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FEEDING HABITS OF PACIFIC COD, *GADUS MACROCEPHALUS*, OFF EASTERN HOKKAIDO, NORTH JAPAN*

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Abstract: We collected a total of 336 specimens of Pacific cod, *Gadus macrocephalus* during April, May and June 1989–1992 off the eastern coast of Hokkaido. Examination of their stomach contents revealed that fishes (mainly walleye pollock, *Theragra chalcogramma*) and decapod crustaceans (mainly crangonid shrimps) were major diet. The cod showed an obvious body size related dietary shift; the importance of shrimps (*Neocrangon communis* and *Argis lar*) and myctophid fishes for ≤300 mm individuals switched abruptly to walleye pollock and other fishes (*e.g. Sardinops melanostictus*, *Laemonema longipes*, stichaeid and cottid fishes) and octopus, *Paroctopus* spp. for larger individuals. The cod showed an obvious feeding periodicity with a peak of feeding during 0600–1200 h. The comparison of prey size and prey type (benthos and nekton) for different size classes of predators indicated that the cod diet is determined by predator-prey size relationship.

1. Introduction

The Pacific cod, *Gadus macrocephalus* TILESIUS, is widely distributed in the Pacific Ocean, extending from Korea, through the Sea of Japan, Okhotsk and Bering Seas, to California (BAKKALA *et al.*, 1984). The food habit of the Pacific cod has been studied in various areas; the Bering Sea (MITO, 1974; BAKKALA, 1984; LIVINGSTON *et al.*, 1986; WAKABAYASHI, 1986), Gulf of Alaska (JEWETT, 1978; ALBERS and ANDERSON, 1985) and the Okhotsk Sea (TOKRANOV and VINNIKOV, 1991). These studies have pointed out its diverse diet composition and significant impact as a predator on the organisms of commercial importance (*e.g.* walleye pollock, *Theragra chalcogramma* and snow crab, *Chionoecetes bairdi*). However, the food habits and ecological role of cod in Japanese waters remained fragmentary (*e.g.* MOTODA and MORIYAMA, 1952; HASHIMOTO, 1974; YAMAMURA *et al.*, 1993).

The water off Hokkaido is the major habitat of cod, and the catch occupied more than 70% of the total around Japan (MISHIMA, 1984). In particular, more than 100 metric tons of cod have been yielded from the shelf off eastern Hokkaido in the last 5 years (HOKKAIDO GOVERNMENT, 1986–1990).

In this study we analyzed stomach contents of cod sampled in trawl survey off eastern Hokkaido conducted by the Hokkaido National Fishery Research Institute, and

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examined feeding habits, prey change with fish size, and feeding periodicity.

2. Materials and Methods

2.1. Sampling

Bottom trawl samples were collected during the seven cruises of RV TANSHU MARU (444 t) during April, May and June 1989–1992. The sampling area was situated on the continental shelf and slope off eastern Hokkaido (Fig. 1). The mesh sizes of the trawl net used were from 180 mm stretched mesh near the head rope to 90 mm near the codend, with a codend liner of 18 mm stretched mesh. For all cruises, tow duration was 30 min at the speed of 5.6 km per hour. Individual fish was measured and weighed to the nearest 1 mm and 5 g, respectively on board or in the laboratory. The stomachs were dissected and were fixed in 10% formalin saline water. Everted stomachs were excluded from the examination. To examine feeding periodicity, 24 h period samplings were made at the intervals of 6 h (1989) or 4 h (1990 and 1991) in subareas E and C. The difference of sunset by location and date was in a range of an hour: *e.g.* 1859 h on April 25, 1991 in subarea E whereas 1931 h on June 5, 1991 at subarea A. The sampling data is summarized in Appendix 1.

2.2. Stomach contents analysis

In the laboratory, stomachs were cut open, and food items were sorted to the lowest taxonomic level as possible. Prey size was categorized into the following five groups: ≤50 mm; 51–100 mm; 101–200 mm; 201–300 mm; >300 mm. When the otoliths or subopercles of digested walleye pollock were found, their body lengths were estimated

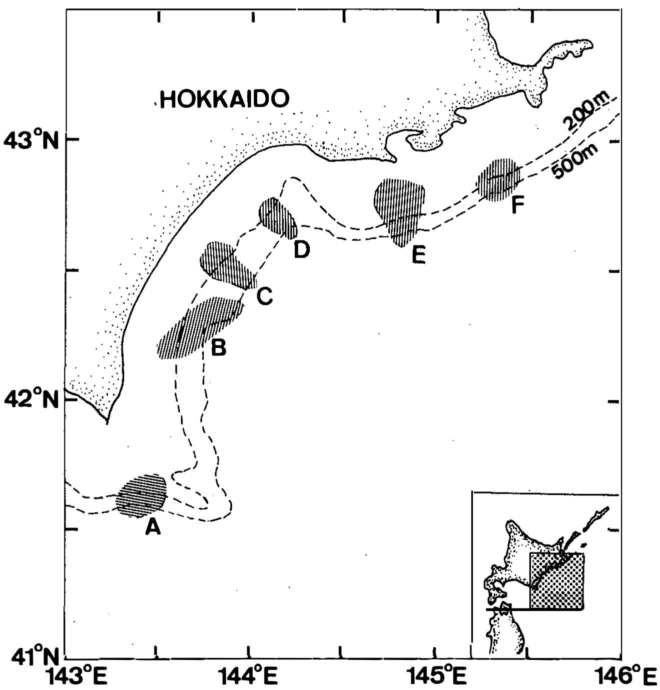

Fig. 1. Chart showing trawl sampling areas of RV TANSHU MARU off the eastern coast of Hokkaido during April, May and July 1989–1992.

according to the conversion equations given by YOSHIDA and KATO (1980). Prey items were individually dried at 52°C in a drying oven for 24 h and in a desiccator for 36–48 h, and weighed to the nearest 1 mg.

2.3. Data analysis

Percentage of total stomach contents weight by taxonomic and size categories, and percentage frequency of occurrence by prey item were calculated for each predator size class of 100 mm. Prey items were also classified into three types (*i.e.* ecological categories): nekton, benthos (including fishes associated with substratum) and plankton. The dry weight composition of cod diet by ecological category was then calculated. Unidentifiable digested matter and pebbles were omitted from the data set. Empty stomachs were omitted for frequency of occurrence.

Stomach content index (SCI) was calculated for each individual: SCI= (SCW/BW)*10^3, where SCW is dry weight of stomach content (g), BW is body weight (g). The mean of SCI was calculated for daytime (0601–1800 h) and nighttime (1801–0600 h) samples based on midtime of hauls. Daytime and nighttime were further subdivided into time segments; 0001–0600 h, 0601–1200 h, 1201–1800 h and 1801–2400 h. The difference of SCI for each pair of time segments was tested with *t*-test.

3. Results

3.1. Diet

The size of the Pacific cod ranged from 167 mm to 902 mm in scale covered length. Of the 336 stomachs examined, 317 (94.1%) contained food which weighed in total 4092.5 g in dry weight. A total of 70 taxa were identified (Table 1). The diet consisted almost entirely of (≥80%) decapoda crustaceans and fishes in every size class. At least 11 species of decapod crustaceans species and 19 fish species were identified. Walleye pollock was the most dominant prey species in every size class. The contribution of aphorditid polychaeta and ophiuroids was very low (<1%) despite their high abundance in the dredge net collection made in the study area (YAMAMURA, unpublished data).

Cods showed an obvious body size related dietary shift (Fig. 2a). More than 40% of the diet of the cod in the smallest size class (≤300mm) cod was represented by crangonid shrimps, *Argis lar* (29.0%) and *Neocrangon communis* (14.2%). The other important items in this size class were walleye pollock (34.3%) and myctophyd fishes (12.4%). In the second size class (301–400 mm), the importance of crangonid shrimps decreased abruptly to 8.3% whereas the importance of walleye pollock increased to 51.5%. The other prey items of importance in this size class were prickleback, *Stichaeus* sp. (17.6%) and thorny sculpin, *Icelus cataphractus* (5.2%). In the three size classes larger than 400 mm, walleye pollock was the dominant prey item. The other prey fishes of importance in these size classes were Japanese sardine (*Sardinops melanostictus*), threadfin hakeling (*Laemonema longipes*), pricklebacks (*Lumpenus sagitta* and *Stichaeus nozawai*), and sculpins (*Icelus cataphractus*, *Cottisculus schmidti* and *Malacocottus zonurus*). These size classes also ingested octopus,

Table 1. Diet of Pacific cod, Gadus macrocephalus *collected off the eastern coast of Hokkaido during April, May and June 1989–1992. Percentage by dry weight (W), and percent frequency of occurrence (F) of prey items for each size class, and ecological category for each prey item are given: N_1; Number of stomachs examined, N_2; Number of empty stomachs, EC; Ecological category, N; Nekton, B; Benthos, P; Plankton.*

Size class		≤300 mm		301–400 mm		401–500 mm		501–600 mm		≥601 mm	
N_1/N_2		56/2		34/1		112/8		75/5		59/3	
		W	*F*	*W*	*F*	*W*	*F*	*W*	*F*	*W*	*F*
Item	EC										
Polychaeta (unid.)	B	1.53	12.96	0.32	12.12	0.17	6.73	0.06	7.14	+	1.79
Aphorditidae	B	0.32	1.85	–	–	0.24	3.85	0.11	2.86	–	–
Polynoidae	B	–	–	–	–	0.09	0.96	–	–	–	–
Echiuroidea	B	–	–	–	–	0.03	0.96	0.05	1.43	–	–
Buccinidae	B	0.41	1.85	0.46	6.06	0.13	1.92	0.25	4.29	0.01	1.79
Nuculana radiata	B	–	–	–	–	+	0.96	0.00	1.43	0.01	1.79
Bibalvia (unid.)	B	–	–	+	3.03	0.02	0.96	–	–	–	–
Ennucla mirifica	B	–	–	–	–	–	–	0.01	1.43	–	–
Cephalopoda (unid.)		–	–	–	–	0.04	1.92	0.05	1.43	–	–
Berryteuthis magister	B	–	–	–	–	3.05	2.88	0.89	2.86	6.75	8.93
Gonatopsis borealis	N	0.10	1.85	–	–	–	–	1.52	2.86	–	–
Paroctopus sp.	B	0.19	3.70	2.42	9.09	6.09	11.54	13.08	24.29	3.81	19.64
Paroctopus conispadiceus	B	–	–	–	–	3.45	3.85	4.52	4.29	4.10	7.14
Paroctopus dolfleini	B	–	–	–	–	0.09	0.96	0.19	2.86	0.41	1.79
Crustacea (total)		47.10	81.48	11.36	81.81	20.92	64.42	6.75	58.57	1.16	33.92
Ostracoda	B	–	–	+	3.03	+	0.96	–	–	–	–
Meterithrops microthalma	P	–	–	–	–	0.01	0.96	–	–	–	–
Cumacea	B	0.01	1.85	–	–	+	0.96	–	–	–	–
Isopoda	B	–	–	–	–	0.01	1.92	+	1.43	–	–
Gammaridea (unid.)	B	0.12	9.26	0.02	6.06	0.02	7.69	+	1.43	–	–
Ampelisca sp.	B	0.15	3.70	1.29	15.15	1.07	13.46	0.39	11.43	0.06	5.36
Ampelisca eschrichti	B	0.80	5.56	0.89	15.15	1.84	13.46	0.08	8.57	–	–
Bibris sp.	B	0.02	1.85	0.09	12.12	0.08	7.69	0.00	1.43	+	1.79
Anonyx sp.	B	0.83	16.67	0.16	24.24	0.16	11.54	0.05	11.43	+	1.79
Caprellidea	B	–	–	–	–	+	0.96	–	–	–	–
Themisto japonica	P	0.40	5.56	0.01	6.06	–	–	–	–	+	1.79
Euphausia pacifica	P	0.24	7.41	0.09	9.09	0.03	1.92	–	–	–	–
Hippolytidae	B	–	–	0.02	3.03	–	–	–	–	–	–
Eualus fabricii	B	0.10	1.85	–	–	0.02	0.96	–	–	–	–
Spirontocaris murdochi	B	0.61	18.52	0.33	18.18	0.20	9.62	0.01	4.29	–	10.71
Lebbeus globenlandicus	B	–	–	–	–	1.22	0.96	2.31	2.86	–	–
Pandalus borealis	B	0.06	1.85	0.04	6.06	1.05	3.85	1.62	11.43	0.10	7.14
Neocrangon communis	B	14.16	38.89	1.88	54.55	2.46	42.31	0.58	28.57	0.04	12.50
Argis lar	B	29.04	48.15	6.38	33.33	7.30	25.96	1.45	17.14	0.82	19.64
Agris hozawai	B	–	–	–	–	–	–	0.03	1.43	–	–
Metacrangon sp.	B	–	–	–	–	–	–	0.01	1.43	–	–
Elassochirus cavimanus	B	–	–	–	–	0.05	0.96	–	–	–	–
Pagurus trigonocheirus	B	0.46	1.85	–	–	3.07	12.50	0.09	5.71	0.14	8.93
Pagurus tonnsendi	B	0.12	1.85	0.18	3.03	1.47	1.92	0.07	2.86	–	–
Chionoecetes opilio	B	–	–	–	–	0.87	2.88	0.07	1.43	–	–
Ophiuroidea	B	0.05	1.85	–	–	0.46	6.73	0.12	8.57	0.03	3.57
Hydrozoa	B	–	–	–	–	0.01	0.96	–	–	–	–

+: <0.01%

Table 1. (Continued).

Size class		≤300 mm		301–400 mm		401–500 mm		501–600 mm		≥601 mm	
		W	*F*	*W*	*F*	*W*	*F*	*W*	*F*	*W*	*F*
Item	EC										
Pisces (unid.)		–	–	5.50	12.12	0.16	4.81	0.66	10.00	0.59	12.50
Pisces (total)		50.30	37.03	79.92	51.51	72.32	72.11	76.35	81.42	83.11	89.28
Sardinops melanostictus	N	–	–	–	–	1.66	0.96	7.95	5.71	4.48	1.79
Myctophidae (unid.)	N	12.39	9.26	1.61	3.03	4.88	2.88	–	–	0.03	1.79
Lampanyctus sp.	N	–	–	–	–	–	–	0.32	1.43	–	–
Lampanyctus jordani	N	–	–	–	–	–	–	0.83	2.86	–	–
Lampanyctus niger	N	–	–	4.13	3.03	4.17	1.92	0.88	2.86	–	–
Phisiculus maximowiczi	B	–	–	–	–	–	–	0.82	1.43	–	–
Laemonema longipes	N	–	–	–	–	–	–	3.10	1.43	25.82	12.50
Theragra chalcogramma (total)	N	34.27	22.22	51.45	30.30	43.44	42.30	44.46	42.90	44.11	66.07
Theragra chalcogramma (≤100 mm)	N	11.27	7.41	–	–	–	–	–	–	–	–
Theragra chalcogramma (101–200 mm)	N	19.46	9.26	30.84	18.18	28.52	24.04	28.88	12.86	14.03	14.29
Theragra chalcogramma (201–300 mm)	N	–	–	–	–	11.49	14.42	7.06	25.71	7.66	25.00
Theragra chalcogramma (301–400 mm)	N	–	–	19.06	3.03	2.14	2.88	8.45	11.43	11.71	25.00
Theragra chalcogramma (401–500 mm)	N	–	–	–	–	0.18	0.96	–	–	0.05	1.79
Theragra chalcogramma (unknown)	N	3.54	5.56	1.55	9.09	1.11	0.96	0.07	1.43	10.66	12.50
Gempylidae (unid.)	N	–	–	–	–	–	–	0.19	1.43	–	–
Stichaeidae (unid.)	B	–	–	–	–	–	–	0.83	1.43	0.41	1.79
Lumpenus sagitta	B	–	–	–	–	5.07	3.85	–	–	0.08	1.79
Stichaeus sp.	B	–	–	17.57	3.03	–	–	–	–	1.20	1.79
Stichaeus nozawai	B	–	–	–	–	3.34	0.96	–	–	2.93	3.57
Anisarchus macropus	B	1.60	1.85	–	–	–	–	0.23	1.43	–	–
Zoarcidae (unid.)	B	–	–	–	–	0.23	0.96	1.27	2.86	–	–
Davidijordania jordania	B	–	–	–	–	0.36	0.96	–	–	–	–
Lycodes hubbsi	B	–	–	–	–	–	–	3.97	1.43	–	–
Sarritor sp.	B	–	–	–	–	–	–	0.06	1.43	–	–
Sarritor frenatus	B	–	–	–	–	0.51	1.92	–	–	–	–
Sarritor leptorhynchus	B	–	–	–	–	–	–	0.27	1.43	–	–
Aspidophoroides bartoni	B	–	–	–	–	–	–	–	–	0.08	1.79
Cottidae (unid.)	B	–	–	–	–	1.44	2.88	0.18	2.86	–	–
Cottisculus schmidti	B	2.03	3.70	–	–	1.72	8.65	1.23	8.57	0.23	5.36
Malacocottus zonurus	B	–	–	–	–	0.52	3.85	5.40	10.00	1.17	1.79
Icelus cataphractus	B	–	–	5.17	3.03	4.09	2.88	1.44	5.71	1.96	12.50
Liparis sp.	B	–	–	–	–	–	–	1.08	1.43	–	–
Careproctus furcellus	B	–	–	–	–	0.92	0.96	1.83	2.86	0.62	1.79
Fecal pellet		–	–	0.03	12.12	0.00	1.92	+	1.43	–	–
Total DW of food examined (g)		72.00		150.30		583.27		1084.23		2202.70	

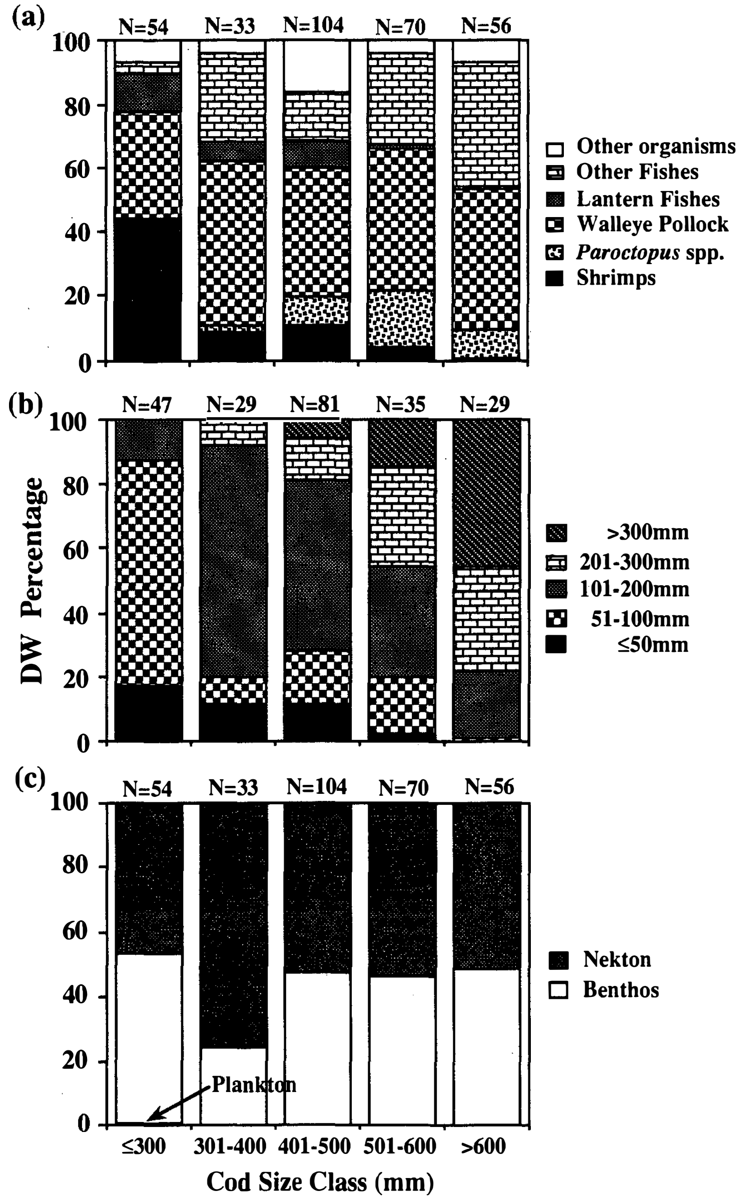

Fig. 2. Percentage by dry weight of (a) major taxonomic categories, (b) size categories, and (c) ecological categories of prey in the diet of the Pacific cod, Gadus macrocephalus *for different size classes of fish collected off eastern Hokkaido during April, May and July 1989–1992.*

Paroctopus spp. at a considerable level (>8%).

3.2. Prey size and type

Prey size category composition is shown in Fig. 2b. There were marked differences in the size of prey among different size classes. Apparently, larger cod tends to ingest larger prey. In the prey type composition (Fig. 2c), plankton shared negligible portions (<0.7%) in the size classes of ≥500 mm. In all but the second (301–400 mm) size class, both nekton and benthos shared approximately half portions. Thus no obvious predator size related pattern was seen in the allocation of ecological prey categories.

3.3. Feeding periodicity

The mean SCI (±SE) for the daytime and nighttime samples were 5.34±0.37 (N=21) and 1.79±0.48 (N=239), respectively. There was a significant difference between them (p<0.001). As for the 6 h time segments (Fig. 3), only two pairs, 0601–1200 h *vs* 1801–2400 h and 1201–1800 h *vs* 1801–2400 h showed a significant difference (p<0.001). This result shows that the cod injects actively during daytime and that the activity declines abruptly after sunset.

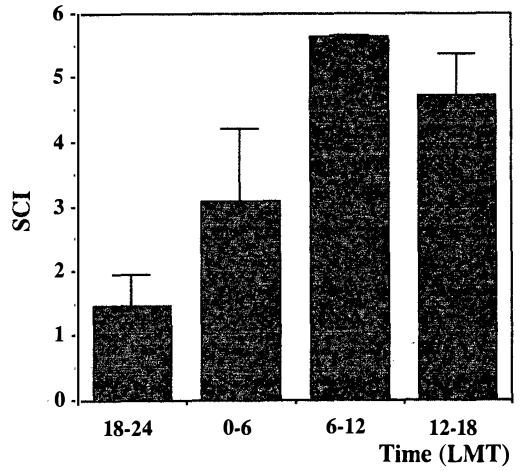

Fig. 3. Stomach contents index (SCI, mean + SE) for 6 h time segments of a day showing feeding periodicity of the Pacific cod, Gadus macrocephalus *collected off eastern Hokkaido during April, May and July 1989–1991.*

4. Discussion

We found that the most important prey item for the Pacific cod in the present study area was walleye pollock. Several studies have shown that walleye pollock is the primary food of the Pacific cod; in the eastern Bering Sea (MITO, 1974; LIVINGSTON *et al.*, 1986; WAKABAYASHI, 1986) and in the Kamchatkan coastal waters (TOKRANOV and VINNIKOV, 1991). In the area off eastern Hokkaido walleye pollock is the most abundant fish with a catch of 700 metric tons in this decade (HOKKAIDO GOVERNMENT, 1980–1990).

On the other hand, snow crab *Chionoecetes bairdi* was reported as the most important food item for the Pacific cod around Kodiak Island (JEWETT, 1978) and in Bristol Bay (BAKKALA, 1984). ALBERS and ANDERSON (1985) found that pink shrimp, *Pandalus borealis* was the most frequently occurring prey item for the Pacific cod in the Gulf of Alaska. These decapods were known as the abundant organisms in each study area. Therefore, it is suggested that the Pacific cod is primarily an opportunistic feeder which preys on these organisms occurring abundantly in the surrounding waters. However, the importance of the benthos, aphorditid polychaeta and ophroids in cod's diet was low despite their abundance. This fact indicates the Pacific cod does not feed on whatever prey available and may have a feeding selectivity to some extent under particular conditions.

Our result has shown that the cod ingests more actively during daytime than during nighttime. This result is contrary to the result found in the Bering Sea cod in which the stomach contents were more abundant during nighttime than during daytime (MITO, 1974). This difference may be partly due to the low stomach evacuation rate of the Pacific cod (1.5% body weight day^{-1}; PAUL *et al.*, 1990). However, according to BRAWN (1969) Atlantic cod, *Gadus morhua* uses sight to locate prey in the water column or on the sea bottom. If the result of his observation fits to the Pacific cod, our result is rather capable.

BRAWN (1969) also indicated that the Atlantic cod has another mode of foraging: searching by olfactory and gustatory senses for small food on the bottom or buried food. Therefore, small benthic prey found in the small cod resulted from foraging using olfactory and gustatory senses. For instance, crangonid shrimps which made up the greatest part of the smallest size class bury themselves during daytime (BULTER, 1980; KOMAI and AMAOKA, 1992). Thus if small-sized cod depends mainly on the olfactory and gustatory senses, it is presumed that small cod does not exhibit a clear feeding periodicity. However, the limited size of our sample prevents us from drawing a conclusion.

Obviously the cod showed the dietary shift from shrimps in small (<300 mm) cods to fishes in larger cods. This shift was accompanied with change in prey size, but not with prey type. This evidence suggests that in cod there is no alternation of feeding mode with growth. BRAWN (1969) found little difference in prey type between the young (5–18 cm) and adult (45–90 cm) Atlantic cods. Therefore, we conclude that the dietary shift of the Pacific cod was derived from a change in prey size.

The dietary shift with fish size has been explained in terms of energy optimization (*e.g.* PYKE, 1984). Generally, the larger prey is more profitable for a predator (SCHOENER, 1979). However, juvenile fishes are constrained by their small size to exploit relatively small food particles (WERNER and GILLIAM, 1984; KEAST, 1985). Further, the optimum foraging model (WERNER and HALL, 1974) predicts an optimal diet for given sized fish using a knowledge of size and abundance of prey (MITTELBACH, 1981). Hence the diet of the cod with certain size is determined by prey abundance and prey size spectrum in its habitat.

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Appendix 1. Summary of trawl collections made off the eastern coast of Hokkaido by RV Tanshu Maru *during 1989–1992. Time is midtime of each hawl. For subareas, see Fig. 1.*

Sub-area	Date	Time (LMT)	Depth (m)	Latitude	Longitude	Number of specimens ≤300	–400	–500	–600	≥601
E	890504	1902	231	42° 40.7' N	144° 49.8' E				1	2
C	890506	0100	216	42° 31.6' N	143° 55.9' E			1	1	
C	890506	0659	215	42° 31.4' N	144° 55.7' E		1	1	4	4
C	890506	1252	216	42° 31.5' N	144° 55.8' E			1	2	1
C	890506	1854	216	42° 31.8' N	144° 56.0' E		1	3	1	3
B	890613	0707	125	42° 09.3' N	143° 33.4' E		1	2		
B	890613	1312	412	42° 16.5' N	143° 43.9' E				1	
D	890614	0833	116	42° 43.2' N	144° 03.8' E				5	3
D	890614	0956	214	42° 41.7' N	144° 06.1' E				7	
E	890615	0831	109	42° 49.1' N	144° 52.1' E			1	3	5
E	890615	1007	209	42° 41.8' N	144° 51.0' E			2	1	4
F	890616	0849	143	42° 53.0' N	145° 22.0' E				1	
F	890616	1006	226	42° 51.1' N	145° 19.9' E				2	1
F	890616	1146	308	42° 50.0' N	145° 18.4' E				2	1
E	900425	0628	160	42° 49.6' N	144° 49.7' E	1				
E	900425	1246	200	42° 42.1' N	144° 49.0' E					1
E	900425	1402	123	42° 49.6' N	144° 49.7' E	1		1		1
E	900426	1223	106	42° 49.6' N	144° 49.7' E	4	5	1		1
A	900529	0704	352	41° 40.3' N	143° 40.4' E					1
A	900529	0905	265	41° 42.3' N	143° 39.5' E			2		
A	900529	1414	251	41° 37.3' N	143° 21.9' E			2	1	
A	900529	1602	152	41° 41.0' N	143° 22.0' E			1		
B	900530	0705	132	42° 11.0' N	143° 35.0' E	10		3		
B	900530	1640	325	42° 11.5' N	143° 42.5' E			1	2	
C	900531	1202	322	42° 31.1' N	143° 56.5' E	5	4	5	2	
C	900531	1328	202	42° 33.3' N	143° 56.5' E			1		2
C	900531	1439	118	42° 31.8' N	143° 53.0' E			1	1	
E	900603	1520	196	42° 42.3' N	144° 50.4' E			1	1	
E	900604	1511	145	42° 52.9' N	144° 21.8' E		3	1	1	2
C	910423	2030	207	42° 32' N	143° 56' E			5	2	1
C	910424	0430	200	42° 32' N	143° 56' E			1		
C	910424	0824	201	42° 32' N	143° 56' E				1	1
C	910424	1233	205	42° 32' N	143° 56' E			2	1	
C	910424	1627	202	42° 32' N	143° 56' E		1	2	2	1
E	910425	0826	201	42° 51' N	145° 19' E			1		
E	910425	1225	204	42° 51' N	145° 19' E				2	
E	910425	1630	203	42° 51' N	145° 19' E				1	1
C	910602	0708	126	42° 31.9' N	143° 53.0' E	12	1	5	2	
C	910602	0934	208	42° 31.6' N	143° 55.1' E			4		
C	910602	1154	334	42° 31.0' N	143° 56.8' E					1
E	910601	0708	117	42° 48.2' N	144° 51.2' E	2	2	2	3	
E	910601	1139	334	42° 40.7' N	144° 52.4' E		1			
F	910531	0706	141	42° 53.1' N	145° 22.3' E		3	15	5	3
B	910603	0707	135	42° 10.2' N	143° 35.2' E	8	6	3	1	
B	910603	0918	214	42° 01.0' N	143° 38.3' E			1		
A	910605	0717	262	41° 37.0' N	143° 21.4' E			2		
A	910604	0712	168	41° 43.2' N	143° 33.6' E	7	1	3		

Appendix 1. (Continued).

Sub-area	Date	Time (LMT)	Depth (m)	Latitude	Longitude	Number of specimens				
						≤300	–400	–500	–600	≥601
A	910604	0929	263	41° 42.0' N	143° 39.4' E			1	1	
A	910604	1145	355	41° 40.3' N	143° 40.3' E			1		
C	920603	1609	123	42° 32.0' N	143° 52.5' E	1	1	1		
E	920607	0902	164	42° 44.4' N	144° 49.7' E				1	2
B	920606	0705	137	42° 10.3' N	143° 35.3' E	2			1	
B	920606	0915	216	42° 10.4' N	143° 38.4' E			4	6	6
B	920606	1143	320	42° 11.6' N	143° 41.1' E			1		1
A	920604	1612	168	41° 40.5' N	143° 22.8' E	3	1	6	1	4
A	920606	1417	266	41° 37.2' N	143° 22.0' E			3	1	3
A	920606	1143	327	41° 36.1' N	143° 23.9' E			4		
A	910605	0940	164	41° 43.2' N	143° 33.0' E		3	10	1	
A	910605	1149	270	41° 42.4' N	143° 39.8' E			4	1	2
A	910605	1404	363	41° 41.3' N	143° 42.4' E				3	