



NOAA Technical Memorandum NMFS-AFSC-164

Food Habits of Groundfishes in the Gulf of Alaska in 1999 and 2001

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M-S. Yang, K. Dodd, R. Hibpshman, and A. Whitehouse

U.S. DEPARTMENT OF COMMERCE

National Oceanic and Atmospheric Administration

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ABSTRACT

A total of 7,899 stomachs from 40 species, walleye pollock (*Theragra chalcogramma*), Pacific cod (*Gadus macrocephalus*), arrowtooth flounder (*Atheresthes stomias*), Pacific halibut (*Hippoglossus stenolepis*), sablefish (*Anoplopoma fimbria*), spiny dogfish (*Squalus acanthias*), big skate (*Raja binoculata*), Bering skate (*Bathyraja interrupta*), Alaska skate (*Bathyraja parmifera*), longnose skate (*Raja rhina*), eulachon (*Thaleichthys pacificus*), shortfin eelpout (*Lycodes brevipes*), black eelpout (*Lycodes diapterus*), wattled eelpout (*Lycodes palearis*), giant grenadier (*Coryphaenoides pectoralis*), rougheyeye rockfish (*Sebastes aleutianus*), Pacific ocean perch (*Sebastes alutus*), redbanded rockfish (*Sebastes babcocki*), shortraker rockfish (*Sebastes borealis*), dusky rockfish (*Sebastes variabilis*), sharpchin rockfish (*Sebastes zacentrus*), shortspine thornyhead (*Sebastolobus alascanus*), Atka mackerel (*Pleurogrammus monopterygius*), spinyhead sculpin (*Dasycottus setiger*), yellow Irish lord (*Hemilepidotus jordani*), bigmouth sculpin (*Hemitripterus bolini*), darkfin sculpin (*Malacocottus zonurus*), great sculpin (*Myoxocephalus polyacanthocephalus*), dusky snailfish (*Liparis gibbus*), Pacific sandfish (*Trichodon trichodon*), searcher (*Bathymaster signatus*), northern ronquil (*Ronquilis jordani*), deepsea sole (*Embassichthys bathybius*), rex sole (*Errex zachirus*), flathead sole (*Hippoglossoides elassodon*), butter sole (*Isopsetta isolepis*), southern rock sole (*Lepidopsetta bilineata*), northern rock sole (*Lepidopsetta polyxystra*), yellowfin sole (*Pleuronectes asper*), and Dover sole (*Microstomus pacificus*) were analyzed to describe the food habits of the major groundfish species in the Gulf of Alaska in 1999 and 2001.

Arrowtooth flounder, Pacific halibut, sablefish, Pacific cod, bigmouth sculpin, big skate, and Bering skate were the main piscivores. Walleye pollock were the dominant prey fish. The main predators that fed on Tanner crabs were Pacific halibut, Pacific cod, big skate, longnose skate, and great sculpin. Flathead sole, sharpchin rockfish, rougheyeye rockfish, longnose skate, and walleye pollock were the main consumers of pandalid shrimp. Sharpchin rockfish, Pacific ocean perch, redbanded rockfish, Atka mackerel, and pollock fed mainly on zooplankton (mainly euphausiids and calanoid copepods). Southern rock sole, northern rock sole, rex sole, Dover sole, deepsea sole, and darkfin sculpin were benthic feeders; they fed mainly on polychaetes, marine worms, and brittle stars.

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INTRODUCTION

The estimated biomass of the groundfish resource in the Gulf of Alaska is about 5.6 million metric tons (t) (NPFMC 2004). Therefore, understanding the food habits of these fish and the interrelationships between them, their predators and their prey, becomes important when we try to understand the Gulf of Alaska ecosystem. In order to understand the multispecies implications of harvesting strategies, it is also important to understand the groundfish food web. These topics were the objective of this study.

In 1990, the Resource Ecology and Ecosystem Modeling (REEM) program of the Resource Ecology and Fisheries Management (REFM) Division at the Alaska Fisheries Science Center (AFSC) began systematic collections of fish stomach samples in the Gulf of Alaska. The collections have continued on a triennial (biennial since 1999) basis through REFM's participation in the bottom trawl survey performed by the Center's Resource Assessment and Conservation Engineering (RACE) Division in the Gulf of Alaska. This report includes information on the stomach collection procedures, data analysis, and comparisons of the diet of 40 groundfish species in the Gulf of Alaska (GOA) for 1999 (Table 1) and 2001 (Table 2).

The western and central GOA regulatory areas of the North Pacific Fishery Management Council (NPFMC) were sampled. Some species which are encountered less often, their sample sizes were small and it is difficult to make inferences regarding their diets.

METHODS

Stomach Collection and Stomach Contents Analysis

The study area (Fig. 1) covered the area from the Islands of Four Mountains (170° W long.) to Cape St. Elias (144°30' W long.), which encompasses the NPFMC's western and central Gulf of Alaska regulatory areas.

Scientists on board chartered bottom trawl vessels collected stomachs from fish captured in AFSC survey trawls. Before excising a stomach, fish were examined for evidence of regurgitation or net feeding. If a fish had food in its mouth or around the gills, or if its stomach was inverted or flaccid, the fish was categorized as having regurgitated food and the specimen was discarded. If a predator had fresh food (usually fish) sticking out of the mouth or the throat, it was categorized as a net-feeding fish and was also discarded. When a sampled stomach was retained, it was put in a cloth stomach bag. A field tag with the species name, fork length (FL) of the fish, and haul data (including vessel, cruise, haul number, specimen number) was also put in the bag. All of the samples collected were then preserved in buckets containing a buffered 10% formalin solution. When the samples arrived at the laboratory, they were transferred into 70% ethanol before the stomach contents were analyzed. In the laboratory, the

Table 1.-- Number of stomachs and fish size analyzed in the Gulf of Alaska in 1999.

F=stomachs with food, E=empty stomachs, T=total, SD=standard deviation.

Species	No. of stomachs			Range	Fork length (cm)*
	F	E	T		Mean \pm SD
Walleye pollock	497	43	540	10-69	38.33 \pm 5.79
Pacific cod	453	1	454	14-104	54.96 \pm 5.73
Pacific halibut	134	35	169	17-114	57.05 \pm 7.16
Arrowtooth flounder	499	536	1035	9-80	41.30 \pm 5.05
Sablefish	59	80	139	29-67	55.19 \pm 3.17
Shortraker rockfish	1	40	41	42-42	42.00 \pm 0.00
Sharpchin rockfish	6	0	6	19-27	23.67 \pm 3.08
Atka mackerel	13	18	31	37-51	46.76 \pm 0.83
Bigmouth sculpin	1	0	1	64-64	64.00 \pm 0.00
Flathead sole	9	6	15	17-36	26.90 \pm 6.19
Southern rock sole	63	43	106	15-50	34.18 \pm 2.85
Northern rock sole	36	21	57	17-41	29.66 \pm 2.05
Yellowfin sole	44	17	61	15-42	28.15 \pm 2.07
Total	1,815	840	2,655		

* data from stomachs with food only

Table 2.-- Number of stomachs and fish size analyzed in the Gulf of Alaska in 2001.
 F=stomachs with food, E=empty stomachs, T=total, SD=standard deviation.

Species	No. Stomachs			Range	Fork length (cm)*
	F	E	T		Mean \pm SD
Walleye pollock	766	50	816	7-75	37.28 \pm 5.17
Pacific cod	803	35	838	9-92	48.92 \pm 4.60
Pacific halibut	808	81	889	13-126	61.63 \pm 7.44
Arrowtooth flounder	1359	424	1783	13-81	37.66 \pm 4.93
Sablefish	284	64	348	23-90	59.08 \pm 2.62
Spiny dogfish	1	0	1	72-72	72.00 \pm 0.00
Big skate	2	0	2	81-87	89.00 \pm 11.31
Bering skate	3	0	3	42-70	51.67 \pm 15.89
Alaska skate	1	1	2	59-59	59.00 \pm 0.00
Longnose skate	3	0	3	112-133	121.60 \pm 10.6
Eulachon	19	20	39	16-21	19.05 \pm 1.35
Shortfin eelpout	17	1	18	19-29	22.30 \pm 1.19
Black eelpout	1	0	1	24-24	24.00 \pm 0.00
Wattled eelpout	2	1	3	37-40	38.50 \pm 2.12
Giant grenadier	17	8	25	27-35	31.15 \pm 0.70
Rougheye rockfish	25	11	36	16-78	34.10 \pm 2.88
Pacific ocean perch	39	11	50	10-40	29.70 \pm 1.73
Redbanded rockfish	3	1	4	20-22	21.00 \pm 1.00
Shortraker rockfish	22	24	46	43-61	54.50 \pm 1.61
Dusky rockfish	1	0	1	39-39	39.00 \pm 0.00
Sharpchin rockfish	7	11	18	25-32	29.00 \pm 2.16
Shortspine rockfish	27	14	41	15-39	25.67 \pm 0.35
Atka mackerel	28	2	30	28-51	37.33 \pm 1.61
Spinyhead sculpin	13	1	14	12-25	17.23 \pm 5.26
Yellow Irish lord	2	0	2	30-38	34.00 \pm 5.66
Bigmouth sculpin	2	1	3	20-75	47.50 \pm 38.89
Darkfin sculpin	16	1	17	7-12	8.56 \pm 1.46
Great sculpin	6	0	6	38-58	48.10 \pm 6.62
Dusky snailfish	1	0	1	53-53	53.00 \pm 0.00
Pacific sandfish	2	0	2	15-16	15.50 \pm 0.71
Searcher	11	0	11	23-29	26.00 \pm 2.17
Northern ronquil	1	0	1	16-16	16.00 \pm 0.00
Deepsea sole	3	0	3	40-43	41.30 \pm 1.53
Rex sole	41	1	42	24-50	37.40 \pm 2.21
Flathead sole	16	15	31	30-51	36.73 \pm 2.85
Butter sole	2	8	10	46-51	48.50 \pm 3.54
Southern rock sole	29	4	33	19-43	32.23 \pm 1.58
Northern rock sole	29	2	31	17-40	29.20 \pm 0.75
Yellowfin sole	2	0	2	38-42	40.00 \pm 2.83
Dover sole	35	3	38	34-60	44.38 \pm 1.66
Total	4449	795	5244		

* data from stomachs with food only

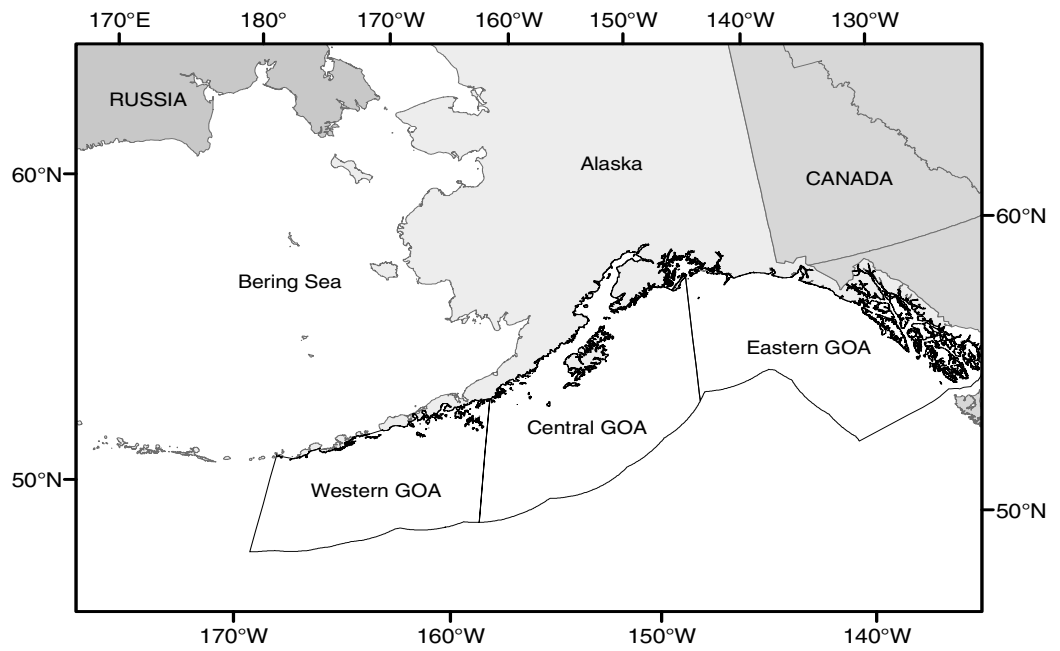


Figure 1. --Study area in the Gulf of Alaska (GOA) in 1990 and 2001.

stomach was cut open, the contents were removed, and then blotted with a paper towel. The wet weight was then recorded to the nearest 0.1 g. After obtaining the total weight for a stomach's contents, the contents were placed in a Petri dish and examined under a microscope. Each prey item was classified to the lowest practical taxonomic level. The prey items of all rockfishes, Pacific halibut, and sablefish were weighed and enumerated. The numbers of non-commercially important prey were not counted for Pacific cod, walleye pollock, and arrowtooth flounder; instead the percent volume of these prey items were visually estimated. Prey weights and numbers of commercially important crabs and fish were recorded. If pollock otoliths were found, otolith lengths were measured and the pollock's standard length (SL) was derived through an otolith length-fish length regression table. Standard lengths of prey fish and carapace widths (CW) of Tanner crab (*C. bairdi*) were also recorded. During this study, discarded fish parts from commercial fish processing operations were also found quite frequently in the stomachs of some marine fishes (e.g., sablefish). Fish were identified as fishery offal if the parts (usually heads or tails) had an evident cut.

Data Analysis

The general diet of each species in each year was summarized to show the mean percent frequency of occurrence, and the mean percent of the total weight of each prey item found in the stomach (these values were calculated as the average of the values calculated from each haul).

Change in diet by predator size in terms of percent by weight of main prey items was shown for each 10 cm FL group (when data are available). The prey size frequency data of the commercially important fish and crabs, and some forage fish, were also summarized by predator size groups.

The commercially important prey found in this study include walleye pollock, Pacific cod, Pacific halibut, yellowfin sole (*Pleuronectes asper*), rock sole (*Pleuronectes bilineatus*), flathead sole (*Hippoglossoides elassodon*), rex sole (*Errex zachirus*), Dover sole (*Microstomus pacificus*), arrowtooth flounder, Greenland turbot (*Reinhardtius hippoglossoides*), Pacific herring (*Clupea pallasii*), coho salmon (*Oncorhynchus kisutch*), all rockfish species, Tanner crabs, and pandalid shrimp. Although capelin (*Mallotus villosus*), Pacific sand lance (*Ammodytes hexapterus*), and eulachon (*Thaleichthys pacificus*) are not commercially important fish in the Gulf of Alaska area, they are food of many commercially

important fish that are economically important in other countries (e.g., Japan); therefore, data on these prey fish were also analyzed in this report.

RESULTS AND DISCUSSION

Overview

The following species chapters summarize the consumption of commercially important and also non-commercially important prey by each predator. Each species chapter is subdivided into subsections that provide information on general diet and effect of predator size.

Walleye Pollock

Walleye pollock (*Theragra chalcogramma*) ranked second (next to arrowtooth flounder) in biomass in the groundfish complex in the Gulf of Alaska in 2004. The exploitable biomass (age 3+) in 2004 was estimated at 765,180 t (NPFMC 2004). Walleye pollock feed mainly on euphausiids, calanoid copepods, and other crustaceans. As pollock increase in size, they also eat juvenile pollock and other teleosts. Therefore, it is important to understand the food habits of pollock and their possible impact on pollock and other commercially important fishes.

General Diet

Walleye pollock fed mainly on zooplankton. Euphausiids, shrimp, and calanoid copepods were their most important prey. In addition, amphipods and planktonic tunicates (larvaceans) were also frequently found in pollock stomachs. Tables 3 - 4 (for 1999 and 2001,

respectively) list the food items found in pollock stomachs, mean percentage of the prey weight to the total food weight, and the mean percentage of the frequency of occurrence of the prey. Total number of stomachs with food, the total number of empty stomachs, and the number of the hauls were also listed in Tables 3 - 4. The percent by weight of the fish consumed was no more than 18% of the total stomach contents in each of the 2 years sampled (Tables 3 - 4). Capelin and juvenile walleye pollock were the most important prey fish consumed by pollock in this study. Other commercially important prey fish included Pacific herring, arrowtooth flounder, and flathead sole. Pacific sand lance and eelpout were also consumed by pollock.

Comparing the diets from the 2 years indicates that the diet of walleye pollock in 1999 and 2001 was similar. In both years, the diets included about 11-22% (by weight) calanoid, 41-48% euphausiids, 13% shrimp, and 14-17% fish. However, fewer pollock were consumed (0.33% by weight) in 1999 than in 2001 (5%) (Fig. 2 and Tables 3 and 4). During the same time period, the consumption of capelin declined from 5% (by weight) in 1999 to 0.13% in 2001; and the consumption of pandalid shrimp was about the same, 8.73% (by weight) in 1999 and 9.06% in 2001.

Variation of Diet Based on Predator Size

Figure 2 illustrates the main prey items of walleye pollock by predator fork length. In 1999 and 2001, calanoid copepods and amphipods were mainly consumed by smaller (< 40 cm FL) pollock. Euphausiids comprised the largest portion of pollock food through all size groups. Shrimp comprised the second largest portion of pollock food in fish larger than 30 cm FL. Cannibalism occurred mainly in the 30-39 cm FL size group and fish larger than 50 cm FL in 2001 (Fig. 2). Pollock comprised less than 10% (by weight) of the total stomach contents weight in each size group, respectively.

Table 3.--Prey items (expressed in mean percent frequency of occurrence, and mean percent total weight) of *Theragra chalcogramma* (walleye pollock) collected in the Gulf of Alaska in 1999.

Prey items	Percent frequency	Percent weight
Polychaeta (worm)	3.83	0.58
Gastropoda (snail)	0.37	0.02
Pteropoda	0.54	0.24
Thecosomata (pteropod)	1.87	0.15
Gymnosomata (pteropod)	0.17	0.08
Bivalvia (clam)	0.16	0.17
<i>Nuculana</i> sp. (clam)	0.19	0.00
Pectinidae (scallops)	0.16	0.00
Teuthoidea (squid)	0.19	0.00
<i>Berryteuthis magister</i> (squid)	0.19	0.42
Crustacea	3.61	0.68
Calanoida (copepod)	37.34	11.35
Malacostraca	0.61	0.19
Mysida (mysid)	1.54	0.03
Mysidae (mysid)	3.35	0.29
Cumacea (cumacean)	1.29	0.01
Isopoda (isopod)	0.52	0.00
Amphipoda (amphipod)	3.41	0.52
Gammaridea (amphipod)	6.02	0.17
Hyperidea (amphipod)	4.02	0.03
Hyperidae (amphipod)	0.19	0.00
Euphausiacea (euphausiid)	1.63	0.17
Euphausiidae (euphausiid)	61.21	48.28
Decapoda (shrimp and crab)	0.44	0.00
<i>Sergestes similis</i> (Pacific sergestid)	0.16	0.27
Caridea (shrimp)	6.24	2.46
Pasiphaeidae (shrimp)	0.37	0.03
Hippolytidae (shrimp)	0.20	0.08
<i>Eualus</i> spp. (shrimp)	0.20	0.02
Pandalidae (shrimp)	4.34	2.76
<i>Pandalus</i> spp. (shrimp)	3.44	1.86
<i>Pandalus borealis</i> (shrimp)	3.50	3.90
<i>Pandalus jordani</i> (shrimp)	0.31	0.12
<i>Pandalopsis</i> spp. (shrimp)	0.56	0.09
Crangonidae (shrimp)	1.66	0.75

Table 3.--Continued.

Prey items	Percent frequency	Percent weight
<i>Crangon</i> spp. (shrimp)	0.51	0.31
Reptantia (crab)	1.28	0.05
Paguridae (hermit crab)	0.17	0.00
Decapoda brachyura (crab)	0.17	0.00
Echiura (marine worm)	0.15	0.11
Chaetognatha (arrow worm)	1.75	0.60
Copelata (larvacea)	10.62	5.77
Teleostei (fish)	6.74	3.02
Non-gadoid fish remains	1.66	2.92
Osmeridae (smelts)	1.96	3.55
<i>Mallotus villosus</i> (capelin)	1.78	5.20
<i>Thaleichthys pacificus</i> (eulachon)	0.82	1.84
Gadidae (gadid fish)	0.20	0.05
<i>Theragra chalcogramma</i> (walleye pollock)	0.19	0.33
Zoarcidae (eelpout)	0.17	0.13
Scorpaeniformes (rockfish and cottid)	0.19	0.01
<i>Ammodytes</i> sp. (sand lance)	0.44	0.22
Pleuronectidae (flatfish)	0.93	0.13
Unidentified organic material	0.89	0.02
Rocks	0.15	0.01

Total non-empty stomachs = 497

Total prey number = 575

Total prey weight = 1460.091 g

Total empty stomachs = 43

Number of hauls = 45

Full stomach summary statistics

Average fork length = 38.33 cm

Standard deviation of fork length = 5.79 cm

Minimum fork length = 10 cm

Maximum fork length = 69 cm

Average fullness = 3.53

Standard deviation of fullness = .36

Minimum fullness = 2

Maximum fullness = 6

Empty stomach summary statistics

Average fork length = 33.37 cm

Standard deviation of fork length = 15.65 cm

Minimum fork length = 10 cm

Maximum fork length = 60 cm

Table 4.--Prey items (expressed in mean percent frequency of occurrence, and mean percent total weight) of *Theragra chalcogramma* (walleye pollock) collected in the Gulf of Alaska in 2001.

Prey items	Percent frequency	Percent weight
Polychaeta (worm)	1.57	0.09
Phyllodocidae (polychaete)	0.18	0.02
Gastropoda (snail)	0.40	0.02
Pteropoda	0.83	0.12
Thecosomata (pteropod)	2.08	0.03
Bivalvia (clam)	0.62	0.01
Cephalopoda (squid and octopus)	0.35	0.05
Teuthoidea (squid)	0.48	0.05
Crustacea	3.95	1.63
Calanoida (copepod)	37.18	21.80
Large calanoid (copepod) > 5mm	1.17	0.02
Medium calanoid (copepod) 2-5mm	0.64	0.00
Small calanoid (copepod) 2mm	0.20	0.00
Harpacticoida (copepod)	0.10	0.00
Mysida (mysid)	1.58	0.04
Mysidae (mysid)	3.60	0.43
Cumacea (cumacean)	1.83	0.79
Amphipoda (amphipod)	1.24	0.14
Gammaridea (amphipod)	5.73	2.18
Hyperidea (amphipod)	10.06	0.60
Euphausiacea (euphausiid)	12.90	6.76
Euphausiidae (euphausiid)	47.79	32.78
<i>Euphausia</i> sp. (euphausiid)	0.31	0.01
<i>Euphausia pacifica</i> (euphausiid)	1.43	0.30
<i>Thysanoessa</i> sp. (euphausiid)	0.84	0.17
<i>Thysanoessa inermis</i> (euphausiid)	1.60	1.31
Decapoda (shrimp and crab)	0.29	0.01
Caridea (shrimp)	6.98	1.70
Pasiphaeidae (shrimp)	1.23	0.46
Hippolytidae (shrimp)	1.21	0.40
<i>Eualus</i> sp. (shrimp)	0.10	0.01
Pandalidae (shrimp)	5.30	2.68
<i>Pandalus</i> sp. (shrimp)	4.49	3.38
<i>Pandalus borealis</i> (shrimp)	2.20	2.50
<i>Pandalus goniurus</i> (shrimp)	0.45	0.32

Table 4.--Continued.

Prey items	Percent frequency	Percent weight
<i>Pandalus montagui tridens</i> (shrimp)	0.10	0.01
<i>Pandalopsis</i> sp. (shrimp)	0.20	0.13
<i>Pandalopsis dispar</i> (sidestripe shrimp)	0.10	0.04
Crangonidae (shrimp)	2.21	0.54
<i>Crangon</i> sp. (shrimp)	0.81	0.22
<i>Crangon dalli</i> (shrimp)	0.10	0.11
<i>Crangon communis</i> (shrimp)	0.19	0.01
<i>Argis</i> sp. (shrimp)	0.09	0.01
<i>Argis dentata</i> (shrimp)	0.28	0.05
Reptantia (crab)	6.77	1.40
Paguridae (hermit crab)	1.68	0.19
<i>Munida quadrispina</i> (pinch bug)	0.10	0.07
Majidae (spider crab)	0.10	0.05
<i>Chionoecetes</i> spp. (snow and Tanner crab)	0.09	0.02
<i>Chionoecetes bairdi</i> (Tanner crab)	0.27	0.21
Echiura (marine worm)	0.10	0.44
Ectoprocta (bryozoan)	0.10	0.00
Chaetognatha (arrow worm)	0.40	0.04
Copelata (larvacea)	7.17	1.75
Teleostei (fish)	6.41	1.89
Non-gadoid fish remains	1.58	1.58
<i>Clupea pallasii</i> (Pacific herring)	0.10	0.72
Osmeridae (smelts)	0.73	0.72
<i>Mallotus villosus</i> (capelin)	0.33	0.13
Gadidae (gadid fish)	0.40	0.40
<i>Theragra chalcogramma</i> (walleye pollock)	1.81	4.93
Zoarcidae (eelpout)	0.27	0.08
<i>Lycodes brevipes</i> (shortfin eelpout)	0.09	0.04
Cottidae (sculpin)	0.10	0.18
<i>Ammodytes</i> sp. (sand lance)	0.80	1.76
<i>Ammodytes hexapterus</i> (Pacific sand lance)	0.19	0.38
Pleuronectidae (flatfish)	0.10	0.01
<i>Atheresthes stomias</i> (arrowtooth flounder)	0.18	0.69
<i>Hippoglossoides elassodon</i> (flathead sole)	0.14	0.35
Unidentified organic material	0.30	0.01
Unidentified eggs	0.10	0.00
Unidentified worm-like organism	0.10	0.01
Unidentified tube	0.10	0.00

Table 4.--Continued.

Total non-empty stomachs = 766

Total prey number = 37157

Total prey weight = 3215.506 g

Total empty stomachs = 50

Number of hauls = 70

Full stomach summary statistics

Average fork length = 37.28 cm

Standard deviation of fork length = 5.17 cm

Minimum fork length = 7 cm

Maximum fork length = 75 cm

Average fullness = 3.77

Standard deviation of fullness = .37

Minimum fullness = 2

Maximum fullness = 7

Empty stomach summary statistics

Average fork length = 31.30 cm

Standard deviation of fork length = 18.01 cm

Minimum fork length = 11 cm

Maximum fork length = 68 cm

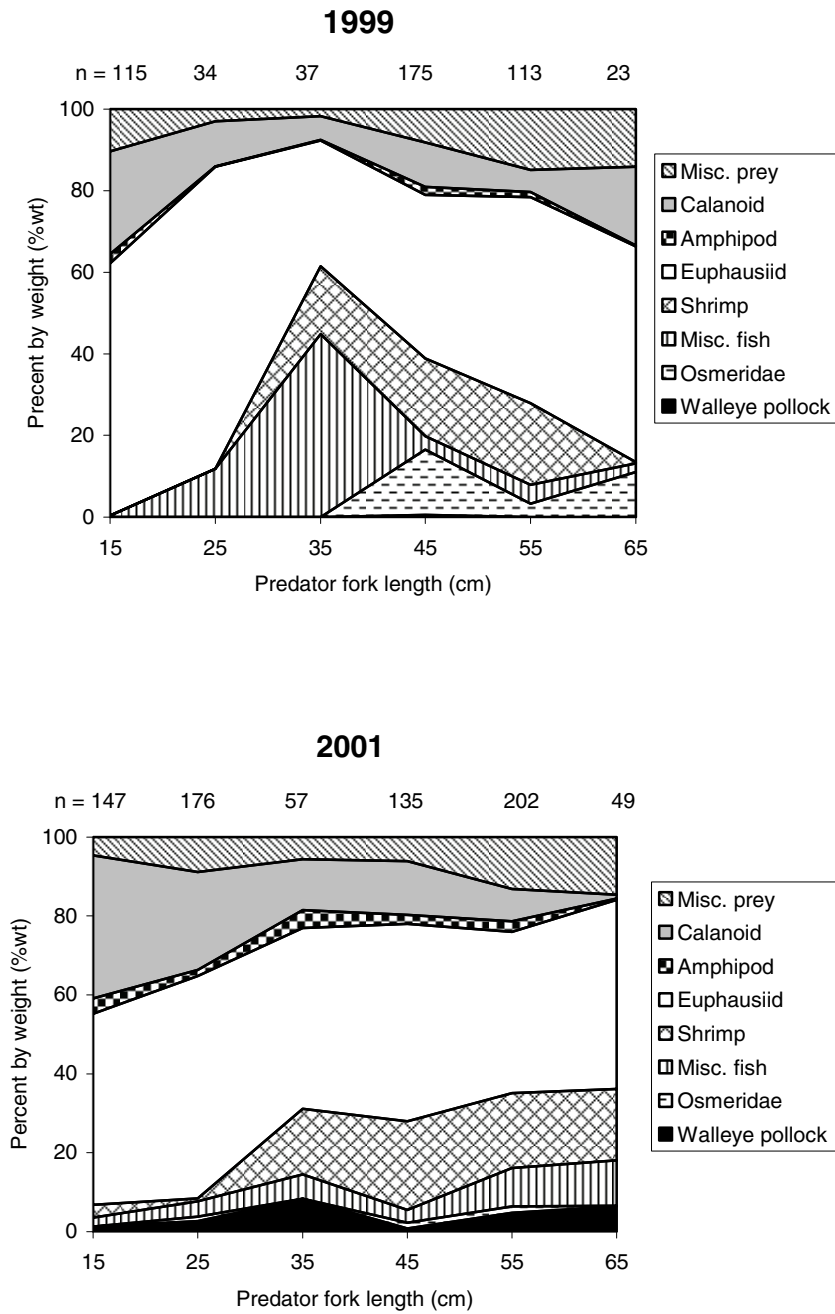


Figure 2.--Variations in the main food items of walleye pollock, by predator size, in the Gulf of Alaska in 1999, and 2001. n = stomachs with food.

Pacific Cod

Pacific cod (*Gadus macrocephalus*), with an exploitable biomass (age 3+) of 472,000 t (NPFMC 2004), ranks third in abundance in the Gulf of Alaska groundfish community. The landings of Pacific cod totaled 54,591 t in 2004. Pacific cod feed both in the water column and in benthic areas; hence, they have a high variety of prey in their diets, including several commercially important fish and crab.

General Diet

The long list of prey items presented in Tables 5-6 suggests that Pacific cod is an opportunistic feeder. These tables present the total number of stomachs with food, total empty stomachs, the mean percent frequency of occurrence, and the mean percent by weight of the prey items found in the stomachs in 1999 and 2001. Polychaetes were the most frequently found invertebrates in Pacific cod stomachs. However, shrimp (mainly pandalids) were relatively more important in terms of the percentage of the total stomach content weight. Pacific cod also consumed large amounts of Tanner crab (*C. bairdi*) (9%, and 10% of the total stomach content weight in 1999 and 2001, respectively). Decorator crabs (*Oregonia* spp.), lyre crabs (*Hyas* spp.), hermit crabs, euphausiids, amphipods, and marine worms were the other invertebrates consumed by

Pacific cod. Of the fish consumed by Pacific cod, walleye pollock made up the highest proportion of the total stomach contents weight in 1999 (11%), and Pacific sand lance comprised the highest percentage (17% by weight) of Pacific cod diet in 2001. Other commercially important prey fish include arrowtooth flounder, flathead sole, and Pacific herring. Pacific cod also consumed many non-commercially important fish, such as capelin, eulachon, zoarcids, cottids, agonids, bathymasterids, and stichaeids. Fish processing offal (processed fish waste) was also consumed by Pacific cod in the Gulf of Alaska.

Based on the data from 1999, we found pollock made up 11% (by weight) of the Pacific cod diet; however, the percentage of pollock in the Pacific cod diet decreased to 4% in 2001. The percentages of capelin consumed by Pacific cod were low: 0 and 2% in 1999 and 2001, respectively. Like pollock, pandalid shrimp were also important food of Pacific cod. However, the amounts of pandalid shrimp consumed by Pacific cod in those 2 years were relatively

Table 5.--Prey items (expressed in mean percent frequency of occurrence, and mean percent total weight) of *Gadus macrocephalus* (Pacific cod) collected in the Gulf of Alaska in 1999.

Prey items	Percent frequency	Percent weight
Porifera (sponge)	0.82	0.07
Anthozoa (anemome)	0.40	0.29
Polychaeta (worm)	42.37	9.41
Nephtyidae (polychaete)	0.22	0.06
Mollusca	0.53	0.03
Gastropoda (snail)	3.05	0.09
Bivalvia (clam)	2.94	0.10
<i>Nuculana</i> sp. (clam)	0.14	0.00
<i>Nuculana fossa</i> (clam)	0.43	0.00
<i>Yoldia</i> sp. (clam)	2.27	0.10
Mytilidae (mussel)	0.50	0.07
Pectinidae (scallops)	0.27	0.00
Teuthoidea (squid)	0.62	0.01
Octopoda (octopus)	10.00	0.84
Crustacea	2.84	0.38
Calanoida (copepod)	0.57	0.00
Mysidae (mysid)	1.37	0.02
Cumacea (cumacean)	0.63	0.00
Isopoda (isopod)	3.83	0.36
Amphipoda (amphipod)	0.13	0.00
Gammaridea (amphipod)	20.66	0.65
Hyperiidea (amphipod)	0.30	0.00
Caprellidea (amphipod)	0.30	0.00
Euphausiacea (euphausiid)	1.78	0.79
Euphausiidae (euphausiid)	23.03	5.66
Decapoda (shrimp and crab)	0.50	0.15
Natantia (shrimp)	2.90	0.23
Caridea (shrimp)	8.50	0.43
Hippolytidae (shrimp)	4.38	0.23
<i>Spirontocaris</i> sp. (shrimp)	0.13	0.00
Pandalidae (shrimp)	25.13	7.41
<i>Pandalus</i> sp. (shrimp)	5.07	2.40
<i>Pandalus borealis</i> (shrimp)	2.12	0.91
<i>Pandalus goniurus</i> (shrimp)	1.57	0.39
<i>Pandalus jordani</i> (shrimp)	2.36	2.15

Table 5.--Continued.

Prey items	Percent frequency	Percent weight
<i>Pandalus montagui tridens</i> (shrimp)	2.24	0.65
Crangonidae (shrimp)	17.96	1.90
<i>Crangon</i> sp. (shrimp)	0.72	0.12
<i>Crangon alaskensis</i> (shrimp)	0.13	0.02
<i>Crangon dalli</i> (shrimp)	2.54	0.39
<i>Crangon communis</i> (shrimp)	0.96	0.21
<i>Argis</i> sp. (shrimp)	1.02	0.27
<i>Argis crassa</i>	0.27	0.24
Reptantia (crab)	14.55	1.16
Decapoda Reptantia legs (for unident. crabs)	0.22	0.01
Anomura (crab)	0.41	0.08
Paguridae (hermit crab)	16.00	5.27
Paguridae legs (hermit crabs)	0.93	0.10
<i>Pagurus</i> sp. (hermit crab)	0.13	0.30
<i>Elassochirus cavimanus</i> (purple hermit crab)	2.17	0.44
<i>Acantholithodes hispidus</i> (fussy crab)	0.13	0.05
<i>Rhinolithodes wosnessenskii</i> (rhinoceros crab)	0.33	0.29
<i>Munida quadrispina</i> (pinch bug)	10.61	8.16
Decapoda brachyura (crab)	1.02	0.12
Oxyrhyncha	0.63	0.56
Decapoda Reptantia legs (for unident. crabs)	0.13	0.01
<i>Oregonia</i> sp. (decorator crab)	0.40	0.01
<i>Oregonia gracilis</i> (decorator crab)	0.27	0.10
<i>Hyas</i> sp. (lyre crab)	3.10	1.30
<i>Hyas lyratus</i> (lyre crab)	0.50	0.45
<i>Hyas coarctatus</i> (lyre crab)	0.30	0.19
<i>Chionoecetes</i> sp. (snow and Tanner crab)	2.93	0.20
<i>Chionoecetes bairdi</i> (Tanner crab)	16.96	9.22
<i>Telmessus cheiragonus</i> (hair crab)	0.13	0.03
<i>Cancer oregonensis</i> (pygmy Cancer crab)	4.58	2.37
Pinnotheridae (pea crab)	2.43	0.27
<i>Pinnixa</i> sp. (pea crab)	2.89	0.47
Sipuncula (marine worm)	3.57	1.02
Echiura (marine worm)	7.62	2.14
Priapulida (worm)	0.15	0.03
Ectoprocta (bryozoan)	0.36	0.01
<i>Ctenodiscus crispatus</i> (mud sea star)	0.40	0.01
Ophiurida (brittle star)	0.30	0.00
Echinoidea (sea urchin and sand dollar)	0.29	0.01
<i>Echinacea</i> sp. (sea urchin)	0.13	0.02
Clypeasteroidea (sand dollar)	0.13	0.00

Table 5.--Continued.

Prey items	Percent frequency	Percent weight
Holothuroidea (sea cucumber)	0.50	0.11
Teleostei (fish)	8.89	0.48
Non-gadoid fish remains	17.89	1.08
<i>Clupea pallasii</i> (Pacific herring)	0.13	0.01
Osmeridae (smelts)	0.40	0.04
<i>Thaleichthys pacificus</i> (eulachon)	0.50	0.98
Gadidae (gadid fish)	1.07	0.53
<i>Theragra chalcogramma</i> (walleye pollock)	5.57	11.34
Zoarcidae (eelpout)	3.00	1.18
<i>Lycodes</i> sp. (eelpout unidentified)	0.14	0.01
Scorpaenidae	0.60	0.21
Cottoidei (sculpin)	7.34	1.34
<i>Icelinus</i> sp.	0.57	0.05
<i>Icelinus borealis</i> (northern sculpin)	1.17	0.24
Agonidae (poacher)	0.92	0.14
<i>Podothecus acipenserinus</i> (sturgeon poacher)	0.50	0.48
Bathymasteridae (ronquils)	4.09	1.53
<i>Bathymaster signatus</i> (searcher)	1.36	2.14
<i>Anarhichas orientalis</i> (Bering wolffish)	0.14	0.03
Stichaeidae (prickleback)	3.85	0.34
Pholidae (gunnel family)	0.50	0.13
<i>Ammodytes</i> sp. (sand lance)	4.72	1.57
<i>Ammodytes hexapterus</i> (Pacific sand lance)	2.67	1.43
Pleuronectoidei (flatfish)	2.41	0.15
Pleuronectidae (flatfish)	2.20	0.40
<i>Atheresthes evermanni</i> (Kamchatka flounder)	0.50	0.28
<i>Atheresthes stomias</i> (arrowtooth flounder)	1.29	0.72
<i>Hippoglossoides elassodon</i> (flathead sole)	0.27	0.20
<i>Isopsetta isolepis</i> (butter sole)	0.13	0.63
Unidentified organic material	1.67	0.05
Unidentified worm-like organism	2.33	0.45
Fishery offal	0.22	0.18
Unidentified tube	0.28	0.02
Wood	0.62	0.03
Unidentified algae	0.78	0.02
Rocks	1.11	0.08

Table 5.--Continued.

Total non-empty stomachs = 453
Total prey number = 1886
Total prey weight = 16196.383 g
Total empty stomachs = 1
Number of hauls = 50

Full stomach summary statistics

Average fork length = 54.96 cm
Standard deviation of fork length = 5.73 cm
Minimum fork length = 14 cm
Maximum fork length = 104 cm
Average fullness = 4.34
Standard deviation of fullness = .41
Minimum fullness = 2
Maximum fullness = 7

Empty stomach summary statistics

Average fork length = 38.00 cm
Standard deviation of fork length = 0 cm
Minimum fork length = 38 cm
Maximum fork length = 38 cm

Table 6.--Prey items (expressed in mean percent frequency of occurrence, and mean percent total weight) of *Gadus macrocephalus* (Pacific cod) collected in the Gulf of Alaska in 2001.

Prey items	Percent frequency	Percent weight
Phaeophycophyta (brown algae)	0.09	0.00
Porifera (sponge)	0.32	0.07
Cnidaria	0.16	0.01
Polychaeta (worm)	25.58	7.14
Polynoidae (polychaete)	0.09	0.00
Phyllodocidae (polychaete)	0.32	0.00
Alciopidae (polychaete)	0.09	0.03
Arabellidae (polychaete)	0.08	0.07
Opheliidae (polychaete)	0.10	0.01
Mollusca	0.29	0.02
Gastropoda (snail)	4.95	2.14
Bivalvia (clam)	3.94	0.29
<i>Nuculana</i> sp. (clam)	0.09	0.00
Veneroida (clam)	0.09	0.00
Cephalopoda (squid and octopus)	2.75	0.38
Teuthoidea (squid)	3.48	1.55
Octopoda (octopus)	3.12	1.43
Crustacea	2.54	0.15
Copepoda	0.35	0.03
Cirripedia (barnacle)	0.09	0.00
Mysida (mysid)	0.09	0.00
Mysidae (mysid)	1.80	0.05
Cumacea (cumacean)	3.50	1.14
Isopoda (isopod)	3.37	0.77
Gammaridea (amphipod)	18.32	3.54
Ampeliscidae (amphipod)	0.36	0.01
Hyperiidea (amphipod)	0.81	0.06
Caprellidea (amphipod)	0.14	0.00
Caprellidae (amphipod)	0.09	0.00
Euphausiidae (euphausiid)	18.23	5.20
<i>Euphausia</i> sp. (euphausiid)	0.32	0.00
<i>Euphausia pacifica</i> (euphausiid)	0.32	0.01
<i>Thysanoessa</i> sp. (euphausiid)	0.41	0.10
Natantia (shrimp)	11.02	2.40
Caridea (shrimp)	9.28	1.10

Table 6.--Continued.

Prey items	Percent frequency	Percent weight
Hippolytidae (shrimp)	4.72	0.32
<i>Lebbeus</i> sp. (shrimp)	0.19	0.05
<i>Lebbeus groenlandicus</i> (shrimp)	0.19	0.03
<i>Eualus</i> sp. (shrimp)	0.09	0.00
<i>Heptacarpus</i> sp. (shrimp)	0.09	0.00
Pandalidae (shrimp)	12.01	3.62
<i>Pandalus</i> sp. (shrimp)	6.39	1.46
<i>Pandalus borealis</i> (shrimp)	5.43	1.61
<i>Pandalus goniurus</i> (shrimp)	0.35	0.02
<i>Pandalus jordani</i> (shrimp)	0.17	0.16
<i>Pandalus montagui tridens</i> (shrimp)	0.17	0.03
<i>Pandalus platyceros</i> (shrimp)	0.91	0.65
<i>Pandalus stenolepis</i> (shrimp)	0.09	0.00
Crangonidae (shrimp)	11.89	1.70
<i>Crangon</i> sp. (shrimp)	1.64	0.31
<i>Crangon alaskensis</i> (shrimp)	0.43	0.07
<i>Crangon dalli</i> (shrimp)	0.93	0.11
<i>Crangon communis</i> (shrimp)	3.79	0.57
Sclerocrangon	0.08	0.02
<i>Argis</i> sp. (shrimp)	3.10	1.33
<i>Argis lar</i> (shrimp)	0.25	0.09
<i>Argis dentata</i> (shrimp)	0.26	0.01
<i>Argis ovifer</i> (shrimp)	0.09	0.02
<i>Argis alaskensis</i> (shrimp)	0.08	0.07
Reptantia (crab)	12.25	3.67
Paguridae (hermit crab)	8.65	3.71
Paguridae legs (hermit crabs)	0.87	0.54
<i>Pagurus ochotensis</i> (hermit crab)	0.09	0.12
<i>Elassochirus</i> sp.	0.09	0.00
<i>Elassochirus cavimanus</i> (purple hermit crab)	0.09	0.03
<i>Acantholithodes hispidus</i> (fussy crab)	0.14	0.35
<i>Lithodes aequispina</i> (golden king crab)	0.17	0.04
<i>Munida quadrispina</i> (pinch bug)	2.11	1.07
Decapoda brachyura (crab)	0.43	0.55
Oxyrhyncha	0.09	0.00
Majidae (spider crab)	0.27	0.13
<i>Oregonia</i> sp. (decorator crab)	0.27	0.03
<i>Oregonia gracilis</i> (decorator crab)	0.09	0.02
<i>Hyas</i> sp. (lyre crab)	1.77	0.96
<i>Hyas lyratus</i> (lyre crab)	0.81	0.79
<i>Chionoecetes</i> spp. (snow and Tanner crab)	0.70	0.36

Table 6.--Continued.

Prey items	Percent frequency	Percent weight
<i>Chionoecetes bairdi</i> (Tanner crab)	15.10	9.94
<i>Chorilia longipes</i> (decorator crab)	0.41	0.26
<i>Telmessus cheiragonus</i> (hair crab)	0.16	0.01
<i>Cancer oregonensis</i> (pygmy Cancer crab)	2.23	0.87
Pinnotheridae (pea crab)	0.35	0.06
<i>Pinnixa</i> sp. (pea crab)	3.09	0.38
Echiura (marine worm)	4.83	1.36
Ectoprocta (bryozoan)	0.35	0.04
Asteroidea (starfish)	0.11	0.00
Ophiurida (brittle star)	0.68	0.26
Clypeasterina (sand dollar)	0.09	0.02
Holothuroidea (sea cucumber)	0.20	0.12
Urochordata (tunicate)	0.09	0.00
Teleostei (fish)	1.99	0.09
Non-gadoid fish remains	3.39	0.43
<i>Clupea pallasii</i> (Pacific herring)	0.11	0.49
Osmeridae (smelts)	1.60	1.24
<i>Mallotus villosus</i> (capelin)	2.11	1.94
<i>Thaleichthys pacificus</i> (eulachon)	0.09	0.20
Gadidae (gadid fish)	2.15	1.66
<i>Theragra chalcogramma</i> (walleye pollock)	2.90	4.16
Zoarcidae (eelpout)	1.62	0.36
<i>Lycodes</i> sp. (eelpout)	0.12	0.00
<i>Lycodes brevipes</i> (shortfin eelpout)	0.17	0.05
Macrouridae (rattail)	0.09	0.01
Cottoidei (sculpin)	3.07	1.84
Cottidae (sculpin)	2.03	0.46
<i>Artediellus</i> sp. (sculpin)	0.09	0.08
<i>Dasycottus setiger</i> (spinyhead sculpin)	0.12	0.17
<i>Gymnocanthus</i> sp. (sculpin)	0.12	0.05
<i>Icelinus</i> sp. (sculpin)	0.19	0.01
<i>Malacocottus zonurus</i> (darkfin sculpin)	0.35	0.23
Agonidae (poacher)	0.63	0.11
<i>Podothecus acipenserinus</i> (sturgeon poacher)	0.12	0.02
Bathymasteridae (ronquils)	0.09	0.07
Stichaeidae (prickleback)	2.10	0.74
<i>Lumpenus maculatus</i> (daubed shanny)	0.12	0.01
<i>Ammodytes</i> sp. (sand lance)	1.51	1.10
<i>Ammodytes hexapterus</i> (Pacific sand lance)	18.67	15.77
Pleuronectoidei (flatfish)	0.78	0.42
Pleuronectidae (flatfish)	2.77	2.29

Table 6.—Continued.

Prey items	Percent frequency	Percent weight
Unidentified organic material	0.58	0.29
Unidentified worm-like organism	0.32	0.02
Unidentified algae	0.44	0.02

Total non-empty stomachs = 803

Total prey number = 14483

Total prey weight = 16083.818 g

Total empty stomachs = 35

Number of hauls = 77

Full stomach summary statistics

Average fork length = 48.92 cm

Standard deviation of fork length = 4.60 cm

Minimum fork length = 9 cm

Maximum fork length = 92 cm

Average fullness = 4.14

Standard deviation of fullness = .41

Minimum fullness = 2

Maximum fullness = 7

Empty stomach summary statistics

Average fork length = 54.71 cm

Standard deviation of fork length = 18.71 cm

Minimum fork length = 22 cm

Maximum fork length = 87 cm

similar (14% in 1999 and 8% in 2001). The percentages of Tanner crab consumed were also similar (9% (by weight) in 1999 and 10% in 2001).

Variation of Diet Based on Predator Size

Figure 3 shows that Pacific cod ate more fish with increasing cod size, especially for larger cod (>70 cm FL). The fish consumed comprised more than 45% of the total stomach contents in this larger size group of Pacific cod the 2 years that were sampled. Only this group of larger Pacific cod (>70 cm FL) consumed a significant amount of walleye pollock (35% (by weight) in 1999 and 11% in 2001). Smaller size groups (<60 cm FL) consumed very small amounts of pollock (<4%). All but the largest size group in 1999 and 2001 consumed a fair amount of shrimp (>10%). Tanner crabs were mainly consumed by Pacific cod larger than 30 cm FL. The smallest size group (<20 cm FL) of cod ate a large amount (>24%) of miscellaneous prey (mainly amphipods and mysids).

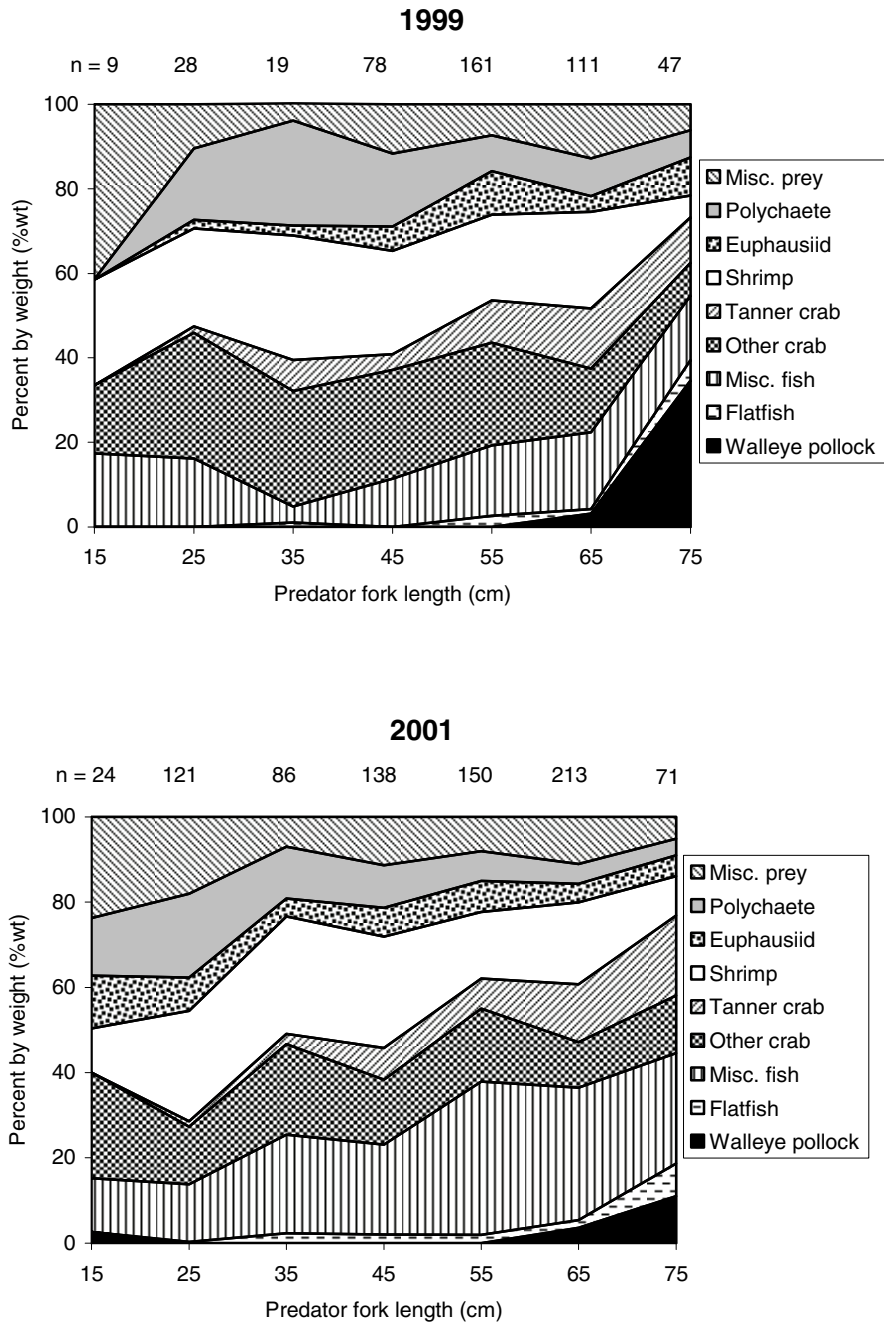


Figure 3.--Variations in the main food items of Pacific cod, by predator size, in the Gulf of Alaska in 1999, and 2001. n = stomachs with food.

Arrowtooth Flounder

Arrowtooth flounder (*Atheresthes stomias*), with an exploitable biomass of 2,453,390 t in 2004, ranked first in the total groundfish biomass in the Gulf of Alaska (NPFMC 2004). Arrowtooth flounder is a large flatfish with a symmetrical mouth and sharp teeth that feeds on commercially important fish such as walleye pollock and capelin as well as shrimp and other crustaceans. Therefore, based on its feeding behavior and its high abundance in the Gulf of Alaska area, arrowtooth flounder is important to study because of its potential impact on commercially important species.

General Diet

Tables 7 and 8 list the total number of stomachs with food, total number of empty stomachs, the mean percent frequency of occurrence and the mean percent by weight of the prey items found in arrowtooth flounder stomachs in 1999, and 2001. Euphausiids and pandalid shrimp were the most important invertebrate food of arrowtooth flounder. However, fish comprised the largest amounts of the total stomach contents of arrowtooth flounder (57% and 73% by weight in 1999 and 2001, respectively). Walleye pollock was the most important prey fish of arrowtooth flounder; followed by Pacific sand lance and capelin. Arrowtooth

flounder also consumed some eulachon, Pacific herring, arrowtooth flounder, flathead sole, *Lepidopsetta* spp., and some non-commercially important species (e.g., zoarcids, cottids, searcher, ronquils, stichaeids, bathylagids, and myctophids).

The percentage of pollock in the diet of arrowtooth flounder was 14% and 31% (by weight) in 1999 and 2001, respectively. Smelts (mainly capelin) made up 8% and 13% of the diet (by weight) of arrowtooth flounder in 1999 and 2001, respectively. The percentages of pandalid shrimp in the diet of arrowtooth flounder was 12% in 1999 and 7% in 2001.

Variations of Diet Based on Predator Size

Figure 4 illustrates the percentage by weight of the main prey items for different arrowtooth flounder size groups in 1999 and 2001. In general, larger arrowtooth flounder (≥ 40 cm FL) fed mainly on fish. Walleye pollock were the predominant prey fish for this size group of arrowtooth flounder. In 2001, pollock made up 31% of the total stomach contents. Smaller arrowtooth flounder (<40 cm FL) fed mainly on euphausiids and pandalid shrimp (Fig. 4).

Table 7.--Prey items (expressed in mean percent frequency of occurrence, and mean percent of total weight) of *Atheresthes stomias* (arrowtooth flounder) collected in the Gulf of Alaska in 1999.

Prey items	Percent frequency	Percent weight
Porifera (sponge)	0.38	0.03
Polychaeta (worm)	2.11	0.42
Hirudinea (leech)	0.32	0.52
Pteropoda (Mollusca)	0.22	0.00
Bivalvia (clam)	0.12	0.00
Teuthoidea (squid)	1.62	0.13
Octopoda (octopus)	0.13	0.01
Crustacea	3.19	1.34
Calanoida (copepod)	3.72	2.20
Mysidae (mysid)	1.43	0.02
Cumacea (cumacean)	0.16	0.00
Gammaridea (amphipod)	2.21	0.04
Euphausiacea (euphausiid)	7.54	4.49
Euphausiidae (euphausiid)	30.00	17.82
<i>Thysanoessa spinifera</i> (euphausiid)	0.26	0.78
Caridea (shrimp)	3.25	0.92
Pandalidae (shrimp)	6.99	3.47
<i>Pandalus</i> sp. (shrimp)	1.23	2.08
<i>Pandalus borealis</i> (shrimp)	3.62	3.49
<i>Pandalus goniurus</i> (shrimp)	1.19	2.44
<i>Pandalus jordani</i> (shrimp)	0.22	0.15
Crangonidae (shrimp)	2.78	0.99
<i>Crangon</i> sp. (shrimp)	0.77	0.11
<i>Crangon alaskensis</i> (shrimp)	0.09	0.02
<i>Crangon dalli</i> (shrimp)	0.21	0.06
<i>Argis</i> sp. (shrimp)	0.27	0.34
Reptantia (crab)	2.77	0.41
<i>Chionoecetes bairdi</i> (Tanner crab)	0.22	0.09
Ectoprocta (bryozoan)	0.16	0.02
Chaetognatha (arrow worm)	0.16	0.00
Copelata (larvacea)	0.16	0.01
Teleostei (fish)	7.36	3.67
Non-gadoid fish remains	8.17	6.97
Clupeidae	0.24	0.38
Osmeridae (smelts)	3.74	4.06
<i>Mallotus villosus</i> (capelin)	1.37	3.75
Gadidae (gadid fish)	3.12	5.03
<i>Theragra chalcogramma</i> (walleye pollock)	6.07	13.81
Zoarcidae (eelpout)	1.42	1.41
<i>Lycodes brevipes</i> (shortfin eelpout)	0.12	0.15
Cottoidei (sculpin)	0.08	0.01
Bathymasteridae (ronquils)	0.13	0.02
<i>Bathymaster signatus</i> (searcher)	0.09	0.99
Stichaeidae (prickleback)	0.86	1.45
<i>Lumpenus maculatus</i> (daubed shanny)	0.58	0.84
<i>Ammodytes</i> sp. (sand lance)	1.48	2.16
<i>Ammodytes hexapterus</i> (Pacific sand lance)	5.71	6.83
Pleuronectoidei (flatfish)	0.83	1.06

Table 7.--Continued.

Prey items	Percent frequency	Percent weight
Pleuronectidae (flatfish)	0.21	0.23
<i>Atheresthes stomias</i> (arrowtooth flounder)	0.42	1.74
<i>Hippoglossoides elassodon</i> (flathead sole)	0.38	2.38
Unidentified organic material	0.80	0.55
Fishery offal	0.91	0.09
Unidentified algae	0.12	0.01

Total non-empty stomachs = 499

Total prey number = 955

Total prey weight = 4896.509 g

Total empty stomachs = 536

Number of hauls = 77

Full stomach summary statistics

Average fork length = 41.30 cm

Standard deviation of fork length = 5.05 cm

Minimum fork length = 9 cm

Maximum fork length = 80 cm

Average fullness = 3.90

Standard deviation of fullness = .48

Minimum fullness = 2

Maximum fullness = 7

Empty stomach summary statistics

Average fork length = 41.29 cm

Standard deviation of fork length = 12.55 cm

Minimum fork length = 15 cm

Maximum fork length = 78 cm

Table 8.--Prey items (expressed in mean percent frequency of occurrence, and mean percent total weight) of *Atheresthes stomias* (arrowtooth flounder) collected in the Gulf of Alaska in 2001.

Prey items	Percent frequency	Percent weight
Polychaeta (worm)	0.84	0.05
Nephtyidae (polychaete)	0.25	0.58
Gastropoda (snail)	0.06	0.00
<i>Nuculana</i> sp. (clam)	0.06	0.00
Cephalopoda (squid and octopus)	0.24	0.18
Teuthoidea (squid)	2.18	2.16
<i>Berryteuthis magister</i> (squid)	0.05	0.21
Crustacea	0.30	0.03
Calanoida (copepod)	0.51	0.00
Mysida (mysid)	1.14	0.15
Mysidae (mysid)	0.05	0.00
Cumacea (cumacean)	0.13	0.10
Gammaridea (amphipod)	0.90	0.12
Hyperidea (amphipod)	0.45	0.00
Euphausiacea (euphausiid)	4.62	1.86
Euphausiidae (euphausiid)	23.90	9.63
<i>Euphausia</i> sp. (euphausiid)	0.06	0.11
<i>Euphausia pacifica</i> (euphausiid)	0.19	0.01
<i>Thysanoessa</i> sp. (euphausiid)	0.39	0.39
<i>Thysanoessa inermis</i> (euphausiid)	1.56	1.55
<i>Thysanoessa longipes</i> (euphausiid)	0.08	0.02
<i>Thysanoessa raschi</i> (euphausiid)	0.14	0.07
<i>Thysanoessa spinifera</i> (euphausiid)	0.24	0.08
Natantia (shrimp)	3.78	0.69
Caridea (shrimp)	2.77	1.03
<i>Pasiphaea pacifica</i> (shrimp)	0.08	0.05
Hippolytidae (shrimp)	0.81	0.06
Pandalidae (shrimp)	6.23	3.31
<i>Pandalus</i> sp. (shrimp)	2.72	1.88
<i>Pandalus borealis</i> (shrimp)	2.25	1.32
<i>Pandalus goniurus</i> (shrimp)	0.14	0.02
<i>Pandalus jordani</i> (shrimp)	0.30	0.38
<i>Pandalus montagui tridens</i> (shrimp)	0.84	0.26
<i>Pandalus hypsinotus</i> (humpback shrimp)	0.08	0.16
<i>Pandalopsis</i> sp. (shrimp)	0.17	0.03
<i>Pandalopsis dispar</i> (sidestripe shrimp)	0.05	0.05
Crangonidae (shrimp)	1.45	0.26
<i>Crangon</i> sp. (shrimp)	0.50	0.04
<i>Crangon dalli</i> (shrimp)	0.65	0.28
<i>Crangon communis</i> (shrimp)	0.14	0.03
<i>Argis dentata</i> (shrimp)	0.06	0.05
Reptantia (crab)	0.18	0.02
<i>Munida quadrispina</i> (pinch bug)	0.20	0.02
Ectoprocta (bryozoan)	0.06	0.00
Chaetognatha (arrow worm)	0.12	0.00
Teleostei (fish)	4.15	0.87
Non-gadoid fish remains	5.52	2.29
Clupeidae	0.08	0.06

Table 8.--Continued.

Prey items	Percent frequency	Percent weight
<i>Clupea pallasii</i> (Pacific herring)	0.19	0.38
Osmeridae (smelts)	8.99	6.77
<i>Mallotus villosus</i> (capelin)	6.44	5.97
<i>Thaleichthys pacificus</i> (eulachon)	0.13	0.13
Bathylagidae (deepsea smelts)	0.11	0.05
Myctophidae (lanternfish)	0.05	0.00
<i>Stenobranchius leucopsarus</i> (northern lampfish)	0.08	0.28
Gadidae (gadid fish)	6.88	5.87
<i>Gadus macrocephalus</i> (Pacific cod)	0.06	0.09
<i>Theragra chalcogramma</i> (walleye pollock)	18.13	31.42
Zoarcidae (eelpout)	1.39	1.15
<i>Lycodes</i> sp. (eelpout unid)	0.09	0.29
<i>Sebastes</i> sp. (rockfish)	0.09	0.66
<i>Sebastolobus alascanus</i> (shortspine thornyhead)	0.36	1.02
Cottoidei (sculpin)	0.38	0.75
Cottidae (sculpin)	0.11	0.29
Agonidae (poacher)	0.15	0.06
Bathymasteridae (ronquils)	0.08	0.12
<i>Bathymaster</i> sp. (searcher)	0.15	0.13
<i>Bathymaster signatus</i> (searcher)	0.06	0.06
Stichaeidae (prickleback)	0.83	0.64
<i>Ammodytes</i> sp. (sand lance)	2.70	4.11
<i>Ammodytes hexapterus</i> (Pacific sand lance)	5.83	5.78
Pleuronectoidei (flatfish)	0.26	0.62
Pleuronectidae (flatfish)	1.01	1.33
<i>Atheresthes</i> sp.	0.15	0.48
<i>Atheresthes stomias</i> (arrowtooth flounder)	0.18	0.90
<i>Lepidopsetta</i> sp. (rock sole type)	0.08	0.11
<i>Lepidopsetta bilineatus</i> (southern rock sole)	0.06	0.00
Unidentified organic material	0.11	0.02
Fishery offal	0.07	0.02
Unidentified tube	0.25	0.01
Unidentified algae	0.05	0.00

Table 8.--Continued.

Total non-empty stomachs = 1359
Total prey number = 2346
Total prey weight = 26954.353 g
Total empty stomachs = 424
Number of hauls = 133

Full stomach summary statistics

Average fork length = 37.66 cm
Standard deviation of fork length = 4.93 cm
Minimum fork length = 13 cm
Maximum fork length = 81 cm
Average fullness = 4.50
Standard deviation of fullness = .36
Minimum fullness = 2
Maximum fullness = 7

Empty stomach summary statistics

Average fork length = 42.54 cm
Standard deviation of fork length = 16.71 cm
Minimum fork length = 16 cm
Maximum fork length = 163 cm

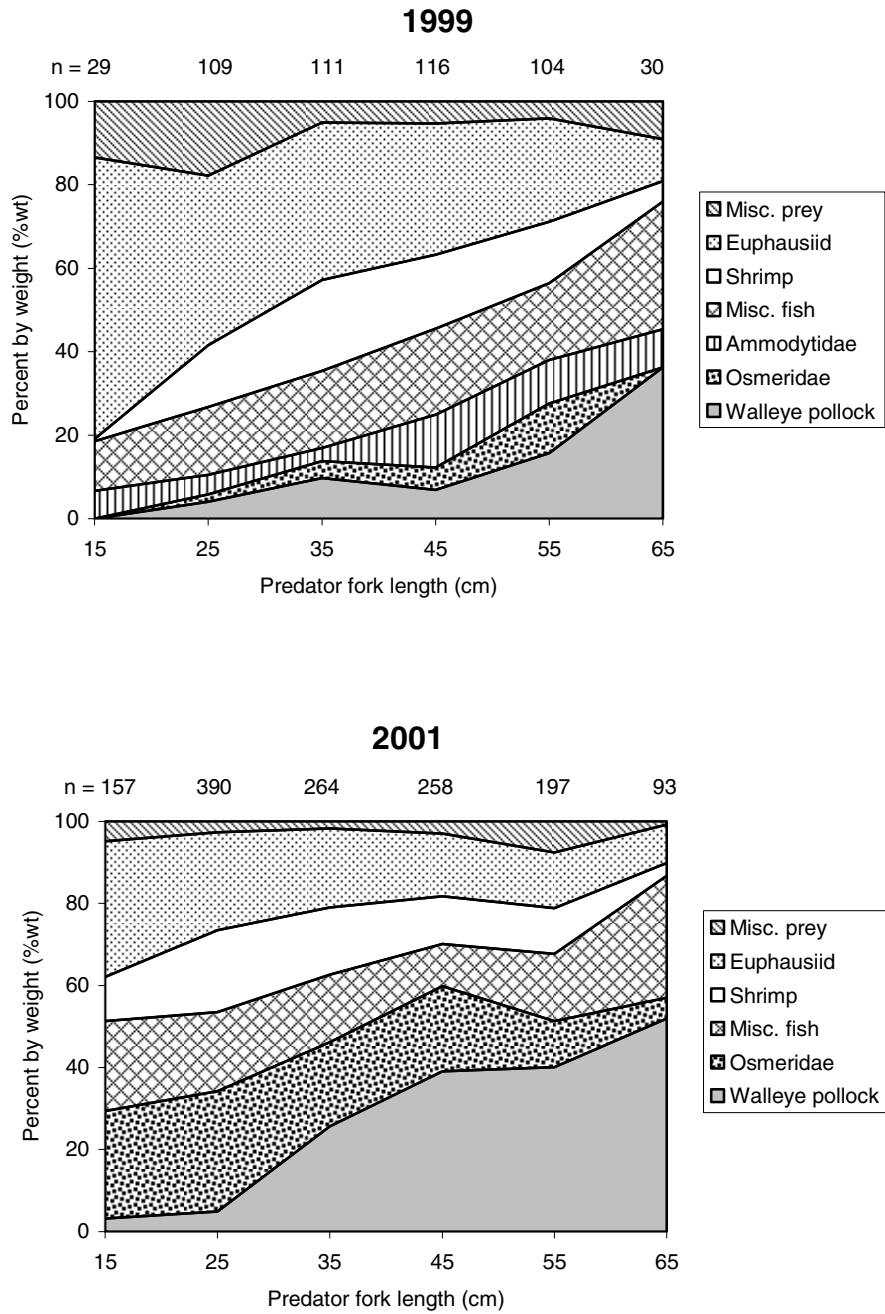


Figure 4.--Variations in the main food items of arrowtooth flounder, by predator size, in the Gulf of Alaska in 1999 and 2001. n = stomachs with food

Pacific Halibut

Pacific halibut (*Hippoglossus stenolepis*) had an exploitable biomass of about 91,818 t in the Gulf of Alaska (NPFMC Regulatory areas 3A and 3B) in 2004. In that same year the commercial catch in the Gulf of Alaska (areas 3A and 3B) was 18,481 t (IPHC 2004). Pacific halibut are important predators feeding on fish, crab, and squid. Knowledge of their food habits is needed to describe their potential impact on other commercially important species in the Gulf of Alaska area.

General Diets

Tables 9 and 10 list the total number of Pacific halibut stomachs containing food, the empty stomachs, the mean percent frequency of occurrence of the prey, and the mean percent by weight of the prey found in Pacific halibut stomachs collected in 1999 and 2001. Walleye pollock was the most important prey. In terms of weight, pollock comprised 10 and 22% of the total stomach contents in 1999 and 2001, respectively. Pacific sand lance made up 17% and 10% of the total stomach contents weight in the 2 years. Capelin comprised 6% and 4% of the total stomach contents weight in 1999 and 2001, respectively. Arrowtooth flounder comprised 4% and 2.5% of the total stomach

contents weight for 1999 and 2001, respectively. Other commercially important fish consumed by Pacific halibut included Pacific cod, eulachon, Pacific ocean perch, flathead sole, southern rock sole, yellowfin sole, and young Pacific halibut. Pacific halibut also consumed some fishery offal. Many non-commercially important fish (e.g., cottids, agonids, cyclopterids, bathymasterids, and stichaeids) were also consumed by Pacific halibut; however, they played a minor role in the diet of the Pacific halibut.

Hermit crabs were the most important invertebrate prey of Pacific halibut; they comprised 17% and 10% of the total stomach contents weight in 1999 and 2001, respectively. Less important invertebrate prey included Tanner crabs (< 1 to 6%), lyre crab (*Hyas* spp.) (3-7%), cancer crab (*Cancer oregonensis*) (6-10%), and decorator crab (*Oregonia* spp.) (1-3%). All of the other invertebrates consumed (polychaetes, gastropods, clams, cephalopods, shrimp, and other crustaceans) were found less frequently and were considered to be relatively less important as food of Pacific halibut.

Table 9.--Prey items (expressed in mean percent frequency of occurrence, and mean percent total weight) of *Hippoglossus stenolepis* (Pacific halibut) collected in the Gulf of Alaska in 1999.

Prey items	Percent frequency	Percent weight
Porifera (sponge)	1.26	0.40
Anthozoa (anemome)	1.30	0.56
Polychaeta (worm)	3.08	0.23
Mollusca	0.83	1.33
Gastropoda (snail)	0.61	0.03
Bivalvia (clam)	6.03	0.23
Cephalopoda (squid and octopus)	2.16	0.30
Octopoda (octopus)	1.52	0.00
Isopoda (isopod)	1.14	0.02
Natantia (shrimp)	5.13	1.48
Caridea (shrimp)	0.61	0.02
Hippolytidae (shrimp)	3.04	0.16
<i>Eualus</i> sp. (shrimp)	1.79	0.05
Pandalidae (shrimp)	2.44	0.43
Crangonidae (shrimp)	4.63	0.95
<i>Crangon</i> sp. (shrimp)	4.35	1.25
<i>Crangon alaskensis</i> (shrimp)	0.65	0.03
<i>Crangon dalli</i> (shrimp)	2.67	0.62
<i>Argis lar</i> (shrimp)	0.70	0.08
Reptantia (crab)	3.63	0.57
Paguridae (hermit crab)	39.24	16.21
Paguridae legs (hermit crabs)	2.60	0.01
<i>Pagurus brandti</i> (sponge hermit crab)	0.65	0.60
Decapoda brachyura (crab)	11.69	0.68
Oxyrhyncha	1.14	0.02
<i>Oregonia</i> sp. (decorator crab)	13.79	11.01
<i>Hyas</i> sp. (lyre crab)	3.50	1.38
<i>Hyas lyratus</i> (lyre crab)	13.42	1.98
<i>Chionoecetes</i> sp. (snow and Tanner crab)	2.27	0.08
<i>Chionoecetes bairdi</i> (Tanner crab)	0.35	0.05
<i>Cancer oregonensis</i> (pygmy Cancer crab)	25.83	10.15
<i>Pinnixa</i> sp. (pea crab)	0.35	0.01
Sipuncula (marine worm)	0.83	0.07
Ophiurida (brittle star)	1.30	0.00
Clypeasteroidea (sand dollar)	0.65	0.06

Table 9.--Continued.

Prey items	Percent frequency	Percent weight
Teleostei (fish)	1.65	0.00
Non-gadoid fish remains	12.60	0.20
Clupeidae	1.60	1.24
<i>Mallotus villosus</i> (capelin)	6.21	5.92
Gadidae (gadid fish)	11.32	1.35
<i>Theragra chalcogramma</i> (walleye pollock)	5.55	10.03
Zoarcidae (eelpout)	0.61	0.57
Cottoidei (sculpin)	2.00	0.03
<i>Triglops szepticus</i> (spectacled sculpin)	0.61	0.08
<i>Podothecus acipenserinus</i> (sturgeon poacher)	1.14	5.70
Stichaeidae (prickleback)	1.58	0.44
Pholidae (gunnel family)	0.61	0.10
<i>Pholis clemensi</i> (longfin gunnel)	0.83	0.32
<i>Ammodytes</i> sp. (sand lance)	6.36	3.82
<i>Ammodytes hexapterus</i> (Pacific sand lance)	19.91	13.30
Pleuronectidae (flatfish)	1.30	0.03
<i>Atheresthes stomias</i> (arrowtooth flounder)	1.52	4.17
<i>Hippoglossus stenolepis</i> (Pacific halibut)	1.14	0.12
Unidentified organic material	0.61	0.40
Unidentified worm-like organism	2.34	0.12
Unidentified algae	1.26	1.01

Total non-empty stomachs = 134

Total prey number = 471

Total prey weight = 3690.757 g

Total empty stomachs = 35

Number of hauls = 11

Full stomach summary statistics

Average fork length = 57.05 cm

Standard deviation of fork length = 7.16 cm

Minimum fork length = 17 cm

Maximum fork length = 114 cm

Average fullness = 4.64

Standard deviation of fullness = .43

Minimum fullness = 2

Maximum fullness = 7

Empty stomach summary statistics

Average fork length = 62.94 cm

Standard deviation of fork length = 20.79 cm

Minimum fork length = 37 cm

Maximum fork length = 107 cm

Table 10.--Prey items (expressed in mean percent frequency of occurrence, and mean percent total weight) of *Hippoglossus stenolepis* (Pacific halibut) collected in the Gulf of Alaska in 2001.

Prey items	Percent frequency	Percent weight
Porifera (sponge)	0.22	0.02
Cnidaria	0.19	0.00
Anthozoa (anemome)	0.42	0.22
Polychaeta (worm)	2.61	0.13
Aphroditidae (sea mouse)	0.20	0.06
Nephtyidae (polychaete)	0.13	0.25
Hirudinea (leech)	0.14	0.09
Mollusca	0.68	0.02
Gastropoda (snail)	0.79	0.01
Bivalvia (clam)	3.56	0.37
Pectinidae (scallops)	0.17	0.00
Cephalopoda (squid and octopus)	0.80	0.23
Teuthida (squid)	1.29	1.01
Octopoda (octopus)	4.91	2.63
Octopodidae (octopus)	0.10	0.20
Cirripedia (barnacle)	0.07	0.00
Mysida (mysid)	0.51	0.00
Isopoda (isopod)	1.40	0.52
Gammaridea (amphipod)	1.31	0.01
Hyperidea (amphipod)	0.13	0.00
Caprellidea (amphipod)	0.15	0.00
Euphausiacea (euphausiid)	0.76	0.10
Euphausiidae (euphausiid)	1.59	0.39
<i>Thysanoessa</i> sp. (euphausiid)	0.07	0.00
<i>Thysanoessa inermis</i> (euphausiid)	0.06	0.02
Natantia (shrimp)	0.51	0.03
Caridea (shrimp)	0.55	0.01
Hippolytidae (shrimp)	0.97	0.11
<i>Lebbeus</i> sp. (shrimp)	0.42	0.09
<i>Lebbeus groenlandicus</i> (shrimp)	0.78	0.21
Pandalidae (shrimp)	0.97	0.07
<i>Pandalus</i> sp. (shrimp)	1.21	0.20
<i>Pandalus jordani</i> (shrimp)	0.11	0.00
<i>Pandalus montagui tridens</i> (shrimp)	0.38	0.21

Table 10.--Continued.

Prey items	Percent frequency	Percent weight
Crangonidae (shrimp)	2.03	0.09
<i>Crangon</i> sp. (shrimp)	0.41	0.02
<i>Crangon alaskensis</i> (shrimp)	0.07	0.02
<i>Crangon stylirostris</i> (shrimp)	0.07	0.02
<i>Crangon dalli</i> (shrimp)	0.11	0.00
<i>Crangon communis</i> (shrimp)	0.09	0.00
<i>Sclerocrangon</i> sp. (shrimp)	0.08	0.01
<i>Sclerocrangon boreas</i> (shrimp)	0.07	0.00
<i>Rhynocrangon alata</i> (saddle-back shrimp)	1.04	0.37
<i>Argis</i> sp. (shrimp)	0.35	0.01
<i>Argis crassa</i> (shrimp)	0.07	0.01
<i>Argis levior</i> (shrimp)	0.14	0.01
Reptantia (crab)	4.08	0.44
Paguridae (hermit crab)	25.23	6.84
Paguridae legs (hermit crabs)	2.11	0.42
<i>Pagurus</i> sp. (hermit crab)	2.09	0.51
<i>Pagurus ochotensis</i> (hermit crab)	0.07	0.00
<i>Pagurus brandti</i> (sponge hermit crab)	0.08	0.00
<i>Elassochirus</i> sp.	3.67	1.87
<i>Elassochirus tenuimanus</i>	0.36	0.02
<i>Elassochirus cavimanus</i> (purple hermit crab)	0.67	0.04
<i>Placetron wosnessenskii</i> (scale crab)	0.14	0.00
<i>Rhinolithodes wosnessenskii</i> (rhinoceros crab)	0.31	0.52
<i>Munida quadrispina</i> (pinch bug)	1.74	1.20
Decapoda brachyura (crab)	0.28	0.01
Majidae (spider crab)	2.12	0.13
<i>Oregonia</i> sp. (decorator crab)	3.07	1.38
<i>Oregonia gracilis</i> (decorator crab)	2.63	1.08
<i>Oregonia bifurca</i> (decorator crab)	1.31	0.56
<i>Hyas</i> sp. (lyre crab)	10.20	3.79
<i>Hyas lyratus</i> (lyre crab)	7.37	2.79
<i>Hyas coarctatus</i> (lyre crab)	0.35	0.35
<i>Chionoecetes</i> spp. (snow and Tanner crab)	1.85	0.77
<i>Chionoecetes opilio</i> (snow crab)	1.26	1.02
<i>Chionoecetes bairdi</i> (Tanner crab)	10.25	4.37
<i>Pugettia gracilis</i> (kelp crab)	0.22	0.00
<i>Chorilia longipes</i> (decorator crab)	1.06	0.13
Atelecyclidae (crab)	0.07	0.05
Cancridae (crab)	0.30	0.00
<i>Cancer</i> sp. (crab)	0.32	0.00

Table 10.--Continued.

Prey items	Percent frequency	Percent weight
<i>Cancer oregonensis</i> (pygmy Cancer crab)	15.58	5.80
Pinnotheridae (pea crab)	0.10	0.02
<i>Pinnixa</i> sp. (pea crab)	1.01	0.04
Sipuncula (marine worm)	0.40	0.16
Echiura (marine worm)	0.71	0.19
Ectoprocta (bryozoan)	0.22	0.06
Ophiurida (brittle star)	1.45	0.07
Echinoidea (sea urchin and sand dollar)	0.08	0.00
<i>Ascidia</i> sp. (tunicate)	0.08	0.01
Thaliacea (pelagic salp)	0.15	0.00
Teleostei (fish)	2.02	0.41
Non-gadoid fish remains	7.23	0.54
Clupeidae	0.30	0.17
<i>Clupea pallasii</i> (Pacific herring)	0.66	1.41
Salmonidae (salmon, whitefish)	1.01	1.00
<i>Oncorhynchus keta</i> (chum salmon)	0.17	0.81
Osmeridae (smelts)	2.08	0.40
<i>Mallotus villosus</i> (capelin)	4.91	3.78
<i>Thaleichthys pacificus</i> (eulachon)	0.34	0.09
Gadidae (gadid fish)	2.99	2.98
<i>Gadus macrocephalus</i> (Pacific cod)	0.19	0.85
<i>Theragra chalcogramma</i> (walleye pollock)	17.76	22.19
Zoarcidae (eelpout)	0.20	0.13
Scorpaenidae (rockfish)	0.11	0.02
<i>Sebastes</i> sp. (rockfish)	0.45	0.04
<i>Sebastes alutus</i> (Pacific ocean perch)	0.34	0.48
Cottoidei (sculpin)	4.00	0.81
Cottidae (sculpin)	0.83	0.54
<i>Rhamphocottus richardsoni</i> (grunt sculpin)	0.44	0.20
Agonidae (poacher)	0.59	0.10
<i>Podothecus acipenserinus</i> (sturgeon poacher)	0.08	0.02
Cyclopteridae (snailfish)	0.15	0.01
<i>Aptocyclus ventricosus</i> (smooth lumpsucker)	0.17	0.11
<i>Eumicrotremus orbis</i> (Pacific spiny lumpsucker)	0.16	0.07
Bathymasteridae (ronquils)	0.78	0.39
<i>Bathymaster</i> sp. (searcher)	0.51	0.05
Stichaeidae (prickleback)	1.10	0.16
<i>Lumpenus sagitta</i> (snake prickleback)	0.20	0.04
Pholidae (gunnel family)	0.44	0.07
<i>Pholis</i> sp. (gunnel)	0.16	0.03
<i>Ammodytes</i> sp. (sand lance)	8.09	4.64

Table 10.--Continued.

Prey items	Percent frequency	Percent weight
<i>Ammodytes hexapterus</i> (Pacific sand lance)	7.04	5.38
Pleuronectoidei (flatfish)	1.61	0.12
Pleuronectidae (flatfish)	4.17	2.56
<i>Atheresthes</i> sp.	0.98	1.43
<i>Atheresthes evermanni</i> (Kamchatka flounder)	0.10	0.31
<i>Atheresthes stomias</i> (arrowtooth flounder)	1.32	0.76
<i>Hippoglossoides elassodon</i> (flathead sole)	0.67	0.53
<i>Lepidopsetta bilineatus</i> (southern rock sole)	0.15	0.88
<i>Limanda</i> sp.	0.20	0.30
<i>Limanda aspera</i> (yellowfin sole)	0.45	0.67
Unidentified organic material	0.50	0.02
Unidentified worm-like organism	0.68	0.03
Fishery offal	1.10	1.90
Unidentified tube	0.20	0.00
Overboard material (non-fishery)	0.08	0.00
Unidentified algae	0.34	0.00
Rocks	0.07	0.01

Total non-empty stomachs = 808

Total prey number = 5401

Total prey weight = 62323.362 g

Total empty stomachs = 81

Number of hauls = 99

Full stomach summary statistics

Average fork length = 61.63 cm

Standard deviation of fork length = 7.44 cm

Minimum fork length = 13 cm

Maximum fork length = 126 cm

Average fullness = 4.67

Standard deviation of fullness = .44

Minimum fullness = 2

Maximum fullness = 7

Empty stomach summary statistics

Average fork length = 64.75 cm

Standard deviation of fork length = 21.77 cm

Minimum fork length = 19 cm

Maximum fork length = 128 cm

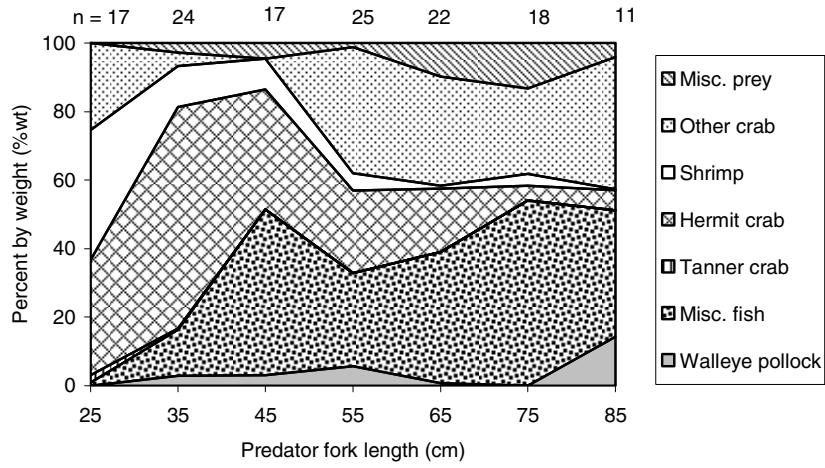
Comparing the diet differences between 1999 and 2001, we noticed that miscellaneous fish (including all fishes other than walleye pollock), hermit crab, and other crabs (including lyre, cancer, and decorator crabs) were the three main prey groups of Pacific halibut. The percentages of these three main prey groups in the diet of Pacific halibut in 1999 and 2001 were similar. Miscellaneous fish comprised 37% and 33% of the stomach contents in 1999 and 2001, respectively, and the other crabs category comprised 26% and 18% of the stomach contents of Pacific halibut in those 2 years.

Variation of Diet Based on Predator Size

The diet of Pacific halibut varied greatly by predator size (Fig. 5). Miscellaneous prey fish (mainly capelin, Pacific sand lance, cottids, zoarcids, stichaeids, and flatfish) were important food for all sizes of Pacific halibut, whereas walleye pollock were mainly consumed by larger Pacific halibut (≥ 80 cm FL). Crabs (Tanner crabs, decorator crabs, lyre crabs, and cancer crabs) were the main food of Pacific halibut between 50 and 80 cm FL. Hermit crabs (pagurids) were important food ($\geq 23\%$ by weight) for Pacific halibut less than 60 cm FL, especially for fish less than 40 cm long (they comprised 47% and 40%

of the total stomach contents weight in 1999 and 2001, respectively). Shrimp were also important food of Pacific halibut less than 30 cm FL.

1999



2001

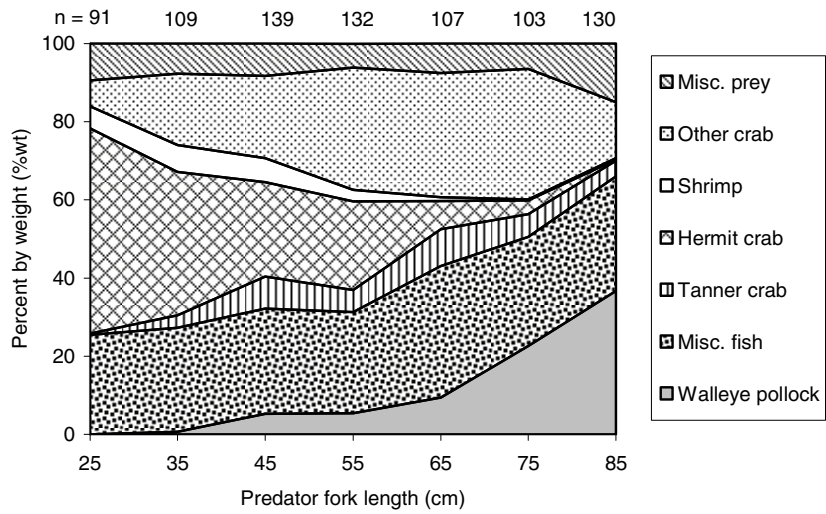


Figure 5.--Variations in the main food items of Pacific halibut, by predator size, in the Gulf of Alaska in 1999 and 2001. n = stomachs with food.

Sablefish

Sablefish, *Anoplopoma fimbria*, ranked sixth in total groundfish biomass in the Gulf of Alaska in 2004 with an exploitable biomass of 185,000 t (NPFMC 2004). The commercial catch of sablefish in 2004 was 14,847 t. Sablefish have been found to feed opportunistically on fish, crustaceans, and worms (Grinols and Gill 1968). Because sablefish is an important commercial species and it probably feeds on other commercially important fish, it is included in this study on food habits and potential impacts on the other marine fishes in the Gulf of Alaska.

General Diet

Tables 11 and 12 list the total number of stomachs with food, the total empty stomachs, the mean percent frequency of occurrence, and the mean percent by weight of the prey found in sablefish stomachs collected in 1999, and 2001. Walleye pollock was the predominate fish prey consumed by sablefish. Pollock comprised 16% and 17% by weight of the total sablefish stomach contents in 1999 and 2001, respectively. Most of the unidentified gadid fish (about 8% by weight of the total stomach contents, Table 12) were probably walleye pollock. Pacific herring, capelin, eulachon, Pacific cod, Pacific ocean perch, shortspine

thornyhead, Pacific sand lance, and some flatfish (Family Pleuronectidae) were also important commercial species consumed by sablefish. Sablefish also consumed fish such as lanternfish (Family Myctophidae), eelpout (Family Zoarcidae), sculpin (Family Cottidae), and poacher (Family Agonidae). It is worth noting that fishery offal (fish carcasses) made up to 27% and 9% by weight of the sablefish diet in 1999 and 2001, respectively.

Cephalopods were the most important invertebrate prey of sablefish. They comprised 12% and 9% of the total stomach contents weight in 1999 and 2001, respectively. Euphausiids were found frequently in stomachs. They comprised about 15% by weight of the stomach contents in 2001. Pandalid shrimps comprised 6% and 3% of the total stomach contents weight in 1999 and 2001, respectively. Tanner crabs were found in sablefish stomachs in 1999 when they comprised 4% of the total stomach contents weight. Sablefish also consumed small amounts of jellyfish, polychaetes, snails, mysids, amphipods, crangonids, pagurids, and some marine worms.

Table 11.--Prey items (expressed in mean percent frequency of occurrence, and mean percent total weight) of *Anoplopoma fimbria* (sablefish) collected in the Gulf of Alaska in 1999.

Prey items	Percent frequency	Percent weight
Scyphozoa (jellyfish)	1.05	0.01
Polychaeta (worm)	3.29	1.13
Gymnosomata (pteropod)	1.75	0.25
Cephalopoda (squid and octopus)	13.95	3.59
Teuthida (squid)	2.63	3.69
Octopoda (octopus)	2.11	4.87
Calanoida (copepod)	3.95	0.71
Mysidae (mysid)	3.51	0.45
Isopoda (isopod)	2.63	1.13
Gammaridea (amphipod)	15.13	3.87
Hyperidea (amphipod)	3.07	0.53
<i>Themisto</i> sp. (amphipod)	1.75	0.00
<i>Thysanoessa</i> sp. (euphausiid)	1.75	1.03
<i>Thysanoessa inspinata</i> (euphausiid)	0.66	0.04
Hippolytidae (shrimp)	2.63	0.07
Pandalidae (shrimp)	0.88	0.31
<i>Pandalus borealis</i> (shrimp)	5.26	5.26
<i>Pandalus jordani</i> (shrimp)	0.44	0.15
Crangonidae (shrimp)	7.02	5.73
Paguridae (hermit crab)	2.63	2.96
Majidae legs (for <i>C. opilio</i> , <i>C. bairdi</i> , etc)	6.14	2.63
<i>Chionoecetes bairdi</i> (Tanner crab)	0.88	1.30
Sipuncula (marine worm)	3.95	5.46
Echiura (marine worm)	2.63	0.09
Thaliacea (pelagic salp)	1.32	0.29
Teleostei (fish)	17.54	7.07
Non-gadoid fish remains	10.53	1.68
<i>Mallotus villosus</i> (capelin)	0.44	0.83
Myctophidae (lanternfish)	0.66	1.75
<i>Theragra chalcogramma</i> (walleye pollock)	11.40	16.07
Fishery offal	20.39	27.04

Table 11.--Continued.

Total non-empty stomachs = 59
Total prey number = 387
Total prey weight = 1381.582 g
Total empty stomachs = 80
Number of hauls = 19

Full stomach summary statistics

Average fork length = 55.19 cm
Standard deviation of fork length = 3.17 cm
Minimum fork length = 29 cm
Maximum fork length = 67 cm
Average fullness = 3.84
Standard deviation of fullness = .92
Minimum fullness = 2
Maximum fullness = 7

Empty stomach summary statistics

Average fork length = 58.54 cm
Standard deviation of fork length = 11.74 cm
Minimum fork length = 28 cm
Maximum fork length = 83 cm

Table 12.--Prey items (expressed in mean percent frequency of occurrence, and mean percent total weight) of *Anoplopoma fimbria* (sablefish) collected in the Gulf of Alaska in 2001.

Prey items	Percent frequency	Percent weight
Phaeophycophyta (brown algae)	0.68	0.07
Porifera (sponge)	0.20	0.02
Cnidaria	2.14	0.58
Scyphozoa (jellyfish)	2.18	1.95
Anthozoa (anemome)	0.51	0.09
Pennatulacea (sea pen)	0.17	0.00
Polychaeta (worm)	4.30	1.70
Aphroditidae (sea mouse)	0.51	0.59
Mollusca	1.45	1.29
Gastropoda (snail)	0.69	0.14
Bivalvia (clam)	1.48	1.21
Cephalopoda (squid and octopus)	2.48	1.88
Teuthida (squid)	6.92	1.01
Octopoda (octopus)	1.87	5.61
Calanoida (copepod)	0.96	0.00
Large calanoid (copepod) > 5mm	1.20	0.00
Medium calanoid (copepod) 2-5mm	0.34	0.00
Mysida (mysid)	2.41	0.04
Mysidae (mysid)	1.42	0.01
Cumacea (cumacean)	0.32	0.01
Isopoda (isopod)	1.00	0.15
Amphipoda (amphipod)	0.51	0.01
Gammaridea (amphipod)	22.85	2.95
Hyperidea (amphipod)	3.42	0.02
Euphausiacea (euphausiid)	1.03	0.02
Euphausiidae (euphausiid)	36.25	13.46
<i>Thysanoessa</i> sp. (euphausiid)	2.42	0.96
<i>Thysanoessa inermis</i> (euphausiid)	1.55	0.30
<i>Thysanoessa spinifera</i> (euphausiid)	0.82	0.34
Natantia (shrimp)	4.55	0.43
Caridea (shrimp)	9.97	0.61
<i>Pasiphaea pacifica</i> (shrimp)	0.77	0.03
Pandalidae (shrimp)	4.82	0.68
<i>Pandalus</i> sp. (shrimp)	0.17	0.00
<i>Pandalus borealis</i> (shrimp)	0.28	0.04

Table 12.--Continued.

Prey items	Percent frequency	Percent weight
<i>Pandalus jordani</i> (shrimp)	0.51	2.50
<i>Pandalus platyceros</i> (shrimp)	0.43	0.07
<i>Pandalopsis</i> sp. (shrimp)	0.85	0.03
Crangonidae (shrimp)	2.73	0.20
Reptantia (crab)	1.16	0.06
Paguridae (hermit crab)	3.40	0.54
Decapoda brachyura (crab)	0.94	0.03
<i>Chionoecetes</i> sp. (snow and Tanner crab)	0.37	0.10
Echiura (marine worm)	0.83	0.15
Priapulida (worm)	0.43	0.06
Ophiurida (brittle star)	0.43	0.20
Holothuroidea (sea cucumber)	0.38	0.21
Chaetognatha (arrow worm)	1.03	0.00
Urochordata (tunicate)	0.32	0.02
Thaliacea (pelagic salp)	0.85	0.13
Copelata (larvacea)	0.28	0.07
Teleostei (fish)	15.16	4.79
Non-gadoid fish remains	6.14	2.21
<i>Clupea pallasii</i> (Pacific herring)	0.17	0.54
Osmeridae (smelts)	2.85	1.33
<i>Mallotus villosus</i> (capelin)	1.37	1.86
<i>Thaleichthys pacificus</i> (eulachon)	2.01	2.46
Gadidae (gadid fish)	12.33	8.17
<i>Gadus macrocephalus</i> (Pacific cod)	1.92	1.60
<i>Theragra chalcogramma</i> (walleye pollock)	12.93	16.96
Zoarcidae (eelpout)	1.20	0.36
Scorpaeniformes (rockfish and cottid)	0.20	0.06
Scorpaenidae	0.17	0.02
<i>Sebastes alutus</i> (Pacific ocean perch)	0.17	0.19
<i>Sebastolobus alascanus</i> (shortspine thornyhead)	1.31	4.01
<i>Dasycottus setiger</i> (spinyhead sculpin)	0.21	0.04
Agonidae (poacher)	2.99	0.23
<i>Aspidophoroides bartoni</i> (Aleutian alligatorfish)	0.18	0.27
<i>Asterotheca alascana</i> (gray starsnout)	1.28	0.15
<i>Ammodytes hexapterus</i> (Pacific sand lance)	7.13	4.85
Pleuronectoidei (flatfish)	0.61	0.38
Unidentified organic material	1.03	0.03
Unidentified worm-like organism	0.85	0.05
Fishery offal	6.81	8.86
Unidentified tube	0.17	0.00

Table 12.--Continued.

Total non-empty stomachs = 284
Total prey number = 3868
Total prey weight = 14407.363 g
Total empty stomachs = 64
Number of hauls = 39

Full stomach summary statistics

Average fork length = 59.08 cm
Standard deviation of fork length = 2.62 cm
Minimum fork length = 23 cm
Maximum fork length = 90 cm
Average fullness = 3.74
Standard deviation of fullness = .58
Minimum fullness = 2
Maximum fullness = 7

Empty stomach summary statistics

Average fork length = 56.66 cm
Standard deviation of fork length = 11.34 cm
Minimum fork length = 26 cm
Maximum fork length = 75 cm

Comparing the 2 years of data, we noticed that the percentages of the main food items in sablefish stomachs were similar for 1999 and 2001. For example, pollock comprised 16% and 17% (by weight) of the diet in 1999 and 2001, respectively. Pandalid shrimp comprised 6% and 3% in those 2 years. Cephalopods ranged from 12% to 9% of the stomach contents for sablefish in 1999 and 2001, respectively. However, sablefish consumed a larger variety of fish (e.g. eelpouts, cottids, poachers.) in 2001. These species made up 50% of the total stomach contents weight in 2001. Sablefish consumed a much higher percentage of fish offal in 1999 than in 2001 (27% vs. 9%). Comparing their diets to the diets of other groundfish species, we noticed that sablefish appeared to feed more frequently on fish offal than walleye pollock, Pacific cod, arrowtooth flounder, or Pacific halibut. This may indicate that sablefish are highly opportunistic feeders.

Variation of Diet Based on Predator Size

Figure 6 illustrates that larger (≥ 60 cm FL) sablefish consumed more fish (walleye pollock, miscellaneous fish, and fishery offal) than the smaller fish (< 60 cm FL). The smaller sablefish (< 60 cm FL) consumed more euphausiids, shrimp, and cephalopods. Sablefish larger than 70 cm FL consumed a high percentage

(31%) of fishery offal in 2001. The miscellaneous prey consumed by the smallest size group (< 50 cm FL) of sablefish in 1999 was made up of mainly gammarid amphipods and sipuncula marine worms (46% by weight).

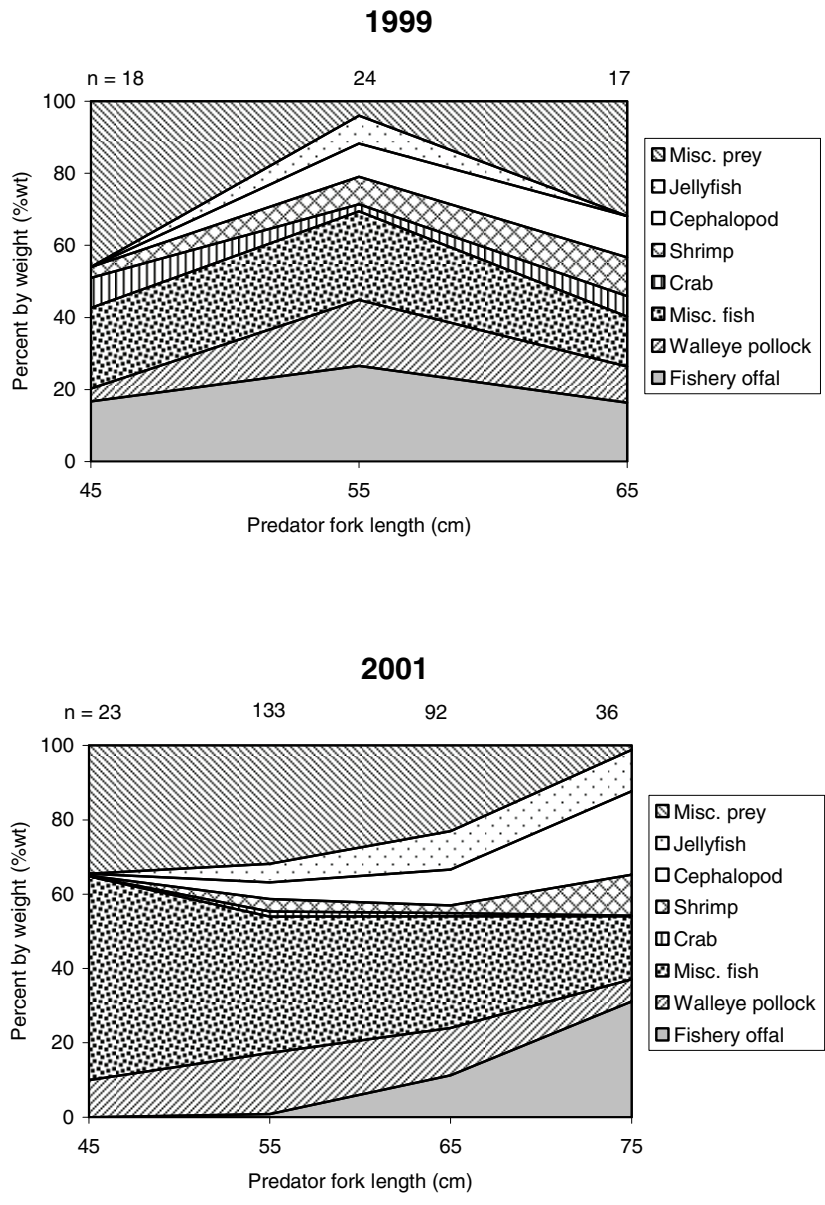


Figure 6.--Variations in the main food items of sablefish, by predator size, in the Gulf of Alaska in 1999 and 2001. n = stomachs with food.

Spiny Dogfish

In the Gulf of Alaska, sharks (including spiny dogfish (*Squalus acanthias*), Pacific sleeper shark (*Somniosus pacificus*), and salmon shark (*Lamna ditropis*)) have been managed as part of the "other species" category under the GOA FMP (Fishery Management Plan), along with other potentially economically important species such as, sculpins, squids, and octopi. The estimated biomass of all sharks was 34,214 t (Gaichas et al. 1999).

Spiny dogfish is a demersal species. In the eastern North Pacific, they occur from Baja California to the Bering Sea (Hart 1973). Their diet varies greatly from euphausiids to many different kinds of fish such as Pacific herring, capelin, and sand lance. Because of this diversity in their diet, it is important to study the role of spiny dogfish in the Gulf of Alaska ecosystem.

General Diet

Euphausiids (7% by weight) and fishery offal (93%) were the only food items found in the spiny dogfish stomachs collected in 2001 in the Gulf of Alaska (Table 13). More stomach samples are needed in the future to provide an accurate description of the diet of spiny dogfish in the GOA.

Table 13.--Prey items (expressed in mean percent frequency of occurrence, and percent total weight) of *Squalus acanthias* (spiny dogfish) collected in the Gulf of Alaska in 2001.

Prey items	Percent frequency	Percent weight
Euphausiacea (euphausiid)	100.00	6.68
Fishery offal	100.00	93.32

Total non-empty stomachs = 1

Total prey number = 15

Total prey weight = 35.73 g

Total empty stomachs = 0

Number of hauls = 1

Full stomach summary statistics

Average fork length = 72.00 cm

Standard deviation of fork length = 0 cm

Minimum fork length = 72 cm

Maximum fork length = 72 cm

Average fullness = 6.00

Standard deviation of fullness = 0

Minimum fullness = 6

Maximum fullness = 6

Big Skate

Big skate (*Raja binoculata*) are distributed in the Bering Sea, Aleutian Islands region, and as far south as Baja California (Mecklenburg et al. 2002). It is the most abundant skate species in the Gulf of Alaska with an estimated biomass of 53,324 t (NPFMC 2004). In 2003, a directed fishery for certain skate species developed in the Gulf of Alaska. Along with longnose skate (*Raja rhina*), they have been one of the two target species of the skate fishery since 2004. Therefore, it is important to study the trophic role of the big skate in the Gulf of Alaska ecosystem.

General Diet

Table 14 lists the total number of stomachs containing food, the empty stomachs, the mean percent frequency of occurrence of the prey, and the mean percent by weight of the prey found in big skate stomachs collected in 2001. Pacific sand lance was the most important prey. In terms of weight, Pacific sand lance comprised 49% of the total stomach contents in 2001. Tanner crabs were the most important invertebrate prey of big skate; they comprised 46% of the total stomach contents weight in 2001. Big skate also consumed some shrimp (2%) and three spine stickleback (1%).

Table 14.--Prey items (expressed in mean percent frequency of occurrence, and mean percent total weight) of *Bathyraja binocularata* (big skate) collected in the Gulf of Alaska in 2001.

Prey items	Percent frequency	Percent weight
Hippolytidae (shrimp)	50.00	2.29
<i>Argis lar</i> (shrimp)	50.00	1.80
<i>Chionoecetes bairdi</i> (Tanner crab)	50.00	45.92
<i>Gasterosteus aculeatus</i> (threespine stickleback)	50.00	1.04
<i>Ammodytes</i> sp. (sand lance)	50.00	48.96

Total non-empty stomachs = 2

Total prey number = 44

Total prey weight = 324.32 g

Total empty stomachs = 0

Number of hauls = 2

Full stomach summary statistics

Average fork length = 89.00 cm

Standard deviation of fork length = 11.31 cm

Minimum fork length = 81 cm

Maximum fork length = 97 cm

Average fullness = 4.50

Standard deviation of fullness = 0.71

Minimum fullness = 4

Maximum fullness = 5

Bering Skate (Sandpaper Skate)

Bering skate (*Bathyraja interrupta*) are distributed from the Bering Sea, Aleutian Islands, to the waters off Southern California (Mecklenburg et al. 2002). This species along with Aleutian skate (*B. aleutica*), Alaska skate (*B. parmifera*), and other *Bathyraja* spp. are managed as "other skates" under the GOA FMP (Gulf of Alaska, Fishery Management Plan). The total biomass of these "other skates" was estimated 17,689 t in 2004 (NPFMC 2004).

As the role of the skates has received more attention, it is important to study the diet of the skates to be able to understand the whole trophic relationships in the Gulf of Alaska ecosystem.

Table 15 lists the total number of stomachs with food, the total empty stomachs, the mean percent frequency of occurrence, and the mean percent by weight of the prey found in Bering skate stomachs collected in 2001. Gadids (probably walleye pollock) were the primary fish prey consumed by Bering skate; they comprised 31% (by weight) of the total stomach contents in 2001.

Lyre crab (*Hyas lyratus*) and hippolytid shrimp were the most important invertebrate prey of Bering skate; they each comprised 33% of the total stomach content weights in

2001. Bering skate also consumed a low amount (2%) of isopods.

Table 15.--Prey items (expressed in mean percent frequency of occurrence, and mean percent total weight) of *Bathyraja interrupta* (Bering skate) collected in the Gulf of Alaska in 2001.

Prey items	Percent frequency	Percent weight
Isopoda (isopod)	33.33	2.10
Hippolytidae (shrimp)	33.33	33.33
<i>Hyas lyratus</i> (lyre crab)	33.33	33.33
Gadidae (gadid fish)	33.33	31.23

Total non-empty stomachs = 3

Total prey number = 14

Total prey weight = 36.342 g

Total empty stomachs = 0

Number of hauls = 3

Full stomach summary statistics

Average fork length = 51.67 cm

Standard deviation of fork length = 15.89 cm

Minimum fork length = 42 cm

Maximum fork length = 70 cm

Average fullness = 4.33

Standard deviation of fullness = 1.53

Minimum fullness = 3

Maximum fullness = 6

Longnose Skate

Longnose skate (*Raja rhina*) are distributed from the southeastern Bering Sea to Baja California (Mecklenburg et al. 2002). It ranked second in the total skate biomass in the Gulf of Alaska in 2004 with an estimated biomass of 37,575 t (NPFMC 2004). The allowable biological catch (ABC) was 2,818 t. It was one of the target species (along with big skate) of the skate fishery in the Gulf of Alaska. Due to concerns over increased fishing rates, it is important to understand the trophic role of longnose skate in the whole Gulf of Alaska ecosystem.

Table 16 lists the total number of stomachs with food, the total number of empty stomachs, the mean percent frequency of occurrence, and the mean percent by weight of the prey found in longnose skate stomachs collected in 2001. Tanner crab was the most important prey consumed by longnose skate; they comprised 45% (by weight) of the total stomach contents in 2001. Pandalid shrimp were the other important prey of longnose skate; they also comprised 45% of the total stomach content weights in 2001. Longnose skate also consumed some dwarf wrymouth (9% by weight).

Table 16.--Prey items (expressed in mean percent frequency of occurrence, and mean percent total weight) of *Raja rhina* (longnose skate) collected in the Gulf of Alaska in 2001.

Prey items	Percent frequency	Percent weight
<i>Pandalus borealis</i> (shrimp)	33.33	24.68
<i>Pandalus goniurus</i> (shrimp)	33.33	20.03
<i>Argis lar</i> (shrimp)	33.33	1.55
<i>Chionoecetes bairdi</i> (Tanner crab)	66.67	44.53
<i>Cryptacanthodes aleutensis</i> (dwarf wrymouth)	33.33	9.21

Total non-empty stomachs = 3

Total prey number = 35

Total prey weight = 185.955 g

Total empty stomachs = 0

Number of hauls = 1

Full stomach summary statistics

Average fork length = 121.60 cm

Standard deviation of fork length = 10.60 cm

Minimum fork length = 112 cm

Maximum fork length = 133 cm

Average fullness = 4.00

Standard deviation of fullness = 1.00

Minimum fullness = 3

Maximum fullness = 5

Alaska Skate

Alaska skate (*Bathyraja parmifera*) are distributed in the Gulf of Alaska, Bering Sea, Aleutian Islands, and northern Sea of Japan (Mecklenburg et al. 2002). This species along with Aleutian skate (*B. aleutica*), Bering skate (*B. interrupta*), and other *Bathyraja* spp. are managed as "other skates" under the GOA FMP (Gulf of Alaska, Fishery Management Plan). The total biomass of these "other skates" was estimated at 17,689 t in 2004 (NPFMC 2004). It is important to study the diet of this species to better understand the predator-prey relationships in the Gulf of Alaska.

Polychaetes were the only prey found in the single Alaska skate stomach collected in 2001 in the Gulf of Alaska (Table 17). More stomach samples are needed to describe the diet of this species in the GOA.

Table 17.--Prey items (expressed in mean percent frequency of occurrence, and mean percent total weight) of *Bathyraja parmifera* (Alaska skate) collected in the Gulf of Alaska in 2001.

Prey items	Percent frequency	Percent weight
Polychaeta (worm)	100.00	100.00

Total non-empty stomachs = 1

Total prey number = 1

Total prey weight = 1.274 g

Total empty stomachs = 1

Number of hauls = 1

Full stomach summary statistics

Average fork length = 59.00 cm

Standard deviation of fork length = 0 cm

Minimum fork length = 59 cm

Maximum fork length = 59 cm

Average fullness = 2.00

Standard deviation of fullness = 0

Minimum fullness = 2

Maximum fullness = 2

Empty stomach summary statistics

Average fork length = 91.00 cm

Standard deviation of fork length = 0 cm

Minimum fork length = 91 cm

Maximum fork length = 91 cm

Eulachon

Eulachon (*Thaleichthys pacificus*) are a small silvery fish commonly encountered in groundfish fisheries in Alaska. Eulachon had an exploitable biomass of 49,061 t in the Gulf of Alaska in 2001. The reported catch of eulachon in the Gulf of Alaska in 2001 was 512 t (Nelson 2003). Although eulachon are not commercially important fish in the Gulf of Alaska area, they are common prey of some commercially important fish (Yang and Nelson 2000) and marine mammals (Womble 2003). Therefore, it is important to study the diet of eulachon in the Gulf of Alaska area.

General Diet

Table 18 lists the total number of stomachs containing food, the total number of empty stomachs, the mean percent frequency of occurrence and mean percent by weight of the prey items of eulachon collected in the Gulf of Alaska in 2001. Euphausiids and fish were the main food of eulachon (66% and 14% of the total stomach contents weight, respectively). Other food items included small invertebrates such as mysids, cumaceans, and hyperiid amphipods.

Barracough (1964) also found that, in British Columbia, euphausiids were the most important food of

eulachon. Further studies should increase the sample size and the sampling locations in the Gulf of Alaska.

Table 18.--Prey items (expressed in mean percent frequency of occurrence, and mean percent total weight) of *Thaleichthys pacificus* (eulachon) collected in the Gulf of Alaska in 2001.

Prey items	Percent frequency	Percent weight
Mysida (mysid)	5.26	2.72
Cumacea (cumacean)	5.26	2.10
Hyperideida (amphipod)	5.26	5.93
Euphausiacea (euphausiid)	52.63	40.85
<i>Thysanoessa inermis</i> (euphausiid)	5.26	25.77
Copelata (larvacea)	5.26	1.67
Teleostei (fish)	21.05	13.78
Non-gadoid fish remains	5.26	2.60
Unidentified organic material	5.26	4.57

Total non-empty stomachs = 19

Total prey number = 33

Total prey weight = 1.618 g

Total empty stomachs = 20

Number of hauls = 1

Full stomach summary statistics

Average fork length = 19.05 cm

Standard deviation of fork length = 1.35 cm

Minimum fork length = 16 cm

Maximum fork length = 21 cm

Average fullness = 3.42

Standard deviation of fullness = 1.17

Minimum fullness = 2

Maximum fullness = 6

Empty stomach summary statistics

Average fork length = 14.55 cm

Standard deviation of fork length = 4.14 cm

Minimum fork length = 7 cm

Maximum fork length = 21 cm

Shortfin Eelpout

Shortfin eelpout (*Lycodes brevipes*) are found throughout the Gulf of Alaska at depths ranging from 27 to 973 m (Mecklenburg et al. 2002). Eelpouts are rarely encountered in observed fisheries, with the exception of a small amount of bycatch in flatfish and rockfish trawl fisheries. Estimated bycatch of eelpouts (not identified to species) from the fisheries in the Gulf of Alaska in 1998 was 4.6 t (Gaichas et al. 1999).

General Diet

Table 19 lists the total number of stomachs containing food, the total number of empty stomachs, the mean percent frequency of occurrence and mean percent by weight of the prey items of shortfin eelpout collected in the Gulf of Alaska in 2001. Clams and cumaceans were the most common prey items of shortfin eelpout (comprising 51% and 30% of mean percent total weight, respectively). Other prey items included shrimp, mysids, and euphausiids.

Brodeur and Livingston (1988) found that brittle stars represented the vast majority (nearly 90%) of the prey biomass of shortfin eelpout in the Bering Sea. A previous study by Smith et al. (1978) found that polychaetes, euphausiids, and decapod crustaceans were the most common prey items in shortfin eelpout stomachs. Lang et al. (2003)

also found that shortfin eelpout in the eastern Bering Sea consumed primarily benthic prey (polychaetes, amphipods, and brittle stars. They comprised 28%, 24%, and 23% of the total stomach contents weight, respectively).

Table 19.--Prey items (expressed in mean percent frequency of occurrence, and mean percent total weight) of *Lycodes brevipes* (shortfin eelpout) collected in the Gulf of Alaska in 2001.

Prey items	Percent frequency	Percent weight
Bivalvia (clam)	36.90	50.56
Mysida (mysid)	10.71	7.20
Cumacea (cumacean)	35.71	30.24
Euphausiacea (euphausiid)	3.57	1.44
Caridea (shrimp)	16.67	10.56

Total non-empty stomachs = 17

Total prey number = 38

Total prey weight = 1.108 g

Total empty stomachs = 1

Number of hauls = 2

Full stomach summary statistics

Average fork length = 22.30 cm

Standard deviation of fork length = 1.19 cm

Minimum fork length = 19 cm

Maximum fork length = 29 cm

Average fullness = 2.50

Standard deviation of fullness = .07

Minimum fullness = 2

Maximum fullness = 4

Empty stomach summary statistics

Average fork length = 27.00 cm

Standard deviation of fork length = 0 cm

Minimum fork length = 27 cm

Maximum fork length = 27 cm

Black Eelpout

Black eelpout (*Lycodes diapterus*) are widespread in the Gulf of Alaska, usually occurring at depths from 100 to 850 m (Mecklenburg et al. 2002). Estimated bycatch of eelpouts (not identified by species) from the fisheries in the Gulf of Alaska in 1998 was 4.6 t (Gaichas et al. 1999).

General Diet

Table 20 lists the total number of stomachs containing food, the total number of empty stomachs, the mean percent frequency of occurrence and mean percent by weight of the prey items of black eelpout collected in the Gulf of Alaska in 2001. Euphausiids were the most common prey items of black eelpout. They comprised 90% of the total stomach contents weight. Black eelpout also consumed crangonid shrimp; they comprised 9% of the total stomach contents weight.

It is difficult to draw any conclusions about the diet of this species since there was only one black eelpout stomach analyzed. Larger sample size is needed for future study of the diet of black eelpout.

Table 20.--Prey items (expressed in mean percent frequency of occurrence, and mean percent total weight) of *Lycodes diapterus* (black eelpout) collected in the Gulf of Alaska in 2001.

Prey items	Percent frequency	Percent weight
<i>Thysanoessa</i> sp. (euphausiid)	100.00	77.07
<i>Thysanoessa inermis</i> (euphausiid)	100.00	13.53
<i>Crangon dalli</i> (shrimp)	100.00	9.40

Total non-empty stomachs = 1

Total prey number = 32

Total prey weight = 2.66 g

Total empty stomachs = 0

Number of hauls = 1

Full stomach summary statistics

Average fork length = 24.00 cm

Standard deviation of fork length = 0 cm

Minimum fork length = 24 cm

Maximum fork length = 24 cm

Average fullness = 6.00

Standard deviation of fullness = 0

Minimum fullness = 6

Maximum fullness = 6

Wattled Eelpout

Wattled eelpout (*Lycodes palearis*) are found throughout the Gulf of Alaska and are typically encountered at depths of less than 150 m. They reach a maximum size of approximately 50 cm (Mecklenburg et al. 2002). Eelpouts are not targeted as commercial species; however, there has been a small amount of bycatch in flatfish and rockfish trawl fisheries. Estimated catch of eelpouts (not identified to species) from the fisheries in the Gulf of Alaska in 1998 was 4.6 t (Gaichas et al. 1999).

General Diet

Table 21 lists the total number of stomachs containing food, the total empty stomachs, the mean percent frequency of occurrence and mean percent by weight of the prey items of wattled eelpout collected in the Gulf of Alaska in 2001. Shortfin eelpout (*Lycodes brevipes*) was the most important prey of wattled eelpout, in terms of the percentage of the total stomach contents weight. It comprised 92% of the total prey weight. Crangonid shrimp (*Argis* spp.) was the other prey of wattled eelpout. It comprised 8% of the total stomach contents weight.

Slipp and DeLacy (1952) found that clams and shrimp were important prey items of wattled eelpout in Puget Sound. Crustaceans and polychaetes comprised the majority of the

diet of wattled eelpout in the Bering Sea (Brodeur and Livingston 1988). Tanner crabs (*Chionoecetes bairdi*) and snow crabs (*C. opilio*) were also important in the diet of wattled eelpouts in the Bering Sea, but this was not seen in the current study. Lang et al. (2003) found similar results to Brodeur and Livingston (1988). The differences between this study and earlier studies may be attributed to the small sample size ($n = 2$) of this study. Larger sample sizes with a wider geographic area would be necessary for future diet studies of the wattled eelpout in the Gulf of Alaska.

Table 21.--Prey items (expressed in mean percent frequency of occurrence, and mean percent total weight) of *Lycodes palearis* (wattled eelpout) collected in the Gulf of Alaska in 2001.

Prey items	Percent frequency	Percent weight
<i>Argis</i> sp. (shrimp)	50.00	7.94
<i>Lycodes brevipes</i> (shortfin eelpout)	50.00	92.06

Total non-empty stomachs = 2

Total prey number = 2

Total prey weight = 4.661 g

Total empty stomachs = 1

Number of hauls = 1

Full stomach summary statistics

Average fork length = 38.50 cm

Standard deviation of fork length = 2.12 cm

Minimum fork length = 37 cm

Maximum fork length = 40 cm

Average fullness = 4.00

Standard deviation of fullness = 0

Minimum fullness = 4

Maximum fullness = 4

Empty stomach summary statistics

Average fork length = 42.00 cm

Standard deviation of fork length = 0 cm

Minimum fork length = 42 cm

Maximum fork length = 42 cm

Giant Grenadier

Giant grenadiers (*Coryphaenoides pectoralis*) are the largest of all grenadier species and their length reach 150 cm total length (Mecklenburg et al. 2002). They are most often encountered at depths greater than 200 m (Iwamoto and Stein 1974) and are commonly observed as bycatch in various fisheries (including sablefish, flatfish, and rockfish) in the Gulf of Alaska. Giant grenadier had a biomass of 386,312 t in the Gulf of Alaska in 1999. Estimated bycatch of grenadiers in the Gulf of Alaska in 1998 was 14.5 t (Gaichas et al. 1999).

General Diet

Table 22 lists the total number of stomachs containing food, the total empty stomachs, the mean percent frequency of occurrence and mean percent by weight of the prey items of giant grenadier collected in the Gulf of Alaska in 2001. Squid and pasiphaeid shrimp were the most common prey items; they comprised 32% and 22% of mean percent total weight, respectively). Other invertebrate prey items included octopi, other shrimp, mysids, and euphausiids. Prey fish consumed included walleye pollock, deepsea smelts, and scorpaenid.

In this study, squid and shrimp were the most important food of giant grenadier. Earlier studies of grenadier in different areas showed some similarities. Brodeur and Livingston (1988) examined grenadier stomachs from the eastern Bering Sea and found that eelpouts and unidentified teleosts were the main food of giant grenadier. Drazen et al. (2001) reported that giant grenadier on the West Coast of the United States ate squid, myctophids, bathylagids, and Pacific viperfish. Yang (2003) found that myctophids and squid were the most important prey items for giant grenadier in the Aleutian Islands region; they comprised 47% and 45% of the total prey weight, respectively.

Table 22.--Prey items (expressed in mean percent frequency of occurrence, and mean percent total weight) of *Coryphaenoides pectoralis* (giant grenadier) collected in the Gulf of Alaska in 2001.

Prey items	Percent frequency	Percent weight
Cephalopoda (squid and octopus)	4.55	0.16
Teuthida (squid)	42.42	32.09
Octopoda (octopus)	18.18	6.04
Mysida (mysid)	16.67	4.13
<i>Euphausia pacifica</i> (euphausiid)	8.33	1.90
<i>Pasiphaea pacifica</i> (shrimp)	9.09	22.13
Hippolytidae (shrimp)	4.55	2.41
Pandalidae (shrimp)	4.55	4.21
<i>Argis dentata</i> (shrimp)	16.67	8.97
Teleostei (fish)	4.55	0.80
Bathylagidae (deepsea smelts)	4.55	0.86
<i>Theragra chalcogramma</i> (walleye pollock)	8.33	4.03
Scorpaenidae	4.55	12.29

Total non-empty stomachs = 17

Total prey number = 42

Total prey weight = 18.305 g

Total empty stomachs = 8

Number of hauls = 2

Full stomach summary statistics

Average fork length = 31.15 cm

Standard deviation of fork length = .70 cm

Minimum fork length = 27 cm

Maximum fork length = 35 cm

Average fullness = 2.50

Standard deviation of fullness = .06

Minimum fullness = 2

Maximum fullness = 4

Empty stomach summary statistics

Average fork length = 30.88 cm

Standard deviation of fork length = 3.36 cm

Minimum fork length = 26 cm

Maximum fork length = 35 cm

Rougheye Rockfish

Rougheye rockfish (*Sebastes aleutianus*) is an important commercial species in the Gulf of Alaska. It had an exploitable biomass of 40,281 t in the Gulf of Alaska in 2004 (Clausen et al. 2004). The reported catch of rougheye rockfish has been combined with shortraker rockfish (*Sebastes borealis*) since 1994. Total catch of these two species in the Gulf of Alaska in 2004 was 973 t (Clausen et al. 2004).

General Diet

Table 23 lists the total number of stomachs containing food, the total number of empty stomachs, the mean percent frequency of occurrence and mean percent by weight of the prey items of rougheye rockfish collected in the Gulf of Alaska in 2001. Pandalid shrimp and euphausiids were the most common prey items; they comprised 26% and 22% of mean percent total weight, respectively. Tanner crab (*Chionoecetes bairdi*), comprising 13% of mean percent total prey weight, was also a significant portion of the diet. Other prey items included octopi, calanoid copepods, and other shrimp species.

In an earlier study Yang and Nelson (2000) found that shrimp was the main food of rougheye rockfish in the Gulf of Alaska. The most noticeable difference is that

consumption of fish prey was much lower in 2001 (1%) by percent weight than in 1990 (18%) and 1993 (13%).

Additionally, roughey rockfish consumed a greater amount (by weight) of Tanner crab in 2001 (13%) than those in 1990 (5%) and 1993 (1%).

Table 23.--Prey items (expressed in mean percent frequency of occurrence, and mean percent total weight) of *Sebastes aleutianus* (rougheye rockfish) collected in the Gulf of Alaska in 2001.

Prey items	Percent frequency	Percent weight
Octopoda (octopus)	3.33	7.66
Crustacea	5.56	0.05
Large calanoid (copepod) > 5mm	16.67	6.23
Medium calanoid (copepod) 2-5mm	5.56	0.18
Mysida (mysid)	5.56	0.09
Cumacea (cumacean)	7.41	0.12
Gammaridea (amphipod)	12.22	2.85
Hyperidea (amphipod)	5.56	0.18
Euphausiacea (euphausiid)	3.33	0.27
Euphausiidae (euphausiid)	11.11	4.03
<i>Thysanoessa inermis</i> (euphausiid)	11.11	17.95
Caridea (shrimp)	8.89	0.80
Hippolytidae (shrimp)	3.70	0.96
Pandalidae (shrimp)	19.63	19.32
<i>Pandalus borealis</i> (shrimp)	3.70	1.91
<i>Pandalus goniurus</i> (shrimp)	3.70	4.67
Crangonidae (shrimp)	5.56	0.18
<i>Crangon</i> sp. (shrimp)	3.70	0.83
<i>Argis</i> sp. (shrimp)	3.70	2.94
Paguridae (hermit crab)	3.70	0.93
<i>Chionoecetes</i> sp. (snow and Tanner crab)	3.70	4.35
<i>Chionoecetes bairdi</i> (Tanner crab)	3.70	8.54
Chaetognatha (arrow worm)	16.67	3.24
Teleostei (fish)	10.37	0.81
Unidentified organic material	10.37	10.88

Total non-empty stomachs = 25

Total prey number = 97

Total prey weight = 45.015 g

Total empty stomachs = 11

Number of hauls = 3

Full stomach summary statistics

Average fork length = 34.10 cm

Standard deviation of fork length = 2.88 cm

Minimum fork length = 16 cm

Maximum fork length = 78 cm

Average fullness = 2.67

Standard deviation of fullness = .54

Minimum fullness = 2

Maximum fullness = 6

Empty stomach summary statistics

Average fork length = 39.91 cm

Standard deviation of fork length = 9.33 cm

Minimum fork length = 18 cm

Maximum fork length = 47 cm

Pacific Ocean Perch

Pacific ocean perch (*Sebastes alutus*) is an important commercial species in the Gulf of Alaska. It had an exploitable biomass of 286,367 t in the Gulf of Alaska in 2004 (Hanselman et al. 2004). The reported catch of Pacific ocean perch in the Gulf of Alaska in 2004 was 11,518 t. Earlier study shows that Pacific ocean perch is mainly a zooplankton feeder. Their food includes calanoid copepod, euphausiids, and miscellaneous prey (Yang 2003).

General Diet

Table 24 lists the total number of stomachs containing food, the total number of empty stomachs, the mean percent frequency of occurrence and mean percent by weight of the prey items of Pacific ocean perch collected in the Gulf of Alaska in 2001. Euphausiids, larvaceans, and copepods were the most common prey items; they comprised 41%, 24%, and 21% of the total stomach contents weight, respectively. Other prey items included octopi, hyperiid amphipods, and shrimp.

Yang (2003) found that calanoid copepods and euphausiids were the most important prey of Pacific ocean perch in the Aleutian Islands region in 1994 and 1997. He also noticed that a large amount of myctophids were consumed by Pacific ocean perch in those 2 years (11% and

12% by weight, respectively). The current study also shows the importance of zooplankton in the diet of Pacific ocean perch. However, fish were not a common prey item in this study.

Table 24.--Prey items (expressed in mean percent frequency of occurrence, and mean percent total weight) of *Sebastes alutus* (Pacific ocean perch) collected in the Gulf of Alaska in 2001.

Prey items	Percent frequency	Percent weight
Thecosomata (pteropod)	3.03	0.45
Teuthida (squid)	2.22	0.15
Octopoda (octopus)	3.03	2.62
Copepoda	5.13	2.76
Calanoida (copepod)	11.19	3.24
Large calanoid (copepod) > 5mm	35.56	10.12
Medium calanoid (copepod) 2-5mm	11.45	0.07
Small calanoid (copepod) < 2mm	23.08	4.39
Mysida (mysid)	4.44	0.01
Gammaridea (amphipod)	2.22	0.01
Hyperidea (amphipod)	24.65	5.08
Euphausiacea (euphausiid)	6.06	18.79
Euphausiidae (euphausiid)	13.33	11.81
<i>Thysanoessa</i> sp. (euphausiid)	17.78	3.95
<i>Thysanoessa inermis</i> (euphausiid)	24.44	6.23
<i>Thysanoessa longipes</i> (euphausiid)	2.22	0.01
Natantia (shrimp)	4.44	0.00
Caridea (shrimp)	14.95	2.72
Hippolytidae (shrimp)	2.22	0.01
Pandalidae (shrimp)	6.06	2.66
Chaetognatha (arrow worm)	17.78	0.84
Copelata (larvacea)	20.17	23.69
Teleostei (fish)	3.03	0.32
<i>Protomyctophum thompsoni</i> (bigeye lanternfish)	2.22	0.07

Total non-empty stomachs = 39

Total prey number = 5353

Total prey weight = 139.182 g

Total empty stomachs = 11

Number of hauls = 3

Full stomach summary statistics

Average fork length = 29.70 cm

Standard deviation of fork length = 1.73 cm

Minimum fork length = 10 cm

Maximum fork length = 40 cm

Average fullness = 3.33

Standard deviation of fullness = .24

Minimum fullness = 2

Maximum fullness = 6

Empty stomach summary statistics

Average fork length = 25.55 cm

Standard deviation of fork length = 10.74 cm

Minimum fork length = 9 cm

Maximum fork length = 39 cm

Redbanded Rockfish

Redbanded rockfish (*Sebastes babcocki*) are distributed from the Bering Sea, Aleutian Islands, south to Southern California (Mecklenburg et al. 2002). It had an exploitable biomass of 6,897 t in the Gulf of Alaska in 2004 (Clausen et al. 2004). The catch of redbanded rockfish in the Gulf of Alaska in 2002 was 35 t (Heifetz et al. 2002).

General Diet

Table 25 shows the total number of stomachs containing food, the total empty stomachs, the mean percent frequency of occurrence and mean percent by weight of the prey items of redbanded rockfish collected in the Gulf of Alaska in 2001. Copepods (mainly *Calanus* spp.) and isopods were the most common prey items of redbanded rockfish. They comprised 50% and 49% of the total stomach contents weight, respectively. Euphausiids were also food of redbanded rockfish; however, they comprised only 1% of the total stomach contents weight.

The current study suggests that redbanded rockfish eat both benthic (e.g., isopods) and pelagic (e.g., copepods and euphausiids) prey. It should be noted, however, that these results are from a sample of only three stomachs.

Larger sample size is needed for future study of the diet of redbanded rockfish in the Gulf of Alaska.

Table 25.--Prey items (expressed in mean percent frequency of occurrence, and mean percent total weight) of *Sebastes babcocki* (redbanded rockfish) collected in the Gulf of Alaska in 2001.

Prey items	Percent frequency	Percent weight
<i>Calanus</i> spp.	50.00	50.00
Isopoda (isopod)	100.00	49.35
<i>Thysanoessa</i> spp. (euphausiid)	50.00	0.65

Total non-empty stomachs = 3

Total prey number = 105

Total prey weight = 4.434 g

Total empty stomachs = 1

Number of hauls = 2

Full stomach summary statistics

Average fork length = 21.00 cm

Standard deviation of fork length = 1.00 cm

Minimum fork length = 20 cm

Maximum fork length = 22 cm

Average fullness = 3.67

Standard deviation of fullness = 1.15

Minimum fullness = 3

Maximum fullness = 5

Empty stomach summary statistics

Average fork length = 23.00 cm

Standard deviation of fork length = 0 cm

Minimum fork length = 23 cm

Maximum fork length = 23 cm

Shortraker Rockfish

Shortraker rockfish (*Sebastes borealis*) are distributed from the Bering Sea, Aleutian Islands region, to Southern California (Mecklenburg et al. 2002). It had an exploitable biomass of 32,723 t in the Gulf of Alaska in 2004. The reported catch of shortraker rockfish has been combined with rougheye rockfish (*Sebastes aleutianus*) since 1994 (Clausen et al. 2004). Total catch of these two species in the Gulf of Alaska in 2004 was 973 t. An earlier study showed that shortraker rockfish fed on squid, shrimp, mysids, bathylagids, and myctophids (Yang and Nelson 2000).

General Diet

Tables 26 and 27 show the total number of stomachs containing food, the total empty stomachs, the mean percent frequency of occurrence and mean percent by weight of the prey items of shortraker rockfish collected in the Gulf of Alaska in 1999 and 2001, respectively. In 1999, only one shortraker rockfish was examined; the prey consumed by the fish was made up non-gadoid fish remains. However, in 2001 a wide variety of prey was eaten. Shrimp was the most important food of shortraker rockfish. It accounted for 44% of the total stomach contents weight. Myctophids were the most common fish prey item. They comprised 30% of the

total prey weight. Squid (comprising 16% by weight) were also important food of shortraker rockfish.

Yang and Nelson (2000) found varying results between years in their examination of shortraker rockfish diet in the Gulf of Alaska. In 1990, only squid and myctophids were found in the stomachs. In 1993, more prey items were found in the stomachs of shortraker rockfish. They included cephalopod, mysids, pandalid shrimp, and bathylagids. In contrast, the diet of shortraker rockfish in 2001 was much more diversified. It included 18 different prey items with shrimp and myctophids as the most important prey.

Table 26.--Prey items (expressed in mean percent frequency of occurrence, and mean percent total weight) of *Sebastes borealis* (shortraker rockfish) collected in the Gulf of Alaska in 1999.

Prey items	Percent frequency	Percent weight
Non-gadoid fish remains	100.00	100.00

Total non-empty stomachs = 1

Total prey number = 1

Total prey weight = 3.46 g

Total empty stomachs = 40

Number of hauls = 1

Full stomach summary statistics

Average fork length = 42.00 cm

Standard deviation of fork length = 0 cm

Minimum fork length = 42 cm

Maximum fork length = 42 cm

Average fullness = 4.00

Standard deviation of fullness = 0

Minimum fullness = 4

Maximum fullness = 4

Empty stomach summary statistics

Average fork length = 50.25 cm

Standard deviation of fork length = 8.91 cm

Minimum fork length = 37 cm

Maximum fork length = 85 cm

Table 27.--Prey items (expressed in mean percent frequency of occurrence, and mean percent total weight) of *Sebastes borealis* (shortraker rockfish) collected in the Gulf of Alaska in 2001.

Prey items	Percent frequency	Percent weight
Cephalopoda (squid and octopus)	8.33	0.84
Teuthida (squid)	19.70	15.76
<i>Gnathophausia gigas</i> (mysid)	3.33	0.23
Mysida (mysid)	29.39	1.41
Gammaridea (amphipod)	4.85	0.09
Hyperidea (amphipod)	3.03	0.03
Euphausiidae (euphausiid)	1.52	0.02
Natantia (shrimp)	1.52	0.03
Caridea (shrimp)	25.00	17.50
Oplophoridae (shrimp)	1.52	1.96
<i>Pasiphaea</i> sp. (glass shrimp)	28.48	23.75
Hippolytidae (shrimp)	3.03	0.37
Pandalidae (shrimp)	8.33	0.80
Bathylagidae (deepsea smelts)	1.52	0.08
Myctophidae (lanternfish)	19.70	13.93
<i>Stenobranchius nannochir</i> (garnet myctophid)	16.67	16.27
Agonidae (poacher)	1.52	0.07
Unidentified organic material	8.33	6.86

Total non-empty stomachs = 22

Total prey number = 44

Total prey weight = 108.486 g

Total empty stomachs = 24

Number of hauls = 6

Full stomach summary statistics

Average fork length = 54.50 cm

Standard deviation of fork length = 1.61 cm

Minimum fork length = 43 cm

Maximum fork length = 61 cm

Average fullness = 2.83

Standard deviation of fullness = .40

Minimum fullness = 2

Maximum fullness = 5

Empty stomach summary statistics

Average fork length = 51.75 cm

Standard deviation of fork length = 7.70 cm

Minimum fork length = 39 cm

Maximum fork length = 72 cm

Dusky Rockfish

The dusky rockfish (*Sebastes ciliatus*) has been considered a single variable species with light and dark forms. Orr and Blackburn (2004) resurrected *Sebastes variabilis* (Pallas) and used dusky rockfish as its common name. They redescribed *Sebastes ciliatus* (Tilesius) and called it dark rockfish. In this study, dusky rockfish (*Sebastes variabilis*) were collected and studied. It had an exploitable biomass of 70,862 t in the Gulf of Alaska in 2003 (Lunsford et al. 2004). The reported catch of dusky rockfish in the Gulf of Alaska in 2004 was 2,651 t.

General Diet

Table 28 lists the total number of stomachs containing food, the total number of empty stomachs, the mean percent frequency of occurrence and mean percent by weight of the prey items of dusky rockfish collected in the Gulf of Alaska in 2001. Pacific sand lance and euphausiids were the most common prey items of dusky rockfish. They comprised 82% and 17% of the total stomach contents weight, respectively. A small amount of copepods were also food of dusky rockfish.

Yang's (1993) earlier diet study of *Sebastes ciliatus* found that euphausiids were the most important food (69% by weight) of *S. ciliatus*. Other food items included:

larvaceans, cephalopods, calanoid copepods, arrow worms,
gammarid amphipods, and shrimp.

Table 28.--Prey items (expressed in mean percent frequency of occurrence, and mean percent Total weight) of *Sebastes variabilis* (dusky rockfish) collected in the Gulf of Alaska in 2001.

Prey items	Percent frequency	Percent weight
Large calanoid (copepod) > 5mm	100.00	1.15
Euphausiidae (euphausiid)	100.00	3.45
<i>Thysanoessa inermis</i> (euphausiid)	100.00	13.79
<i>Ammodytes hexapterus</i> (Pacific sand lance)	100.00	81.61

Total non-empty stomachs = 1

Total prey number = 4

Total prey weight = 0.87 g

Total empty stomachs = 0

Number of hauls = 1

Full stomach summary statistics

Average fork length = 39.00 cm

Standard deviation of fork length = 0 cm

Minimum fork length = 39 cm

Maximum fork length = 39 cm

Average fullness = 3.00

Standard deviation of fullness = 0

Minimum fullness = 3

Maximum fullness = 3

Sharpchin Rockfish

Sharpchin rockfish (*Sebastes zacentrus*) had an exploitable biomass of 20,698 t in the Gulf of Alaska in 2004 (Clausen et al. 2004). Sharpchin rockfish is one of the species classified in the "shortraker/rougheye rockfish and other slope rockfish" management group in the Gulf of Alaska. Since 1992, this species has ranked second in abundance among "other slope rockfish" species found in commercial catches in the Gulf of Alaska, behind only harlequin rockfish (*Sebastes variegatus*) (Clausen et al. 2003). Sharpchin rockfish and other species comprising the "other slope rockfish" group are caught predominately in the trawl fishery and not the longline fishery. The avoidance of the longline bait suggests that this species has a diet consisting primarily of plankton. It is important to study the food habits of sharpchin rockfish because it is a commercially valuable species in the Gulf of Alaska.

General Diet

Tables 29 and 30 show the total number of full stomachs, the total number of empty stomachs, the minimum and maximum fork length, average fork length, the minimum and maximum stomach fullness, the average fullness, the mean percent frequency of occurrence, and the mean percent

total weight of the prey items of sharpchin rockfish in the Gulf of Alaska in 1999 and 2001, respectively. In 1999, calanoid copepods were the most abundant prey item for sharpchin rockfish, comprising 76% (by weight) of the stomach contents. Euphausiids were the second most abundant prey item in 1999, comprising 18% (by weight) of the total stomach contents. In 2001, the shrimp *Pandalus borealis* was the most abundant prey item, comprising 50% (by weight) of the stomach contents. Euphausiids were also a major component of the sharpchin rockfish's diet in 2001, accounting for 45% by weight of the stomach contents. Pteropods, amphipods, ostracods, and hermit crabs were also consumed by sharpchin rockfish.

The percent frequency of occurrence and percent by weight of prey items of the sharpchin rockfish varied from 1999 to 2001. The shrimp *Pandalus borealis* was the most abundant prey item by percent weight found in stomachs in 2001, but it was not found in any sharpchin rockfish stomach samples in 1999. Calanoid copepods were found in every sharpchin rockfish stomach analyzed in 1999 and were also found in the highest percent by weight, but made up less than 1% by weight of the prey items found in sharpchin rockfish in 2001. The variation between the food habits of

sharpchin rockfish between 1999 and 2001 could be attributed to the small sample sizes of stomachs analyzed.

Table 29.--Prey items (expressed in mean percent frequency of occurrence, and mean percent total weight) of *Sebastes zacentrus* (sharpchin rockfish) collected in the Gulf of Alaska in 1999.

Prey items	Percent frequency	Percent weight
Pteropoda	50.00	2.52
Ostracoda	16.67	0.38
Calanoida (copepod)	100.00	76.40
<i>Themisto</i> sp. (amphipod)	66.67	2.35
Euphausiacea (euphausiid)	33.33	17.87
Paguridae (hermit crab)	16.67	.47

Total non-empty stomachs = 6

Total prey number = 26

Total prey weight = 2.339 g

Total empty stomachs = 0

Number of hauls = 1

Full stomach summary statistics

Average fork length = 23.67 cm

Standard deviation of fork length = 3.08 cm

Minimum fork length = 19 cm

Maximum fork length = 27 cm

Average fullness = 4.33

Standard deviation of fullness = 1.21

Minimum fullness = 3

Maximum fullness = 6

Table 30.--Prey items (expressed in mean percent frequency of occurrence, and mean percent total weight) of *Sebastes zacentrus* (sharpchin rockfish) collected in the Gulf of Alaska in 2001.

Prey items	Percent frequency	Percent weight
Pteropoda	25.00	0.34
Calanoida (copepod)	16.67	0.20
Euphausiidae (euphausiid)	50.00	45.41
Caridea (shrimp)	8.33	4.05
<i>Pandalus borealis</i> (shrimp)	50.00	50.00

Total non-empty stomachs = 7

Total prey number = 18

Total prey weight = 8.53 g

Total empty stomachs = 11

Number of hauls = 2

Full stomach summary statistics

Average fork length = 29.00 cm

Standard deviation of fork length = 2.16 cm

Minimum fork length = 25 cm

Maximum fork length = 32 cm

Average fullness = 4.43

Standard deviation of fullness = 1.27

Minimum fullness = 3

Maximum fullness = 6

Empty stomach summary statistics

Average fork length = 25.27 cm

Standard deviation of fork length = 3.74 cm

Minimum fork length = 19 cm

Maximum fork length = 33 cm

Shortspine Thornyhead

Shortspine thornyhead (*Sebastolobus alascanus*) had an estimated exploitable biomass of 86,200 t in the Gulf of Alaska in 2004 (Gaichas and Ianelli 2004). Shortspine thornyheads are a commercially important rockfish in both the trawl and longline fisheries in the Gulf of Alaska, with most of the domestic catch exported to Japan (Gaichas and Ianelli 2002). The total catch for shortspine thornyhead in 2004 was 805 t. Previous stomach analyses show that shortspine thornyhead diet consists of a variety of crustaceans, mollusks, and fish (Yang and Nelson 2000). The commercial value of shortspine thornyhead, and its role as a potential predator on commercially valuable crab and fish, makes it important to understand its food habits in the Gulf of Alaska.

General Diet

Table 31 shows the total number of full stomachs, the total number of empty stomachs, the minimum and maximum fork length, average fork length, the minimum and maximum stomach fullness, the average fullness, the mean percent frequency of occurrence, and the mean percent total weight of the prey items of shortspine thornyhead in 2001 in the Gulf of Alaska. Fish (shortspine thornyhead, zoarcids, gadids, and myctophids), comprising 35% by weight, were the

most abundant prey found in the stomachs of shortspine thornyhead. The decorator crab *Chorilia longipes* represented 30% by weight of the diet. Euphausiids (16% by weight) and shrimp (9% by weight) were also integral components of the shortspine thornyhead stomach contents. Polychaetes, larvaceans, octopus, amphipods, mysids, chaetognaths, isopods, and copepods, were also consumed by shortspine thornyheads.

Shrimp (mostly pandalids) were the most abundant prey by percent weight found in shortspine thornyhead stomachs in 1990 and 1993 (Yang and Nelson 2000). However, in 2001, fish and decorator crabs were the most abundant prey, while shrimp comprised less than 10% of their diet by percent weight. In the Aleutian Islands, Yang (2003) found that fish was the shortspine thornyhead's most important prey (44% by weight). Of the fish species consumed by shortspine thornyhead in 2001, shortspine thornyhead was most abundant by percent weight. However, this does not suggest that cannibalism is common among shortspine thornyhead since no instances of cannibalism were recorded in 1990 or 1993 in the Gulf of Alaska, and no cannibalism was observed in the 1994 Aleutian Islands survey. Euphausiids were an important prey for shortspine thornyheads in 2001, but were only a small part of the diet

(3% by weight) in 1993, and were not found at all in stomachs in 1990. The variations in the diets between the different years discussed can be attributed to the smaller sample size in the 2001 survey. A total of 81 and 147 full stomachs were analyzed in 1990 and 1993, respectively, compared to only 27 full stomachs analyzed in 2001. Also, stomachs were only analyzed from three hauls in 2001, compared to 11 and 24 hauls in 1990 and 1993, respectively.

Table 31.--Prey items (expressed in mean percent frequency of occurrence, and mean percent total weight) of *Sebastolobus alascanus* (shortspine thornyhead) collected in the Gulf of Alaska in 2001.

Prey items	Percent frequency	Percent weight
Polychaeta (worm)	7.14	0.60
Aphroditidae (sea mouse)	2.38	0.71
Onuphidae (polychaete)	2.38	0.88
Octopoda (octopus)	2.38	1.07
Large calanoid (copepod) > 5mm	4.76	0.02
Medium calanoid (copepod) 2-5mm	2.38	0.00
Mysida (mysid)	26.35	0.51
<i>Pseudomma</i> sp. (mysid)	4.76	0.06
Isopoda (isopod)	4.76	0.19
Gammaridea (amphipod)	25.40	0.66
Caprellidae (amphipod)	2.38	0.02
Euphausiacea (euphausiid)	3.33	0.11
Euphausiidae (euphausiid)	11.90	0.25
<i>Thysanoessa</i> sp. (euphausiid)	30.95	12.58
<i>Thysanoessa inermis</i> (euphausiid)	4.76	0.88
Natantia (shrimp)	2.38	0.01
Caridea (shrimp)	7.14	3.92
<i>Eualus</i> sp. (shrimp)	2.38	0.30
Pandalidae (shrimp)	11.43	0.55
<i>Pandalus</i> spp. (shrimp)	2.38	2.12
Crangonidae (shrimp)	4.76	0.56
<i>Crangon</i> sp. (shrimp)	7.14	1.50
<i>Argis ovifer</i> (shrimp)	2.38	0.47
Paguridae (hermit crab)	3.33	2.01
Majidae (spider crab)	3.33	0.30
<i>Chorilia longipes</i> (decorator crab)	13.49	30.41
Chaetognatha (arrow worm)	4.76	0.52
Copelata (larvacea)	3.33	1.20
Teleostei (fish)	3.33	0.02
Non-gadoid fish remains	6.67	0.93
Myctophidae (lanternfish)	3.33	0.79
Gadidae (gadid fish)	11.11	0.37
Zoarcidae (eelpout)	3.33	8.49
<i>Sebastolobus alascanus</i> (shortspine thornyhead)	3.33	15.73
Unidentified organic material	3.33	0.25
Unidentified tube	2.38	0.02

Table 31.--Continued.

Total non-empty stomachs = 27

Total prey number = 198

Total prey weight = 40.267 g

Total empty stomachs = 14

Number of hauls = 3

Full stomach summary statistics

Average fork length = 25.67 cm

Standard deviation of fork length = 1.69 cm

Minimum fork length = 15 cm

Maximum fork length = 39 cm

Average fullness = 3.33

Standard deviation of fullness = .35

Minimum fullness = 2

Maximum fullness = 6

Empty stomach summary statistics

Average fork length = 24.93 cm

Standard deviation of fork length = 7.38 cm

Minimum fork length = 16 cm

Maximum fork length = 39 cm

Atka Mackerel

Atka mackerel (*Pleurogrammus monopterygius*) is an important food source for marine birds, predatory fish, and marine mammals, including the endangered Steller sea lion (Yang 1999). There are no reliable estimates of the current biomass of Atka mackerel due to high variability in survey estimates. In 1996 the estimated biomass of Atka mackerel in the Gulf of Alaska was 345,990 t (Martin 1997). However, over 98% of the catch came from one haul within a large stratum (Lowe and Lauth 2003). This led to a large stratum biomass with a large confidence interval. Several factors make it difficult to determine biomass of Atka mackerel. First, they lack a swim bladder, making it difficult to conduct hydroacoustic surveys for them. Second, the preferred habitat of Atka mackerel is hard, rough, rocky substrates that are not ideal for bottom trawl surveys. Finally, the schooling behavior and patchy distribution of Atka mackerel lead to large variances in catch data (Lowe and Lauth 2003).

It is important to understand the food habits of Atka mackerel in the Gulf of Alaska because it is a commercially valuable species. The total catch of Atka mackerel in the Gulf of Alaska in 2004 was 817 t, exceeding the total allowable catch for the first time since the quotas were

implemented in 1998 (Lowe and Lauth 2004). Also, Atka mackerel were found as prey in the stomachs of Pacific cod and arrowtooth flounder, both commercially important fish species (Yang and Nelson 2000).

General Diet

Tables 32 and 33 show the total number of full stomachs, the total number of empty stomachs, the minimum and maximum fork length, average fork length, the minimum and maximum stomach fullness, the average fullness, the mean percent frequency of occurrence, and the mean percent total weight of the prey items of Atka mackerel in the Gulf of Alaska in 1999 and 2001, respectively. Euphausiids were the dominant food item found in the stomachs of Atka mackerel in 1999 and 2001, comprising 66% and 67% by weight, respectively. Larvaceans (15% by weight in 1999 and 2001) were the second most abundant prey item. In 1999, fish (sculpin and Pacific halibut) made up less than 1% of the diet by weight; however, in 2001, fish (Pacific sand lance) made up over 14% of the diet by weight. Atka mackerel consumed less than 1% by weight of crab (hermit and atelecyclid) in 2001, but no crab were found in the samples from 1999. Other prey items consumed by Atka mackerel were gastropods, jellyfish, pteropods, copepods, amphipods, isopods, and shrimp.

In the 1996 study of Atka mackerel food habits in the Gulf of Alaska, the major prey was copepods (64% by weight) (Yang and Nelson 2000). However, in the current studies, euphausiids were the most abundant prey item, while copepods comprised less than 1% by weight. In the Aleutian Islands region, Yang (2003) found copepods and euphausiids to be the most important prey for Atka mackerel. Fish (primarily Pacific sand lance) was a more important part of the diet of Atka mackerel in 2001 (14% by weight) compared with 1996 and 1999 when, in both years, it made up less than 1% by weight of the prey. Similarly, in the eastern Bering Sea, fish (primarily walleye pollock) was the most important food of Atka mackerel representing 53% by weight of the diet (Brodeur and Livingston 1988). In 1996 and 1999, gastropods were the most frequently encountered prey item in the stomachs of Atka mackerel, 71% frequency of occurrence and 43% frequency of occurrence, respectively; however, in 2001, gastropods were found less frequently (11% frequency of occurrence). The variations in the diets from the different years could be attributed to the patchy distribution of Atka mackerel, and the different areas that the samples were collected from.

Table 32.--Prey items (expressed in mean percent frequency of occurrence, and mean percent total weight) of *Pleurogrammus monopterygius* (Atka mackerel) collected in the Gulf of Alaska in 1999.

Prey items	Percent frequency	Percent weight
Cnidaria	4.76	0.18
Gastropoda (snail)	42.86	5.96
Gymnosomata (pteropod)	23.81	8.48
<i>Clione limacina</i> (pteropod)	4.76	0.44
Calanoida (copepod)	9.52	0.19
Isopoda (isopod)	4.76	3.43
Euphausiacea (euphausiid)	38.10	20.24
<i>Thysanoessa</i> sp. (euphausiid)	4.76	7.14
<i>Thysanoessa inermis</i> (euphausiid)	26.19	38.60
Caridea (shrimp)	7.14	0.01
Copelata (larvacea)	19.05	14.50
Teleostei (fish)	7.14	0.24
Cottoidei (sculpin)	4.76	0.01
<i>Hippoglossus stenolepis</i> (Pacific halibut)	4.76	0.58

Total non-empty stomachs = 13

Total prey number = 49

Total prey weight = 61.291 g

Total empty stomachs = 18

Number of hauls = 7

Full stomach summary statistics

Average fork length = 46.76 cm

Standard deviation of fork length = .83 cm

Minimum fork length = 37 cm

Maximum fork length = 51 cm

Average fullness = 4.00

Standard deviation of fullness = .71

Minimum fullness = 2

Maximum fullness = 7

Empty stomach summary statistics

Average fork length = 47.67 cm

Standard deviation of fork length = 3.58 cm

Minimum fork length = 40 cm

Maximum fork length = 52 cm

Table 33.--Prey items (expressed in mean percent frequency of occurrence, and mean percent total weight) of *Pleurogrammus monopterygius* (Atka mackerel) collected in the Gulf of Alaska in 2001.

Prey items	Percent frequency	Percent weight
Gastropoda (snail)	10.63	0.05
Bivalvia (clam)	1.04	0.01
Cephalopoda (squid and octopus)	16.67	1.72
Calanoida (copepod)	28.54	0.73
Hyperideida (amphipod)	3.33	0.00
Euphausiacea (euphausiid)	16.67	2.65
Euphausiidae (euphausiid)	96.74	56.05
<i>Euphausia pacifica</i> (euphausiid)	5.56	0.22
<i>Thysanoessa</i> sp. (euphausiid)	5.56	0.69
<i>Thysanoessa inermis</i> (euphausiid)	16.67	8.10
Reptantia (crab)	16.67	0.05
Paguridae (hermit crab)	8.33	0.04
Atelecyclidae (crab)	8.33	0.11
Copelata (larvacea)	38.96	15.08
Teleostei (fish)	8.33	0.03
<i>Ammodytes hexapterus</i> (Pacific sand lance)	16.67	14.46

Total non-empty stomachs = 28

Total prey number = 161

Total prey weight = 231.458 g

Total empty stomachs = 2

Number of hauls = 6

Full stomach summary statistics

Average fork length = 37.33 cm

Standard deviation of fork length = 1.61 cm

Minimum fork length = 28 cm

Maximum fork length = 51 cm

Average fullness = 3.83

Standard deviation of fullness = .30

Minimum fullness = 2

Maximum fullness = 6

Empty stomach summary statistics

Average fork length = 42.00 cm

Standard deviation of fork length = 1.41 cm

Minimum fork length = 41 cm

Maximum fork length = 43 cm

Spinyhead Sculpin

The estimated biomass for all sculpin species in the Gulf of Alaska in 1999 was 30,827 t (Gaichas et al. 1999). Spinyhead sculpin (*Dasycottus setiger*), along with other species of sculpin, are common bycatch in bottom trawls and pot fisheries (Gaichas et al. 1999). Spinyhead sculpin have been found to prey upon fish from food habits studies in the Aleutian Islands (Yang 2003) and near Kamchatka and the Kuril Islands (Tokranov and Orlov (2001). It is important to study the food habits of spinyhead sculpin in the Gulf of Alaska because it is a potential predator on commercially important species of fish, crab, and shrimp.

General Diet

Table 34 lists the total number of full stomachs, the total number of empty stomachs, the minimum and maximum fork length, average fork length, the minimum and maximum stomach fullness, the average fullness, the mean percent frequency of occurrence, and the mean percent total weight of the prey items of spinyhead sculpin in 2001 in the Gulf of Alaska. Shrimp (mainly pandalids) comprised 93% by weight of the diet of spinyhead sculpin in the Gulf of Alaska in 2001. Fish (primarily zoarcids) made up 6% by weight of stomach contents. Mysids and hyperiid amphipods were also consumed by spinyhead sculpin.

Tokranov and Orlov (2001) found that fish (48% by weight) was the most important food of spinyhead sculpin in the waters off southeastern Kamchatka and the northern Kuril Islands. In the Aleutian Islands region, fish (56% by weight) were also found to be the predominant prey for spinyhead sculpin (Yang 2003). In contrast, this study found that shrimp (mainly pandalid) was the most important food of spinyhead sculpin collected in the Gulf of Alaska. Shrimp comprised 93% of the total stomach contents weight; while fish was a much smaller portion of the diet, comprising less than 6% by weight. The small sample sizes, in both the current survey and the Aleutian Islands survey, could contribute to the variation in the food habits of spinyhead sculpin observed for the two regions.

Table 34.--Prey items (expressed in mean percent frequency of occurrence, and mean percent total weight) of *Dasycottus setiger* (spinyhead sculpin) collected in the Gulf of Alaska in 2001.

Prey items	Percent frequency	Percent weight
<i>Pseudomma</i> sp. (mysid)	53.85	1.74
Hyperiidea (amphipod)	7.69	0.00
Natantia (shrimp)	23.08	5.69
Caridea (shrimp)	7.69	0.39
Pandalidae (shrimp)	15.38	29.97
<i>Pandalus borealis</i> (shrimp)	15.38	26.65
<i>Pandalus goniurus</i> (shrimp)	7.69	10.22
Crangonidae (shrimp)	30.77	3.75
<i>Crangon</i> sp. (shrimp)	23.08	7.65
<i>Argis</i> sp. (shrimp)	7.69	8.29
Teleostei (fish)	15.38	0.05
Non-gadoid fish remains	7.69	0.39
Zoarcidae (eelpout)	7.69	5.20

Total non-empty stomachs = 13

Total prey number = 69

Total prey weight = 25.361 g

Total empty stomachs = 1

Number of hauls = 1

Full stomach summary statistics

Average fork length = 17.23 cm

Standard deviation of fork length = 5.26 cm

Minimum fork length = 12 cm

Maximum fork length = 25 cm

Average fullness = 3.85

Standard deviation of fullness = 1.14

Minimum fullness = 2

Maximum fullness = 6

Empty stomach summary statistics

Average fork length = 28.00 cm

Standard deviation of fork length = 0 cm

Minimum fork length = 28 cm

Maximum fork length = 28 cm

Yellow Irish Lord

The estimated biomass of yellow Irish lord (*Hemilepidotus jordani*) in the Gulf of Alaska was 20,220 t in 1999 (Gaichas et al. 1999). Of the individual sculpin species assessed in 1999, yellow Irish lord was the most abundant. Food habit studies from the eastern Bering Sea (Brodeur and Livingston 1988) and from coastal Kamchatka (Tokranov 1995) have found that crab is an important prey in the diet of yellow Irish lord. Because of the high abundance of yellow Irish lord, and its role as a predator of commercially important crabs, it is important to study the food habits of yellow Irish lord in the Gulf of Alaska.

General Diet

Table 35 lists the total number of full stomachs, the total number of empty stomachs, the minimum and maximum fork length, average fork length, the minimum and maximum stomach fullness, the average fullness, the mean percent frequency of occurrence, and the mean percent total weight of the prey items of yellow Irish lord in 2001 in the Gulf of Alaska. Tanner crab (*Chionoecetes bairdi*), comprising 85% by weight, was the most abundant prey of yellow Irish lord in the Gulf of Alaska in 2001. Lyre crab, *Hyas lyratus*, was also consumed, but only comprised 3% (by weight) of the total stomach content. Other prey items

found in the stomachs of yellow Irish lord were copepods and hydrozoa.

Brodeur and Livingston (1988) found fish (40% by weight), hermit crabs (27% by weight), and *Chionoecetes* crabs (11% by weight) were the most important prey for yellow Irish lord in the eastern Bering Sea. In contrast, the current study found yellow Irish lord fed mostly on *Chionoecetes bairdi* (85% by weight), while fish and hermit crabs were absent from the stomach contents from the Gulf of Alaska. Tokranov (1995) found similar results in the coastal waters off Kamchatka, where decapods (42% by weight) were the most abundant food for yellow Irish lord. The small sample size of the current study and the different locations of collection could contribute to the variation between the studies discussed.

Table 35.--Prey items (expressed in mean percent frequency of occurrence, and mean percent total weight) of *Hemilepidotus jordani* (yellow Irish lord) collected in the Gulf of Alaska in 2001.

Prey items	Percent frequency	Percent weight
Hydrozoa	50.00	2.32
Calanoida (copepod)	50.00	10.09
<i>Hyas lyratus</i> (lyre crab)	50.00	2.85
<i>Chionoecetes bairdi</i> (Tanner crab)	50.00	84.73

Total non-empty stomachs = 2

Total prey number = 785

Total prey weight = 40.491 g

Total empty stomachs = 0

Number of hauls = 1

Full stomach summary statistics

Average fork length = 34.00 cm

Standard deviation of fork length = 5.66 cm

Minimum fork length = 30 cm

Maximum fork length = 38 cm

Average fullness = 5.50

Standard deviation of fullness = 0.71

Minimum fullness = 5

Maximum fullness = 6

Bigmouth Sculpin

Bigmouth sculpin (*Hemitripterus bolini*) had an estimated biomass of 3,974 t in 1999 in the Gulf of Alaska (Gaichas et al. 1999). Bigmouth sculpin is a predatory sculpin with an extremely large mouth reaching a length of over 73 cm (Mecklenburg, et al. 2002). Previous studies have shown bigmouth sculpin preyed on commercially important fish in the eastern Bering Sea (Brodeur and Livingston 1988) and in the Aleutian Islands (Yang 2003). It is important to understand the food habits of bigmouth sculpin because it is a potential predator on commercially important fish species in the Gulf of Alaska.

General Diet

Tables 36 and 37 list the total number of full stomachs, the total number of empty stomachs, the minimum and maximum fork length, average fork length, the minimum and maximum stomach fullness, the average fullness, the mean percent frequency of occurrence, and the mean percent total weight of the prey items of bigmouth sculpin in the Gulf of Alaska in 1999 and 2001, respectively. Arrowtooth flounder (*Atheresthes stomias*) was the only prey item found in the single stomach of bigmouth sculpin analyzed in 1999 from the Gulf of Alaska. In 2001, fish (zoarcids and

sculpins) comprised 91% and hermit crab comprised 9% by weight of the total stomach contents, respectively.

Bigmouth sculpin have preyed on commercially valuable fish in both the Aleutian Islands and the eastern Bering Sea. Yang (2003) found the main prey item for bigmouth sculpin in the Aleutian Islands was Atka mackerel (100% by weight), while in the eastern Bering Sea, walleye pollock (71% by weight) was the most abundant prey (Brodeur and Livingston 1988). Brodeur and Livingston (1988) also found Tanner crabs (less than 1%) in the diets of bigmouth sculpin in the eastern Bering Sea. The current study showed that fish (arrowtooth flounder, zoarcids, and cottids) were the most important prey for bigmouth sculpin in the Gulf of Alaska, but no Tanner crabs were found. The small sample size (one stomach in 1999 and two stomachs in 2001) of the current study could contribute to the lack of more commercially important fish and crab found in the stomachs of bigmouth sculpin in the Gulf of Alaska.

Table 36.--Prey items (expressed in mean percent frequency of occurrence, and mean percent total weight) of *Hemitripterus bolini* (bigmouth sculpin) collected in the Gulf of Alaska in 1999.

Prey items	Percent frequency	Percent weight
<i>Atheresthes stomias</i> (arrowtooth flounder)	100.00	100.00

Total non-empty stomachs = 1

Total prey number = 1

Total prey weight = 191.58 g

Total empty stomachs = 0

Number of hauls = 1

Full stomach summary statistics

Average fork length = 64.00 cm

Standard deviation of fork length = 0 cm

Minimum fork length = 64 cm

Maximum fork length = 64 cm

Average fullness = 6.00

Standard deviation of fullness = 0

Minimum fullness = 6

Maximum fullness = 6

Table 37.--Prey items (expressed in mean percent frequency of occurrence, and mean percent total weight) of *Hemitripterus bolini* (bigmouth sculpin) collected in the Gulf of Alaska in 2001.

Prey items	Percent frequency	Percent weight
Paguridae (hermit crab)	50.00	8.59
Zoarcidae (eelpout)	50.00	50.00
Cottoidei (sculpin)	50.00	41.41

Total non-empty stomachs = 2

Total prey number = 3

Total prey weight = 20.468 g

Total empty stomachs = 1

Number of hauls = 2

Full stomach summary statistics

Average fork length = 47.50 cm

Standard deviation of fork length = 38.89 cm

Minimum fork length = 20 cm

Maximum fork length = 75 cm

Average fullness = 4.00

Standard deviation of fullness = 0

Minimum fullness = 4

Maximum fullness = 4

Empty stomach summary statistics

Average fork length = 51.00 cm

Standard deviation of fork length = 0 cm

Minimum fork length = 51 cm

Maximum fork length = 51 cm

Darkfin Sculpin

Darkfin sculpin (*Malacocottus zonurus*) had an estimated biomass of 312 t in 1999 in the Gulf of Alaska (Gaichas et al. 1999). In the Aleutian Islands area, shrimp and fish were preyed upon by darkfin sculpin (Yang 2003). Darkfin sculpin was also found as prey in the stomachs of Pacific cod. In the Gulf of Alaska, it is important to understand the food habits of darkfin sculpin because of its role as both predator and prey in relation to commercially important species.

General Diet

Table 38 lists the total number of full stomachs, the total number of empty stomachs, the minimum and maximum fork length, average fork length, the minimum and maximum stomach fullness, the average fullness, the mean percent frequency of occurrence, and the mean percent total weight of the prey items of darkfin sculpin in 2001 in the Gulf of Alaska. Polychaete worms (52% by weight) were the most common prey item found in the diet of darkfin sculpin in 2001 in the Gulf of Alaska. Euphausiids ranked second at 23% by weight. Other prey items found in stomachs of darkfin sculpin were shrimp (including pandalid and crangonid), amphipods (gammarid and caprellid), and mysids.

Darkfin sculpin and blackfin sculpin (*Malacocottus kincaidi*) are believed by some researchers to be the same species and the two names are often used interchangeably (Mecklenburg et al. 2002). The diets of both species are compared for this report. In the Aleutian Islands, the most important prey items for darkfin sculpin were polychaetes (43% by weight), amphipods (20% by weight), and shrimp (16% by weight) (Yang 2003). Simenstad et al. (1977) found that blackfin sculpin in the Amchitka Island area fed primarily on polychaetes, isopods, shrimp, and amphipods. These two studies reported diets similar to the diet observed for darkfin sculpin in the current study. However, euphausiids (23% by weight) were a more important part of the diet in the current study compared to the Aleutian Islands study where euphausiids made up less than 1% (by weight) of the total stomach contents. The larger role of euphausiids in the current study may be because smaller darkfin sculpins (8.56 ± 1.46 cm average fork length) were sampled compared to the larger darkfin sculpins (14.7 ± 5.3 cm average fork length) sampled in the Aleutian Islands study, and the smaller sculpins may prey more on plankton than the larger sculpins. In contrast, darkfin sculpin, analyzed from southeastern Kamchatka and the northern Kuril Islands, preyed less on polychaetes and amphipods (less

than 30% by weight) and more on gastropods and octopus (more than 50% by weight) (Tokranov and Orlov 2001).

Table 38.--Prey items (expressed in mean percent frequency of occurrence, and mean percent total weight) of *Malacocottus zonurus* (darkfin sculpin) collected in the Gulf of Alaska in 2001.

Prey items	Percent frequency	Percent weight
Polychaeta (worm)	80.00	45.14
Phyllodocidae (polychaete)	50.00	3.80
Nephtyidae (polychaete)	3.33	3.55
<i>Pseudomma</i> sp. (mysid)	50.00	0.54
Gammaridea (amphipod)	63.33	6.14
Caprellidea (amphipod)	10.00	4.27
Euphausiacea (euphausiid)	3.33	1.48
Euphausiidae (euphausiid)	50.00	21.74
Natantia (shrimp)	50.00	3.26
Caridea (shrimp)	10.00	6.58
Pandalidae (shrimp)	3.33	2.95
Crangonidae (shrimp)	50.00	0.54

Total non-empty stomachs = 16

Total prey number = 51

Total prey weight = 4.85 g

Total empty stomachs = 1

Number of hauls = 2

Full stomach summary statistics

Average fork length = 8.56 cm

Standard deviation of fork length = 1.46 cm

Minimum fork length = 7 cm

Maximum fork length = 12 cm

Average fullness = 5.19

Standard deviation of fullness = 0.83

Minimum fullness = 3

Maximum fullness = 6

Empty stomach summary statistics

Average fork length = 9.00 cm

Standard deviation of fork length = 0 cm

Minimum fork length = 9 cm

Maximum fork length = 9 cm

Great Sculpin

Great sculpins (*Myoxocephalus polycanthocephalus*) had an estimated biomass of 3,912 t in the Gulf of Alaska in 1999 (Gaichas et al. 1999). The great sculpin is a large predatory sculpin that can grow to over 75 cm in length (Mecklenburg et al. 2002). Studies from the Aleutian Islands (Yang 2003) and eastern Bering Sea (Brodeur and Livingston 1988) found crab and fish to be the major prey items in the diet of great sculpin. The food habits of great sculpin in the Gulf of Alaska are important to study because this species is a potential predator of commercially important species of crab and fish.

General Diet

Table 39 lists the total number of full stomachs, the total number of empty stomachs, the minimum and maximum fork length, average fork length, the minimum and maximum stomach fullness, the average fullness, the mean percent frequency of occurrence, and the mean percent total weight of the prey items of great sculpin in 2001 in the Gulf of Alaska. The only prey item found in the stomachs of great sculpin sampled in the Gulf of Alaska in 2001 was Tanner crab, *Chionoecetes bairdi*.

Studies from different regions showed brachyuran crabs to be an important prey of the great sculpin. In the Amchitka Islands area, brachyuran and gammarid amphipods were also found in great sculpin stomachs (Simenstad et al. 1977). In the eastern Bering Sea, *Chionoecetes* spp. (50% by weight) was its most important prey (Brodeur and Livingston 1988). In the Aleutian Islands, Yang (2003) found Tanner crab (31% by weight) and Korean horse-hair crab (*Erimacrus isenbeckii*) (21% by weight) to be the most important prey for great sculpins. These diets are similar to the diet of great sculpin in the current study, where Tanner crab was the only prey observed. Although fish (including the commercially important walleye pollock and Atka mackerel), were found in previous studies, no fish were observed in the current study. The lack of fish in the diet of great sculpin in the current study could be attributed to the small sample size.

Table 39.--Prey items (expressed in mean percent frequency of occurrence, and mean percent total weight) of *Myoxocephalus polyacanthocephalus* (great sculpin) collected in the Gulf of Alaska in 2001.

Prey items	Percent frequency	Percent weight
<i>Chionoecetes bairdi</i> (Tanner crab)	100.00	100.00

Total non-empty stomachs = 6

Total prey number = 26

Total prey weight = 498.282 g

Total empty stomachs = 0

Number of hauls = 1

Full stomach summary statistics

Average fork length = 46.10 cm

Standard deviation of fork length = 6.62 cm

Minimum fork length = 38 cm

Maximum fork length = 58 cm

Average fullness = 4.17

Standard deviation of fullness = .75

Minimum fullness = 3

Maximum fullness = 5

Dusky Snailfish

Dusky snailfish (*Liparis gibbus*) is a widespread species of snailfish found in the Gulf of Alaska, Aleutian Islands, Bering Sea, and Arctic Alaska waters. Dusky snailfish can grow to a length of over 50 cm (Mecklenburg et al. 2002). Dusky snailfish is a potential predator on commercially valuable species of crab, fish, and shrimp in the Gulf of Alaska.

General Diet

Table 40 shows the total number of full stomachs, the total number of empty stomachs, the minimum and maximum fork length, average fork length, the minimum and maximum stomach fullness, the average fullness, the mean percent frequency of occurrence, and the mean percent total weight of the prey items of dusky snailfish in 2001 in the Gulf of Alaska. Shrimp was the only prey found in the one dusky snailfish stomach that was sampled. Hippolytid shrimp accounted for 58% of the stomach contents by weight. Humpy shrimp (*Pandalus goniurus*) were also found in the stomach. They made up 42% by weight of the total stomach contents.

In Canadian Arctic waters, amphipods, and polychaete worms were the most important prey in the diet of dusky snailfish (Atkinson and Percy 1992). In contrast, shrimp comprised 100% by weight of the diet of dusky snailfish in

the current study from the Gulf of Alaska. However, only a single stomach was analyzed in the current study. The different locations of the two surveys discussed as well as the small sample size of the current study could be attributed to the differences in the prey observed.

Table 40.--Prey items (expressed in mean percent frequency of occurrence, and mean percent total weight) of *Liparis gibbus* (dusky snailfish) collected in the Gulf of Alaska in 2001.

Prey items	Percent frequency	Percent weight
Hippolytidae (shrimp)	100.00	58.15
<i>Pandalus goniurus</i> (shrimp)	100.00	41.85

Total non-empty stomachs = 1

Total prey number = 13

Total prey weight = 15.82 g

Total empty stomachs = 0

Number of hauls = 1

Full stomach summary statistics

Average fork length = 53.00 cm

Standard deviation of fork length = 0 cm

Minimum fork length = 53 cm

Maximum fork length = 53 cm

Average fullness = 4.00

Standard deviation of fullness = 0

Minimum fullness = 4

Maximum fullness = 4

Pacific Sandfish

In 2003 the estimated biomass of Pacific sandfish (*Trichodon trichodon*) was 3,894 t in the Gulf of Alaska (Nelson 2003). Pacific sandfish made up approximately 2% by weight of the diets of Pacific cod and Pacific halibut in the Gulf of Alaska in 1996 (Yang and Nelson 2000). Also, in the eastern Bering Sea, Pacific sandfish preyed upon commercially important fish such as walleye pollock (Brodeur and Livingston 1988). It is important to study the food habits of Pacific sandfish in the Gulf of Alaska because of its role as both predator and prey of commercially important fish.

General Diet

Table 41 shows the total number of full stomachs, the total number of empty stomachs, the minimum and maximum fork length, average fork length, the minimum and maximum stomach fullness, the average fullness, the mean percent frequency of occurrence, and the mean percent total weight of the prey items of Pacific sandfish in 2001 in the Gulf of Alaska. Mysids were the most important prey item for Pacific sandfish in the Gulf of Alaska in 2001, comprising 85% by weight of the diet. Calanoid copepods made up 9% of the prey items.

Brodeur and Livingston (1988) found that Pacific sandfish in the eastern Bering Sea consumed fish (97% by weight), including walleye pollock, as its major food. Crustaceans, including copepods, made up less than 2% (by weight) of the diet. In contrast, the current study found mysids and copepods to be the most abundant prey items, while fish were not consumed at all. The small sample size of the current study and the different locations of the two studies discussed could have contributed to the variations in the diets observed for Pacific sandfish. A more extensive analysis of the food habits of Pacific sandfish would need to be conducted to determine what role commercially valuable fish play in their diet in the Gulf of Alaska.

Table 41.--Prey items (expressed in mean percent frequency of occurrence, and mean percent total weight) of *Trichodon trichodon* (Pacific sandfish) collected in the Gulf of Alaska in 2001.

Prey items	Percent frequency	Percent weight
Calanoida (copepod)	50.00	8.61
Mysida (mysid)	50.00	85.24
Unidentified organic material	50.00	6.15

Total non-empty stomachs = 2

Total prey number = 9

Total prey weight = 0.569 g

Total empty stomachs = 0

Number of hauls = 1

Full stomach summary statistics

Average fork length = 15.50 cm

Standard deviation of fork length = 0.71 cm

Minimum fork length = 15 cm

Maximum fork length = 16 cm

Average fullness = 5.50

Standard deviation of fullness = 0.71

Minimum fullness = 5

Maximum fullness = 6

Searcher

Searchers (*Bathymaster signatus*) are bottom-dwelling members of the family Bathymasteridae. They are found from eastern Kamchatka, the Commander Islands, the Aleutian Islands and east to Washington State (Allen and Smith 1988). The diet of searchers has previously been studied by Tokranov (1998) from specimens collected near the northern Kurils and southeast Kamchatka. Tokranov found searchers to have a wide and diverse diet including many different types of invertebrates and fishes. Searchers have previously been found in the stomachs of commercially important predators such as Pacific cod, Pacific halibut, and arrowtooth flounder in the Gulf of Alaska (Yang and Nelson 2000). Because searchers are the prey of commercially important species, it is important to study the food habits to help understand the interrelationships of the groundfish community and the food web.

General Diet

Table 42 lists the total number of stomachs, total number of empty stomachs, mean percent frequency of occurrence of the prey, mean percent weight of prey, and full stomach summary statistics for stomachs collected in the Gulf of Alaska in 2001. Larvaceans were the most important prey in terms of both mean percent frequency of

occurrence and mean percent weight at 91% and 81%, respectively. Searchers also consumed gammarid amphipod, jellyfish, polychaetes, and euphausiids (Table 42).

The results of this study showed that searchers feed on many different kinds of invertebrates. Tokranov (1998) also found searchers of the northwestern Pacific to feed on many types of invertebrates, in particular, gammarids were the most abundant prey accounting for nearly 42% of the total stomach contents by weight. This study similarly found that gammarids were important invertebrate prey of searcher. Larvaceans were the most dominant prey in the current study but were not noted as prey in Tokranov's study. Possible differences in the two studies may be accounted for by geographical separation, bathymetry and substrate differences, time of day and year, the small sample size at only one sampling location in this study, and localized abundance of prey.

Table 42.--Prey items (expressed in mean percent frequency of occurrence, and mean percent total weight) of *Bathymaster signatus* (searcher) collected in the Gulf of Alaska in 2001.

Prey items	Percent frequency	Percent weight
Scyphozoa (jellyfish)	9.09	2.52
Phyllodocidae (polychaete)	18.18	1.02
Nephtyidae (polychaete)	9.09	1.89
Gammaridea (amphipod)	36.36	10.38
Euphausiidae (euphausiid)	9.09	0.82
<i>Thysanoessa inermis</i> (euphausiid)	18.18	2.51
Copelata (larvacea)	90.91	80.85

Total non-empty stomachs = 11

Total prey number = 986

Total prey weight = 13.408 g

Total empty stomachs = 0

Number of hauls = 1

Full stomach summary statistics

Average fork length = 26.00 cm

Standard deviation of fork length = 2.17 cm

Minimum fork length = 23 cm

Maximum fork length = 29 cm

Average fullness = 3.00

Standard deviation of fullness = 1.04

Minimum fullness = 2

Maximum fullness = 5

Northern Ronquil

Northern ronquils (*Ronquilis jordani*) are bottom-dwelling members of the family Bathymasteridae. They range from the Bering Sea and Amchitka Island in the Aleutians east through the Gulf of Mexico and south to the waters off Monterey, California; inhabiting depths less than 275 m (Mecklenburg et al. 2002). Northern ronquils have previously been found in the stomachs of arrowtooth flounder (Yang and Nelson 2000). To help further understanding of the interrelationships of the groundfish community, it is important to study the food habits of the Northern ronquils.

General Diet

Table 43 lists the total number of stomachs, total number of empty stomachs, mean percent frequency of occurrence of prey, mean percent weight of prey, and full stomach summary statistics for stomachs collected in the Gulf of Alaska. One northern ronquil stomach was collected in 2001 and contained food. The stomach contained five prey items from two taxonomic categories and weighed 0.142 g. By percent weight, Phyllodocidae polychaetes were the most important prey accounting for 86% of the stomach contents weight. The remaining 14% of weight were gammarid amphipods.

Table 43.--Prey items (expressed in mean percent frequency of occurrence, and mean percent total weight) of *Ronquilis jordani* (northern ronquil) collected in the Gulf of Alaska in 2001.

Prey items	Percent frequency	Percent weight
Phyllodocidae (polychaete)	100.00	85.92
Gammaridea (amphipod)	100.00	14.08

Total non-empty stomachs = 1

Total prey number = 5

Total prey weight = 0.142 g

Total empty stomachs = 0

Number of hauls = 1

Full stomach summary statistics

Average fork length = 16.00 cm

Standard deviation of fork length = 0 cm

Minimum fork length = 16 cm

Maximum fork length = 16 cm

Average fullness = 2.00

Standard deviation of fullness = 0

Minimum fullness = 2

Maximum fullness = 2

Deepsea Sole

Deepsea sole (*Embassichthys bathybius*) is a small-mouthed flatfish that ranges from the Bering Sea and Aleutian Islands to Southern California at depths between 320 to 1,433 m (Mecklenburg et al. 2002). In 2003, the estimated biomass of deepsea sole was 999 t in the Gulf of Alaska (Turnock et al. 2004). Deepsea sole is not managed as a single species in the Gulf of Alaska; however, because it is commonly caught with other flatfish, they are managed together as the larger complex "deep water flatfish" (NPFMC 2004). In addition to deepsea sole, this complex includes Greenland turbot (*Reinhardtius hippoglossoides*) and Dover sole (*Microstomus pacificus*) and in 2004 the complex had an estimated biomass of 99,620 t (NPFMC 2004). Between 1978 and 1995, deepsea sole had an average catch of 6 t in the Gulf of Alaska (Turnock et al. 2001). Deepsea sole is part of a commercially important complex of flatfish species and it is therefore important to study their food habits.

General Diet

Table 44 lists the total number of stomachs, total number of empty stomachs, mean percent frequency of occurrence of the prey, mean percent weight of prey, and full stomach summary statistics from deepsea sole stomachs collected in 2001 from the Gulf of Alaska. A total of

three stomachs were collected from one haul, all of which contained food. Polychaetes were the most important prey item by weight; they accounted 72% of the total stomach contents weight. Octopus was the second most important prey by weight accounting for 18% of the stomach contents. Gammarid and caprellid amphipods accounted for the remaining stomach weight at 4.5% and 5.5%, respectively. All four prey categories were equally important in terms of mean percent frequency of occurrence at 33%.

Table 44.--Prey items (expressed in mean percent frequency of occurrence, and mean percent total weight) of *Embassichthys bathybius* (deepsea sole) collected in the Gulf of Alaska in 2001.

Prey items	Percent frequency	Percent weight
Polychaeta (worm)	33.33	72.22
Octopoda (octopus)	33.33	17.92
Gammaridea (amphipod)	33.33	4.48
Caprellidea (amphipod)	33.33	5.38

Total non-empty stomachs = 3

Total prey number = 8

Total prey weight = 0.558 g

Total empty stomachs = 0

Number of hauls = 1

Full stomach summary statistics

Average fork length = 41.30 cm

Standard deviation of fork length = 1.53 cm

Minimum fork length = 40 cm

Maximum fork length = 43 cm

Average fullness = 3.00

Standard deviation of fullness = 0

Minimum fullness = 3

Maximum fullness = 3

Rex Sole

Rex sole (*Errex zachirus*) is a small-mouthed flatfish found in the Bering Sea and Aleutian Islands south to Baja California at depths less than 850 m (Mecklenburg et al. 2002). Rex sole biomass estimates in the Gulf of Alaska decreased from 87,042 t in 1993 to 71,326 t in 2001 then increased to 99,950 t in 2003 (Turnock and A'mar 2004). Previous studies on the rex sole diet have been conducted off the coast of Oregon (Pearcy and Hancock 1978 and Kravitz et al. 1976) and found rex sole to feed primarily on polychaetes and crustaceans. As a species of commercial importance in the Gulf of Alaska, the food habits of rex sole is reviewed in this document.

General Diet

A total of 42 stomachs (41 with food) were analyzed from 7 hauls. Table 45 lists the total number of stomachs, total empty stomachs, mean percent frequency of occurrence, mean percent weight of prey, and full stomach summary statistics. Rex sole has a diverse diet eating many different types of invertebrates. Polychaetes and gammarid amphipods were the most frequently encountered prey with mean percent frequency of occurrences of 36% and 43%, respectively. At least 11 polychaete families were represented in the stomach contents and combined accounted

for approximately 26% of the total prey weight. Despite the high frequency that gammarids were found to occur with, they accounted for only 4% of the total prey weight. Combined together, crustaceans accounted for 35% of the total prey weight. Echiuran worms were also frequently encountered (28% frequency of occurrence) and accounted for 18% of the total prey weight. Vertebrates present in the diet of rex sole included gadid fish which had a frequency of occurrence of 14% and accounted for approximately 14% of the total prey weight and unidentified fish which accounted for another 5% of the total prey weight and were encountered in 4% of the stomachs. Other prey included pelagic snails, clams, copepods, mysids, cumaceans, isopods, amphipods, euphausiids, shrimp, hermit crabs, and sipunculans.

In this study, we found the diet of rex sole to be primarily composed of crustaceans and polychaetes. Together, crustaceans and polychaetes accounted for 61% of the total prey weight. This is consistent with the findings of previous studies conducted on specimens from Oregon waters. Kravitz et al. (1976) found amphipods and polychaetes to be the first and second most frequently encountered prey, respectively. Pearcy and Hancock (1978)

also found polychaetes followed by crustaceans to be the most important prey by weight.

Table 45.--Prey items (expressed in mean percent frequency of occurrence, and mean percent total weight) of *Errex zachirus* (rex sole) collected in the Gulf of Alaska in 2001.

Prey items	Percent frequency	Percent weight
Polychaeta (worm)	36.19	5.94
Aphroditidae (sea mouse)	1.90	0.14
Phyllodocidae (polychaete)	24.29	4.02
Nephtyidae (polychaete)	25.48	2.51
Goniadidae (polychaete)	9.05	1.14
Onuphidae (polychaete)	0.95	0.02
Lumbrineridae	7.86	8.59
Arbellidae (polychaete)	3.81	3.16
Opheliidae (polychaete)	3.81	0.09
Sternaspidae (polychaete)	2.86	0.08
Maldanidae (polychaete)	1.90	0.04
Pectinariidae (polychaete)	4.76	0.34
Pteropoda	0.95	0.00
Bivalvia (clam)	5.71	1.11
Large calanoid (copepod) > 5mm	0.95	0.00
Mysida (mysid)	12.38	6.29
Cumacea (cumacean)	5.71	2.82
Isopoda (isopod)	6.67	0.49
Gammaridea (amphipod)	42.86	4.46
Hyperiidea (amphipod)	22.86	5.29
Caprellidae (amphipod)	2.86	0.06
Euphausiacea (euphausiid)	4.05	3.79
Euphausiidae (euphausiid)	9.52	5.15
<i>Thysanoessa</i> sp. (euphausiid)	1.90	1.97
<i>Thysanoessa inermis</i> (euphausiid)	8.57	3.02
Natantia (shrimp)	0.95	0.00
Caridea (shrimp)	4.05	0.40
Hippolytidae (shrimp)	0.95	0.01
<i>Eualus</i> sp. (shrimp)	0.95	0.04
Pandalidae (shrimp)	3.10	0.85
<i>Pandalus</i> sp. (shrimp)	0.95	0.01
Crangonidae (shrimp)	0.95	0.00
<i>Crangon</i> spp. (shrimp)	5.71	0.25
<i>Crangon dalli</i> (shrimp)	0.95	0.06
Paguridae (hermit crab)	0.95	0.00
Sipuncula (marine worm)	9.52	0.66
Echiura (marine worm)	28.10	17.95
Teleostei (fish)	4.05	4.92
Gadidae (gadid fish)	14.29	14.29

Table 45.--Continued.

Total non-empty stomachs = 41
Total prey number = 1028
Total prey weight = 74.05 g
Total empty stomachs = 1
Number of hauls = 7

Full stomach summary statistics

Average fork length = 37.40 cm
Standard deviation of fork length = 2.21 cm
Minimum fork length = 24 cm
Maximum fork length = 50 cm
Average fullness = 3.29
Standard deviation of fullness = .15
Minimum fullness = 2
Maximum fullness = 6

Empty stomach summary statistics

Average fork length = 35.00 cm
Standard deviation of fork length = 0 cm
Minimum fork length = 35 cm
Maximum fork length = 35 cm

Flathead Sole

Flathead sole (*Hippoglossoides elassodon*) is a large-mouthed flatfish ranging from the Bering Sea and Aleutian Islands to northern California at depths up to 1,000 m (Mecklenburg et al. 2002). In 2004, flathead sole had an estimated exploitable biomass in the Gulf of Alaska of 292,670 t (NPFMC 2004). This is an increase from the 2001 estimated exploitable biomass of 170,915 t (Turnock et al. 2003). Previous studies of flathead sole food habits in Alaska have shown that they consume commercially important prey including walleye pollock (*Theragra chalcogramma*) and snow and Tanner crabs (*Chionoecetes* spp.) (Yang and Nelson 2000, Pacunski 1990). Because they are a commercially important species and they prey on other commercially important species, flathead sole are included in this study.

General Diet

Thirty-one flathead sole stomachs from three hauls were collected in the Gulf of Alaska in 2001, 16 of which contained food. In 1999, 15 flathead sole were collected in one haul and nine fish of them had stomachs containing prey. Tables 46 and 47 list the total number of stomachs, total empty stomachs, mean percent frequency of occurrence, mean percent weight of prey, and full stomach summary statistics for stomachs collected in the Gulf of Alaska in

1999 and 2001. Shrimp were the most important prey by weight in the flathead sole diet in both 1999 (81%) and 2001 (66%). Specifically, pandalid shrimp accounted for 41% (1999) and 64% (2001) of the of the total prey weight and were also the most important prey in terms of frequency of occurrence in 2001 (Table 47). Other invertebrate prey included polychaetes, cumaceans, isopods, amphipods, euphausiids, brittle stars, and unidentified crab. Fishery offal was the second most important prey in terms of weight in 2001 at 17%. Fish were not present in flathead sole stomachs from 1999 but were represented in 2001 by stichaeids (6% of the total prey weight).

The results from 1999 and 2001 both show shrimp, particularly pandalids, as the most important prey to flathead sole. Yang and Nelson (2000) conducted a similar study in the Gulf of Alaska in 1993 and also found pandalid shrimp to be the most important prey (39% by weight) in the flathead sole diet. In addition, Yang and Nelson (2000) found walleye pollock among the prey from 1993 Gulf of Alaska specimens, however they were of little importance accounting for less than 1% of the total prey weight. No walleye pollock were found in this study of 1999 and 2001 flathead sole stomachs. Similarly, tanner crabs were found to account for 3% of the prey by weight in 1993 but were

not present in 1999 or 2001 (Yang and Nelson 2000). Some of the differences between the previous study by Yang and Nelson (2000) and this current one may be due to the small sample size and limited number of sampling stations in 1999 and 2001.

Table 46.--Prey items (expressed in mean percent frequency of occurrence, and mean percent total weight of *Hippoglossoides elassodon* (flathead sole) collected in the Gulf of Alaska in 1999.

Prey items	Percent frequency	Percent weight
Polychaeta (worm)	11.11	1.69
<i>Yoldia</i> sp. (clam)	11.11	1.69
Isopoda (isopod)	11.11	1.69
Gammaridea (amphipod)	22.22	4.64
Euphausiidae (euphausiid)	11.11	5.49
Caridea (shrimp)	11.11	10.97
Hippolytidae (shrimp)	22.22	29.96
<i>Pandalus jordani</i> (shrimp)	11.11	40.51
Reptantia (crab)	11.11	3.38

Total non-empty stomachs = 9

Total prey number = 10

Total prey weight = 2.37 g

Total empty stomachs = 6

Number of hauls = 1

Full stomach summary statistics

Average fork length = 26.90 cm

Standard deviation of fork length = 6.19 cm

Minimum fork length = 17 cm

Maximum fork length = 36 cm

Average fullness = 3.00

Standard deviation of fullness = .82

Minimum fullness = 2

Maximum fullness = 4

Empty stomach summary statistics

Average fork length = 34.00 cm

Standard deviation of fork length = 3.03 cm

Minimum fork length = 29 cm

Maximum fork length = 37 cm

Table 47.--Prey items (expressed in mean percent frequency of occurrence, and mean percent total weight of *Hippoglossoides elassodon* (flathead sole) collected in the Gulf of Alaska in 2001.

Prey items	Percent frequency	Percent weight
Polychaeta (worm)	4.76	0.17
<i>Pseudomma</i> sp. (mysid)	14.29	0.22
Cumacea (cumacean)	4.76	0.01
Isopoda (isopod)	4.76	0.37
Hippolytidae (shrimp)	4.76	0.10
<i>Eualus</i> spp. (shrimp)	4.76	0.09
Pandalidae (shrimp)	14.29	12.38
<i>Pandalus</i> spp. (shrimp)	21.43	20.11
<i>Pandalus borealis</i> (shrimp)	26.19	31.79
<i>Crangon</i> spp. (shrimp)	9.52	1.15
<i>Argis</i> sp. (shrimp)	4.76	0.05
Reptantia (crab)	4.76	0.60
Ophiurida (brittle star)	9.52	2.80
<i>Ophiura sarsi</i> (brittle star)	14.29	7.42
Teleostei (fish)	4.76	0.01
Stichaeidae (prickleback)	4.76	5.68
Fishery offal	4.76	17.05

Total non-empty stomachs = 16

Total prey number = 64

Total prey weight = 46.041 g

Total empty stomachs = 15

Number of hauls = 3

Full stomach summary statistics

Average fork length = 37.75 cm

Standard deviation of fork length = 6.03 cm

Minimum fork length = 30 cm

Maximum fork length = 51 cm

Average fullness = 3.69

Standard deviation of fullness = 1.35

Minimum fullness = 2

Maximum fullness = 6

Empty stomach summary statistics

Average fork length = 34.80 cm

Standard deviation of fork length = 10.77 cm

Minimum fork length = 14 cm

Maximum fork length = 47 cm

Butter Sole

Butter sole (*Isopsetta isolepis*) is a small-mouthed flatfish found throughout the Gulf of Alaska from Amchitka Island in the Aleutians to California, usually at depths less than 150 m (Allen and Smith 1988). From 1993 to 2001, butter sole biomass estimates in the Gulf of Alaska decreased from 29,809 to 9,812 t, and then increased to 31,148 t in 2003 (Turnock et al. 2003). Butter sole is not managed as a single species but is part of a larger shallow water flatfish complex including seven other flatfish species (NPFMC 2004). As part of a larger management body of flatfish, it is important to study the food habits of butter sole.

General Diet

In 2001, 10 stomachs from butter sole collected from one haul in the Gulf of Alaska were analyzed. Only two of the stomachs contained prey (Table 48). Cumaceans accounted for 100% of the prey both by weight and frequency. Due to the small sample size and the high proportion (80%) of empty stomachs it is difficult to make any general conclusions about the diet of butter sole based on the stomach contents.

Table 48.--Prey items (expressed in mean percent frequency of occurrence, and mean percent total weight of *Isopsetta isolepis* (butter sole) collected in the Gulf of Alaska in 2001.

Prey items	Percent frequency	Percent weight
Cumacea (cumacean)	100.00	100.00

Total non-empty stomachs = 2

Total prey number = 45

Total prey weight = 0.27 g

Total empty stomachs = 8

Number of hauls = 1

Full stomach summary statistics

Average fork length = 48.50 cm

Standard deviation of fork length = 3.54 cm

Minimum fork length = 46 cm

Maximum fork length = 51 cm

Average fullness = 2.00

Standard deviation of fullness = .00

Minimum fullness = 2

Maximum fullness = 2

Empty stomach summary statistics

Average fork length = 37.50 cm

Standard deviation of fork length = 6.35 cm

Minimum fork length = 25 cm

Maximum fork length = 45 cm

Southern Rock Sole

Southern rock sole (*Lepidopsetta bilineata*) is a small-mouthed flatfish found in the southeast Bering Sea, in the Aleutian Islands around the Islands of Four Mountains, and as far south as Baja California at depths shallower than 340 m (Mecklenburg et al. 2002). Southern rock sole has been a separate species from northern rock sole (*Lepidopsetta polyxystra*) since the revision of the genus *Lepidopsetta* in 2000 (Orr and Matarese 2000). Both species are managed as part of the shallow water flatfish complex which includes six other species (NPFMC 2004). In 2003, the exploitable biomass of GOA southern rock sole was the largest of all the species in the shallow water flatfish complex at 127,267 t (Turnock et al. 2003). From 2001 to 2003, the catch of southern rock sole declined from 2,462 to 2,103 t (Turnock et al. 2003). Because southern rock sole is both abundant and commercially important, its food habit is reviewed in this document.

General Diet

Tables 49 and 50 list the total number of stomachs, total empty stomachs, number of hauls, mean percent frequency of occurrence, mean percent weight of prey, and full stomach summary statistics for stomachs collected in 1999 and 2001 in the Gulf of Alaska. Polychaetes were

important food in the diet of southern rock sole in both 1999 and 2001 (27% and 16% by weight, respectively). Crustaceans accounted for 5% of the prey weight in 1999 but had a much stronger presence in 2001 comprising 35% of the prey weight. In both years brittle stars were frequently encountered, ranking second in frequency of occurrence in 1999 (30%) and first in 2001 (41%). Brittle stars represented 10% of the prey weight in 1999 and 35% in 2001. Fish prey had a much stronger presence in 1999 than in 2001 (23% and 2% by weight, respectively). Sculpins were the most prominent fish prey in 1999, representing 13% of the mean total prey weight, followed by Pacific sand lance which accounted for 9% of the total prey weight. Walleye pollock were only found as prey in 1999 and were of little importance (<1% by weight). Stichaeids were the only fish prey found in 2001 and accounted for 2% of the total prey weight.

Polychaetes and brittle stars were featured parts of the southern rock sole diet in both 1999 and 2001, in terms of mean percent frequency of occurrence and mean percent total weight. Other prey that had a notable presence in weight and frequency in 1999 and were not present in 2001 or were present in a much more diminished capacity, included sipunculans, fish, and crustaceans. In 1999,

sipunculans accounted for 15% of the mean total prey weight but were absent in 2001. Fish prey combined represented 23% of the mean total prey weight in 1999. Sculpins had a mean percent frequency of occurrence of 14% in that year. In 2001, sculpins were not present in the stomach contents, and fish prey only comprised 2% of the total stomach contents weight. Crustaceans together accounted for 5% of the prey weight in 1999, but had a much more pronounced presence in 2001 constituting 35% of the prey weight. The differences between study years may be a reflection of flexibility in the southern rock sole diet, sample size, different sample locations, and prey availability.

Table 49.--Prey items (expressed in mean percent frequency of occurrence, and mean percent total weight) of *Lepidopsetta bilineata* (southern rock sole) collected in the Gulf of Alaska in 1999.

Prey items	Percent frequency	Percent weight
Anthozoa (anemome)	1.25	0.10
Polychaeta (worm)	51.20	23.30
Phyllodocidae (polychaete)	1.25	0.08
Onuphidae (polychaete)	1.25	0.09
Cirratulidae (polychaete)	1.25	0.90
Opheliidae (polychaete)	3.75	2.90
Serpulidae (polychaete)	0.96	0.19
Mollusca	4.96	0.28
Bivalvia (clam)	13.13	2.63
Pectinidae (scallops)	5.58	1.25
Cardiidae (cockles)	1.85	1.55
Cephalopoda (squid and octopus)	1.85	0.31
Cumacea (cumacean)	4.09	0.06
Isopoda (isopod)	1.92	0.14
Gammaridea (amphipod)	15.19	1.31
Hyperidea (amphipod)	1.56	0.01
Euphausiidae (euphausiid)	1.92	0.01
Natantia (shrimp)	5.70	0.49
Crangonidae (shrimp)	0.89	0.09
<i>Argis</i> sp. (shrimp)	0.96	1.48
Paguridae (hermit crab)	3.49	0.55
Paguridae legs (hermit crabs)	0.96	0.13
Decapoda brachyura (crab)	0.96	0.13
<i>Hyas</i> spp. (lyre crab)	1.56	0.35
<i>Cancer oregonensis</i> (pygmy Cancer crab)	0.96	0.05
<i>Pinnixa</i> sp. (pea crab)	2.81	0.10
Sipuncula (marine worm)	7.52	15.47
Echiura (marine worm)	1.25	0.14
Priapulida (worm)	4.38	0.98
Asteroidea (starfish)	2.50	0.43
Ophiurida (brittle star)	30.07	10.30
Echinoidea (sea urchin and sand dollar)	1.56	0.65
Clypeasteroidea (sand dollar)	4.24	0.29
Holothuroidea (sea cucumber)	4.60	1.11
Enteropneusta (acorn worm)	3.13	8.77

Table 49.--Continued.

Prey items	Percent frequency	Percent weight
Non-gadoid fish remains	0.89	0.19
<i>Theragra chalcogramma</i> (walleye pollock)	0.89	0.84
Cottoidei (sculpin)	14.06	12.81
<i>Ammodytes hexapterus</i> (Pacific sand lance)	7.50	8.79
Pleuronectidae (flatfish)	1.79	0.35
Unidentified worm-like organism	2.81	0.05
Unidentified tube	2.81	0.33

Total non-empty stomachs = 63

Total prey number = 121

Total prey weight = 173.655 g

Total empty stomachs = 43

Number of hauls = 8

Full stomach summary statistics

Average fork length = 34.18 cm

Standard deviation of fork length = 2.85 cm

Minimum fork length = 15 cm

Maximum fork length = 50 cm

Average fullness = 3.88

Standard deviation of fullness = .27

Minimum fullness = 2

Maximum fullness = 6

Empty stomach summary statistics

Average fork length = 36.86 cm

Standard deviation of fork length = 7.01 cm

Minimum fork length = 24 cm

Maximum fork length = 49 cm

Table 50.--Prey items (expressed in mean percent frequency of occurrence, and mean percent total weight) of *Lepidopsetta bilineata* (southern rock sole) collected in the Gulf of Alaska in 2001.

Prey items	Percent frequency	Percent weight
Polychaeta (worm)	25.56	9.92
Phyllodocidae (polychaete)	5.00	0.11
Nereidae (polychaete)	5.56	0.08
Nephtyidae (polychaete)	2.22	0.96
Goniadidae (polychaete)	33.33	3.98
Flabelligeridae (polychaete)	2.78	0.02
Opheliidae (polychaete)	2.22	0.76
Maldanidae (polychaete)	2.78	0.01
Bivalvia (clam)	19.44	5.08
Isopoda (isopod)	5.00	0.24
Gammaridea (amphipod)	26.11	6.90
Hyperidea (amphipod)	2.78	0.07
Decapoda Reptantia legs (crabs)	16.67	10.23
Paguridae (hermit crab)	4.44	3.21
<i>Hyas lyratus</i> (lyre crab)	16.67	13.89
Echiura (marine worm)	8.33	0.10
Ophiurida (brittle star)	41.11	23.83
<i>Ophiura</i> sp. (brittle star)	2.22	3.84
<i>Ophiura sarsi</i> (brittle star)	8.89	7.36
Echinoidea (sea urchin and sand dollar)	5.56	0.21
Clypeasteroidea (sand dollar)	5.00	4.64
Holothuroidea (sea cucumber)	5.56	2.42
Stichaeidae (prickleback)	2.22	2.15

Total non-empty stomachs = 29

Total prey number = 257

Total prey weight = 38.335 g

Total empty stomachs = 4

Number of hauls = 3

Full stomach summary statistics

Average fork length = 32.23 cm

Standard deviation of fork length = 1.58 cm

Minimum fork length = 19 cm

Maximum fork length = 43 cm

Average fullness = 3.67

Standard deviation of fullness = .25

Minimum fullness = 2

Maximum fullness = 6

Empty stomach summary statistics

Average fork length = 35.00 cm

Standard deviation of fork length = 12.83 cm

Minimum fork length = 22 cm

Maximum fork length = 47 cm

Northern Rock Sole

Northern rock sole (*Lepidopsetta polyxystra*) is a small-mouthed flatfish found throughout the Bering Sea shelf and Aleutian Islands south to Washington at depths less than 250 m (Mecklenburg et al. 2002). Northern and southern rock sole have previously been considered a single species until the genus *Lepidopsetta* was revised in 2000 and the new species *L. polyxystra* was described (Orr and Matarese 2000). The estimated exploitable biomass of northern rock sole increased from 64,240 t in 2001 to 79,998 t in 2003. The catch increased as well from 2,711 t in 2001 to 3,031 t in 2002 but then decreased to 1,279 t in 2003. Northern rock sole are managed as part of the shallow water flatfish complex in the Gulf of Alaska. Because of their commercial importance, their food habits are included in this study.

General Diet

Tables 51 and 52 list the total number of stomachs, total number of empty stomachs, number of hauls, mean percent frequency of occurrence, mean percent weight of prey, and full stomach summary statistics for stomachs collected in 1999 and 2001 in the Gulf of Alaska. In both years polychaetes were present in the diet of northern rock sole. They accounted for 39% of the prey by weight in 1999

and 13% in 2001. Brittle stars also figured prominently in both years representing 20% of the prey by weight in 1999 and 29% in 2001. In terms of fish prey, Pacific sand lance was consumed in both years and constituted 7% of the prey weight in 1999 and 19% in 2001. In 1999, unidentified algae comprised 20% of the mean percent total weight but were not present in 2001. Conversely, in 2001, sea cucumbers constituted 23% of the mean percent total weight but were absent from the prey in 1999. Other prey included mollusk, clams, cephalopods, cumaceans, isopods, amphipods, euphausiids, shrimp, crab, hermit crab, and echinoderms.

Both 1999 and 2001 show polychaetes, brittle stars, and Pacific sand lance to be featured parts of the northern rock sole diet. A study of rock sole diet in the Bering Sea between 1984 and 1988 showed polychaetes to be of paramount importance in terms of frequency and weight (Lang 1992). However, Lang's study was prior to the revision of the genus *Lepidopsetta* and did not differentiate between northern and southern rock sole. Similar to the results of this study, Lang (1992) also showed that Pacific sand lance were the primary fish prey in 1988. In waters off the northern Kurils and southeastern Kamchatka, amphipods were found to be the most dominant prey for *L. polyxystra* in

terms of frequency of occurrence at 71%, followed by polychaetes at 45% (Kuznetsova and Kunin 2002).

Table 51.--Prey items (expressed in mean percent frequency of occurrence, and mean percent total weight) of *Lepidopsetta polyxystra* (northern rock sole) collected in the Gulf of Alaska in 1999.

Prey items	Percent frequency	Percent weight
Polychaeta (worm)	47.71	38.51
Maldanidae (polychaete)	5.00	0.52
Mollusca	9.04	1.77
Bivalvia (clam)	3.76	0.05
Cephalopoda (squid and octopus)	2.50	0.15
Cumacea (cumacean)	1.54	0.03
Arcturidae (isopod)	1.54	0.19
Gammaridea (amphipod)	14.91	2.60
Natantia (shrimp)	2.50	0.77
Reptantia (crab)	1.54	0.04
<i>Pinnixa</i> sp. (pea crab)	5.00	3.00
Ophiurida (brittle star)	28.65	20.40
Clypeasteroidea (sand dollar)	4.62	4.59
Teleostei (fish)	3.08	0.01
<i>Ammodytes hexapterus</i> (Pacific sand lance)	1.54	6.87
Unidentified tube	3.08	0.47
Unidentified algae	20.00	20.00

Total non-empty stomachs = 36

Total prey number = 46

Total prey weight = 57.837 g

Total empty stomachs = 21

Number of hauls = 5

Full stomach summary statistics

Average fork length = 29.66 cm

Standard deviation of fork length = 2.05 cm

Minimum fork length = 17 cm

Maximum fork length = 41 cm

Average fullness = 3.80

Standard deviation of fullness = .56

Minimum fullness = 3

Maximum fullness = 6

Empty stomach summary statistics

Average fork length = 32.57 cm

Standard deviation of fork length = 4.48 cm

Minimum fork length = 23 cm

Maximum fork length = 40 cm

Table 52.--Prey items (expressed in mean percent frequency of occurrence, and mean percent total weight) of *Lepidopsetta polyxystra* (northern rock sole) collected in the Gulf of Alaska in 2001.

Prey items	Percent frequency	Percent weight
Polychaeta (worm)	24.76	8.66
Phyllodocidae (polychaete)	10.24	0.69
Nereidae (polychaete)	13.33	0.38
Nephtyidae (polychaete)	10.71	1.05
Glyceridae (polychaete)	7.14	0.44
Arabellidae (polychaete)	6.67	0.50
Cirratulidae (polychaete)	3.57	0.69
Capitellidae (polychaete)	7.14	0.76
Maldanidae (polychaete)	3.33	0.01
Bivalvia (clam)	26.67	5.84
Isopoda (isopod)	6.90	0.26
Gammaridea (amphipod)	10.24	1.20
Hyperidea (amphipod)	10.00	0.14
Caprellidea (amphipod)	6.67	0.01
Euphausiacea (euphausiid)	3.57	0.07
Hippolytidae (shrimp)	3.33	0.01
Paguridae (hermit crab)	13.57	0.70
Ophiurida (brittle star)	68.10	23.73
Chilophiurina (brittle star)	3.57	0.42
<i>Ophiura sarsi</i> (brittle star)	7.14	4.62
Echinoidea (sea urchin and sand dollar)	6.67	1.47
Clypeasteroidea (sand dollar)	10.48	0.51
Holothuroidea (sea cucumber)	30.00	23.05
<i>Ammodytes</i> sp. (sand lance)	7.14	18.81
Unidentified worm-like organism	14.29	5.99

Total non-empty stomachs = 29

Total prey number = 398

Total prey weight = 55.844 g

Total empty stomachs = 2

Number of hauls = 2

Full stomach summary statistics

Average fork length = 29.20 cm

Standard deviation of fork length = .75 cm

Minimum fork length = 17 cm

Maximum fork length = 40 cm

Average fullness = 4.00

Standard deviation of fullness = .05

Minimum fullness = 3

Maximum fullness = 5

Empty stomach summary statistics

Average fork length = 22.00 cm

Standard deviation of fork length = 4.24 cm

Minimum fork length = 19 cm

Maximum fork length = 25 cm

Yellowfin Sole

Yellowfin sole (*Limanda aspera*) is a small-mouthed flatfish with an extensive range in the North Pacific that stretches from the Sea of Japan to the Bering and Beaufort Seas, the Aleutian Islands and through the Gulf of Alaska to British Columbia (Mecklenburg et al. 2002). The estimated exploitable biomass in 2003 for the Gulf of Alaska was 54,738 t and the catch was 58.8 t (Turnock et al. 2003). A study in the southwestern Bering Sea from 1979 to 1986 on the food habits of yellowfin sole found their diet to be chiefly composed of polychaetes and bivalves (Tokranov 1990). Similarly, a study in the eastern Bering Sea from 1984 to 1988 found polychaetes, gammarid amphipods, marine worms, and bivalves to be the most important prey items in the yellowfin sole diet (Lang 1992). As an abundant and commercially important species, the food habits of yellowfin sole is examined in this document.

General Diet

Tables 53 and 54 list the total number of stomachs, total empty stomachs, number of hauls, mean percent frequency of occurrence, mean percent weight of prey, and full stomach summary statistics for stomachs collected in 1999 and 2001 in the Gulf of Alaska. In terms of mean percent frequency of occurrence and mean percent total

weight, polychaetes were the most important prey in 1999 (48% and 35%, respectively). Bivalves were second in both categories in 1999 at 37% frequency of occurrence and 26% by weight. Other prey that figured prominently in mean percent frequency of occurrence in 1999 include gammarid amphipods (24%) and cumaceans (19%). By weight, crangonid shrimp (including *Crangon dalli*) constituted a notable portion of the mean percent total weight at 10%. The only commercial prey was Tanner crab (*Chionoecetes bairdi*), but was of little importance accounting for less than 1% mean percent total weight and having a 2% mean frequency of occurrence.

In 2001 only two stomachs from yellowfin sole collected from one haul. These revealed a much smaller prey data set than 1999. All were examined. Three prey groups, polychaetes, copepods, and cumaceans were equal with respect to mean percent frequency of occurrence (50%). However, by weight, cumaceans were the dominant prey items; they comprised 91% of the prey weight.

The 1999 results feature polychaetes and bivalves as the most prevalent prey groups by both frequency and weight. This is consistent with the findings of both Tokranov (1990) in the southwest Bering Sea and Lang (1992) in the eastern Bering Sea. Polychaetes and bivalves combined accounted

for 61% of the mean percent total weight in 1999. Tokranov (1990) found these two taxonomic groups to account for 43-81% (by weight) of the yellowfin sole prey. Lang (1992) had these two prey categories among the top three in both frequency of occurrence and by percent weight. The 2001 results from this document show a departure from the previously observed pattern of results in 1999 and the other two studies from the Bering Sea. This may be explained in part by the small sample size (n=2) for 2001.

Table 53.--Prey items (expressed in mean percent frequency of occurrence, and mean percent total weight of *Limanda aspera* (yellowfin sole) collected in the Gulf of Alaska in 1999.

Prey items	Percent frequency	Percent weight
Polychaeta (worm)	48.26	34.67
Mollusca	1.79	0.86
Gastropoda (snail)	2.78	1.25
Bivalvia (clam)	37.26	23.35
<i>Nuculana</i> sp. (clam)	3.13	1.17
<i>Nuculana fossa</i> (clam)	3.13	0.59
<i>Siliqua</i> sp. (razor clam)	1.92	1.32
Calanoida (copepod)	1.92	0.00
Cumacea (cumacean)	18.75	1.00
Gammaridea (amphipod)	24.03	2.16
Euphausiidae (euphausiid)	1.92	0.03
Decapoda (shrimp and crab)	1.79	0.23
Crangonidae (shrimp)	5.49	2.56
<i>Crangon dalli</i> (shrimp)	3.57	7.75
Reptantia (crab)	1.79	0.39
Paguridae (hermit crab)	5.63	5.87
<i>Chionoecetes bairdi</i> (Tanner crab)	1.92	0.03
Pinnotheridae (pea crab)	3.13	0.78
<i>Pinnixa</i> sp. (pea crab)	3.13	2.20
Echinodermata (sea star, cucumber, urchin)	1.92	0.08
Ophiurida (brittle star)	6.97	2.35
Brittle star legs (brittle star)	3.85	0.07
<i>Echinacea</i> sp. (sea urchin)	1.92	0.09
Clypeasteroida (sand dollar)	1.92	1.37
Unidentified organic material	2.78	2.72
Unidentified worm-like organism	5.05	7.12

Total non-empty stomachs = 44

Total prey number = 102

Total prey weight = 48.98 g

Total empty stomachs = 17

Number of hauls = 4

Full stomach summary statistics

Average fork length = 28.15 cm

Standard deviation of fork length = 2.07 cm

Minimum fork length = 15 cm

Maximum fork length = 42 cm

Average fullness = 3.25

Standard deviation of fullness = .31

Minimum fullness = 2

Maximum fullness = 6

Empty stomach summary statistics

Average fork length = 28.94 cm

Standard deviation of fork length = 4.93 cm

Minimum fork length = 20 cm

Maximum fork length = 36 cm

Table 54.--Prey items (expressed in mean percent frequency of occurrence, and mean percent total weight of *Limanda aspera* (yellowfin sole) collected in the Gulf of Alaska in 2001.

Prey items	Percent frequency	Percent weight
Polychaeta (worm)	50.00	3.97
<i>Calanus</i> spp. (copepod)	50.00	5.44
Cumacea (cumacean)	50.00	90.59

Total non-empty stomachs = 2

Total prey number = 71

Total prey weight = 0.478 g

Total empty stomachs = 0

Number of hauls = 1

Full stomach summary statistics

Average fork length = 40.00 cm

Standard deviation of fork length = 2.83 cm

Minimum fork length = 38 cm

Maximum fork length = 42 cm

Average fullness = 3.00

Standard deviation of fullness = 1.41

Minimum fullness = 2

Maximum fullness = 4

Dover Sole

The Dover sole (*Microstomus pacificus*) is a small-mouthed flatfish found from the Bering Sea and Aleutian Islands south to Baja California at depths up to 1,200 m (Mecklenburg et al. 2002). In 2005, Dover sole had an estimated exploitable biomass of 102,395 t in the Gulf of Alaska (Turnock et al. 2004b). Dover sole is managed in the Gulf of Alaska as part of the deep-water flatfish complex which includes Greenland turbot (*Reinhardtius hippoglossoides*) and deepsea sole (*Embassichthys bathybius*) (NPFMC 2004). The catch of Dover sole increased from 23 t in 1986 to 9,741 t in 1991. It gradually decreased to 492 t in 2002. The catch was 682 t in 2004 (Turnock et al. 2004b). Because Dover sole is a commercially important species, its food habits are explored in this study.

General Diet

Table 55 lists the total number of stomachs, total empty stomachs, number of hauls, mean percent frequency of occurrence, mean percent weight of prey, and full stomach summary statistics for Dover sole collected in 2001 in the Gulf of Alaska. Polychaetes were the most dominant prey overall, accounting for 49% of the prey by mean percent total weight and having the highest mean percent frequency of occurrence (27%). Secondarily, brittle stars

represented 24% of the prey by weight and had a 25% frequency of occurrence. Echiuran worms were also commonly encountered at 24% frequency of occurrence and comprised 5% of the prey by weight. Other prey with high frequencies of occurrence were gammarid amphipods (22%) and cumaceans (17%); however, each of these prey taxa modestly accounted for less than 1% of the total prey weight. Prey of diminishing importance included anemones, bivalves, isopods, euphausiids, shrimp, hermit crabs, and sipunculans.

The chief prey items of Dover sole were polychaetes and brittle stars, ranking first and second, respectively (Table 55). Gabriel and Pearcy (1981) also found the diet of Dover sole off the Oregon coast was primarily composed of polychaetes and brittle stars. Similarly, Pearcy and Hancock (1978) found polychaetes were the most common prey of Dover sole off the Oregon coast.

Table 55.--Prey items (expressed in mean percent frequency of occurrence, and mean percent total weight) of *Microstomus pacificus* (Dover sole) collected in the Gulf of Alaska in 2001.

Prey items	Percent frequency	Percent weight
Anthozoa (anemome)	4.00	0.15
Polychaeta (worm)	26.67	6.87
Aphroditidae (sea mouse)	1.33	2.11
Polynoidae (polychaete)	4.00	0.13
Euprosinidae	20.00	11.86
Phyllodocidae (polychaete)	17.33	5.51
<i>Phyllodoce</i> sp. (polychaete)	1.67	0.22
Nephtyidae (polychaete)	1.33	0.30
Arabellidae (polychaete)	1.67	0.56
Maldanidae (polychaete)	4.00	1.16
Terebellida (polychaete)	20.00	20.00
Bivalvia (clam)	8.00	1.02
Cumacea (cumacean)	17.00	0.62
Isopoda (isopod)	8.00	0.23
Gammaridea (amphipod)	21.67	0.74
Hyperidea (amphipod)	13.33	1.21
Caprellidea (amphipod)	5.33	1.02
Euphausiidae (euphausiid)	8.00	4.60
<i>Euphausia pacifica</i> (euphausiid)	5.00	0.37
<i>Thysanoessa</i> sp. (euphausiid)	8.00	2.59
<i>Thysanoessa inermis</i> (euphausiid)	8.00	1.95
Caridea (shrimp)	1.33	0.68
Hippolytidae (shrimp)	2.67	2.31
Paguridae (hermit crab)	10.00	3.01
Sipuncula (marine worm)	4.00	1.16
Echiura (marine worm)	24.00	5.33
Ophiurida (brittle star)	25.33	17.10
Ophiuridae (brittle star)	20.00	7.19

Table 55.--Continued.

Total non-empty stomachs = 35
Total prey number = 334
Total prey weight = 56.638 g
Total empty stomachs = 3
Number of hauls = 5

Full stomach summary statistics

Average fork length = 44.38 cm
Standard deviation of fork length = 1.66 cm
Minimum fork length = 34 cm
Maximum fork length = 60 cm
Average fullness = 3.60
Standard deviation of fullness = .37
Minimum fullness = 2
Maximum fullness = 6

Empty stomach summary statistics

Average fork length = 48.67 cm
Standard deviation of fork length = 10.02 cm
Minimum fork length = 41 cm
Maximum fork length = 60 cm

SUMMARY

Important Prey of Groundfish

A total of 7,899 stomachs from 40 species were analyzed to describe the food habits of the major groundfish species in the Gulf of Alaska in 1999 and 2001. Our analysis emphasized groundfish predation on commercially important fish, crab, and shrimp. The predator sizes and the number of the stomachs collected for each species are summarized in Tables 1 and 2 for 1999 and 2001, respectively. Although juveniles of some species (walleye pollock, Pacific cod, Pacific halibut, and arrowtooth flounder) were sampled, the main focus of our study was the food habits of adult fish.

Tables 56 and 57 list the percent by weight of the commercially important fish, crab, shrimp, and other major prey or prey groups consumed by groundfish in 1999 and 2001, respectively. Arrowtooth flounder, Pacific halibut, sablefish, Pacific cod, bigmouth sculpin, big skate, and Bering skate were the main predators that consumed fish. The main predators that consumed Tanner crabs were Pacific halibut, Pacific cod, great sculpin, yellow Irish lord, big skate, and longnose skate. Flathead sole, Pacific cod, spinyhead sculpin, dusky snailfish, longnose skate, rougheye rockfish, and sharpchin rockfish, were the primary

consumers of pandalid shrimp. Sharpchin rockfish, Atka mackerel, Pacific ocean perch, redbanded rockfish, and searchers are thought to not have substantial impact on the commercially important species in the Gulf of Alaska since they feed mainly on zooplankton (primarily euphausiids and calanoid copepods). The data in Tables 56 and 57 indicate that pollock were the dominant prey fish in both years and were consumed predominately by arrowtooth flounder, Pacific halibut, sablefish, Pacific cod, and Bering skate. Pollock cannibalism, which accounted for less than 1% in 1999 and 5% in 2001 of the total stomach contents weight, were not an important phenomenon in the Gulf of Alaska compared with the Bering Sea (Livingston 1991). Other forage fish such as Pacific herring, capelin, eulachon, and Pacific sand lance can be categorized as the next most important prey fishes. Pacific halibut was the main predator of Pacific herring in 2001 (2% of the total stomach content weight), whereas arrowtooth flounder consumed a relatively large amount of capelin (13% by weight) in the same year. Other large amounts (9% by weight, respectively) of capelin were consumed in 1999 by arrowtooth flounder and pollock. Pacific sand lance was consumed by the main piscivorous species (arrowtooth flounder, Pacific halibut, sablefish, Pacific cod, and big skate). Flatfish consumed by

groundfish include arrowtooth flounder, Kamchatka flounder, flathead sole, butter sole, rock sole, yellowfin sole, and Pacific halibut. Arrowtooth flounder was consumed mostly by Pacific halibut, Pacific cod, arrowtooth flounder, and bigmouth sculpin. Pacific cod (<2% each) were consumed by Pacific halibut and sablefish. Chum salmon (*Oncorhynchus keta*) (1% stomach content weight) were found in Pacific halibut stomachs. *Sebastes* spp. were found in arrowtooth flounder, Pacific halibut, and sablefish stomachs. Tanner crabs were mainly consumed by Pacific cod, sablefish, and Pacific halibut though they were also consumed by bigmouth sculpin, longnose sculpin, great sculpin, roughey rockfish, yellowfin sole, and arrowtooth flounder. Tables 56 and 57 show that many predator species consumed a certain amount of cephalopods (squid and octopus) but shortraker rockfish, giant grenadier, and sablefish were the main predators of the cephalopods. Many predators preyed on pandalid shrimp, which includes all the *Pandalus* and *Pandalopsis* species. The sharpchin rockfish, spinyhead sculpin, dusky snailfish, longnose skate, Pacific cod, and roughey rockfish were the primary predators of the pandalids.

Table 56.--Percent by weight of the important prey or prey group consumed by the groundfish in the Gulf of Alaska in 1999. AMP, amphipod; ATK, Atka mackerel; ATF, arrowtooth flounder; BAS, bathymasterid; BMS, bigmouth sculpin; BRI, brittle star; CAL, calanoid; CAP, capelin; CEP, cephalopod; CHA, chaetognath; COD, Pacific cod; COT, cottid; EUL, eulachon; EUP, euphausiid; FHS, flathead sole; FOF, fish offal; HER, herring; LAR, larvacean; MAW, marine worm; MOL, molluska; MYC, myctophid; MYS, mysid; NRS, northern rock sole; OCR, other crabs; OSH, other shrimp; PAG, pagurid; PAH, Pacific halibut; PAN, pandalid; PLK, pollock; POL, polychaete; ROS, rock sole; SAB, sablefish; SAL, salmonid; SAN, Pacific sand lance; SHA, sharpchin rockfish; SHR, shortraker rockfish; SRS, southern rock sole; TAN, Tanner crab; UNF, unknown fish; YFS, yellowfin sole; ZOA, zoacid.

Prey	Predator												
	FHS	SRS	NRS	YFS	SHR	SHA	ATK	BMS	PLK	COD	SAB	PAH	ATF
POL	2	27	39	35	0	0	0	0	1	9	1	<1	<1
MAW	0	17	0	7	0	0	0	0	0	0	0	0	0
BRI	0	10	20	2	0	0	0	0	0	0	0	0	0
MOL	2	8	2	29	0	3	15	0	1	<1	<1	2	<1
CHA	0	0	0	0	0	0	0	0	1	0	0	0	<1
LAR	0	0	0	0	0	0	15	0	6	0	0	0	<1
CAL	0	0	0	0	0	76	<1	0	11	<1	1	0	2
MYS	0	0	0	0	0	0	0	0	<1	<1	<1	0	<1
AMP	5	1	3	2	0	2	0	0	1	1	4	0	<1
EUP	6	<1	0	<1	0	18	66	0	48	6	1	0	23
OSH	41	2	1	10	0	0	<1	0	4	4	6	5	2
PAN	41	0	0	0	0	0	0	0	9	14	6	<1	12
OCR	3	1	3	3	0	0	0	0	<1	16	0	26	<1
PAG	0	1	0	6	0	1	0	0	<1	6	3	17	0
TAN	0	0	0	<1	0	0	0	0	0	9	4	<1	<1
CEP	0	<1	<1	0	0	0	0	0	<1	1	12	<1	<1
ZOA	0	0	0	0	0	0	0	0	<1	1	0	1	2
COT	0	13	0	0	0	0	0	0	<1	3	0	<1	<1
STI	0	0	0	0	0	0	0	0	0	<1	0	1	2
BAS	0	0	0	0	0	0	0	0	0	4	0	0	1
EUL	0	0	0	0	0	0	0	0	2	1	0	0	0
MYC	0	0	0	0	0	0	0	0	0	0	2	0	0
SAN	0	9	7	0	0	0	0	0	<1	3	0	17	9
ATF	0	0	0	0	0	0	0	100	0	1	0	4	2
FHS	0	0	0	0	0	0	0	0	0	<1	0	0	2
ROS	0	0	0	0	0	0	0	0	0	<1	0	0	0
CAP	0	0	0	0	0	0	0	0	9	<1	1	6	9
HER	0	0	0	0	0	0	0	0	0	<1	0	1	<1
PLK	0	1	0	0	0	0	0	0	<1	11	16	10	19
FOF	0	0	0	0	0	0	0	0	0	0	27	0	0
UNF	0	<1	0	0	100	0	<1	0	6	2	9	<1	11

Table 57.--Percent by weight of the important prey or prey group consumed by the groundfish in the Gulf of Alaska in 2001. AKS, Alaska skate; AMP, amphipod; ATK, Atka mackerel; ATF, arrowtooth flounder; BAS, bathymasterid; BES, Bering skate; BGS, big skate; BKE, black eelpout; BMS, bigmouth sculpin ;BRI, brittle star; BUT, butter sole; CAL, calanoid; CAP, capelin; CEP, cephalopod; CHA, chaetognath; COD, Pacific cod; COT, cottid; CUC, sea cucumber; CUM, cumacean; DES, deepsea sole; DFS, darkfin sculpin; DOG, spiny dogfish; DOV, Dover sole; DSS, dusky snailfish; DUR, dusky rockfish; EUL, eulachon; EUP, euphausiid; FHS, flathead sole; FOF, fish offal; GRS, great sculpin; GTG, giant grenadier; HER, herring; JFH, jellyfish; LAR, larvacean; LNS, longnose skate; MAW, marine worm; MOL, molluska; MYC, myctophid; MYS, mysid; NRQ, northern ronquil; NRS, northern rock sole; OCR, other crabs; OSH, other shrimp; OTF, other fish; PAG, pagurid; PAH, Pacific halibut; PAN, pandalid; PLK, pollock; POL, polychaete; POP, Pacific ocean perch; PSF, Pacific sandfish; RBR, redbanded rockfish; REX, rex sole; ROS, rock sole; ROU, rougheye rockfish; SAB, sablefish; SAL, salmonid; SAN, Pacific sand lance; SER, searcher; SFE, shortfin eelpout; SHA, sharpchin rockfish; SHR, shortraker rockfish; SHS, spinyhead sculpin; SRS, southern rock sole; SST, shortspine thornyhead; STI, stichaeid; TAN, Taner crab; UNF, unknown fish; WTE, Wattled eelpout; YFS, yellowfin sole; YIL, yellow Irish lord; ZOA, zoarcid.

Prey	Predator							
	SHA	SHS	DSS	PSF	SER	POP	RBR	
JFH	0	0	0	0	3	0	0	
POL	0	0	0	0	3	0	0	
MAW	0	0	0	0	0	0	0	
MOL	<1	0	0	0	0	<1	0	
CHA	0	0	0	0	0	1	0	
LAR	0	0	0	0	81	24	0	
CAL	<1	0	0	9	0	21	50	
MYS	0	2	0	85	0	<1	0	
AMP	0	<1	0	0	10	5	0	
EUP	45	0	0	0	3	41	49	
OSH	4	26	58	0	0	3	0	
PAN	50	67	42	0	0	3	1	
OCR	0	0	0	0	0	0	0	
PAG	0	0	0	0	0	0	0	
TAN	0	0	0	0	0	0	0	
CEP	0	0	0	0	0	0	0	
ZOA	0	5	0	0	0	0	0	
COT	0	0	0	0	0	0	0	

Table 57.-- Continued.

Prey	Predator											
	DOG	BGS	BES	LNS	ATK	PLK	COD	SAB	PAH	ATF	BMS	GRS
JFH	0	0	0	0	0	0	0	3	0	0	0	0
POL	0	0	0	0	0	<1	7	2	1	1	0	0
MAW	0	0	0	0	0	<1	<1	<1	<1	0	0	0
MOL	0	0	0	0	<1	<1	2	3	<1	<1	0	0
CHA	0	0	0	0	0	<1	0	<1	0	<1	0	0
LAR	0	0	0	0	15	2	0	<1	0	0	0	0
CAL	0	0	0	0	1	22	<1	<1	0	<1	0	0
MYS	0	0	0	0	0	<1	<1	<1	<1	<1	0	0
AMP	0	0	0	0	<1	3	4	3	<1	<1	0	0
EUP	7	0	0	0	67	41	5	15	1	14	0	0
OSH	0	4	33	2	0	4	8	1	1	3	0	0
PAN	0	0	0	45	0	9	8	3	1	7	0	0
OCR	0	0	33	0	<1	2	9	<1	17	<1	0	0
PAG	0	0	0	0	<1	<1	4	1	10	0	9	0
TAN	0	46	0	45	0	<1	10	<1	6	0	0	100
CEP	0	0	0	0	0	<1	3	9	3	3	0	0
BRI	0	0	0	0	0	0	<1	<1	<1	0	0	0
ZOA	0	0	0	0	0	<1	<1	<1	<1	1	50	0
COT	0	0	0	0	0	<1	3	<1	2	1	41	0
STI	0	0	0	0	0	0	1	0	<1	1	0	0
BAS	0	0	0	0	0	0	<1	0	<1	<1	0	0
EUL	0	0	0	0	0	0	<1	2	<1	<1	0	0
MYC	0	0	0	0	0	0	0	0	0	<1	0	0
SAN	0	49	0	0	15	2	17	5	10	10	0	0
ATF	0	0	0	0	0	1	0	0	3	1	0	0
FHS	0	0	0	0	0	<1	0	0	1	0	0	0
ROS	0	0	0	0	0	0	0	0	1	<1	0	0
CAP	0	0	0	0	0	1	3	3	4	13	0	0
HER	0	0	0	0	0	1	1	1	2	<1	0	0
PLK	0	0	31	0	0	5	6	25	25	37	0	0
COD	0	0	0	0	0	0	0	2	1	0	0	0
FOF	93	0	0	0	0	0	0	9	2	<1	0	0
UNF	0	0	0	0	0	3	1	7	1	3	0	0
OTF	0	1	0	9	0	<1	2	5	6	4	0	0

Table 57.-- Continued.

Prey	Predator								
	SHR	ROU	SST	DUR	SFE	BKE	WTE	EUL	GTG
JFH	0	0	0	0	0	0	0	0	0
POL	0	0	2	0	0	0	0	0	0
MAW	0	0	0	0	0	0	0	0	0
MOL	0	0	0	0	51	0	0	0	0
CHA	0	3	1	0	0	0	0	0	0
LAR	0	0	1	0	0	0	0	2	0
CAL	0	6	<1	1	0	0	0	0	0
MYS	1	<1	1	0	7	0	0	3	4
CUM	0	0	<1	0	30	0	0	2	0
ISO	0	0	3	0	0	0	0	0	0
AMP	<1	3	1	0	0	0	0	6	0
EUP	<1	22	16	17	1	91	0	67	2
OSH	44	6	7	0	11	9	8	0	34
PAN	1	26	3	0	0	0	0	0	4
OCR	0	0	31	0	0	0	0	0	0
PAG	0	1	2	0	0	0	0	0	0
TAN	0	13	0	0	0	0	0	0	0
CEP	17	8	1	0	0	0	0	0	38
BRI	0	0	0	0	0	0	0	0	0
ZOA	0	0	8	0	0	0	92	0	0
COT	0	0	0	0	0	0	0	0	0
STI	0	0	0	0	0	0	0	0	0
BAS	0	0	0	0	0	0	0	0	0
EUL	0	0	0	0	0	0	0	0	0
MYC	30	0	4	0	0	0	0	0	0
SAN	0	0	0	82	0	0	0	0	0
ATF	0	0	0	0	0	0	0	0	0
FHS	0	0	0	0	0	0	0	0	0
ROS	0	0	0	0	0	0	0	0	0
CAP	0	0	0	0	0	0	0	0	0
HER	0	0	0	0	0	0	0	0	0
PLK	0	0	6	0	0	0	0	0	4
COD	0	0	0	0	0	0	0	0	0
FOF	0	0	0	0	0	0	0	0	0
UNF	0	0	0	0	0	0	0	0	0
OTF	<1	1	1	0	0	0	0	16	14

Table 57.-- Continued.

Prey	Predator									
	FHS	SRS	NRS	REX	DOV	NRQ	DES	DFS	YFS	BUT
JFH	0	0	0	0	0	0	0	0	0	0
POL	<1	16	13	26	49	86	72	52	4	0
MAW	0	<1	6	19	6	0	0	0	0	0
MOL	0	5	6	1	1	0	0	0	0	0
CHA	0	0	0	0	0	0	0	0	0	0
LAR	0	0	0	0	0	0	0	0	0	0
CAL	0	0	0	<1	0	0	0	0	5	0
MYS	<1	0	0	6	0	0	0	1	0	0
CUM	<1	0	0	3	1	14	0	10	91	100
ISO	<1	<1	<1	0	<1	0	0	23	0	0
AMP	0	7	1	10	3	0	10	10	0	0
EUP	0	0	<1	14	10	0	0	3	0	0
OSH	1	0	<1	1	3	0	0	0	0	0
PAN	64	0	0	1	0	0	0	0	0	0
OCR	1	24	0	0	0	0	0	0	0	0
PAG	0	3	1	<1	3	0	0	0	0	0
TAN	0	0	0	0	0	0	0	0	0	0
CEP	0	0	0	0	0	0	18	0	0	0
BRI	10	35	29	0	24	0	0	0	0	0
CUC	0	2	23	0	0	0	0	0	0	0
ZOA	0	0	0	0	0	0	0	0	0	0
COT	0	0	0	0	0	0	0	0	0	0
STI	6	2	0	0	0	0	0	0	0	0
BAS	0	0	0	0	0	0	0	0	0	0
EUL	0	0	0	0	0	0	0	0	0	0
MYC	0	0	0	0	0	0	0	0	0	0
SAN	0	0	19	0	0	0	0	0	0	0
ATF	0	0	0	0	0	0	0	0	0	0
FHS	0	0	0	0	0	0	0	0	0	0
ROS	0	0	0	0	0	0	0	0	0	0
CAP	0	0	0	0	0	0	0	0	0	0
HER	0	0	0	0	0	0	0	0	0	0
PLK	0	0	0	14	0	0	0	0	0	0
COD	0	0	0	0	0	0	0	0	0	0
FOF	17	0	0	0	0	0	0	0	0	0
UNF	0	0	0	5	0	0	0	0	0	0

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