FINAL REPORT

Contract: #03-5-022-56
Task Order: #21
Research Unit: #284
Reporting Period: 4/1/77-3/31/78
Number of Pages: 70

FOOD AND FEEDING RELATIONSHIPS IN THE BENTHIC AND DEMERSAL FISHES OF THE GULF OF ALASKA AND BERING SEA

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March 1978

TABLE OF CONTENTS

LIST OF TABLES

LIST OF TABLES (CONT'D)

LIST OF FIGURES

I. SUMMARY OF OBJECTIVES AND IMPLICATIONS

Our ultimate goal was to construct *a* detailed picture of the food and feeding relationships of the fishes in these two study areas. This should include analyses of predator size vs. prey composition; bottom type, temperature and location vs. prey composition; prey composition in diets vs. prey abundance; prey composition vs. season. The rationale behind this study was to develop an ability to predict the impact of oil development activities on the fishes in these two areas. Clearly, for example, activities which affect benthic invertebrates will directly affect those fish species which feed on them. This study, coupled with others designed to study acute and chronic toxic effects on the fish populations, will help establish the predictive base necessary to make management decisions. It is already known that certain specific geographic areas are fairly critical as overwintering areas or feeding areas for some of the fishes. Exploration and drilling activity could have a much greater impact in these areas than in others. Again, one of the ultimate goals of this study is to elucidate some of these area effects,

The relevance of these considerations should be obvious. The fishing industry is one of the most important in the state of Alaska. Commercial fishing in Alaskan waters has, in the past, contributed heavily to the landings of foreign countries such as Japan, Korea and the U.S.S.R. To an unknown extent, oil exploration and development on the outer continental shelf will impact these fisheries. Impacts other than economic will also occur but will be difficult to assess. The relevance of this project is that it adds to the total fund of information available on the risks of oil development, Other information will be provided, hopefully, on the benefits of development. With the risks and benefits of a particular course of action clearly defined, the politicians will have some firm ground upon which to base their decisions.

II. CURRENT STATE OF KNOWLEDGE

This section includes the discussion of our research findings when possible in the context of previous studies on the same species. Nine of the species we report on are ones for which we have contributed original research. They are: pollock, rex sole, rock sole, clover sole, flathead sole, arrowtooth flounder, Greenland halibut, capelin and shortfin eelpout . In addition, we were asked to summarize existing information on Pacific cod, yellowfin sole and Pacific halibut. Each of these twelve species is treated below, in a section of its own. An exception is that the rex, rock, clover and flathead soles are treated in a single chapter since their analysis has been integrated.

Walleye pollock, *Theragra chalcogramma*, southeast Bering and northeast Gulf of Alaska

Several previous studies have dealt with food habits of the pollock. Young British Columbia pollock, from 4-22 mm standard length, feed on copepods and their eggs (Barraclough, 1967) while adults feed on shrimps, sand lance and herring (Hart, 1949). Armstrong and Winslow (1968) report Alaska pollock feeding on young pink, chum and coho salmon. Suyehiro (1942) reported small shrimps, benthic amphipods, euphausiids and copepods in the stomachs of pollock from the Aleutians. Andriyashev (1964) listed mysids and amphipods as the major foods of Bering pollock with *Chionoecetes opilio* (tanner crab) also present. He also reports that pollock from Peter the Great Bay and Sakhalin feed on surf smelt and capelin in the spring and shift to planktonic crustaceans in the summer. Nikolskii (1961) lists pollock food organisms from Asian waters as mysids, euphausiids, silver smelt and capelin. The purpose of this study is to add information on the food habits of Alaska pollock, with special. reference to the effect of predator size.

A summary of stomach contents of pollock from the southeast Bering Sea is presented in Table I. That summary presents information on percent frequency of occurrence (F), numerical frequency (N), percent volumetric contribution (V), and Index of Relative Importance (IRI).

Identifiable euphausiids represented the genera *Euphausia* and *Thysanoessa*. Crabs in the family Majidae, when identifiable, were usually *Chionoecetes* sp. but *Hyas* SP. also occurred. All the Majids were in the megalops stage. The Amphipoda contributing to the food of Bering Sea pollock were all pelagic Hyperiidae.

Table 11 is an analysis of the same feeding data as above, but divided into six size categories. Data presented are F, V, and IRI for each pollock size interval.

Table 111 summarizes the stomach contents from pollock sampled from the northeast Gulf of Alaska. The molluscan prey organisms consisted of small benthic clams and snails and larval cephalopods. Amphipods were predominantly the pelagic hyperiids but several benthic forms were present. All the Majidae were megalops larvae.

An analysis of the Gulf of Alaska food habits by pollock size category is presented in Table IV. As in Table 11, F, V and IRI are presented.

TABLE I

A SUMMARY OF STOMACH CONTENTS FROM ALL SIZE CATEGORIES OF POLLOCK CAUGHT IN THE SOUTHEAST BERING SEA

Standard lengths ranged from 85 to 526 mm ($\bar{x}$ = 270 ± 145 mm). Results are reported as frequency of occurrence (F), numerical frequency (N), percent volumetric contribution (V), and index of relative importance (IRI). Number of feeding individuals examined was 163.

Prey taxon	F	N	V	IRI
Polychaeta	0.6	0.1	0.1	0.1
Crustacea	87	95	30	10799
Copepoda	6	2	0.02	15
Amphipoda	15	7	0.7	124
Mysidae	2	0.3	0.2	1
Euphausiidae	60	77	10	5211
Hippolytidae	0.6	0.1	0.02	0.1
Pandalidae	3	1	2	10
Crangonidae	4	6	16	82
Maj idae	1	0.2	0.03	0.2
Unident. Crust.	21	3	0.4	80
Teleostei	12	2	70	886
Unident. Anim. Mat.	12	3	0.2	

TABLE 11

FEEDING HABITS OF POLLOCK IN SIX SIZE CATEGORIES FROM THE SOUTHEAST BERING SEA

Results are reported as percent frequency of occurrence (F), percent volumetric contribution (V), and index of relative importance (IRI). Mean length ($\bar{x}$) and sample size (n) are reported for each interval.

Prey taxon	o-99 mm >93, n=22	100-199 mm $\bar{x}$=159, n=55	200-299 mm $\bar{x}$=228, n=25	300-399 mm $\bar{x}$=343, n=17	400-499 mm $\bar{x}$=438, n=36	500-1000 mm $\bar{x}$=615, n=8
Polychaeta			4,1.3,6.5			
Crustacea	86,92,13441	95,100,18831	88,51,13189	82,52,12382	75,28,9313	88,24,9855
Copepoda	32,4,1243	5.5,0,4.5				
Amphipoda	31,4,871	16,0,59	12,0.8,33	18,0,32		
Mys idae						38,0.3,158
Euphausiidae	68,80,8199	64,92,11537	56,47,7821	76,52,11286	56,19,4650	13,0.02,25
Hippolytidae		1.8,0.5,1.5				
Crangonidae						75,20,7030
Pandalidae			4,2.1,11			75,3,634
Maj idae			4,0.3,2.3		3,0.2,2.1	
Teleostei			12,47,579	18,48,876	22,69,1637	63,76,5395
Unident. Animal Material	4,8,-	9.1,0,-	4,0.3,-		11,2,-	

TABLE III

A SUMMARY OF STOMACH CONTENTS FROM ALL SIZE CATEGORIES OF POLLOCK CAUGHT IN THE NORTHERN GULF OF ALASKA

Standard lengths ranged from 139 to 560 mm ($\bar{x}$ = 344 ± 84 mm). Results are reported as frequency of occurrence (F), numerical frequency (N), percent volumetric contribution (V), and index of relative importance (IRI). Number of feeding individuals examined was 253.

Prey taxon	F	N	v	IRI
Polychaeta	2	0.01	0.2	0.4
Mollusca	2	0.08	0.6	1.4
Pelecypoda	1.2	0.03	0.5	0.6
Gastropoda	0.4	0.01	0	0.04
Cephalopoda	0.8	0.03	0.06	0.07
Crustacea	90	99.6	90	17064
Copepoda	1.2	0.14	0.02	0.2
Amphipoda	9	0.6	0.1	6
Euphausiidae	83	95.5	87	15148
Pandalidae	6	0.2	2.5	16
Crangonidae	1.2	0.03	0.2	0.3
Maj idae	16	2.8	0.5	53
Unident. Crustacea	2	-	0.04	
Teleostei	9	0.3	7.5	70
Unident. Anim. Mat.	19		0.5	

TABLE IV

FEEDING HABITS OF POLLOCK IN FIVE SIZE CATEGORIES FROM THE NORTHERN GULF OF ALASKA

Results are reported as percent frequency of occurrence (F), percent volumetric contribution (V), and index of relative importance (IRI). Mean length ($\bar{x}$) and sample size (n) are reported for each interval.

Prey taxon	100-199 mm $\bar{x}$=158, n=24	200-299 mm $\bar{x}$=276, n=19	300-399 mm $\bar{x}$=357, n=151	400-499 mm $\bar{x}$=426, n=56	500-1000 mm $\bar{x}$=540, n=3
Polychaeta	17, 27, 464		0.7, 0.02, 0.01		
Mollusca			3, 1, 3		
Crustacea	75, 59, 11888	89, 98, 17739	94, 90, 17766	88, 90, 16540	67, 97, 13104
Copepoda		5, 0, 2.4	1.3, 0.03, 0.3		
Amphipoda	8, 3, 49	25, 0.8, 121	7, 0.08, 3	9, 0.1, 4.2	33, 0.2, 26
Euphausiidae	21, 38, 2146	84, 97, 15863	91, 86, 16380	86, 87, 15822	67, 97, 13052
Pandalidae	4, 2, 9	5, 0.3, 2.5	7, 3, 23	5, 2, 13	
Crangonidae	8, 3, 35			2, 0.5, 1	
Maj idae	63, 11, 2334	26, 0.8, 109	11, 0.6, 45	7, 0.2; 7	
Teleostei			9, 8.1, 82	18, 8, 152	33, 3, 115
Unident. Animal Material	21, 14, -	32, 2, -	13, 1, -	32, 2, -	33, 0, -

This study reports the same types of food organisms in pollock as were found in other studies. Our results differ markedly from those of Nikolskii (1961) and Andriyashev (1964) in that we found mysids to be of very little importance in the southeast Bering Sea and were completely absent from northern Gulf pollock stomachs.

In examining Table I and Table 111, it is clear that euphausiids are the predominant food organisms (in terms of F, N and IRI) in pollock from both the geographic regions considered. The second most important food category is Teleostei, based on IR1, both in the Gulf and the Bering Sea. However, in terms of volumetric contribution in the stomachs sampled, fishes were very important in the Bering Sea (V=70%) and much less so in the Gulf (V=7.5%).

In examining food habits versus size in pollock from the Bering Sea (Table II) several trends appear. The smallest food organisms, the copepods, are present only in the two smallest size intervals and are only important (lRI) in the smallest size interval. Conversely, fishes, large sized food organisms, are absent from the first two size intervals and become progressively more important in the remaining four size intervals. This suggests an increased emphasis on fishes in the diets with increasing size in Bering Sea pollock. In terms of IRI, amphipods decline in importance with increased predator size. Euphausiids are the most important food organisms in all but the largest size interval. Sample size in that interval is small suggesting that the results we found may not be completely representative of natural populations. The largest interval was the only one in which mysids and crangonid shrimps appear in the diet. Majid crabs appear very infrequently in Bering Sea pollock stomachs sampled.

Analysis of Gulf of Alaska pollock foods by size intervals reveals some similarities to the Bering Sea results. Again, euphausiids are the most important food organisms (IRI) in all size intervals except one. Only in the 100-199 mm interval are euphausiids overshadowed by majid crabs. Another similarity to the Bering Sea findings is the presence of fishes in the stomachs of only the larger pollock. The Gulf results contrast with the Bering Sea results in several respects, however. As noted above, fishes are much less important in pollock diets in the Gulf than in the southeast Bering as evidenced by comparisons of IRI and V values. Also, in the Gulf specimens examined, copepods are much less prevalent and majid megalops larvae are much more prevalent. The majid crabs are the most important food organisms (F, IRI) in the smallest predator interval and progressively decline in frequency of occurrence and relative importance with increased size. Pandalid shrimps are much more prevalent in the various size intervals of Gulf pollock than Bering Sea. The same is true of benthic organisms in general.

Insufficient data were obtained to speculate about diurnal periodicity in feeding, seasonality in feeding intensity, or food composition versus season. Larger sample sizes could confirm the tentative conclusions reached concerning food habits in Alaskan pollock.

Rex, flathead, rock and clover soles

The rex sole, *Glyptocephalus zachirus*, occurs from southern California to the eastern Bering Sea. Needler (1954) reported that this species grows slowly with a lifespan of at least 24 years. Females grow faster and live longer than males (Hosie and Horton, 1977). Mineva (1968) noted that 75%

of fish captured in the Bering Sea were between 12 and 16 years of age. Hart (1973) reports females more abundant in Pacific Ocean catches while Mineva (1968) found males more abundant in the Bering Sea. As juveniles grow, they move out of shallow water down to 150 m, and as adults are most abundant from 200 to 550 m. The rex sole has been reported down to 1100 m (Grinols, 1965).

The flathead sole, *Hippoglossoides elassodon*, occurs from northern California to the Bering Sea, at depths ranging from the surface to 550 m. While maximum abundance tends to occur at depths of 91-181 m in the Gulf of Alaska and 2-90 m in the Bering Sea (Alderdice and Forrester, 1974), geographic and bathymetric migrations have been described with respect to season and maturity (Hughes, 1974). The possibility of flathead sole rising to the surface at night, and returning to the bottom during the day was proposed by Cooney (1967).

Limited information on feeding in this species has been reported by Suyehiro (1934), Smith (1936), and Skalkin (1963). These studies suggested that the flathead sole feeds on both benthic organisms such as polychaetes, molluscs, and brittle stars, and nektonic organisms such as fishes and shrimps. Mineva (1968) found that the flathead sole feeds in winter, unlike allied species. Miller (1970) discussed changes in the diet of the flathead sole with size and season in Washington waters.

The rock sole, *Lepidopsetta bilineata*, ranges from southern California through the Bering Sea to the Sea of Japan. Hart (1973) states that females may attain a length of 60 cm and males 53 cm. A maximum lifespan of 22 years for females and 15 years for males is suggested by Forrester (1964). While the rock sole occurs from the surface to 366 m, it is rare below 100 m in the Gulf of Alaska and British Columbia. In the eastern Bering Sea, the rock sole is rare below 300 m (Pereyra *et al.*, 1976). A summer movement into shallower water has been reported throughout the range (Forrester, 1969; Shubnikov and Lisovenko, 1964).

Little is known about the feeding habits of the rock sole. Skalkin (1963) and Shubnikov and Lisovenko (1964) report that the Bering Sea diet consists chiefly of polychaetes followed by molluscs and crustaceans. Kravitz *et al.* (1976) found that rock sole in Oregon waters fed mainly on ophiuroids. Feeding is much reduced during the winter, and is most intense in June and July.

The clover sole, *Microstomus pacificus*, is found from northern Baja California to the Bering Sea. Individuals may attain a length of 71 cm, and have been found from the surface to 1100 m (Hart, 1973). Little is known about the habits of this species in Alaskan waters. Hagerman (1952) stated that the clover sole feeds on molluscs, polychaetes and echinoderms in Californian waters.

Rex sole were captured by otter trawl from May through July 1975. Gulf of Alaska trawl stations occupied in this study are from among those used by the International Pacific Halibut Commission in their yearly surveys (Fig. 1). Abdomens were slit and the whole fishes were packed in 10% formalin (per total volume of water and fish), buffered with 20 g of hexamethylenetetramine per liter. Upon return to the lab, specimens were measured for standard length to the nearest millimeter. Sex and maturity were recorded.

Flathead sole were captured at six stations in the Gulf of Alaska from May through July 1975. Five trawls in the Bering Sea were made in August

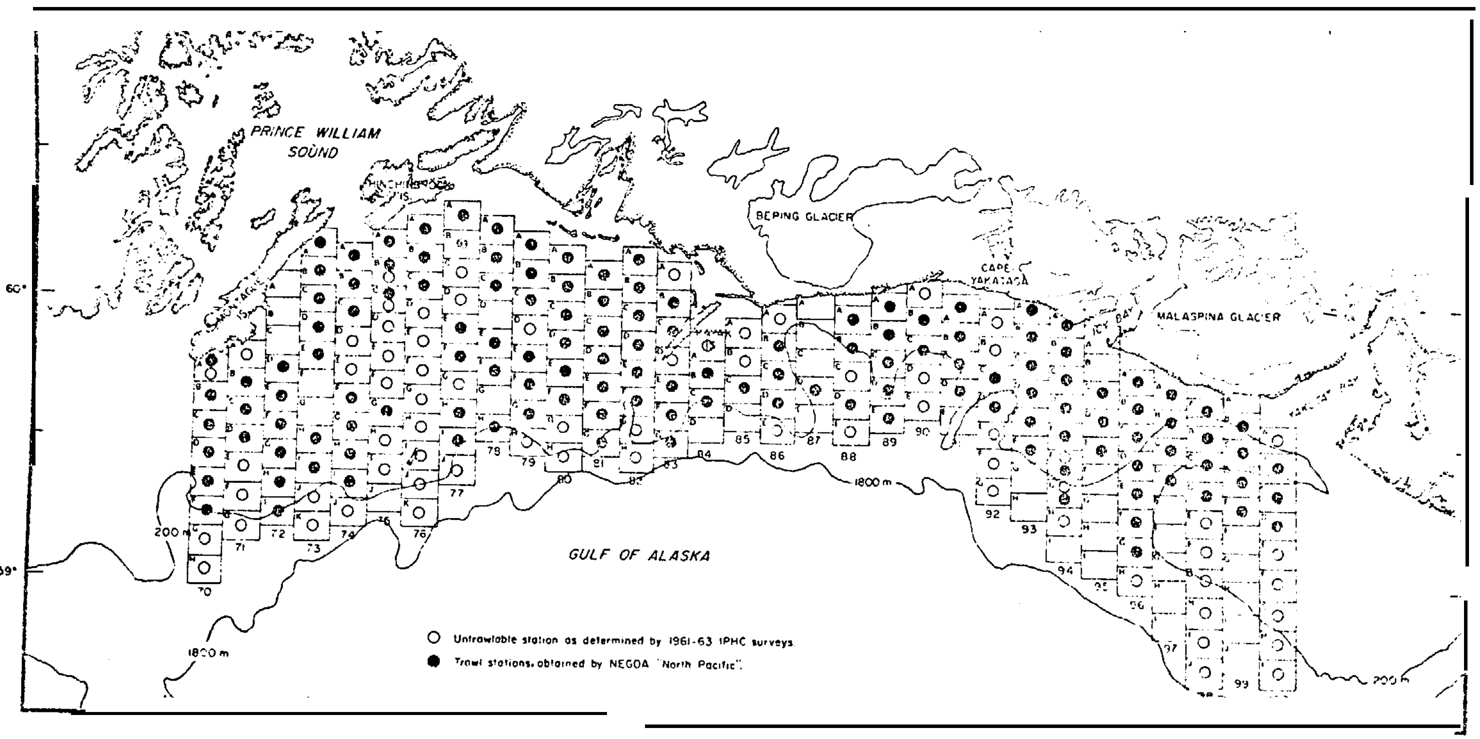

Figure 1. Trawl stations occupied during 1975 in the Gulf of Alaska.

1975, October 1975 and May 1976, representing summer, autumn and spring, respectively.

Dover sole were taken at seven Gulf of Alaska stations during the same period as the rex sole. Nine Bering Sea stations occupied from August through October 1975 provided the rock sole. It was impossible to influence when *or* where any trawls were made in this study, so collections were opportunistic rather than according to a particular sampling plan.

Prey were identified to the most specific taxa permitted by their state of preservation. Counts were made of all items, and volumes were measured for each taxon to the nearest 0.1 ml. The frequency of prey occurrence (F), the percent contribution by volume (V), the percent by number (N), and an Index of Relative Importance (IRI) were calculated for each station and for all stations combined. The index was developed by Pinkas *et al.* (1971) using the formula IRI = (N + V)F. It should be noted that values reported for consumption of a prey taxon may be conservative. This is reflected in partially unidentifiable material being assigned to a higher taxon; for example, the importance of the Amphipoda in the rex sole diet (Table VI) is far greater than suggested by values for amphipods identified to lower taxa.

An index of stomach fullness was recorded for each predator such that 0 = no information, 1 = empty, 2 = trace, 3 = 25%, 4 = 50%, 5 = 75%, 6 = 100%, and 7 = distended. Mean stomach fullness was calculated for each prey taxon at a station, for all taxa at a station, for each taxon combining all stations, and for all taxa combining all stations. Mean predator length was calculated in the same fashion. It was hoped that these last two criteria might elucidate possible changes in food preference with stomach fullness (i.e., satiation) or with predator size. The fortran program developed for this study is highly machine specific for the Honeywell 66/40.

Prey availability data came from Best (1964), Feder *et al.* (1976), and R. T. Cooney (personal communication). Biologically important taxa (BIT) in terms of prey availability were determined using the method of Feder *et al.* (1976). To qualify as a BIT, a taxon must be distributed in 50% or more of total stations sampled, comprise over 10% of population numbers or biomass at any one station, or satisfy a population density or biomass criterion. These density and biomass criteria are based upon a percentage calculated for each taxon, with the sum of the population density or biomass of all taxa equaling 100%. These percentages are ranked in descending order. The percentages of each taxon are then summed in descending order until a cut-off point of 50% is reached. BIT by these population density or biomass criteria are those taxa whose percentages are used to reach the 50% cut-off point.

Diets were statistically compared using 2-tailed (α:0.005) Spearman's rank correlation coefficients (Zar, 1974).

Of 300 rex sole stomachs collected in 1975, seven were empty and 293 contained food (Table V), Ten families of polychaetes contributed most of the food consumed. Pelecypods, cumaceans, amphipods, euphausiids, and decapods (especially *Pandalus borealis* and postlarval *Chionoecetes bairdi*) were also common in the diet (Table VI; Fig. 2). Table VII compares feeding in the rex sole according to three predator size classes. Using the Spearman's rank correlation coefficient (SRCC), no significant changes in diet were found with predator size.

TABLE V

STATION DATA FOR REX SOLE COLLECTIONS IN THE GULF OF ALASKA

Variable	Station 81C	98B	771	78H	100B	82D	Combined Gulf of Alaska
Latitude (“N)	59°88	59°53	59°55	59°73	59°45	59°88	59°67
Longitude (“W)	144°95	140°73	145°98	145°73	140°23	144°73	143°73
Time of day (l-24 h)	23	1	22	6	22	21	21
Date	7-14	7-4	7-27	5-14	6-3	5-15	
Depth (m)	111	149	76	89	122	63	102
Number feeding	106	65	3	36	16	67	293
Number empty	4	1	1	0	0	1	7
Mean fullness of feeding individuals	60	59	8	46	77	82	63
Mean length of predator (mm)	240	267	121	250	251	261	228

TABLE VI

PREY CONSUMED BY REX SOLE FOR ALL GULF OF ALASKA STATIONS

Data are expressed as percent frequency of occurrence (F), percent by number (N), percent by volume (V), and by index of relative importance (IRI). Biologically important taxa in terms of prey availability are noted by an asterisk under BIT. Mean predator length in mm (MPL) and mean fullness of stomach in percent (MFS) are given for each prey taxon consumed.

Taxon	MPL	MFS	F	N	V	IRI	BIT
POLYCHAETA	231	68	79.7	42.3	54.6	7722	*
Phyllodocidae	207	84	3.9	1.1	0.3	5	
Anaitides sp.	250	100	0.7	0.2	0.0	0.2	
Eulalia sp.	174	25	0.4	0.1	0.0	0.0	
Notophyllum sp.	228	100	0.4	0.1	0.0	0.1	
Nephtyidae	241	100	0.7	0.1	0.8	0.6	*
Goniadidae	245	76	6.6	1.3	1.1	16	*
Glycinde picta	182	100	0.4	0.1	0.0	0.0	
Goniada annulata	247	74	5.9	1.2	1.1	13	*
Onuphidae	231	87	28.7	18.8	21.9	1166	*
Onuphis iridescens	232	89	25.5	18.0	21.0	996	
Lumbrineridae	210	79	6.3	1.4	1.5	18	*
Lumbrinereis sp.	253	38	0.7	0.1	0.2	0.2	
Sternaspidae	261	88	5.2	1.0	0.7	9	*
Sternaspis scutata	261	88	5.2	l.0	0.7	9	*
Sabellariidae	222	0	0.4	0.1	0.2	0.1	
Pectinaridae	278	100	0.7	0.1	0.1	0.2	
Ampharetidae	217	100	0.7	0.1	0.1	0.1	*
Sabellidae	326	100	0.4	0.1	O*1	0.0	*
MOLLUSCA							*
Pelecypoda	265	71	16.8	6.3	3.1	157	*
CRUSTACEA	160	83	95.5	74.3	21.6	9148	*
Copepoda	214	38	0.7	0.1	0.0	0.1	
Calanus sp.	214	38	0.7	0.1	0.0	0.1	
Cumacea	196	74	26.6	6.0	0.2	164	*
Eudorella sp.	198	60	4.6	1.5	0.2	8	
Eudorella emarginata	187	56	2.8	1.2	0.2	4	*
Diastylis sp.	174	100	0.4	0.1	0.0	0.0	
Campylaspis sp.	194	69	3.2	0.4	0.2	2	
Amphipoda	190	75	27.3	14.2	0.8	408	*
Haploops tubercula	250	100	0.7	0.3	0.0	0.2	*

TABLE VI

CONTINUED

Taxon	MPL	MFS	F	N	V	IRI	BIT
Amphipoda (cent'd)							
Ampithoidae	273	50	0.4	0.1	0.2	0.1	
Neohela sp.	232	100	0.4	0.1	0.0	0.0	
Gammaridae	251	25	0.4	0.1	0.0	0.0	
Hyperia sp.	256	100	0.4	0.1	0.0	0.0	
Caprellidae	230	88	2.1	0.4	0.0	0.9	
Euphausiacea	228	78	16.8	3.7	4.3	134	*
Euphausia pacifica	265	81	1.4	0.3	0.6	1.2	*
Thysanoessa sp.	174	80	1.8	0.2	0.2	0.8	
Thysanoessa rashii	205	100	0.4	0.1	0.1	0.1	
Decapoda	219	70	52.1	20.4	16.7	1933	*
Pandalidae	258	84	9.1	3.3	7.5	98	
Pandalus borealis	264	79	4.6	1.9	6.3	37	
Hippolytidae	205	88	6.3	1.8	2.1	24	
Spirontocaris sp.	284	50	0.4	0.5	0.4	0.3	
Callionassidae	289	88	0.7	0.1	0.4	0.3	
Maj idae	214	70	39.5	13.9	4,7	734	*
Hyas sp.	139	100	0.7	0.1	0,0	0.1	
Chionoecetes bairdi	214	70	38.8	13.6	4.8	709	*
Xanthidae	262	25	0.4	0.1	0.1	0.1	
ECHINODERMATA							
Ophiuroidea	266	82	3.9	0.5	0.4	4	*
TELEOSTEI	258	75	1.4	0.2	1.0	2	*
Zoarcidae	225	100	0.4	0.1	0.1	0.0	
Unidentified animal material			38.8	0.0	15.8		

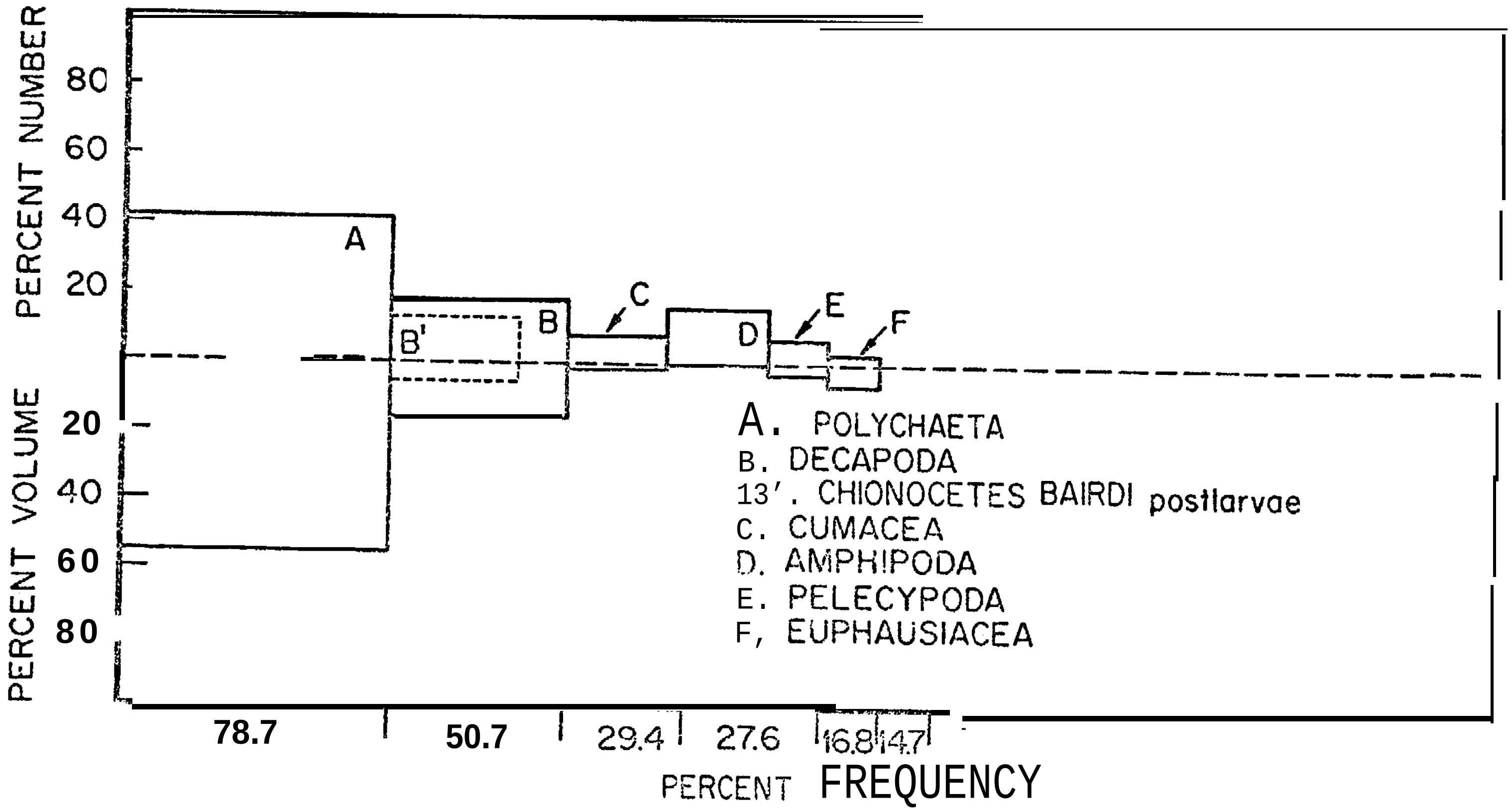

Figure 2. Feeding habits of the rex sole in the Gulf of Alaska.

TABLE VII

REX SOLE - FEEDING HABITS BY SIZE

Taxon	0-200 mm IRI	201-300 mm IRI	301-600 mm IRI
POLYCHAETA	6021	6597	14307
Phyllodocidae	13	5	0
Goniadidae	13	20	10
Onuphidae	914	574	4552
Lumbrineridae	54	6	28
Sternaspidae	2	11	21
PELECYPODA	1	298	354
CRUSTACEA	9237	6111	1536
Cumacea	764	220	2
Amphipoda	1688	454	37
Euphausiacea	106	225	10
Decapoda	2688	1946	889
Pandalidae	55	70	425
Hippolytidae	67	26	0
Maj idae	1210	741	136
OPHIUROIDEA	0.2	10	1
TELEOSTEI	0	8	0

Of 129 clover sole stomachs collected in the Gulf of Alaska, 8 were empty and 121 contained food. Ten families of polychaetes contributed most of the food consumed (Table VIII). Ophiuroids, pelecypods, amphipods and decapods were also important.

Table IX shows clover sole feeding habits by predator size category. Paired comparisons using SRCC show that there is no difference between the feeding habits of the two largest categories, while all other combinations are different.

Prey consumption by 247 flathead sole in the Gulf of Alaska is listed in Table X. Euphausiids (probably all *Thysanoessa* spp.) and the brittle star, *Ophiura sarsi*, contributed most of the diet of the 139 feeding individuals. Only 39 flathead sole were collected in the Bering Sea (Table XI). These limited data suggest that the shrimp *Pandalus borealis* is the most important spring prey, while mysids, amphipods, and *Ophiura sarsi* dominated summer feeding. Crangonid shrimps and juvenile pollock were the most important autumn prey in the Bering Sea.

Table XII compares the diet of flathead sole according to predator size. Paired tests using SRCC demonstrate no significant difference between the diets of the two largest categories, but all other combinations are different.

Of 166 rock sole stomachs collected in the Bering Sea, 80 were empty. Eleven families of polychaetes contributed most of the food consumed (Table XIII). Crustaceans, pelecypods, fishes, and ophiuroids were also important.

Feeding habits by predator size are found in Table XIV. Using SRCC all paired comparisons *were* different. Thus feeding habits of the rock sole change significantly with increasing size. Crustaceans (chiefly

TABLE VIII

DOVER SOLE - STOMACH CONTENTS ALL STATIONS

Taxa	MPL	MFS	F	N	V	IRI
POLYCHAETA	277	62	71.1	59.6	72.2	9369
Glyceride	239	0	0.8	0.1	0.0	0.1
Goniadidae	321	75	0.8	0.1	0.1	0.1
Goniada annulata	321	75	0.8	0.1	0.1	0.1
Onuphidae	292	81	17.4	18.6	42.7	1063
Onuphis iridescens	303	87	14,9	18.1	41.9	892
Lumbrineridae	263	32	5.8	4.6	0.2	28
Sternaspidae	328	56	3.3	0.5	0.3	3
Sternaspis scutata	328	56	3.3	0.5	0.3	3
Maldanidae	232	100	0.8	0.9	0.5	1.2
Sabellariidae	301	75	0.8	0.2	0.1	0.2
Ampharetidae	249	78	8.3	1.3	0.7	17
Ampharete sp.	249	78	8.3	1.3	0.7	17
Terebellidae	227	83	8.3	7.9	6.1	116
Aphroditidae	287	50	1.7	0.2	1.1	2
Aphrodita parva	287	50	1.7	0.2	1.1	2
MOLLUSCA	290	49	26.5	5*3	2.0	192
Pelecypoda	288	47	24.0	4.6	1.9	156
Nuculidae	278	57	5.8	1.1	0.2	8
Nucula tenuis	278	57	5.8	1.1	0.2	8
Nuculanidae	310	46	10.7	1.7	1.0	27
Nuculana fossa	329	75	1.7	0.5	0.4	1.5
Yoldia sp.	325	100	0.8	0.2	0.1	0.2
Y. *montereyensis*	307	41	9.1	1.1	0.5	14
Mytilidae	315	88	1.7	0.2	0.5	1.1
Musculus discors	315	88	1.7	0.2	0.5	1.1
Gastropoda	217	75	0.8	0.1	0.0	0.1
Scaphopoda	365	50	1.7	0.6	0.1	1.0
Cadulus sp.	365	50	1.7	0.6	0.1	1.0
Cephalopod	329	100	0.8	0.1	0.0	0.1
CRUSTACEA	267	57	26.5	8.6	4.1	334
Cumacea	290	67	5.0	1.2	0.0	6
Eudorella sp.	325	100	0.8	0.2	0.0	0.2

TABLE VIII

CONTINUED

Taxa	MPL	MFS	F	N	V	IRI
CRUSTACEA (cent'd)						
Amphipoda	262	53	14.9	5.1	2.8	116
Corophiidae	252	42	2.5	2.0	0.3	6
Erichthonius hunteri	227	34	1.7	1.8	0.1	3
Neohila **sp.**	301	50	0.8	0.2	0.3	0.4
Kuriidae	297	75	0.8	0.4	0.9	1.1
Caprellidae	341	88	1.7	1.1	1.4	4
Euphausiacea	271	55	4.1	0.6	0.5	5
Euphausiidae	264	33	2.5	0.5	0.4	2
Thysanoessa sp.	281	88	1.7	0.2	0.1	0.4
Decapoda	264	53	7.4	1.4	0.9	17
Pandalidae	237	100	0.8	0.3	0.4	0.6
Pandalus borealis	237	100	0.8	0.3	0.4	0.6
Maj idae	266	43	5.8	1.1	0.4	8
Hyas sp.	260	50	1.7	0.2	0.1	0.4
Chionoecetes bairdi	285	35	4.1	0.8	0.3	4
ECHINODERMATA	314	48	40.5	26.3	18.1	1800
Asteroidea	381	63	1.7	0.2	0.3	0.7
Ctenodiscus crispatus	381	63	1.7	0.2	0.3	0.7
Ophiuroidea	314	48	40.5	26.2	17.8	1782
Ophiopenia disacantha	341	88	1.7	0.2	0.1	0.4
Ophiopenia vacina	217	75	0.8	0.1	0.0	0.1
Ophiura sarsi	320	48	33.1	22.8	15.9	1280
TELEOSTEI	325	100	0.8	0.1	0.8	0.7
Lycodes diapterus	325	100	0.8	0.1	0.8	0.7
Unidentified Animal Material	273	42	18.2		2.8	55

TABLE IX

DOVER SOLE - FEEDING HABITS BY SIZE

Taxon	0-200 mm IRI	201-300 mm IRI	301-600 mm IRI
POLYCHAETA	19087	12461	6148
Onuphidae	0	1018	1178
Lumbrineridae	238	47	7
Sternaspidae	0	3	3
Ampharetidae	119	57	0
Terebellidae	9232	313	0
Aphroditidae	0	9	0
MOLLUSCA	0	138	274
Pelecypoda	0	126	204
Nuculanidae	0	10	64
Nuculidae	0	8	8
Mytilidae	0	0	5
Scaphopoda	0	0	5
CRUSTACEA	119	458	226
Cumacea	0	4	9
Amphipoda	119	137	87
Euphausiacea	0	13	0.5
Decapoda	0	31	8
ECHINODERMATA	0	538	4235
Ophiuroidea	0	538	4183
TELEOSTEI	0	0	3

TABLE X

PREY CONSUMED BY FLATHEAD SOLE FOR ALL GULF OF ALASKA STATIONS (n=247)

Data are expressed as percent frequency of occurrence (F), percent by number (N), percent by volume (V), and by index of relative importance **(IRI).** Biologically important taxa in terms of prey availability are noted by an asterisk under BIT. Mean predator length (MPL) in mm and mean fullness of stomach in percent (MFS) are given for each prey taxon consumed.

Taxon	MPL	MFS	F	N	V	IRI	BIT
MOLLUSCA	240	100	1.4	0.1	0.1	0.3	*
Pelecypoda	253	100	0.7	0.0	0.0	0.0	*
Gastropoda	227	100	0.7	0.0	0.0	0.0	*
Cephalopod	227	100	0.7	0.1	0.0	0.0	
CRUSTACEA	210	77	51.1	73.8	38.2	5718	*
Euphausiidae	209	78	49.6	73.7	37.9	5537	*
Thysanoessa sp.	201	82	20.1	37.6	18.3	1125	*
T. *spinifera*	177	104	13.0	33.4	18.0	665	*
Decapoda	243	50	2.2	0.1	0.3	0.9	*
Maj idae	263	63	1.4	0.1	0.2	0.4	*
Hyas Sp.	248	75	0.7	0.0	0.0	0.0	
OPHIUROIDEA	263	53	61.9	26.1	59.6	5297	*
Ophiura sarsi	263	57	56.8	26.0	58.4	4793	*
TELEOSTEI	258	50	1.4	0.1	1.8	2.6	*
Unident. Animal Material			3.6	0.0	0.4		

TABLE XI

SEASONAL PREY CONSUMPTION BY FLATHEAD SOLE IN THE BERING SEA

Data are expressed as index of relative importance (IRI), and biologically important taxa in terms of prey availability are noted by an asterisk under BIT. Probable BIT are noted by a question mark.

Taxon	Spring 1976	Summer 1975	Autumn 1975	BIT
POLYCHAETA	381			*
PELECYPODA	116		108	*
Nuculana fossa	70			
CRUSTACEA	7936	7645	11651	*
Neomysis rayii	55	1031		?
Amphipoda		2700	69	*
Rhachatropis oculatus		2700	-	
Decapoda	6561	159	11234	*
Crangon dalli			11234	?
Majidae	23			?
Pandalus borealis	5485	159		?
OPHIUROIDEA	68	1946	35	?
Ophiopenia disacantha	35			
Ophiura sarsi		1946		?
Ophiuroidae			35	
TELEOSTEI	235	157	416	*
Theragra chalcogramma			416	*

TABLE XII

FLATHEAD SOLE - FEEDING HABITS BY SIZE

Taxon	0-200 mm IRI	201-300 mm IRI	301-600 mm IRI
CRUSTACEA	17098	3582	1437
Amphipoda	44	0.2	0
Mysidae	19	0.4	0
Euphausiidae	12261	2393	46
Decapoda	25	106	760
Pandalidae	16	30	73
Crangonidae	0.5	1.6	351
OPHIUROIDEA	102	7313	9997
Ophiura sarsi	102	6456	8594
Ophiopenia disacantha	0	0.2	0
TELEOSTEI	5	19	36

TABLE XIII

ROCK SOLE STOMACH CONTENTS - ALL STATIONS FROM THE BERING SEA

Taxa	MPL	MFS	F	N	V	IRI
POLYCHAETA	237	40	74.4	48.2	36.9	6332
Phyllodocidae	300	100	1.2	0.1	0.1	0.2
Spionidae	174	25	1.2	0.2	0.1	0.4
Nereidae	332	25	1.2	0.1	0.6	0.7
Nephtyidae	212	88	2.3	0.2	1.3	4
Nephtys Sp.	185	100	1.2	0.1	1.2	1.5
Onuphidae	205	42	3.5	0.2	1.1	4
Lumbrineridae	288	100	1.2	0.7	4.5	6
Paraonidae	300	75	1.2	0.4	0.2	0.7
Anaspio sp.	174	25	1.2	0.2	0.1	0.4
Opheliidae	270	67	3.5	0.3	0.9	4
Travisia sp.	270	67	3*5	0.3	0.9	4
Maldanidae	311	67	3.5	0.4	0.1	2
Ampharetidae	315	25	1.2	0.1	0.1	0.3
Ampharete Sp.	315	25	1.2	0.1	0.1	0.3
Sabellidae	341	50	1.2	0.1	0.3	0.4
MOLLUSCA	245	43	17.4	2.0	9.2	196
Pelecypoda	250	45	12.3	1.9	9.2	180
Nuculanidae	199	33	3.5	0.2	0.0	0.6
Nuculana sp.	199	33	3.5	0.2	0.0	0.6
Cariidae	238	125*	1.2	0.9	7.9	10
Serripes Sp.	238	125*	1.2	0.9	7.9	10
Gastropoda	198	38	2.3	0.1	0.1	0.4
CRUSTACEA	229	40	29.1	48.4	7.9	1635
Cumacea	201	42	7.0	1.3	0.0	9
Eudorella sp.	192	25	1.2	0.1	0.0	0.1
Diastylidae	182	25	2.3	0.3	0.0	0.7
Diastylis bidentata	172	25	2.3	0.2	0.0	0.5
Isopoda	190	25	1.2	0.1	0.0	0.1
Amphipoda	229	39	26.7	46.7	5.3	1389
Ampeliscidae	199	42	3.5	3.8	0.3	14
Ampelisca sp.	241	50	1.2	0.1	0.1	0.2
Bylilus sp.	179	38	2.3	3.8	0.2	9
Calliopiidae	172	25	1.2	3.0	0.2	4
Calliopius sp.	172	25	1.2	0.7	0.0	0.8

TABLE XIII

CONTINUED

Taxa	MPL	MFS	F	N	V	IRI
Corophiidae	185	50	1.2	3.0	0..2	4
Ericthonius sp.	185	50	1.2	3.0	0.2	4
Gammaridae	258	25	1.2	1.4	0.8	3
Melita sp.	258	25	1.2	1.4	0.8	3
Isaeidae	183	33	3.5	18.8	1.4	70
Photis Sp.	172	25	1.2	0.7	0.0	0.8
Protomedeia **sp.**	183	33	3.5	15.9	1.4	60
Podoceropsis sp.	179	38	2.3	2.2	0.1	5
Lysianassidae	222	25	4.7	2.2	0.5	12
Anonyx nugax	239	25	3.5	1.5	0.5	7
Orchomene sp.	172	25	1.2	0.7	0.0	0.8
Phoxocephalidae	172	25	1.2	0.7	0.1	0.8
Paraphoxus sp.	172	25	1.2	0.7	0.1	0.8
Euphausiacea	207	50	2.3	0.1	0.0	0.3
Decapoda	231	25	3.5	0.2	2.5	9
Pandalidae	202	50	1.2	0.1	1.9	2
Hyas sp.	229	25	1.2	0.1	0.1	0.2
OPHIUROIDEA	265	58	3.5	1.0	4.3	19
Ophiolebes pavcispina	289	38	2.3	0.2	0.5	2
Ophiura atacta	218	100	1.2	0.8	3.8	5
TELEOSTEI	360	90,	5.8	0.4	36.3	213
Ammodytidae	427	108	3.5	0.3	33.2	117
Unidentified Animal Material	227	42	7.0	-	5.4	

* indicates distended stomachs

TABLE XIV

ROCK SOLE - FEEDING HABITS BY SIZE

Taxon	0-200 mm IRI	201-300 mm IRI	301-600 mm IRI
POLYCHAETA	4827	10957	5165
Spionidae	8	0	0
Nereidae	0	0	30
Nephtyidae	50	1.1	0
Onuphidae	69	1.4	0
Lumbrineridae	0	21	0
Opheliidae	13	3	41
Maldanidae	0	4	20
Ampharetidae	0	0	41
Sabellidae	0	0	25
MOLLUSCA	72	238	436
Pelecypoda	43	237	436
CRUSTACEA	4823	474	119
Cumacea	50	0.3	0
Amphipoda	4722	258	19
Decapoda	0	32	0
OPHIUROIDEA	0	40	64
TELEOSTEI	0	3	3294

amphipods) become less important as predator size increases, while fishes become more important.

Rock sole diets from this study were compared with Skalkin's (1963) limited Bering Sea data and the Oregon data of Kravitz *et al.* (1976). The diets were significantly different.

Table XV compares the feeding habits of the rex, dover, flathead, and rock soles, using the Spearman's rank correlation coefficient. Comparisons are made between comparable size categories plus all data combined. All interspecific comparisons were significantly different, even when controlled for predator size. Intraspecific diet comparisons by size are also summarized in this table.

De Groot (1971) discussed the interrelationships of alimentary morphology, behavior, and feeding of flatfishes. From the feeding habits of 59 species, he concluded that flatfishes can be classified according to three feeding strategies: (1) fish feeders, (2) crustacean feeders, and (3) polychaete-mollusc feeders. De Groot classified two congenerics of the rex sole, *Glyptocephalus cynoglossus* and G. *stelleri*, as feeding group (3) (polychaete-mollusc feeders). He described their principal prey as polychaetes, crustaceans, and molluscs. Compatible with De Groot's polychaete-mollusc strategy are the limited feeding data in these species by Rae (1969), Hayase and Hamai (1974) and Kravitz *et al.* (1976). These studies suggest that polychaetes and crustaceans were the dominant food items, with molluscs far less important.

Mineva (1968) states that feeding data on the rex sole are limited, and suggests that the intensity of feeding is less in the middle of September than at the beginning of the month. There is no information

TABLE XV

COMPARISONS OF FEEDING HABITS BY PREDATOR SIZE,
USING SPEARMAN'S RANK CORRELATION COEFFICIENTS
[a(2) :0.005]

Significantly different diets are shown by minus (-)
and significantly similar diets are shown by plus (+) signs

	mm	REX SOLE 0-600	0-200	201-300	301-600	DOVER SOLE 0-600	0-200	201-300	301-600	FLATHEAD SOLE 0-600	0-200	201-300	301-600	ROCK SOLE 0-600	0-200	201-300	301-600
REX SOLE	0-600																
	0-200																
	201-300		+														
	301-600		+	+													
DOVER SOLE	0-600																
	0-200																
	201-300																
	301-600						-	+									
FLATHEAD SOLE	0-600													-			
	0-200																
	201-300																
	301-600											+					
ROCK SOLE	0-600																
	0-200																
	201-300																
	301-600														-	-	

concerning prey composition. Figure 2 portrays the feeding habits of the rex sole. Clearly the rex sole feeds predominantly on polychaetes and crustaceans. Molluscs and other prey taxa contribute much less. Thus, the rex sole feeds much as the two congenerics already discussed, and can also be classified as De Groot's feeding group (3). This feeding strategy was used by 23 of the 49 species of Pleuronectidae investigated by De Groot. A detailed comparison with the rex sole data of Kravitz *et al.*, 1976 using SRCC, shows a significant difference in diets of Oregon and Alaskan populations. It should be noted that only 21 stomachs were examined in the Oregon study. A comparison of diets by predator size using SRCC failed to demonstrate any differences (Table XV),

The scope of this study is too limited to permit a detailed discussion of prey selectivity by the rex sole, but several points are worth mentioning. Molluscs consumed were predominantly in the Nuculanidae. Most individuals were only several millimeters long, suggesting that they had recently settled. Thus, postlarval molluscs and crabs (Fig. 2) seem to be important in the early summer diet of the rex sole. Table 11 shows that the Onuphidae contributed most of the polychaetes consumed. Probably most of the unidentified polychaetes that gave the large F, N, V, and IRI values for the Polychaeta were also Onuphidae. Yet the only species identified from this family was *Onuphis iridescens*, which is not a BIT in this area according to Feder *et al.* (1976). They reported *Onuphis geophiliformis* as the only BIT from this family. With this exception, taxa important in the diet of the rex sole tend to be important members of the local community.

Diet differences of flathead sole with depth in the Gulf of Alaska are pronounced, and therefore the importance of the euphausiids in Table X may be somewhat misleading. Five trawls at 66 to 88 m ($\bar{x}$ = 73 m) yielded 176 flathead sole. Empty stomachs occurred in 49% of these fishes. The index of relative importance for ophiuroids (IRI = 18,279) far exceeded the value for euphausiids (IRI = 274) for these five trawls. A single trawl south of Hinchinbrook Island at 26 m yielded 71 fishes, of which 30% had empty stomachs. Here the importance of euphausiids (IRI = 17,854) in the diet contrasts with that of the ophiuroids (IRI = 1). The theoretically maximum IRI value is 20,000 (given feeding predators have a particular prey species in every stomach, and this prey comprises 100% of the volume and count) . Thus the respective dominance of eupahusiids in shallow water, and ophiuroids in the deep water feeding is nearly absolute. Comparisons of diet with predator size using SRCC demonstrated a significant difference between fishes under 201 mm and the larger size categories (Table XV).

The flathead sole diet in the Gulf of Alaska differs from that of a population in East Sound, Orcas Island, a shallow (28 m) embayment in Washington. Miller (1970) found that mysids comprised most of the diet (F = 77) followed by shrimps, fishes, clams, and polychaetes. Miller found 31% of the stomachs empty. Feeding. intensity of Alaskan populations was greater in shallow areas (above the 50 m isobath), as evidenced by the frequency of empty stomachs and the mean fullness of stomachs. The flathead sole feeding in shallow water had a mean fullness of 57% while the deeper individuals had a mean fullness of 29%.

Miller (1970) discussed how predator size, season, and bottom temperature affected the frequency of empty stomachs in a Washington population of flathead sole. Season does not account for the apparent depth-related differences in the Gulf of Alaska population and temperature data are not available. Size may be partly responsible, as suggested by Table XII. Fishes below a length of 201 mm feed almost entirely on crustaceans. Fishes from 201-300 mm feed somewhat more intensively on ophiuroids than crustaceans. Larger fishes feed still more heavily on ophiuroids, but crustaceans remain an important part of the diet. While feeding by Washington and Alaskan flathead sole may always be more intense on nektonic organisms, one would expect from the Van't Hoff rule that the higher metabolic rate induced by warmer shallow waters would require a higher feeding rate than deeper populations.

Mineva (1968) found that, in the Bering Sea, flathead sole fed chiefly on ophiuroids, followed by shrimps, amphipods, fishes, and molluscs , The limited sampling of this study tends to support these conclusions. According to Mineva the flathead sole is caught together with yellowfin sole, Alaska plaice and rock sole in the southeast Bering. The present study suggests a similarity in geographic and depth-related feeding patterns of the flathead sole with Skalkin's (1963) study of the yellowfin sole. The flathead sole seems to feed primarily on pink shrimp and fishes from 200 to 100 m, on ophiuroids and pink shrimp just above the 100 m isobath, and crangonid shrimps, fishes and molluscs below the 50 m isobath, and upon nekton such as mysids in more shallow waters. Seasonal differences suggested by Table XI may simply result from migration-induced changes in prey availability with depth.

This study suggests that taxa important in the diet of the flathead sole tend to be important members of the local community. Both benthic and nektonic prey are consumed. This study plus the data of Mineva (1968) and Skalkin (1963) suggest a depth-related change from predominantly benthic to nektonic feeding somewhere around the 50 m isobath.

Very little is known about the feeding habits of the clover sole. Hart (1973) simply states that it is usually found on soft bottoms and feeds on burrowing organisms. A congeneric from the Atlantic, *Microstomus kitt*, feeds chiefly on polychaetes, followed by crustaceans, molluscs, echinoderms and fishes (De Groot, 1971). This study shows that *M. pacificus* also feeds predominantly on polychaetes, and to a lesser extent on ophiuroids, crustaceans and molluscs.

One sees a progressive decline in the importance of polychaetes as predator size increases (Table IX), molluscs and crustaceans become more important, and there is a dramatic increase in the importance of ophiuroids in larger predators. Using rank index (SRCC) comparisons, there is a significant difference between diets of the smallest and each of the larger size categories. No significant difference can be demonstrated between the two larger categories.

De Groot (1971) classified the rock sole as a crustacean feeder. Shubnikov and Lisovenko (1964) reported that, in the Bering Sea, polychaetes were the most important prey, followed by molluscs and crustaceans. Fishes and ophiuroids were sometimes taken. Forrester and Thomson (1969) found a British Columbia population feeding on clams, polychaetes, crustaceans, fishes and echinoderms. Kravitz *et al.* (1976) found rock sole in Oregon waters fed mainly on ophiuroids.

This study shows that rock sole in the Bering Sea feed mainly on polychaetes. Crustaceans (especially amphipods), fishes, and molluscs were also important. When the present study was compared using rank index (SRCC) with Skalkin (1963) and Kravitz *et al.* (1976), the diets were found to be significantly different.

The feeding habits of the rock sole change with size (Table XIV). All paired combinations were significantly different when compared by rank index (SRCC).

Rank index comparisons show that the feeding habits of all flatfish species in this study differ significantly from one another. This conclusion holds true when species are compared within a given size category. The diet of rex sole does not change with predator size. Small (0-200 mm) and large (201-600 mm) flathead sole have significantly different diets. Feeding by small and large clover sole also differ significantly. Small (0-200 mm), medium (201-300 mm), and large (301-600 mm) rock sole all have significantly different diets.

Arrowtooth flounder, *Atheresthes stomias*,
northeastern Gulf of Alaska

The stomach of 558 *Atheresthes stomias* were examined to determine the feeding habits of the species. Of these specimens, 236 contained prey items; the remaining 322 specimens had empty stomachs.

The specimens were taken from 28 trawl stations in the northeast Gulf of Alaska, from Yakutat Bay, on the east, to Cape Cleare, on the west (Table XVI). The majority of specimens were collected from May 3, 1975 to June 27, 1975. Additional specimens were collected from July 4, 1975 to August 8, 1975.

TABLE XVI

STATIONS WHERE SAMPLES OF *ATHERESTHES STOMIAS* WERE OBTAINED

Station #	Tow No.	Date	Time	Depth fished (m)
070C	2	5/3/75	1345	102.0 - 113.0
070D	3	5/3	1740	103 .7 - 111.0
076A	16	5/10	1335	105.5 - 107.3
074H	20	5/12	1150	151.0 -158.3
086C	43	5/30	1440	116.4 - 127.4
092D	50	6/2	0825	222.0 - 225.6
094D	51	6/2	1200	123.7 - 127.4
100B	55	6/4	0820	220.2 - 222.0
100C	56	6/5	.0915	158.3 - 161.9
094G	63	6/27	1150	182.0 - 182.0
098C	74	7/4	1350	287.5 - 291.0
070B	111	7/20	0630	109.2 - 116.5
071B	112	7/20	0910	109.2 - 111.0
073A	115	7/25	0655	262.1- 263.1
073C	117	7/25	1330	142.0 - 149.2
074G	121	7/26	1705	113.0 - 115.0
075G	122	7/27	0735	95.0 - 98.3
073H	123	7/27	1055	202.0 -204.0
0771	125	7/28	0740	133.0 - 145.6
077E	128	7/28	1550	93.0 - 97.0
075A	132	8/1	0750	131.0 - 133.0
077B	133	8/1	1115	100.1 - 102.0
077A	134	8/1	1345	53.0 - 54.6
079C	137	8/2	1150	100.1 - 104.0
081F	140	8/3	0935	173.0 - 178.4
083F	141	8/3	1450	137.0 - 140.1
083E	142	8/4	0800	129.2 - 131.0
081G	144	8/4	1510	208.0 - 220.2

Fishes and crustaceans were the most frequently occurring prey items, with polychaetes, molluscs, and echinoderms occurring very rarely (Table XVII) .

Crustaceans were the most frequently occurring prey items consumed (Table XVII). Of this group, decapods were most often taken, with euphausiids the second most commonly consumed. By number and volume, however, euphausiids were more important.

Fishes were the second most frequently occurring prey items (Table XVII) . Members of the families Osmeridae, Gadidae, and Zoarcidae, in descending order of frequency of occurrence, where the most commonly occurring teleostean prey. Representatives of the families Clupeidae, Cottidae, Stichaeidae, and Pleuronectidae were also found among the stomach contents.

It should be noted that although fishes did not occur as frequently as prey as did crustaceans, their contribution to total prey volume was slightly greater than that contributed by the crustaceans (Table XVII).

Yazdani (1969) discussed adaptation in the jaws of flatfishes, and relates jaw structure to feeding habits. His "turbot-type" species, *Scophthalmus maximus*, *Lepidorhombus whiff-iagonis*, and *Arnoglossus laterna*, all possess large, relatively symmetrical jaws. These species feed primarily on free swimming prey such as small fishes and shrimp. The arrowtooth flounder is morphologically similar to these species, and its feeding habits are also quite similar.

Annual migratory cycles, with associated changes in diets have been observed in *Limanda aspera*, *Lepidopsetta bilineata*, *Hippoglossoides elassodon*, and *Pleuronectes quadrituberculatus* from the southeastern Bering Sea (Skalkin, 1963). Several of these species undergo periods of starvation during the winter months, and resume feeding from late April to September.

TABLE XVII

SUMMARY OF PREY ITEMS BY PHYLUM FOR *ATHERESTHES STOMIAS* FROM THE GULF OF ALASKA, MAY-AUGUST 1975

Prey Phylum	% Freq. of Occurrence	% "by Number	% by Volume	Index of Relative Importance
Arthropoda:				
Crustacea	53.81	78.70	40.10	6393
Chordata:				
Teleostei	42.80	17.16	41 .09	2493
Mollusca	0.85	0.24	0.33	0.48
Annelida	0.42	0.12	0.00	0.05
Echinodermata	0.42	0.12	0.00	0.05

Over the period of time that the specimens of *A. stomias* were collected, there was no evidence of changes in diet. The intensity of feeding was not as great as in the species mentioned above. For each month, the percentage of fish feeding remained relatively constant. Of the 265 fish taken in May, 46% had been feeding; 37% of 200 fish collected in June and 45% of 58 fish collected in July were feeding. Only 25 fish were collected in August, of which 52% had been feeding. Indices of stomach fullness varied widely within each month, with no observable trend.

Skalkin (1963) also gives data concerning changes in diet with regard to depth. Changes in diet of *H. elassodon* in the Gulf of Alaska and Bering Sea are discussed in this report. There was no clearcut difference in prey items consumed by *A. stomias* with regard to depth, however, a distinct difference in diet was seen between certain groups of stations. Specimens taken from stations 71B, 73H, 74H, 75G and 771 were feeding primarily on pandalid shrimp, including *Pandalus borealis* and *Pandalopsis dispar*. These stations are located on the fringe of an area recognized as untrawlable by the International Pacific Halibut Commission because of the rocky substrate.

Stations located in nearshore areas of Montague, Hinchinbrook, and Kayak islands (stations 70B, 75A, 76A, 77A and 83E) yielded specimens whose principal prey items were *Mallotus villosus*, other osmerids, and representatives of the family Clupeidae. Many of the *M. villosus* found in the stomachs of the flounders were ripe females.

Euphausiids were the single most important prey item in terms of percent by number and percent by volume. They were second only to unidentified teleosts in frequency of occurrence (Table XVIII). The majority of

TABLE XVIII

INDIVIDUAL PREY ITEMS OF *ATHERESTHES STOMIAS* FROM THE GULF OF ALASKA, MAY-AUGUST 1975

Listed in descending order of frequency of occurrence

Prey Taxon	% Freq. of Occurrence	% by Number	% by Volume	Index of Relative Importance
Teleostei (Unidentified)	30.08	10.18	23.45	1012
Euphausiacea	25.85	46.51	37.22	2164
Decapoda	13.56	24.85	0.88	349
Mallotus villosus	5.51	3*79	2.60	35
Pandalidae	4.66	1.66	0.26	8.9
Pandalus borealis	2.97	1.18	1.09	6.8
Crangonidae	2.54	0.71	0.04	1.91
Zoarcidae	2.12	0.71	0.43	2.43
Theragra chalcogramma	1.27	0.36	9.81	13
Pandalus spp.	0.85	0.36	0.07	0.36
Eualus sp.	0.85	0.24	0.03	0.23
Osmeridae	0.85	0.36	0.21	0.48
Polychaeta	0.42	0.12	0.00	
Pelecypoda	0.42	0.12	0.00	
Cephalopod	0.42	0.12	0.33	0.19
Isopoda	0.42	2.25	0.06	0.98
Pandalus jordani	0.42	0.12	0.07	0.08
P. platyceros	0.42	0.12	0.01	0.05
Pandalopsis sp.	0.42			
P. dispar	0.42	0.24		
P. ampla	0.42	0.24		
Crangon communis	0.42	0.12	0.01	0.06
Sclerocrangon sp.	0.42	0.12	0.01	0.05
Ophiuroidea	0.42	0.12	0.00	0.05
Clupeidae	0.42	0.36	0.22	0.24
Clupea pallasii	0.42	0.12	3.90	1.70

TABLE XVIII

CONTINUED

Prey Taxon	% Freq. of Occurrence	% by Number	% by Volume	Index of Relative Importance
Salmoniformes	0.42	0.12	0.07	0.08
Thaleichthys pacificus	0.42	0.12		
Gadidae	0.42	0.12		
Cottidae	0.42	0.12	0.06	0.07
Stichaeidae	0.42	0.12	0.06	0.08
Lumpenus sp.	0.42	0.36	0.07	0.18
Pleuronectidae	0.42	0*12	0.09	0.09
Atheresthes stomias	0.42	0.12	0.06	0.08
Glyptocephalus zachirus	0.42	0.12	0.06	0.07
Unidentified Animal Material	7.63	2.37	0.07	

the euphausiids consumed were from 10 mm to 20 mm long, and were often the only prey items found in a particular stomach.

The more widespread and numerically abundant species of euphausiids found in the northeast Gulf of Alaska inhabit the 0.0 m to 100 m depth zone, but frequently descend to greater depths (Brinton, 1962). However, the larger members of many species live permanently below 200 m, and do not ascend and descend diurnally as do their smaller, younger conspecifics (Ponomareva, 1963). It has been found that the euphausiid species *Thysanoëssa inermis* and *T. raschii* from Russian waters do not descend to the benthopelagic layers, as they do elsewhere during their diurnal migrations (Ponomareva, 1963). This is apparently a predator avoidance adaptation, freeing them from predation by demersal fishes.

It may be possible that *A. stomias* leaves the bottom and moves up into the water column to feed upon euphausiids. This has been suggested by Gotschall (1969). *Reinhardtius hippoglossoides*, a closely related and morphologically very similar species, is suspected of similar behavior (De Groot, 1970). The importance of the capelin (*M. villosus*) in the diet of the arrowtooth flounder may also support the hypothesis that *A. stomias* leaves the bottom to feed.

Information on the feeding habits of the arrowtooth flounder with regard to predator length was obtained by arbitrarily dividing the sample into six length categories (Table XIX). Due to great differences in sample size, the length groups may not be strictly comparable, but a trend towards increased piscivory with increase in predator length is apparent (Table XX).

Very small specimens of *A. stomias* (10-19 mm) were found to be feeding on copepods (Barraclough, 1968). The smallest arrowtooths from this study

TABLE XIX

CATEGORIES USED FOR FOOD HABITS ANALYSIS BY PREDATOR LENGTH FOR *ATHERESTHES STOMIAS* CAUGHT IN NORTHEAST GULF OF ALASKA, MAY-AUGUST 1975

Length category (mm)	# of fish	Mean length of fish (mm)	# feeding	# empty
0-150	7	106	5	2
151-250	217	214	120	97
251-350	252	292	90	162
351-450	39	381	8	31
451-550	23	499	4	19
≥ 551	20	614	9	11

TABLE XX

SUMMARY OF PREY TAXA BY PHYLUM OR CLASS FOR LENGTH
0)? PREDATOR, *ATHERESTHES STOMIAS*

Length Category	Prey Taxon	% Freq. of Occurrence	% of Number	% of Volume	Index of Relative Importance
0-150 mm	Euphausiacea	40.00	97.78	71.43	6768
	Decapoda	20.00	2.22	1.59	76
	Unident. Animal Mat.	40.00		26.98	
151-250 mm	Annelida	0.83	0.26	0.02	0.23
	Mollusca	0.83	0.26		
	Crustacea	63.33	79.58	5.88	5413
	Echinodermata	0.83	0.26	0.02	0.23
	Teleostei	40.00	14.66	13.82	1139
	Unident. Animal Mat.	5.00	2.09	0.06	
251-350 mm	Mollusca	1.11	0.26	0.78	1.15
	Crustacea	47.78	79.03	88.72	8014
	Teleostei	46.67	19.18	10.45	1383
	Unident. Animal Mat.	7.78	1.53	0.06	
351-450 mm	Crustacea	62.50	38.89	18.57	3591
	Teleostei	37.50	33.33	81.36	4301
	Unident. Animal Mat.	12.50	27.78	0.07	
451-550 mm	Teleostei	100.00	100.00	100.00	20000
≥ 551 mm	Teleostei	100.00	100.00	100.00	20000

ate euphausiids and small decapods. Specimens from 151-250 mm in standard length were found to ingest the greatest variety of prey items when compared to the other size classes. Crustaceans were the most frequently consumed prey of fish up to 450 mm in length. Specimens over 450 mm long preyed exclusively on other fishes, primarily on pollock (*Theragra chalcogramma*) and other gadoids.

Euphausiids were of increasing importance in the diet of the arrowtooth flounders up to 350 mm long; none were found among the stomach contents of specimens larger than 350 mm.

Arrowtooth flounders from northern California were examined by Gotschall *(1969).* Over a period of *13* months, they were found to feed upon many of the same genera of prey that the arrowtooths from the northeast Gulf of Alaska use for food. The proportions of the various groups of prey between the two areas were quite similar also.

The importance of euphausiids in the diet of the northern California arrowtooth flounders was greatest during the months of April through July; Spetember and October also yielded specimens feeding on euphausiids. Such seasonal data is not available from this study. However, considering the similarity of feeding habits between the two areas, there is the possibility that NEGOA arrowtooths utilize euphausiids primarily during the warm months.

In examining the feeding habits of *A. stomias* from the northeast Gulf of Alaska, and comparing these data with those of Gotschall, it appears that, within the range of its diet, the arrowtooth flounder is opportunistic and will feed upon those prey items that are most available at a given time. However, the similarities in diet between the two areas indicate that the arrowtooth flounder feeds primarily upon pandalid shrimp, osmerids, gadoids, and euphausiids. The greater importance of euphausiids in the diet of the NEGOA arrowtooth flounders may be due to their greater abundance in northern waters during the warmer months. Further seasonal feeding data would be required in order to determine whether NEGOA arrowtooth flounders feed on euphausiids throughout the year.

Greenland halibut, *Reinhardtius hippoglossoides*, Bering Sea

The stomachs of 123 specimens of *Reinhardtius hippoglossoides* were examined, of which 54 contained prey items. The remaining 69 stomachs were empty. Specimens were collected from seven trawl stations in the Bering Sea from April 9, 1976 to May 27, 1976 (Table XXI).

Fishes were the most important component of the diet of *R. hippoglossoides*. Only one specimen was found to be preying on crustaceans; the particular specimen was 141 mm, standard length.

Of the identifiable fish found among the stomach contents, the walleye pollock, T. *chalcogramma*, was the most frequently occurring (Table XXII). Prey species unidentifiable beyond the family level were most often members of the family Gadidae. The possibility exists that many of these were also pollock.

Other prey items were *M. villosus*, found in one stomach; and a representative of the familly Cottidae, also found in only one stomach.

Although specimens were collected from only two months, a trend was evident in the number of fish found feeding. Of the 50 fish collected from April 9 to April 18, only 10 were feeding, and the average stomach fullness was 11.5%. The 73 fish collected from May 20 to May 27 yielded 44 feeding specimens with an average stomach fullness of 52.7%. It is apparent from

TABLE XXI

STATIONS AT WHICH SPECIMENS OF *REINHARDTIUS HIPPOGLOSSOIDES* WERE OBTAINED IN APRIL-MAY 1976, BERING SEA

Station	Tow No.	Date	Time	Depth fished (m)
C5	20	4/9	2200	112.0
AB56	50	4/16	2121	155.0
D8	56	4/18	1801	93.7
MB13	102	5/20	1603	48.0
MB16	110	5/25	1527	203.0
MB69	112	5/27	1602	116.5
MB86B	113	5/27	2312	117.0

TABLE XXII

SUMMARY OF INDIVIDUAL PREY TAXA OF *REINHARDTIUS HIPPOGLOSSOIDES*
APRIL-MAY 1976, BERING SEA

Listed in descending order of frequency of occurrence

Taxon	% Freq. of Occurrence	% by Number	% by Volume	Index of Relative Importance
Teleostei (Unidentified)	62.52	59.37	9.55	4723
Theragra chalcogramma	16.67	20.31	9.79	501
Gadidae (Unidentified)	12.96	12.50	79.43	1192
Gadiformes (Unidentified)	1.85	1.56	0.33	4
Mallotus villosus	1.85	1.56	0.41	4
Cottidae	1.85	1.56	0.43	4
Decapoda	1.85	3.12	0.05	6

these data that *R. hippoglossoides* may feed little during the winter months and resume feeding in mid to late May. Similar habits have been observed in other flatfishes from the Bering Sea (Skalkin, 1963).

The feeding data from the fishes collected in May also suggest that there may be differences in feeding habits in relation to the depth at which the fish are taken. Fifteen *R. hippoglossoides* were collected at station MB13 on May 20, 1976. The station depth was 48 m, and none of the specimens were found to be feeding. At station MB69, at a depth of 116 m, 19 specimens were collected, 16 of which had been feeding. This station was occupied on May 27, 1976.

In order to determine whether or not *R. hippoglossoides* undergoes a change in feeding habits as a function of length, the specimens were arbitrarily divided into three length groupings (Table XXIII). The results of the food habits versus predator length analyses can be seen in Table XXIV.

It can be seen that no substantial change is evident in the diet as the predator increases in length. However, the single incidence of prey other than fish being taken is from the smallest specimen (141 mm, standard length) examined. This suggests the possibility that crustaceans (or other invertebrates) may be more important in the diet of smaller size *Reinhardtius*. De Groot (1970) maintains that conspecifics in the Atlantic Ocean change their feeding habits as they grow. Fish up to 100 mm long feed largely upon decapod crustaceans, while larger individuals feed on polar cod, redfish, and capelin.

De Groot (1970) also suggests that in feeding, *R. hippoglossoides* may habitually leave the bottom and swim far up into the water column. When doing so, it is thought that the fish swims as roundfish do, with the dorsal side up.

TABLE XXIII

ARBITRARY LENGTH CATEGORIES OF *REINHARDTIUS HIPPOGLOSSOIDES* USED IN FEEDING HABITS ANALYSIS

Category (mm)	# of fish	Mean length (mm)	# feeding	# empty
101-275	40	229	23	17
276-450	80	300	30	50
≥ 451	3	742	1	2

TABLE XXIV

INDIVIDUAL PREY TAXA OF *REINHARDTIUS HIPPOGLOSSOIDES* BY PREDATOR LENGTH CATEGORIES
APRIL-MAY 1976, BERING SEA

Length Category	Prey Taxon	% Freq. of Occurrence	% by Number	% by Volume	Index of Relative Importance
101-275 mm	**Teleostei**	52.17	44.44	34.96	4142
	Theragra chalcogramma	*26.09*	*25.93*	*37.68*	*1659*
	Gadidae	17.39	14.81	17.43	561
	Gadiformes	4.35	3.70	4.03	34
	Cottidae	4.35	3.70	5.25	39
	Decapoda	4*35	7,41	0.66	35
276-450 mm	**Teleostei**	83.33	72.22	42.38	9550
	Theragra chalcogramma	10.00	16.67	42.48	591
	Gadidae	6.67	8.33	12.54	139
	Mallotus villosus	3.33	2.78	2.60	18
≥ 451 mm	**Gadidae**	100.00	100.00	100.00	20000

More data on the feeding habits of *R. hippoglossoides* is needed to give a complete picture of the species' role in the Bering Sea ecosystem. Especially, more seasonal data are needed. Also, a greater number of specimens in the smaller size classes need to be examined in order to determine whether or not Bering Sea *Reinhardtius* undergo a change in feeding habits with increased length.

Capelin, *Mallotus villosus*, southeastern Bering Sea

Little information is available on the biology of capelin from Alaskan waters. The species is distributed from Washington state to Korea and has been commercially fished by the Japanese. The economic importance of Pacific and Bering capelin has, to the present, been slight. Commercially important fish species such as salmon have been shown to feed on capelin (Jangaard, 1974) and recent studies on the food of other commercial and forage fishes in Alaska identify the capelin as a food organism of the arrowtooth flounder, pollock, and Greenland halibut, (this report). Additionally, Wehle (pers. comm.) has identified the capelin as an important food source for Alaskan seabirds of the family Alcidae. We here report on the food of capelin from the southeastern Bering Sea.

A summary of information on food of Bering Sea capelin is presented in Table XXV Only two phyla are represented among the food organisms, the Arthropoda (all crustaceans) and the Chaetognatha. The chaetognaths were so digested that no more specific identification could be made.

The most numerous prey organisms were calanoid copepods. The only identifiable genus was *Calanus*. Virtually all of the amphipods present were members of the pelagic Hyperiidae. Identifiable euphausiid speci-

TABLE XXV

A SUMMARY OF STOMACH CONTENTS FROM ALL SIZE CATEGORIES OF CAPELIN CAUGHT IN THE SOUTHEAST BERING SEA

Standard lengths ranged from ($\bar{x}$ = 141 ± 12 mm). Results are reported as frequency of occurrence (F), numerical frequency (N), percent volumetric contribution (V), and index of relative importance (IRI). Number of feeding individuals examined was 135.

Prey taxon	F	N	V	IRI
Crustacea	98	93	93	18258
Copepoda	19	63	8	1356
Mysidae	4	0.8	2	12
Amphipoda	6	10	6	92
Euphausiidae	73	19	74	6792
Chaetognatha	14	7	6	183
Unident. Animal Mat.	8		0.1	

mens were all of the genus *Thysanoessa*. *T. longipes* and T. *raschii* were present in the stomachs of some capelin.

Table XXVI presents the food habits of the same population subdivided into three size categories. F, V and IRI values for each food category are presented for each size interval. In terms of relative importance (IRI), euphausiids rank first in all size categories, followed by copepods.

In this study, euphausiids constitute the most important food category in terms of IRI, volumetric contribution and frequency of occurrence. Copepods are most numerous in occurrence, contributing 63% of the individual food organisms counted. These findings differ somewhat from those reported for the Atlantic capelin by Prokhorov (1965) and Templeman (1948). In those studies, eupahusiids contributed the greatest proportion by weight but copepods were highest in frequency of occurrence. All studies to date agree, however, that capelin are plankton feeders and undoubtedly filter relatively small planktonic organisms with their mesh of elongated gill rakers.

One might speculate that filter mesh size increases in proportion to body size and, therefore, that smaller fishes might rely more heavily on smaller food organisms. This hypothesis could best be tested by examining the foods of widely divergent size categories of capelin. Unfortunately, such divergence was not available in our limited sample of Bering Sea capelin. However, the data on prey organisms versus size, in Table XXVI, does show some interesting trends.

The smallest food item, copepoda, has its greatest volumetric and relative importance in the smallest size category. The same is true of the next to smallest food items, the Mysidae. All of the mysids found in capelin stomachs were very small ($\leq$5 mm).

TABLE XXVI

FEEDING HABITS OF CAPELIN IN THREE SIZE CATEGORIES FROM THE SOUTHEAST BERING SEA

Results are reported as percent frequency of occurrence (F), the first number; percent volumetric contribution (V), the second number; and index of relative importance (IRI), the third number. Mean length ($\bar{x}$) and sample size (n) are reported for each interval.

Prey taxon	105-124 mm $\bar{x}$=116 n=9	125-144 mm $\bar{x}$=135, n=64	145-164 mm $\bar{x}$=151, n=61
Copepoda	22, 39, 2869	19, 6, 1239	20, 7, 1265
Amphipoda		3, 3, 30	10, 8, 215
Mysidae	11, 11, 140	3, 2, 6	5, 1, 11
Euphausiidae	78, 50, 4480	77, 80, 7903	69, 71, 6201
Chaetognatha	22, 0, 16	14, 7, 211	13, 7, 180

All specimens examined in this study were captured during the period from late spring to early fall. Therefore, no information is available on seasonality of feeding in Bering Sea capelin. Jangaard (1974), in summarizing studies on Atlantic capelin, indicates that feeding activity is highly seasonal. During midwinter feeding ceases, followed by early spring feeding activity. Feeding intensity declines with the beginning of spawning migrations and ceases during the spawning season. After spawning, feeding reaches high intensity and proceeds at high intensity until early winter. Condition, as indicated by percent fat content, changes seasonally in response to the seasonality of feeding. Winters (1969) reports fat content as low as 1% in postspawning fish and as high as 23% in fish in prime condition. Presumably, Bering Sea capelin experience similar fluctuations in feeding intensity and condition.

Shortfin eelpout, *Lycodes brevipes*

The shortfin eelpout is a widely distributed zoarcid, ranging from Oregon to Alaska, the Bering Sea and the Sea of Okhotsk (Hart, 1973). I could find no information specifically dealing with the feeding habits of this species.

The wattled eelpout, *Lycodes palearis*, feeds on small clams, and shrimps in the Puget Sound region (Slipp and DeLacy, 1952). *Lycodes raridens* from the Bering Sea consumes small bivalves (*Yoldia*) and crustaceans (Andriyashev, 1964). The blackbelly eelpout, *Lycodopsis pacifica*, feeds on bivalves, polychaetes, amphipods, small crabs and ophiuroids in British Columbia waters (Levings, 1969).

Table XXVII reports the stomach contents of a sample of 103 feeding individuals from the northeast Gulf of Alaska. In descending order of relative importance (IRI) are the following prey phyla: Arthropoda (Crustacean), Annelida (Polychaeta), Mollusca, Echinodermata and Chordata (Teleostei).

Important benthic food organisms were polychaetes, crabs (Majidae), clams, and ophiuroids, in descending order of IRI. Euphausiids, usually thought of as pelagic, were a major source of foods to shortfin eelpouts in the northern Gulf.

A sample of 24 feeding individuals was examined from the southeast Bering Sea (Table XXVIII). Food organisms were in an advanced state of digestion and/or degradation, allowing little identification. These limited data suggest that polychaetes and crustaceans were about equally important in shortfin diets, both in terms of volumetric contribution and the IRI parameter. However, the large contribution made by unidentifiable animal remains makes any further speculation futile.

Pacific cod, *Gadus macrocephalus*

Only a few authors have reported on food habits of the Pacific cod. Suyehiro (1942) lists the food organisms of cod captured in Bristol Bay. They include pollock, yellowfin sole, other flatfishes, crangonid and other shrimps, several crabs, several amphipods, hermit crabs, polychaetes and the clam *Yoldia*. Hart (1973) includes herring, sand lance, pollock, flatfishes, worms, crabs, molluscs and shrimps among Pacific cod foods.

Feeding may be somewhat tied to migrations in some populations of Pacific cod. Ketchen (1961) has shown that cod along the British Columbia coast move into deep water in autumn and back to shallow water in the

TABLE XXVII

A SUMMARY OF STOMACH CONTENTS FROM SHORTFIN EELPOUT CAUGHT IN THE NORTHERN GULF OF ALASKA

Standard lengths ranged from ($\bar{x}$ = 187 ± 32 mm). Results are reported as frequency of occurrence (F) , numerical frequency (N) , percent volumetric contribution (V), and index of relative importance (IRI). Sample size of feeding individuals was 103.

Prey taxon	F	N	V	IRI
Polychaeta	42	25	23	1984
Mollusca	12	8	11	220
Pelecypoda	11	8	10	187
Cephalopoda	1	0.4	1	1.3
Crustacea	56	59	51	6182
Isopoda	1	0.4	0.5	0.9
Gammaridae	1	0.4	0.5	0.9
Euphausiidae	15	25	24	718
Pandalidae	16	10	9	291
Hippolytidae	1	0.4	0.5	0.9
Maj idae	17	16	11	437
Echinodermata	11	8	5	139
Asteroidea	1	0.4	1	1.3
Ophiuroidea	10	7	5	114
Teleostei	1	0.4	0.5	0.9

TABLE XXVIII

A SUMMARY OF STOMACH CONTENTS FROM
BERING SEA SHORTFIN EELPOUT

The sample of 24 feeding individuals ranged in standard length from ($\bar{x}$ = 224 ± 31 mm). Results are reported as frequency of occurrence (F), numerical frequency (N), percent volumetric contribution (V), and index of relative importance (IRI).

Prey taxon	F	N	V	IRI
Polychaeta	42	1.5	37	1599
Crustacea	33	1.2	37	1267
Amphipoda	13	1.1	26	342
Unident. Animal Material	46	97	26	

springtime. Hart (1973) points out that B.C. cod congregate for spawning (winter) and disperse for feeding (presumably, spring).

Recently, Jewett (1978) has presented data on stomach contents from some 4200 Pacific cod from the vicinity of Kodiak, Alaska. Most of these fish were captured in crab pots; some 344 were taken in bottom trawls from the same area. Data are presented in percent frequency of occurrence and actual frequency of occurrence. Only summer sampling was conducted.

The most important food categories in both pot-caught and trawl caught cod were fishes, crabs, shrimps and amphipods, in decreasing order of occurrence. The fish most frequently eaten was the walleye pollock, T. *chalcogramma*, with Pacific sandlance, *Ammodytes hexapterus*, and flatfishes (Pleuronectidae) also contributing frequently to cod diets. Snow crab, *Chionoecetes bairdi*, was the most frequently occurring food species, appearing in almost 40% of the stomachs examined.

Jewett (1978) also presents data which indicate a year-to-year variation in the diet of Pacific cod in the Kodiak area. He also suggests that food organisms shift in frequency with increased size in cod. Fish and cephalopod frequencies seemed to be directly related to size, while amphipod and polychaete frequencies were inversely related to size of predator.

Yellowfin sole, *Limanda aspera*

Information on food habits of the yellowfin sole has been extracted from Russian workers. Andryiashev (1964) states that *Limanda aspera* feeds mainly on polychaetes, molluscs and ophiuroids.

Skalkin (1963) dealt with the diets of three flatfishes from the Bering Sea, and reported that about 50 different taxa contributed to the food of the yellowfin sole. He identified a group of taxa which contributed significantly in terms of frequency of occurrence and in numerical contribution.

This group includes amphipods, mysids, euphausiids, the bivalve *Gomphina fluctuosa* and *Cardium ciliatum* and the ascidian *Molgula*. A second group, the members of which occurred frequently but in smaller numbers, included *Echiurus echiurus*, *Crangon dalli*, *Pandalus borealis*, *Yoldia johanni* and Y. *hyperborea*. A third group, containing *Serripes groenlandicus* and *Ophiura sarsi*, consisted of forms which commonly occurred in yellowfin stomachs but always in fragmented condition.

Skalkin suggests that yellowfin feeding habits vary with geographic subregion within the southeastern Bering Sea and also vary with depth. For instance, he states that mysids and euphausiids predominate in the diet in the northeastern sector (southwest of Cape Newenham and Kuskokwim Bay), while other crustacean species begin to dominate further to the southwest and to the northwest. In terms of depth versus diet, he cites a predominance of polychaetes in guts from 50-60 m, molluscs from 65-80 m and O. *sarsi* from depths greater than 80 m.

Marked seasonality of feeding intensity is suggested by Skalkin. Yellowfin sole apparently do not feed until late April on the wintering grounds (north of Unimak Island). Feeding intensity is low as fish migrate toward shallow water in May. July is a period of high feeding intensity in the southeast Bering Sea. Intensity of feeding falls off during the fall as yellowfin populations begin moving back down to deeper water.

It is worth mentioning that these conclusions were reached based on an analysis of 263 fish captured from July-September 1958, and 285 fish captured from April-June 1960. This is a total of 548 individuals from two different years.

Pacific Halibut, *Hippoglossus stenolepis*

This species continues to be an important fish from a commercial standpoint. Impacts felt farther down in the food chain will certainly have an effect on this large carnivore.

Young halibut become established on the bottom after 6 to 7 months of pelagic larval existence. The earliest juveniles occur in water shallower than 100 m. During ontogeny individuals tend to move offshore to deeper water. Immature halibut are relatively nonmigratory while adults from the Gulf of Alaska are known to migrate rather long distances, up to 700 miles in some cases.

Some information on food of halibut from the northeastern Pacific has been gathered by the International Pacific Halibut Commission. Analysis of stomach contents has largely been confined to sub-commercial size individuals since the stomach contents of longline-caught halibut are not typical of halibut in general (Skud, pers. comm.). Based on a sample size of over 2000 individuals lumped from different years and from southern British Columbia to Kodiak, the following conclusions are offered.

Halibut less than 4 inches long, not yet one year old, feed primarily on small crustaceans. At larger sizes, halibut begin feeding on shrimps, crabs and fish. The latter food category, especially sand lances, becomes the predominant food item in individuals over 10 inches long (IPHC Rept. 29, 1960). An exception to this latter generalization may be found in Cook Inlet, Alaska, where halibut up to 16 inches in length feed largely upon shrimp (IPHC Rept. 27, 1959).

Unpublished information on food of juvenile halibut from the Bering Sea has kindly been provided by Dr. Skud of the International Pacific

Halibut Commission. Information on a sample of 132 individuals indicates that the major food organisms in terms of frequency of occurrence are shrimp (32%), digested fish (25%), sand lance (15%) and crab (6%). Other food items included sculpin (3%), cod (2%), poacher (1%), sandfish (1%), snow crab (1%), amphipods (1%) and smelt (1%).

Novikov (1968) has reported on the food habits from the southeastern Bering Sea. Small halibut (30 cm or less) fed primarily on crustaceans (89%F) while medium sized fishes (30 to 60 cm) shift to a largely fish diet (61%F). Flatfishes, smelt, capelin, pollock and sand lances are included while crustaceans appear in 33% of the stomachs. Fishes larger than 60 cm fed predominantly on fishes, especially the yellowfin sole. Feeding intensity was greater in summer than in winter. Marked seasonal movements of halibut in the southeast Bering Sea have been reported.

Information for this species was abstracted from Gray (1964), Hart (1973) and Novikov (1968).

III. STUDY AREA

The study area includes the Gulf of Alaska, primarily the area bounded by Yakutat on the east and Resurrection Bay on the west. The Bering Sea study area lies principally in the southeast. Almost all collections came from stations south of Nunivak Island. Collections include fishes from Bristol Bay, the vicinity of the Pribilof Islands and along the continental slope.

IV. RESULTS

The results of feeding analyses have been incorporated into the section on State of Current Knowledge.

V. DISCUSSION

Current information, including our own contributions, has been summarized for twelve species from the Gulf of Alaska and the Bering Sea. That information indicates that, in terms of frequency of occurrence, benthic organisms are very important in the diets of clover sole, halibut, rock sole and rex sole. The pollock rely heavily on pelagic organisms and must, therefore, feed up off the bottom to a great extent. Intermediate in feeding habits are the arrowtooth flounder and the flathead sole. These two species take large numbers of pelagic euphausiids and also feed intensively on benthic prey organisms. From our studies it appears that major predators on fishes are the Pacific halibut, arrowtooth flounder, and Greenland halibut. Euphausiids are a major food item of pollock and capelin. Polychaetes are consumed intensively by clover sole, rock sole, and rex sole.

Activities which impact the benthic environment and its invertebrate fauna will have an impact on the benthic feeders mentioned above. Activities which primarily affect the pelagic environment will have effects on the pelagic feeders quickly. However, since the benthic fauna is ultimately dependent on primary production in the pelagic environment, it too will be affected, as will the fishes feeding on the benthos.

From the little information at hand on seasonal variation in distribution and feeding, a number of critical areas can be suggested. In the

Bering Sea, winter concentrations of halibut, yellowfin sole, rock sole and perhaps flathead sole as well are all found just to the northwest of Unimak Island.

Much more data is needed on the feeding habits and seasonality of feeding within the fish fauna. This is especially true of the Gulf of Alaska, which has not come under as much scrutiny by the Russian workers. Much information will be supplied by this present study but seasonal information for the Gulf of Alaska will still be largely unavailable.

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