.3
12	22	180.0	57	77.4	4.7	73.8	588	7.6	8.0	3.3
13	22	111.7	66	38.0	7.1	35.3	251	6.6	7.1	2.2
14	22	121.1	60	48.4	6.8	45.2	349	7.2	7.7	2.9
15	22	126.6	60	50.6	6.0	47.6	370	7.3	7.8	2.9
16	22	160.9	56	70.8	5.9	66.6	531	7.5	8.0	3.3
17	22	174.7	64	62.9	6.1	59.0	434	6.9	7.3	2.5
18	22	169.7	60	67.9	5.7	64.0	509	7.5	8.0	3.0
19	22	196.9	59	80.7	5.9	76.0	597	7.4	7.9	3.0
20	22	190.0	62	72.2	6.6	67.5	491	6.8	7.3	2.6
Capelin										
21	12	21.0	71	6.1	7.9	5.6	37	6.1	6.6	1.8
22	12	12.8	73	3.5	6.7	3.2	21	6.2	6.5	1.6
23	12	17.3	73	4.7	6.7	4.4	29	6.1	6.7	1.7
24	12	17.3	72	4.8	7.1	4.5	30	6.2	6.7	1.7
25	12	15.0	72	4.2	6.8	3.9	26	6.2	6.6	1.7
26	13	13.7	76	3.3	15.8	2.8	14	4.2	5.1	1.0
27	13	14.8	74	3.8	6.9	3.6	23	6.0	6.4	1.6
28	13	16.1	71	4.7	8.3	4.3	28	5.9	6.5	1.7
29	13	12.4	74	3.2	9.6	2.9	18	5.6	6.2	1.5
30	19	24.0	76	5.8	7.5	5.3	35	6.0	6.6	1.5
31	19	19.9	73	5.4	6.7	5.0	33	6.2	6.6	1.7
32	19	19.3	72	5.4	6.4	5.1	35	6.5	6.9	1.8
33	19	18.5	72	5.2	8.6	4.7	32	6.2	6.8	1.7
34	19	20.3	69	6.3	5.8	5.9	41	6.5	6.9	2.0
35	19	20.7	70	6.2	5.3	5.9	39	6.3	6.6	1.9
36	19	19.6	74	5.1	6.9	4.7	31	6.0	6.5	1.6

Appendix Table A-2.--Continued.

Species/ Sample number	Collection group [a]	Whole body: Wet mass (g) [b]	Percent moisture	Dry mass (g)	Percent ash [c]	Ash-free dry mass (g)	Energy value: Total sample (kcal)	Dry mass (kcal/g)	Ash-free dry mass (kcal/g)	Wet mass (estimate) (kcal/g)
Capelin (continued)										
37	24	9.8	69	3.1	0.0	3.0	20	6.6	6.6	2.0
38	24	8.4	76	2.0	9.2	1.8	11	5.6	6.0	1.3
39	24	10.5	70	3.1	7.0	2.9	21	6.6	7.2	2.0
40	24	6.2	69	1.9	0.0	1.9	12	6.2	6.2	1.9
41	24	10.0	78	2.2	12.3	1.9	11	5.2	5.7	1.1
42	24	11.5	75	2.9	9.6	2.6	17	5.9	6.5	1.5
43	24	10.1	70	3.0	7.0	2.8	20	6.6	7.1	2.0
44	24	9.4	69	2.9	6.1	2.7	20	6.9	7.3	2.1
45	24	9.0	78	2.0	11.4	1.8	11	5.4	6.3	1.2
46	24	8.5	69	2.6	6.8	2.5	17	6.6	6.9	2.0
47	24	10.2	74	2.7	9.6	2.4	16	5.9	6.7	1.6
48	24	7.7	72	2.2	7.9	2.0	13	6.2	6.5	1.7
49	24	8.9	70	2.7	6.7	2.5	18	6.6	7.2	2.0
50	24	11.8	71	3.4	6.9	3.2	23	6.6	7.2	1.9
51	24	6.6	75	1.7	8.8	1.5	8	4.8	5.3	1.2
Eulachon										
52	10	37.9	64	13.6	3.9	13.1	102	7.5	7.8	2.7
53	10	23.8	64	8.6	5.3	8.1	63	7.3	7.8	2.6
54	10	43.3	62	16.5	2.9	16.0	123	7.5	7.7	2.8
55	10	35.1	66	11.9	4.1	11.4	88	7.4	7.7	2.5
56	10	35.3	64	12.7	4.2	12.2	94	7.4	7.7	2.7
57	10	37.9	63	14.0	3.5	13.5	104	7.4	7.7	2.7
58	10	31.0	66	10.5	3.8	10.1	78	7.4	7.7	2.5
59	10	32.5	66	11.1	4.7	10.5	82	7.4	7.8	2.5
60	10	49.0	63	18.1	4.1	17.4	134	7.4	7.7	2.7
61	10	36.4	65	12.7	2.9	12.4	96	7.5	7.8	2.6
62	10	36.9	65	12.9	4.0	12.4	96	7.4	7.7	2.6
63	10	25.5	66	8.7	5.0	8.2	65	7.5	7.9	2.5
64	10	24.6	64	8.9	5.0	8.4	66	7.5	7.8	2.7
65	10	29.0	66	9.9	4.1	9.5	74	7.5	7.8	2.6
66	10	36.3	64	13.1	4.2	12.5	99	7.6	7.9	2.7
67	10	19.4	66	6.6	5.3	6.2	49	7.5	7.8	2.5
68	10	21.3	68	6.8	3.7	6.6	49	7.2	7.5	2.3
69	10	62.9	63	23.3	4.1	22.3	179	7.7	8.0	2.8
70	10	48.0	63	17.8	3.5	17.1	133	7.5	7.8	2.8
71	25	37.9	59	15.5	3.7	15.0	112	7.2	7.5	3.0
72	25	43.9	63	16.2	3.8	15.6	112	6.9	7.2	2.6
73	25	29.4	63	10.9	4.3	10.4	78	7.2	7.5	2.7
74	25	27.8	65	9.7	4.6	9.3	69	7.1	7.4	2.5
75	25	51.5	65	18.0	4.0	17.3	130	7.2	7.5	2.5

Appendix Table A-2.--Continued.

Species/ Sample number	Collection group [a]	Whole body: Wet mass (g) [b]	Percent moisture	Dry mass (g)	Percent ash [c]	Ash-free dry mass (g)	Energy value: Total sample (kcal)	Dry mass (kcal/g)	Ash-free dry mass (kcal/g)	Wet mass (estimate) (kcal/g)
Eulachon (continued)										
76	25	48.7	64	17.5	3.9	16.9	123	7.0	7.3	2.5
77	25	44.3	63	16.4	3.8	15.8	121	7.4	7.7	2.7
78	25	39.6	63	14.7	4.1	14.1	104	7.1	7.4	2.6
79	25	31.1	64	11.2	4.4	10.7	83	7.4	7.8	2.7
80	25	35.5	64	12.8	4.2	12.2	91	7.1	7.4	2.6
Pacific cod										
81	17	160.6	80	32.1	22.0	25.1	148	4.6	5.9	0.9
82	17	199.4	79	41.9	13.3	36.3	184	4.4	5.1	0.9
83	17	206.2	79	43.3	14.8	36.9	199	4.6	5.4	1.0
84	17	198.5	80	39.7	16.0	33.3	191	4.8	5.7	1.0
85	17	208.9	80	41.8	17.0	34.7	192	4.6	5.5	0.9
86	17	192.1	79	40.3	15.2	34.2	186	4.6	5.4	1.0
87	17	166.4	79	34.9	16.7	29.1	154	4.4	5.3	0.9
88	17	184.1	78	40.5	15.0	34.4	182	4.5	5.3	1.0
89	17	163.8	78	36.0	20.5	28.7	159	4.4	5.5	1.0
90	17	152.2	77	35.0	15.2	29.7	147	4.2	5.0	1.0
91	26	228.0	80	45.6	16.0	38.3	205	4.5	5.4	0.9
92	26	352.0	81	66.9	18.9	54.2	314	4.7	5.8	0.9
93	26	691.9	79	145.3	16.7	121.1	654	4.5	5.4	0.9
94	27	250.7	80	50.1	14.5	42.9	221	4.4	5.2	0.9
95	27	331.7	80	66.3	19.5	53.4	292	4.4	5.5	0.9
96	27	355.2	80	71.0	16.0	59.7	355	5.0	5.9	1.0
97	27	322.0	80	64.4	20.0	51.5	296	4.6	5.7	0.9
Walleye pollock										
98	11	1,039.5	78	228.7	12.3	200.6	1,140	5.0	5.7	1.1
99	11	705.6	79	148.2	21.4	116.4	696	4.7	6.0	1.0
100	11	762.9	79	160.2	12.4	140.4	769	4.8	5.5	1.0
101	11	576.5	77	132.6	10.9	118.2	650	4.9	5.5	1.1
102	11	1,064.5	78	234.2	14.5	200.1	1,120	4.8	5.6	1.1
103	11	904.9	76	217.2	16.7	181.0	1,060	4.9	5.9	1.2
104	11	757.0	75	189.3	9.6	171.1	965	5.1	5.6	1.3
105	11	783.6	78	172.4	13.6	148.9	827	4.8	5.6	1.1
106	11	853.8	76	204.9	15.0	174.2	1,000	4.9	5.7	1.2
107	11	911.8	78	200.6	12.7	175.1	1,020	5.1	5.8	1.1
108	15	291.5	78	64.1	11.8	56.6	340	5.3	6.0	1.2
109	15	151.1	78	33.2	12.3	29.2	163	4.9	5.6	1.1
110	15	469.5	77	108.0	12.2	94.8	594	5.5	6.3	1.3
111	15	339.6	74	88.3	10.0	79.5	494	5.6	6.2	1.5
112	22	100.3	78	22.1	14.1	19.0	115	5.2	6.1	1.1

Appendix Table A-2.--Continued.

		Whole body					Energy value			
Species/ Sample number	Collection group [a]	Wet mass (g) [b]	Percent moisture	Dry mass (g)	Percent ash [c]	Ash-free dry mass (g)	Total sample (kcal)	Dry mass (kcal/g)	Ash-free dry mass (kcal/g)	Wet mass (estimate) (kcal/g)
Walleye pollock (continued)										
113	22	49.1	76	11.8	14.2	10.1	57	4.8	5.6	1.2
114	22	61.9	76	14.9	12.1	13.1	73	4.9	5.6	1.2
115	22	68.9	77	15.8	13.0	13.8	48	3.0	3.5	0.7
116	22	79.8	77	18.4	13.0	16.0	55	3.0	3.4	0.7
117	22	74.8	76	17.9	15.8	15.1	93	5.2	6.2	1.2
118	22	68.0	76	16.3	15.4	13.8	85	5.2	6.2	1.3
119	22	106.9	77	24.6	14.8	21.0	135	5.5	6.4	1.3
120	22	62.0	76	14.9	11.7	13.1	77	5.2	5.9	1.2
121	22	106.8	76	25.6	15.0	21.8	133	5.2	6.1	1.2
122	24	70.7	78	15.5	13.6	13.4	82	5.3	6.1	1.2
123	24	54.7	79	11.5	12.9	10.0	56	4.9	5.6	1.0
124	24	53.0	79	11.1	14.3	9.5	55	4.9	5.8	1.0
125	24	66.8	79	14.0	14.3	12.0	73	5.2	6.1	1.1
126	24	41.6	80	8.3	13.0	7.2	39	4.7	5.4	0.9
127	24	42.9	80	8.6	13.5	7.4	43	5.0	5.8	1.0
128	24	69.8	79	14.7	12.9	12.8	73	5.0	5.7	1.0
129	24	73.4	78	16.2	10.9	14.4	86	5.3	6.0	1.2
130	24	63.8	79	13.4	12.4	11.7	63	4.7	5.4	1.0
131	24	70.7	78	15.6	12.7	13.6	84	5.4	6.2	1.2
Pacific ocean perch										
132	5	433.7	71	125.8	13.8	108.4	654	5.2	6.0	1.5
133	5	771.3	74	200.5	17.7	165.1	1,060	5.3	6.4	1.4
134	5	1,011.1	72	283.1	13.9	243.7	1,640	5.8	6.7	1.6
135	5	883.8	73	238.6	17.4	197.1	1,290	5.4	6.5	1.5
136	5	750.5	71	217.6	15.9	183.1	1,260	5.8	6.9	1.7
137	5	256.4	77	59.0	14.3	50.5	336	5.7	6.7	1.3
138	5	888.5	72	248.8	18.6	202.6	1,240	5.0	6.1	1.4
139	5	965.4	73	260.7	16.3	218.2	1,330	5.1	6.1	1.4
Dusky rockfish										
140	28	306.9	75	76.7	16.4	64.1	414	5.4	6.5	1.3
141	28	373.3	74	97.1	15.4	82.1	553	5.7	6.7	1.5
142	29	322.9	73	87.2	16.7	72.7	471	5.4	6.5	1.5
143	29	362.8	73	98.0	14.8	83.4	558	5.7	6.7	1.5
144	29	389.3	72	109.0	16.8	90.7	578	5.3	6.4	1.5
Northern rockfish										
145	8	373.5	70	112.1	13.3	97.1	627	5.6	6.5	1.7
146	8	275.3	71	79.8	12.1	70.2	415	5.2	5.9	1.5
147	8	288.3	70	86.5	12.3	75.8	467	5.4	6.2	1.6

Appendix Table A-2.--Continued.

Species/ Sample number	Collection group [a]	Whole body: Wet mass (g) [b]	Whole body: Percent moisture	Whole body: Dry mass (g)	Whole body: Percent ash [c]	Whole body: Ash-free dry mass (g)	Energy value: Total sample (kcal)	Energy value: Dry mass (kcal/g)	Energy value: Ash-free dry mass (kcal/g)	Energy value: Wet mass (estimate) (kcal/g)
Northern rockfish (continued)										
148	8	292.8	69	90.8	15.2	77.0	481	5.3	6.2	1.6
149	8	323.1	72	90.5	14.3	77.5	479	5.3	6.2	1.5
150	8	345.9	70	103.8	13.7	89.6	550	5.3	6.1	1.6
151	8	410.8	69	127.3	12.9	110.9	726	5.7	6.5	1.8
152	8	361.5	70	108.5	14.7	92.5	596	5.5	6.4	1.6
153	8	352.2	70	105.7	13.0	91.9	571	5.4	6.2	1.6
154	8	364.6	68	116.7	14.7	99.5	642	5.5	6.4	1.8
155	8	381.3	69	118.2	13.5	102.2	638	5.4	6.2	1.7
156	18	341.4	72	95.6	14.3	81.9	488	5.1	6.0	1.4
157	18	385.7	74	100.3	15.8	84.5	481	4.8	5.7	1.2
158	18	432.6	76	103.8	14.2	89.1	498	4.8	5.6	1.2
159	18	277.0	73	74.8	13.7	64.5	389	5.2	6.0	1.4
160	18	448.9	74	116.7	16.9	97.0	607	5.2	6.3	1.4
161	18	222.6	75	55.7	17.6	45.9	284	5.1	6.2	1.3
162	18	384.2	74	99.9	18.5	81.5	469	4.7	5.8	1.2
163	18	203.0	74	52.8	16.9	43.8	253	4.8	5.8	1.2
164	18	327.1	75	81.8	21.6	64.1	409	5.0	6.4	1.3
165	18	493.6	69	153.0	12.6	133.8	842	5.5	6.3	1.7
Rockfish (unidentified)										
166	5	809.3	71	234.7	19.3	189.4	1,240	5.3	6.5	1.5
167	5	362.3	77	83.3	20.0	66.7	383	4.6	5.7	1.1
168	5	472.5	80	94.5	16.0	79.4	473	5.0	6.0	1.0
169	5	154.2	80	30.8	14.0	26.5	154	5.0	5.8	1.0
170	5	879.1	73	237.4	16.3	198.7	1,310	5.5	6.6	1.5
171	5	502.1	75	125.5	16.8	104.4	678	5.4	6.5	1.4
172	5	846.6	70	254.0	16.0	213.3	1,470	5.8	6.9	1.7
173	5	581.0	68	185.9	15.9	156.3	1,080	5.8	6.9	1.9
174	5	883.8	70	265.1	15.3	224.5	1,220	4.6	5.4	1.4
Sablefish										
175	5	586.2	80	117.2	8.5	107.3	633	5.4	5.9	1.1
176	5	499.1	79	104.8	9.0	95.3	535	5.1	5.6	1.1
177	5	525.8	78	115.7	9.5	104.6	636	5.5	6.1	1.2
178	5	462.5	79	97.1	9.0	88.3	515	5.3	5.8	1.1
179	5	632.7	75	158.2	8.0	145.5	965	6.1	6.6	1.5
180	5	711.4	76	170.7	9.2	155.1	1,020	6.0	6.6	1.4
181	5	706.9	79	148.4	12.4	130.1	787	5.3	6.1	1.1
182	5	820.7	80	164.1	10.0	147.7	952	5.8	6.4	1.2
183	5	887.1	79	186.3	11.0	165.9	1,040	5.6	6.3	1.2
184	5	832.3	71	241.4	6.2	226.4	1,670	6.9	7.4	2.0

Appendix Table A-2.--Continued.

Species/ Sample number	Collection group [a]	Whole body: Wet mass (g) [b]	Percent moisture	Dry mass (g)	Percent ash [c]	Ash-free dry mass (g)	Energy value: Total sample (kcal)	Dry mass (kcal/g)	Ash-free dry mass (kcal/g)	Wet mass (estimate) (kcal/g)
Sablefish (continued)										
185	9	258.0	73	69.7	8.9	63.5	397	5.7	6.3	1.5
186	9	183.6	75	45.9	10.0	41.3	252	5.5	6.1	1.4
187	9	249.0	76	59.8	10.4	53.5	323	5.4	6.0	1.3
188	22	412.5	78	90.8	13.6	78.4	508	5.6	6.5	1.2
189	24	473.9	76	113.7	9.2	103.3	671	5.9	6.5	1.4
190	24	290.1	79	60.9	11.0	54.2	341	5.6	6.3	1.2
191	24	355.0	78	78.1	10.5	69.9	422	5.4	6.0	1.2
192	24	252.8	78	55.6	10.9	49.5	306	5.5	6.2	1.2
Armorhead sculpin										
193	17	260.0	80	52.0	22.5	40.3	208	4.0	5.2	0.8
194	17	242.3	78	53.3	22.3	41.4	240	4.5	5.8	1.0
195	17	231.5	77	53.2	19.1	43.1	234	4.4	5.4	1.0
196	17	227.7	78	50.1	28.2	36.0	180	3.6	5.0	0.8
197	17	260.9	78	57.4	19.1	46.4	253	4.4	5.4	1.0
198	17	260.4	78	57.3	25.0	43.0	223	3.9	5.2	0.9
199	17	240.7	78	53.0	24.1	40.2	212	4.0	5.3	0.9
200	17	246.0	76	59.0	28.3	42.3	248	4.2	5.9	1.0
Blackfin sculpin										
201	7	59.2	80	11.8	24.5	8.9	51	4.3	5.7	0.9
202	7	52.1	80	10.4	22.0	8.1	43	4.1	5.3	0.8
203	7	49.7	79	10.4	22.9	8.1	41	3.9	5.1	0.8
Sculpin (*Triglops* sp.)										
204	17	12.4	75	3.1	16.8	2.6	14	4.6	5.4	1.1
205	17	55.3	73	14.9	16.3	12.5	75	5.0	6.0	1.4
206	17	64.9	73	17.5	17.8	14.4	84	4.8	5.8	1.3
207	17	61.9	74	16.1	20.0	12.9	76	4.7	5.9	1.2
208	17	26.1	74	6.8	17.3	5.6	30	4.4	5.3	1.1
209	17	9.3	74	2.4	0.0	2.4	12	4.8	4.8	1.3
210	17	46.7	75	11.7	14.0	10.0	58	5.0	5.8	1.2
Sculpin (unidentified)										
211	23	542.2	77	124.7	15.2	105.7	611	4.9	5.8	1.1
212	23	562.4	78	123.7	18.2	101.2	582	4.7	5.7	1.0
213	23	520.2	76	124.8	19.2	100.9	599	4.8	5.9	1.2
214	23	483.0	78	106.3	17.7	87.4	499	4.7	5.7	1.0
215	23	481.6	76	115.6	15.8	97.3	589	5.1	6.1	1.2

Appendix Table A-2.--Continued.

Species/ Sample number	Collection group [a]	Whole body: Wet mass (g) [b]	Whole body: Percent moisture	Whole body: Dry mass (g)	Whole body: Percent ash [c]	Whole body: Ash-free dry mass (g)	Energy value: Total sample (kcal)	Energy value: Dry mass (kcal/g)	Energy value: Ash-free dry mass (kcal/g)	Energy value: Wet mass (estimate) (kcal/g)
Snailfish (unidentified)										
216	14	4.4	78	1.0	0.0	1.0	4	4.1	4.1	0.9
Searcher										
217	7	285.0	73	76.9	11.9	67.8	392	5.1	5.8	1.4
218	7	296.5	74	77.1	13.8	66.4	385	5.0	5.8	1.3
219	7	293.0	74	76.2	13.8	65.6	396	5.2	6.0	1.4
220	7	220.8	73	59.6	14.8	50.8	316	5.3	6.2	1.4
221	7	335.2	73	90.5	13.3	78.4	443	4.9	5.6	1.3
222	16	290.7	77	66.9	14.8	57.0	341	5.1	6.0	1.2
223	16	367.8	76	88.3	12.1	77.6	468	5.3	6.0	1.3
Pacific sandfish										
224	22	82.8	77	19.0	15.2	16.1	97	5.1	6.0	1.2
225	22	61.0	78	13.4	12.7	11.7	67	5.0	5.7	1.1
226	22	70.3	76	16.9	10.8	15.0	96	5.7	6.4	1.4
227	22	78.5	80	15.7	11.5	13.9	82	5.2	5.9	1.0
228	22	52.5	84	8.4	14.4	7.2	40	4.8	5.6	0.8
229	22	54.7	77	12.6	13.9	10.8	68	5.4	6.3	1.2
230	22	60.3	76	14.5	12.9	12.6	78	5.4	6.2	1.3
231	22	89.8	76	21.6	12.1	18.9	125	5.8	6.6	1.4
232	22	53.3	77	12.3	13.0	10.7	66	5.4	6.2	1.2
233	22	37.8	79	7.9	13.8	6.8	40	5.0	5.8	1.1
Arrowtooth flounder										
234	9	248.0	76	59.5	10.8	53.1	310	5.2	5.8	1.3
235	9	217.8	72	61.0	9.6	55.1	348	5.7	6.3	1.6
236	9	218.9	73	59.1	8.9	53.8	337	5.7	6.3	1.5
237	9	324.0	75	81.0	9.2	73.5	454	5.6	6.2	1.4
238	9	181.0	76	43.4	9.6	39.3	235	5.4	6.0	1.3
239	9	238.4	74	62.0	11.2	55.1	335	5.4	6.1	1.4
240	9	168.3	78	37.0	13.2	32.1	181	4.9	5.6	1.1
241	9	309.3	76	74.2	10.0	66.8	379	5.1	5.7	1.2
242	9	281.5	76	67.6	10.0	60.8	358	5.3	5.9	1.3
243	9	231.4	76	55.5	10.4	49.8	283	5.1	5.7	1.2
244	9	214.0	76	51.4	12.1	45.2	262	5.1	5.8	1.2
245	9	224.2	76	53.8	13.7	46.4	274	5.1	5.9	1.2
246	9	184.1	76	44.2	11.7	39.0	225	5.1	5.8	1.2
247	17	290.5	75	72.6	11.2	64.5	385	5.3	6.0	1.3
248	17	182.5	78	40.2	12.3	35.2	205	5.1	5.8	1.1
249	17	185.7	79	39.0	12.4	34.2	187	4.8	5.5	1.0
250	17	288.4	75	72.1	10.4	64.6	382	5.3	5.9	1.3

Appendix Table A-2.--Continued.

Species/ Sample number	Collection group [a]	Whole body: Wet mass (g) [b]	Whole body: Percent moisture	Whole body: Dry mass (g)	Whole body: Percent ash [c]	Whole body: Ash-free dry mass (g)	Energy value: Total sample (kcal)	Energy value: Dry mass (kcal/g)	Energy value: Ash-free dry mass (kcal/g)	Energy value: Wet mass (estimate) (kcal/g)
Arrowtooth flounder (continued)										
251	17	306.2	76	73.5	10.0	66.1	397	5.4	6.0	1.3
252	17	228.5	77	52.6	10.4	47.1	252	4.8	5.4	1.1
253	17	134.4	79	28.2	13.8	24.3	130	4.6	5.3	1.0
254	17	261.7	77	60.2	11.3	53.4	301	5.0	5.6	1.2
255	17	245.2	77	56.4	11.3	50.0	299	5.3	6.0	1.2
256	17	279.9	78	61.6	10.9	54.9	308	5.0	5.6	1.1
257	25	182.9	80	36.6	18.0	30.0	161	4.4	5.4	0.9
258	25	212.5	78	46.8	12.7	40.8	210	4.5	5.1	1.0
259	25	478.9	72	134.1	8.2	123.1	818	6.1	6.6	1.7
260	25	425.1	77	97.8	10.4	87.6	528	5.4	6.0	1.2
261	25	384.9	75	96.2	10.8	85.8	539	5.6	6.3	1.4
262	25	233.5	76	56.0	10.4	50.2	303	5.4	6.0	1.3
263	25	225.8	78	49.7	12.7	43.4	248	5.0	5.7	1.1
264	25	320.2	77	73.6	13.5	63.7	368	5.0	5.8	1.1
265	25	195.9	76	47.0	10.8	41.9	254	5.4	6.1	1.3
266	25	158.3	77	36.4	13.0	31.7	171	4.7	5.4	1.1
267	25	161.1	78	35.4	11.8	31.3	174	4.9	5.6	1.1
Magistrate armhook squid										
268	6	689.5	80	137.9	8.0	126.9	883	6.4	7.0	1.3
269	6	850.7	76	204.2	6.7	190.6	1,330	6.5	7.0	1.6
270	6	866.8	77	199.4	6.1	187.2	1,360	6.8	7.3	1.6
271	6	421.2	79	88.5	7.6	81.7	531	6.0	6.5	1.3
272	6	704.6	80	140.9	8.0	129.6	846	6.0	6.5	1.2
273	6	201.5	81	38.3	8.4	35.1	222	5.8	6.3	1.1
274	6	760.4	78	167.3	6.4	156.6	1,070	6.4	6.8	1.4
275	6	310.9	78	68.4	7.7	63.1	383	5.6	6.1	1.2
276	6	222.0	81	42.2	8.4	38.6	236	5.6	6.1	1.1
277	6	278.2	75	69.6	6.0	65.4	424	6.1	6.5	1.5
Gonate squid (*Berryteuthis* sp.)										
278	21	429.1	82	77.2	8.3	70.8	394	5.1	5.6	0.9
Boreopacific gonate squid										
279 [d]	3	782.7	82	140.9	5.0	133.8	873	6.2	6.5	1.1
Boreal clubhook squid										
280	1	362.3	74	94.2	6.5	88.0	565	6.0	6.4	1.6
281	1	241.6	72	67.6	5.4	64.0	386	5.7	6.0	1.6
282 [e]	2	784.8	79	164.8	5.7	155.4	923	5.6	5.9	1.2
283 [e,f]	2	714.3	79	150.0	4.8	142.9	855	5.7	6.0	1.2

Appendix Table A-2.--Continued.

Species/ Sample number	Collection group [a]	Whole body: Wet mass (g) [b]	Percent moisture	Dry mass (g)	Percent ash [c]	Ash-free dry mass (g)	Energy value: Total sample (kcal)	Dry mass (kcal/g)	Ash-free dry mass (kcal/g)	Wet mass (estimate) (kcal/g)
Boreal clubhook squid (continued)										
284 [e,g]	2	799.8	79	168.0	5.2	159.2	957	5.7	6.0	1.2
285 [e,h]	2	864.1	78	190.1	5.4	179.7	1,100	5.8	6.1	1.3
286 [e,i]	2	687.1	80	137.4	5.5	129.9	742	5.4	5.7	1.1
287	4	715.0	79	150.2	3.9	144.3	886	5.9	6.1	1.2
Neon flying squid										
288 [g]	1	1,720.8	74	447.4	6.2	419.9	2,680	6.0	6.4	1.6

[a] The date and location of each collection group are given in Appendix Table A-1.
[b] Total wet mass measured upon receipt by the analytical laboratory.
[c] Dry mass basis.
[d] Mature female with eggs.
[e] Mature specimen.
[f] Both fins missing.
[g] One tentacle missing
[h] Parts of tentacles missing.
[i] One fin missing.

Appendix Table A-3.--Sample number, collection group, species, sex, length, and wet mass of whole bodies of 42 fish and 20 squid specimens collected in the Bering Sea and North Pacific Ocean.[a]

. :mple n. mber [b]	Collection group [c]	Species	Sex	Length (cm) [d]	Wet mass (g) [e]
98	11	Walleye pollock	Male	50.0	1,039.5
99	11	Walleye pollock	Male	46.0	705.6
100	11	Walleye pollock	Male	46.0	762.9
101	11	Walleye pollock	Male	43.0	576.5
102	11	Walleye pollock	Female	53.0	1,064.5
103	11	Walleye pollock	Female	51.0	904.9
104	11	Walleye pollock	Female	46.0	757.0
105	11	Walleye pollock	Female	48.0	783.6
106	11	Walleye pollock	Female	49.0	853.8
107	11	Walleye pollock	NR	50.0	911.8
145	8	Northern rockfish	Male	NR	373.5
146	8	Northern rockfish	Male	NR	275.3
147	8	Northern rockfish	Male	NR	288.3
148	8	Northern rockfish	Male	NR	292.8
149	8	Northern rockfish	Male	NR	323.1
150	8	Northern rockfish	Male	NR	345.9
151	8	Northern rockfish	Female	NR	410.8
152	8	Northern rockfish	Female	NR	361.5
153	8	Northern rockfish	Female	NR	352.2
154	8	Northern rockfish	Female	NR	364.6
155	8	Northern rockfish	Female	NR	381.3
185	9	Sablefish	Male	NR	258.0
186	9	Sablefish	Male	NR	183.6
187	9	Sablefish	Male	NR	249.0
201	7	Blackfin sculpin	Male	NR	59.2
202	7	Blackfin sculpin	Male	NR	52.1
203	7	Blackfin sculpin	Female	NR	49.7
217	7	Searcher	Female	NR	285.0
218	7	Searcher	Female	NR	296.5
234	9	Arrowtooth flounder	Male	NR	248.0
235	9	Arrowtooth flounder	Male	NR	217.8
236	9	Arrowtooth flounder	Male	NR	218.9
237	9	Arrowtooth flounder	Male	NR	324.0
238	9	Arrowtooth flounder	Male	NR	181.0
239	9	Arrowtooth flounder	Female	NR	238.4

Appendix Table A-3.--Continued.

Sample number [b]	Collection group [c]	Species	Sex	Length (cm) [d]	Wet mass (g) [e]
240	9	Arrowtooth flounder	Female	NR	168.3
241	9	Arrowtooth flounder	Female	NR	309.3
242	9	Arrowtooth flounder	Female	NR	281.5
243	9	Arrowtooth flounder	Female	NR	231.4
244	9	Arrowtooth flounder	Female	NR	214.0
245	9	Arrowtooth flounder	Female	NR	224.2
246	9	Arrowtooth flounder	Female	NR	184.1
268	6	Magistrate armhook squid	Male	NR	689.5
269	6	Magistrate armhook squid	Male	NR	850.7
270	6	Magistrate armhook squid	Male	NR	866.8
271	6	Magistrate armhook squid	Male	NR	421.2
272	6	Magistrate armhook squid	Male	NR	704.6
273	6	Magistrate armhook squid	Female	NR	201.5
274	6	Magistrate armhook squid	Female	NR	760.4
275	6	Magistrate armhook squid	Female	NR	310.9
276	6	Magistrate armhook squid	Female	NR	222.0
277	6	Magistrate armhook squid	Female	NR	278.2
279	3	Boreopacific gonate squid	Female	26.2	782.7
280	1	Boreal clubhook squid	Male	22.7	362.3
281	1	Boreal clubhook squid	Male	18.6	241.6
282	2	Boreal clubhook squid	Female	31.3	784.8
283	2	Boreal clubhook squid	Female	28.3	714.3
284	2	Boreal clubhook squid	Female	28.8	799.8
285	2	Boreal clubhook squid	Female	32.0	864.1
286	2	Boreal clubhook squid	Female	29.4	687.1
287	4	Boreal clubhook squid	Female	29.4	715.0
288	1	Neon flying squid	Female	38.2	1,720.8

NR = data not recorded.

[a] This table lists only the fish and squid samples from Appendix Table A-2 for which sex or length measurements were recorded.
[b] Identical to the samples listed in Appendix Table A-2.
[c] The date and location of each collection group are given in Appendix Table A-1.
[d] Standard length for fishes and dorsal mantle length for squids.
[e] Wet mass recorded after thawing upon receipt by the analytical laboratory.

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26 LOW, L-L. (coordinator). 1993. Status of living marine resources off the Pacific coast of the United States for 1993, 90 p. NTIS number pending.

25 KINOSHITA, R. K., A. GREIG, J. D. HASTIE, and J. M. TERRY. 1993. Economic status of the groundfish fisheries off Alaska, 1992, 102 p. NTIS number pending.

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18 PELLA, J., M. HOFFMAN, S. HOFFMAN, M. MASUDA, S. NELSON, and L. TALLEY. 1993. Adult sockeye and pink salmon tagging experiments for separating stocks in northern British Columbia and southern Southeast Alaska, 1982-1985, 134 p. NTIS No. PB93-226660.

17 SEASE, J. L., J. P. LEWIS, D. C. MCALLISTER, R. L. MERRICK, and S. M. MELLO. 1993. Aerial and ship-based surveys of Steller sea lions (Eumetopias jubatus) in Southeast Alaska, the Gulf of Alaska, and Aleutian Islands during June and July 1992, 57 p. NTIS No. PB93-226025.