FOOD HABITS OF LARGHA SEAL PUPS IN THE PACK ICE AREA

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ABSTRACT

The stomach contents from largha seal (ice-breeding harbor seals) collected in the pack ice areas off the eastern Hokkaido and the east coast of Sakhalin were examined. Analyses revealed that fishes, cephalopods, euphausiids and decapods were principal foods. Among them, fishes were primary foods as well as *Theragra chalcogramma*, secondary cephalopods as well as squids and octopus. The result of stomach contents analyses suggested that this seal used many organisms of wide range as foods in the pack ice areas.

Although there are no definite trends of changes in foods by age among the older seals, specialized feeding on euphausiids was found in newly weaned pups. Euphausiids appeare to be not only available but also indispensable foods for pups after the weaning, this would be evolved feeding adapted to the pack ice condition.

INTRODUCTION

Ice-breeding harbor seals (largha seal), *Phoca largha*, is relatively frequent species in the pack ice areas off the Western Hokkaido and Southern Okhotsk Sea occurring in early spring (Inukai, 1942; Wilke, 1954; Tikhomirov, 1968; Naito and Nishiwaki, 1972; Naito and Konno, 1980). In these days, the informations related to the reproduction and distribution have been reported (Naito and Nishiwaki, 1972; Naito and Konno, 1980). However, no studies on food of this species have been made except the fragmental informations.

Fay (1974) reviewed the relations between sea ice and marine mammals, and he pointed out that one of the roles of sea ice for pagophilic seals was food supply. In this connection, the investigations on food of largha seals would be meaningful so as to consider the relations between sea ice and this seal.

In the present study, stomach contents of largha seals collected in the open pack ice area of the east coast of Sakhalin and Nemuro Strait were examined. The sampling was carried out in the early to mid spring of post-breeding season for largha seals. Then, changes in food with age, especially for pups after the weaninng, were examined.

MATERIALS AND METHODS

Sampling areas and seasons

During this study, some parts of stomachs were collected from the carcase

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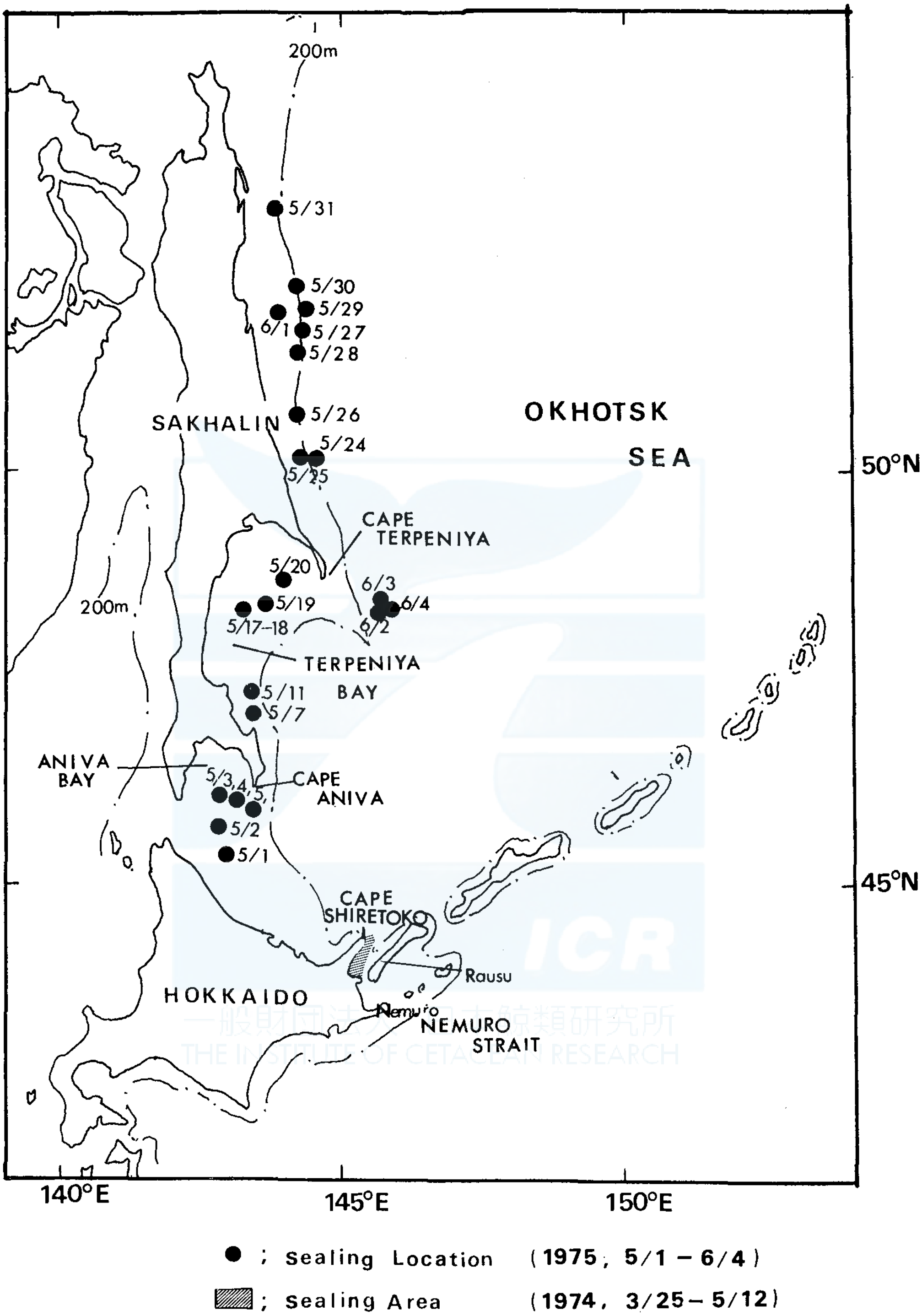

Fig. 1. Catch locations of the largha seal.

accumulated in Kanazawa Fur Co., Nemuro, Hokkaido. Those seals were hunted in the pack ice area of Nemuro Strait during 25 March and 12 May 1974. Others were obtained in the pack ice area off the east of Sakhalin from the operation of *Dairin maru No. 5* (75.00 gross ton.), which is floating factory sealing type, in the early spring during 4 March and 2 July 1975 with chasing to " front " of pack ice area. Both of sampling areas are shown in Fig. 1.

Stomach contents and data collection

All seals used in the present study were killed by shot guns or rifles. Initially, for the convenience of sampling stomach contents, all stomachs which were supposed to contain foods were reserved, but empty stomachs were not sampled after checking of contents. The stomachs were removed from the carcase bound at acrdiac orfice and pylorus with strings to avoid flowing out of contents. Sampled stomachs were reserved in 20% of formalin solution. The details of samples are summarized in Table 1. At the same time, body length and sex data follow on the all samples in both areas.

For the ageing carnine teeth were taken from under jaws, the growth layers were counted based on the same methods as reported in Naito and Nishiwaki (1972). Among the Sakhalion samples, 43 animals with stomach contents were aged by above methods, however, no ageing materials were collected in Nemuro Strait.

Identification of food species

Stomach contents were examined at the laboratory after the sampling works. If the contents are found under the very fresh condition in the stomach, food species was identified based on the outside characters, whereas in the case of contents heavily digested identification was aided by several collections of fish skelton, otolith and beak of cephalopods obtained in the adjacent waters of Hokkaido, as well as following publications; Hotta (1961), Matsubara (1955) and Watanabe (1958).

However, I was not able to succeed in satisfactorily identifying most of squids and octopus which consisted of only beak.

TABLE 1. SAMPLING SAMMARY ON STOMACHS OF LARGHA SEALS IN THE PRESENT STUDY

Sampling Area & periods	No. stomach examined	No. stomach with age and length data	No. stomach with length data
Nemuro Strait			
25 March—9 May 1974	47	—	47
15 March—15 May 1970	26*	26*	26*
Sakhalin			
1 May—4 July 1975	43	43	18

* Samples collected by Mr T. Itoh in 1970, these were used in only examination of changes in food with age.

Index of food composition

Several problems have been devoted in index of stomach contents analysis, therefore following two methods similar to the indices used in Spalding (1964) were considered for the present study.

Weight index: The stomach contents were weighed in each 5 g scale under the wet condition separately by food species. Small amounts of heavily digested materials less than 5 g which should not be regarded as food were recorded as " trace " in weight. Weights of each food species in each stomach are summed and index was represented as a percentage of summed weight against combined weight of each item of the total stomachs examined.

Occurrence index: Regardless of number of individuals, if at least one food species occurred in a stomach, this species was recorded as " one occurrence ". This index is expressed as a percentage of number of occurrence against the total number of stomach examined.

STOMACH CONTENTS

As shown in Table 2, the analyses of largha seal stomach contents revealed that fishes, cephalopods were the primary food in the Nemuro Strait and waters off the east coast of Sakhalin.

Among the Nemuro strait samples, fishes was the primary food item for largha seals, comprising 78.9% and 91.7% in occurrence and weight indices, respectively. Among them, *Theragra chalcogramma* was the dominant species at 48.9% of occurence index and 47.0% of weight index, Pleuronectidae and *Hypomesus japonicus* seemed to be also major species.

Cephalopods was secondary item, comprising 42.6% and 6.3% in occurrence and weight indices, respectively. It should be taken in account of under-representation in weight index of this item, because the remainder of cephalopods in stomachs usually consisted of beaks, eye lenses and pens. Concerning the identification, most of cephalopods were found under the heavily digested condition, it was considerably difficult, therefore, to identify species among the squid's beaks, although octopus was identified to be *Paraoctopus dofleini* by the chracteristic their beaks.

Euphausiids including *Thysanoessa inermis* were found in the ten stomachs comprising 21.3% and 2.0% in occurrence and weight indices, respectively. There were clearly two types in occurrence of this item; one case was very small amount of fragments of euphausiids occurred, the other was large amounts of euphausiids occupied the most portions of the stomach contents. The latter type feeding seemed to be more frequent in younger animals. This will be examined in the latter chapter.

The results of stomach contents analyses in the Sakhalin samples, were almost similar to that in the Nemuro samples. *T. chalcogramma* was also the most important food far from the others, comprising 72.1% and 82.5% in occurrence and weight indices, respectively. *Clupea pallasi*, which is abundant species in sea ice

TABLE 2. FOOD COMPOSITIONS OF LARGHA SEALS IN NEMURO STRAIT AND OFF THE EAST COAST OF SAKHALIN

Food species	Nemuro Strait n=47				Sakhalin n=43			
	Occurrence index		Weight index		Occurrence index		Weight index	
	Number Oc-curred	%	g	%	Number Oc-curred	%	g	%
Fishes	37	78.9	24,495	91.7	31	72.1	13,560	82.5
Theragra chalcogramma	23	48.9	12,645	47.0	23	53.5	7,710	46.9
Pleuronectidae	10	21.3	1,020	3.8	1	2.3	trace	0.0
Eleginus gracilis	2	4.3	435	1.6	3	7.0	1,585	9.6
Pleurogrammus sp.	1	2.1	70	0.3	2	4.7	1,460	8.9
Hypomesus japonocus	5	10.6	4,180	15.5	—	—	—	—
Osmerus dentex	2	4.3	465	1.7	1	2.3	70	0.4
Sebastolobus macrochir	2	4.3	1,735	6.5	—	—	—	—
Sebastes schleigeli	1	2.1	300	1.1	—	—	—	—
Ammodytes sp.	1	2.1	10	0.0	—	—	—	—
Aptocyclus ventricosus	1	2.1	300	1.1	—	—	—	—
Gymnocanthus sp.	1	2.1	950	3.5	—	—	—	—
Gadus macrocephalius	1	2.1	310	1.2	—	—	—	—
Lycogramma zesta	1	2.1	2,140	8.0	—	—	—	—
Clupea pallasi	—	—	—	—	6	14.0	2,665	16.2
Cottidae	—	—	—	—	2	4.7	70	0.4
Unidentified fish	2	4.3	100	0.4	5	11.6	trace	0.0
Cephalopods	20	42.6	1,710	6.3	15	34.9	720	4.3
Octopus, *Paraoctopus dofleini*	3	6.4	225	0.8	12	27.9	90	0.2
Squids	17	36.2	1,485	5.5	3	7.0	630	3.8
Euphausiids	10	21.3	530	2.0	12	27.9	2,035	12.4
Thysanoessa inermis	2	4.3	390	1.5	4	9.3	290	1.8
T. raschii	—	—	—	—	5	11.6	1,505	9.2
Decapods	—	—	—	—	7	16.3	130	0.7
Pandalus borealis	—	—	—	—	3	7.0	130	0.7
Chionoecetes opitio	—	—	—	—	1	2.3	trsce	0.0

area in Okhotsk Sea, was ranked in second species among fishes.

It was notable, among the item of cephalopods, that octopus were more frequent than squids in contrast with that in Nemuro samples.

Euphausiids revealed two species, *T. inermis* and *T. raschii* indicating almost same occurrence. Two species of decapods, *Pandalus borealis* and *Chionoecetes opitio* were found, but these were minor item as foods for largha seals.

The analyses show that *T. chalcogramma* are heavily used as a most important food for largha seals in the early spring of both areas. This fish is also important foods for land-breeding harbor seal, *P. richardi*, in the northwestern region of North Pacific (Imer and Sarber, 1947; Wilke, 1954; Kenyon, 1965), furthermore Pitcher (1977) found that this fish was most dominant prey for *P. richardi* throughout the year in Prince William Sound.

Table 3 shows the fishing yields statistics in the Nemuro Strait during March

TABLE 3. FISHING YIELD STATISTICS FOR 1973 MARCH-MAY FROM NEMURO STRAIT AND FOR 1975 MAY FROM ANIVA AND TERPENIYA BAY

Species	Nemuro Strait March-May, 1973		Aniva and Terpeniya Bay May, 1975	
	tons	(%)	tons	(%)
Gadus macrocephalus	4,455.3	(13.3)	2.2	(0.1)
Theragra chalcogramma	18,029.1	(55.8)	1,425.3	(81.5)
Eleginus gracilis	—	—	17.9	(1.0)
Pleurogrammus sp.	773.6	(0.2)	0.1	(0.0)
Clupea pallasi	5.1	(0.0)	0.1	(0.0)
Pleuronec tidae	1,872.1	(5.6)	205.4	(11.4)
Hypomesus sp.	—	—	0.1	(0.0)
Sebastolobus sp.	177.5	(0.5)	—	—
Other fishes	8,269.5	(24.6)	—	—
Octopus	10.0	(0.0)	0.4	(0.0)
Squid	1.5	(0.0)	—	—
Shrimp	—		9.0	(0.5)
Others	—	—	98.5	(5.5)

and May 1973 and in the waters off the east coast of Sakhalin in May 1975 (Hokkaido suisanbu, 1974; 1976), approximately coinciding with the sampling seasons and areas in the present study. The catch of *T. chalcogramma* was also dominant far from those of others. Although there are still several problems, assuming the fisheries catch shows fish-fauna in the both of two waters, largha seals feed primarily on abundant species. This suggests no preference on species if the organisms are available size and behavior for seals as foods. Generally speaking in the trends of stomach contents, most of food species which occurs in stomachs are basically in the category of coastal species in this season inhabiting from the surface to the bottom, moreover, schooling fishes such as *T. chalcogramma*, *Hypomesus japonocus* contributed as major food species for this seal. The only few informations of fishes, cephalopods and others are available in the ice areas, but largha seals can possibly use the most of nekton inhabiting ice areas as their foods.

CHANGES IN FOOD WITH AGE

Spalding (1964) pointed out an increase in food size and suggested changes in food species with age in northern fur seals, *Callorhinus ursinus*. Moreover specialized feeding habits of newly weaned pups in *P. richardi* has been reported by Havinga (1933), Fisher (1952), Bigg (1973) and Pitcher (1977). Therefore, substantial changes in food with age would be expected in the samples of the present study.

For the convenience of this examination, " growth stage " which was classified into four categories, pups, youngs, maturings and adults, based on primarily ages was adopted instead of age classes due to small sample size. Among the samples of no age data, however, growth stages were classified tentatively by their body length based on age-length relations in Tikhomilov (1964) and Naito and

Nishiwaki (1972). As a result, following criteria were used in this examination:

Stage	Age	Body length (cm) Male	Female
Pups	0	distinguishable from other stages	
Youngs	1–2	–130	–127
Maturings	3–4	131–145	128–141
Adults	5–	146–	142–

The 26 stomach samples with age data obtained in Nemuro Strait in 1970 were added to the present study examined in previous section, then the total of 116 stomachs were available in this examination.

Food compositions

Food compositions in each growth stage are indicated in Table 4.

Pups: 16 stomachs were examined in this stage, revealing fishes, cephalopods, euphausiids and decapods. Among them, euphausiids are the dominant

TABLE 4. COMPOSITION OF FOOD ITEMS IN RELATION TO THE GROWTH STAGE IN HARBOUR SEAL

Food items	Pups Oc.%	N=16 W.%	Young Oc.%	N=35 W.%	Maturing Oc.%	N=16 W.%	Adult Oc.%	N=49 W.%
Fishes	18.8	1.0	74.3	90.9	75.0	88.7	91.8	95.8
Theragra chalcogramma	6.3	0.2	34.3	36.4	56.3	58.7	65.3	53.7
Clupea pallasi	—	—	8.6	3.5	6.3	0.7	6.1	7.2
Pleuronectidae	6.3	0.0	8.6	9.4	31.3	8.7	12.2	3.5
Eleginus gracilis	—	—	11.4	4.5	—	—	4.1	8.2
Pleurogrammus sp.	—	—	—	—	6.3	0.9	2.0	0.2
Hypomesus japonicus	—	—	—	—	—	—	2.1	1.6
Osmerus dentex	—	—	8.6	18.7	—	—	6.1	1.7
Sebastolobus macrochior	—	—	5.7	8.9	—	—	4.1	0.4
Sebastes schleigeli	—	—	8.6	7.8	—	—	4.1	3.7
Sebastes sp.	—	—	—	—	—	—	8.2	4.4
Ammodytes sp.	—	—	2.9	0.1	—	—	—	—
Aptocyclus ventricosus	—	—	—	—	—	—	4.1	1.3
Gymnocanthus sp.	—	—	—	—	12.5	19.7	6.1	1.0
Lycogramma zesta	—	—	—	—	—	—	2.0	6.9
Unidentified fish	6.3	0.8	5.7	1.6	—	—	2.0	1.0
Cephalopods	6.3	0.8	54.2	6.7	75.0	9.6	50.0	4.0
Octopus	—	—	22.9	0.2	25.0	4.7	30.6	1.2
Squid	6.3	0.8	31.4	6.5	50.0	4.9	24.5	2.8
Euphausiids	81.3	95.5	25.7	2.4	18.8	1.7	6.1	0.0
Thysanoessa inermis	25.0	24.0	—	—	—	—	—	—
Thysanoessa raschii	31.3	67.8	—	—	—	—	—	—
Decapods	12.5	2.7	—	—	—	—	12.2	0.2
Pandalus borealis	6.3	1.2	—	—	—	—	—	—
Chionoecetes opitio	—	—	—	—	—	—	2.0	0.0

Oc.% = percentages of frequency of occurrence
W.% = Percentages of weight composition

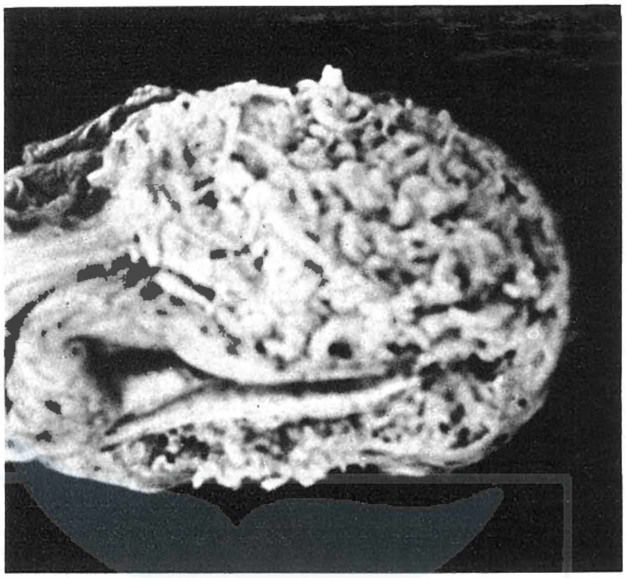

Fig. 2. Stomach contents of pups containing *Thysanesas inermis.*

item in both indices (81.3% and 95.5% in occurrence and weight indices, respectively), *T. inermis* and *T. raschii* were identified in this item. It was notable that 13 out of 16 pups fed on only euphausiids, showing clearly " true foods " rather than " accidental foods " as shown in Fig. 2. On the other hand, fish (*T. chalcogramma*) and cephalopods were minor item in this stage, and these were found in only one stomach collected in 17 May.

Young: 35 stomachs were available in this stage. Fish was primary item comprising 74.3% and 90.9% in occurrence and weights indices, however, *T. chalcogramma* of dominant species showed only 34.5% and 36.4% in occurrence and weight indices, respectively, indicating considrably lower value than that in older stages. On the other hand, indices of euphausiids revealed lower value than pups stage and these are seemed to be not " true food " in this stage, although two seals fed on relatively large amounts of euphausiids.

Maturing: Fish was primary item in the 16 stomachs, indicating almost same value as previous stage. It was notable that cephalopods occurred frequently (75.0%) among the all growth stages.

Adult: Fish contributed as more important foods indicating 91.8% and 95.8% in occurrence and weight indices, respectively. At least 13 species as well as *T. chalcogramma* were identified. The segments of euphausiids occurred in three stomachs, but these were cleary accidental foods.

Summarizing above, euphausiids were mainly used as a substantial food for pups, whereas this item was minor as " accidental food " in the other older stages, although few seals in young stage fed on relatively large amounts of euphausiids. These suggested specialized feeding on euphausiids in pups. On the other hand, fishes and cephalopods much contributed as major items in older three

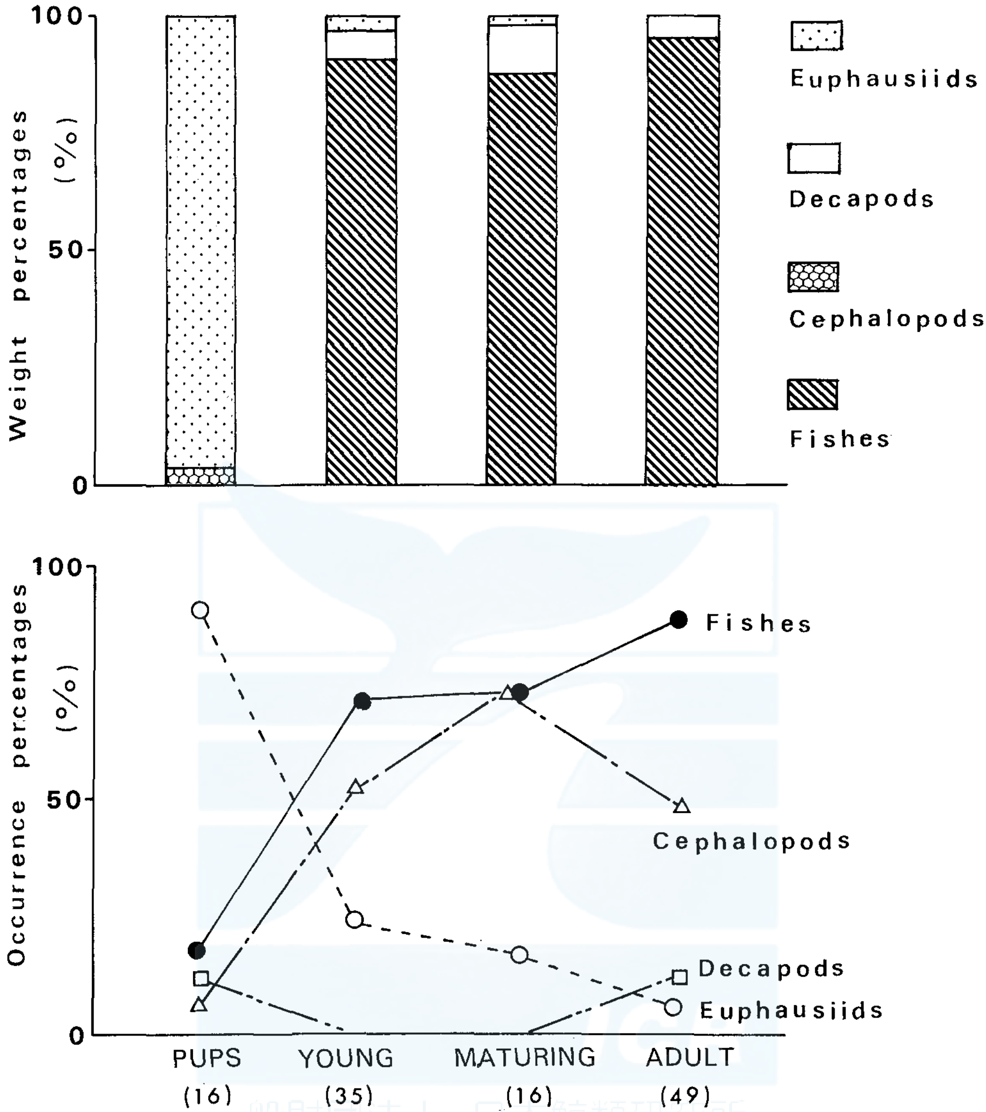

Fig. 3. Changes of food composition in relation to the growth stages in largha seal. upper: weight index, below: occurrence index.

stages. It was notable that the values in both indices of *T. chalcogramma* seem to increase with growth stages. Fig. 3 shows changes in foods composition based on food items with growth stages. These changes were confirmed by the statistical test in both indices. In the case of weight index, 2-n test utilizing χ^2 values was adopted so as to examine changes between nearest two growth stages. The test revealed the significant difference between pups and young stages ($\chi^2_{cal}=26.26>\chi^2=(0.05, 3)$), whereas any differences were not detected between the other stages. For the convenience of statistical test in occurrence index, 2-2 test utilizing χ^2

values was adopted. The test revealed significant differences between pups and youngs stages in items of euphausiids ($\chi^2_{cal}=13.81>\chi^2$ (0.05, 1)), fishes ($\chi^2_{cal}=13.81>\chi^2$ (0.05, 1)) and cephalopods ($\chi^2_{cal}=10.63>\chi^2$ (0.05, 1)).

Both of tests confirmed different food composition between pups and other stages, that is, pups preferred euphausiids to fishes and cephalopods.

Food size

It seems that food size probably changed with growth stages with changes in food species. However, it is slightly difficult to measure food size directly utilizing stomach contents. *T. chalocogramma* was dominant food species in the stomach contents examination of this seal, and occurred in all growth stages. Then, assuming that this fish is the representative food item, food size was examined. The subopercle of this fish has very unique shape as shown in Fig. 4, and it often contributed to the identification of this fish in the stomach contents. Moreover,

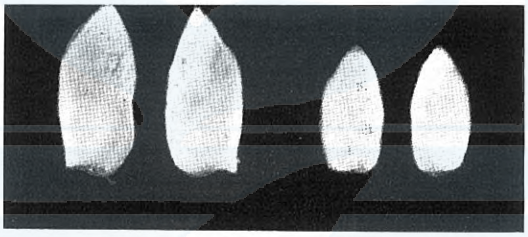

Fig. 4. Subopercle of *Theragra chalcogramma* found in stomach of largha seals.

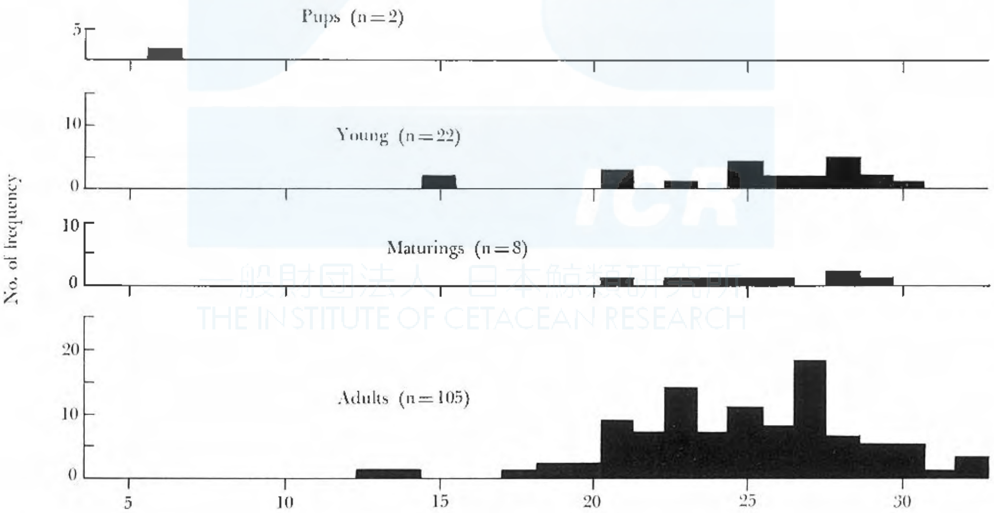

Fig. 5. Size distributions of subopercles of *Theragra chalcogramma* found in the stomach contents in each growth stage.

at the counts of number of individuals, this character appears to be better than that of otolith.

The length distributions of undamaged subopercles in each growth stage are shown in Fig. 5. The means and variances (95% confidence limits) of those in each stage were:

pups,	7.00 (mm)
youngs,	25.09±7.55
maturing,	25.50±5.10
adult,	25.15±6.96

The differences of mean length of subopercles between stages were examined utilizing t-values. The test revealed no significant difference between three older stages. Yoshida and Kato (1981) examined the relation between length of subopercle and standard length of *T. chalcogramma*, following relation was made:

$$Y=0.0936\ X^{0.958}$$

where, X=length of fish and Y=length of subopercle.
Utilizing above relation, stnadard length of *T. chalcogramma* can be reproduced as follows:

pups	90.35 (mm)
youngs	342.51±97.78
maturing	348.36±64.93
adults	343.37±89.82

From the above estimations, it is clear that pups fed on smaller size of *T. chalcogramma* compared with older animals in other three stages.

Taking account of sizes of other food organisms, *T. chalcogramma* was in the largest category of food size in each older three stage. It was notable that all food species found under the fresh condition retained whole body. These suggest swallowing feeding type rather than gnawing. Therefore, there is no difference in available food size among the three older stages.

DISCUSSION

As mentioned previously, sample collections in the present study were carried out during the post breeding seasons, where is front of sea ice area when sea ice were melting and retreating toward the north. The chronological reproductive behavior of largha seal in this period have been reported by Naito and Nishiwaki (1972). According to their reports, the parturition took place between middle and end of March, moulting of the white coat and weaning occurred 2–3 weeks after birth. It is also notable in their report that independence of pups from their mothers occurred suddenly compared with land-breeding harbour seal, suggesting no mother's care of feeding to pups. Although the behavior of pups of early stage of life after weaning is still not known, even for such pups as never experienced and learned diving and feeding, available food would be only euphausiids which is stational and smaller organisms in the ice area. Moreover, *T. inermis* and

T. raschii found in stomachs of pups usually formed patch distribution near the surface (Ponomareva, 1963), these would be also convenient for pups. Furthermore, Naito and Nishiwaki (1972) found the decreasing in the thickness of blubber among the after weaning pups compared with suckling animals. If the euphausiids or similar organisms were absent in the pack ice area, most of pups would not be able to survive in such a critical period above. It appears, therefore, that the presence of euphausiids in the area and zone in which newly weaned pups can swim and dive guarantees survival of pups in the early life stage of this species.

Fay (1974) pointed out that one of the major role of sea ice for pagophilic seals was food supply. In this connection, generally speaking, specialized ice community of organisms are formed under inner parts of ice floes (McRoy, 1974; Horner, 1976), and the zoo plankton such as euphausiids which used organisms above as food are concentrated in the pack ice area (Fukushima and Meguro, 1966). Therefore, specialized feeding on euphausiids of pups seems to utilize fully above phenomena.

However, specialized feeding of pups would be only continued during limited periods in post breeding season, that is, this feeding may be transitional feeding, until pups can feed on fishes and cephalopods with increasing of feeding experience. This would be supported by the result of stomach contents of pup collected in latest periods among the stomach samples from pups, and also would be closely related to the behavior of sea ice in this season. Moreover, considerably short suckling periods of this seal reported by Naito and Nishiwaki (1972) possibly related to the specialized feeding on euphausiids of pups. After the specialized feeding in pups, it appears that young seals forage over a larger feeding area with development and increasing in feeding experience, select a greater number of food species and take prey of larger size. As a result, throughout their life, largha seals use organisms in very wide range inhabiting the pack ice area.

Finally, the pack ice served not only reproductive grounds but also food supply for largha seals, especially in early stage of their life. In other words, largha seals have evolved feeding habits adapted to the ice condition.

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