PE 3

NOT BE CITED WITHOUT A WRITTEN PERMISSION FROM THE AUTHORS

APPENDIX 4

FOOD HABITS OF SPERM WHALES BASED ON JARPN II (2000-03)

TSUTOMU TAMURA[1)], TSUNEMI KUBODERA[2)], HIROSHI OHIZUMI[3)], KENJI KONISHI[1)], TATSUYA ISODA[1)] AND YOSHIHIRO FUJISE[1)]

1): The Institute of Cetacean Research, 4-5 Toyomi-cho, Chuo-ku, Tokyo 104-0055, Japan
2): National Science Museum, 3-23-1, Hyakunin-cho, Shinjuku-ku, Tokyo, 169-0026, Japan
3): Tokai university, 3-20-1, Shimizu-Orido, Shizuoka 424-8633, Japan
Contact e-mail: tamura@cetacean.jp

ABSTRACT

The stomach contents of twenty-eight sperm whale (*Physeter macrocephalus*) sampled in the western North Pacific from May to September as part of the 2000 - 2003 JARPN II surveys, were analyzed. Thirty-two prey species consisting of 28 squid, 1 octopus and 3 fish, were identified. Sperm whales fed mainly on various mesopelagic squids. The most important prey species in the JARPNII surveys were 5 squids (*Taningia danae, Histioteuthis dofleini, Belonella pacifica borealis, Ancistrocheirus lesueu* and Neon flying squid *Ommastrephes bartrami*). Four species of these five squids are mesopelagic squids, while one species, neon flying squid is pelagic one and is an important resource for commercial fisheries. Preliminary estimates indicate that eight hundred thousand tons of neon flying squid are consumed by sperm whales equivalent to roughly eight times the total estimated fisheries catch of this species in the western North Pacific. In stomach contents of sperm whales, estimated proportion of squids living in surface layer and those migrating to surface during night time in each sub-area ranged from 0.0 to 11.4%. It is considered that the influence on the surface ecosystem by sperm whale feeding should not be disregarded, because the biomass of sperm whales is huge. To elucidate the food habits of sperm whales (especially, qualitative information in sub-areas 8 and 9) and to understand the influence of sperm whale feeding on the surface ecosystem, more data is needed.

KEYWORDS: SPERM WHALE; NORTH PACIFIC; FOOD/PREY; SQUIDS; MODELING; SCIENTIFIC PERMITS

INTRODUCTION

The sperm whale (*Physeter macrocephalus*) is distributed in waters from the equator to the edge of the polar pack ice area. The abundance of sperm whales in the western North Pacific was estimated to be 102,112 animals (CV=0.155)(Kato and Miyashita, 1998).

Some papers have reported on the stomach contents of sperm whales from the Sanriku-Hokkaido coastal whaling ground and the North Pacific pelagic whaling ground in the past. Berzin (1971). Kawakami (1980) summarizes these reports lists the species of fish in found in the stomachs of sperm whales. He notes that the proportion of fishes in the stomach contents of sperm whales varies substantially depending on areas with a range of 1-68 %. In the northern part of the west of 180 longitude fishes comprised 7-29 % of the stomach contents. Squids were the most dominant prey. The most important prey species in the Sanriku-Hokkaido area during winter season were neon flying squid *Ommastrephes bartrami*, Kurage ika *Histioteuthis dolfleini*, Yatude ika *Octopoteuthis* sp. and giant squid *Moroteuthis robusta*. Stomach content data were classified according to prey groups in most cases, such as krill, fish and squid. There were also records of empty stomachs and blanks. The fullness of stomach contents was categorized into five classes (R = 3/4 - 4/4, rrr = 2/4 – 3/4, rr = 1/4 – 2/4, r = < 1/4, 0 = empty) and the freshness of stomach contents was categorized into four classes (F = fresh, fff = lightly digested, ff = moderately digested, f = heavily digested).

However, since 1980, there have been few published reports of the feeding habits of sperm whales in the North Pacific. Furthermore, there are few quantitative data on stomach contents.

Sperm whales seem to play an important role in the food web, especially, in the mesopelagic and deep sea, because their high abundance and huge biomass.

In this study, prey species and prey size based on the stomach contents of 28 sperm whales sampled as part of the JARPN II in the western North Pacific are examined. The results improve our knowledge of the feeding habits of sperm whales in this region. Furthermore, these data will contribute to the design of a long-term research program and the consideration of a more realistic strategy for building an ecosystem model in future.

MATERIALS AND METHODS

Research area and period

The sperm whales were sampled in sub-areas 7, 8 and 9 excluding the EEZ of foreign countries. Fig. 1 shows the sighting positions of sperm whales sampled in each month from May through September (combined data for the years 2000, 2001, 2002, and 2003). Table 1 shows sex, body length, stomach contents weight and its ratio to body weight in each area. Sampled whales were immediately transported to a research base vessel, where biological measurements and sampling was carried out.

Sampling of stomach contents

As soon as the sperm whale was on the research base vessel upper deck, the stomachs were removed within a few hours after capture. Then, contents from each stomach (both cases of including and excluding liquid) was weighed to the nearest 0.1 kg and kept frozen for later analyses.

Data analyses

In the laboratory, prey species in the samples were identified to the lowest taxonomic level as possible. Undigested prey items were identified using morphological characteristic (Kubodera and Furuhashi, 1987, Okutani, 1995). The otoliths and jaw plate were used to identify the fish, squid and octopus with advanced stage of digestion (Kubodera and Furuhashi, 1987).

When undigested squid were found, mantle length and the weights were measured to the nearest 1 mm and 1 g, respectively.

The total number of each prey species in the sample was calculated. Digested prey and buccal masses of squid and octopus and half of the total number of free otoliths were added to the numbers of undigested prey items in forestomach and fundus contents. The total weight of each prey species was added, apparently.

Feeding Indices

The relative frequency of occurrence of each prey species (*RF*) in each whale was calculated as follows:

$$RF = (Ni / N_{all}) \times 100 \quad (1)$$

Ni = the number of prey species i in each whale

N_{all} = the total number of prey species in each whale

Then, the relative prey importance by weight of each prey species (*RW*) was calculated as follows:

$$RW = (W_i / W_{all}) \times 100 \quad (2)$$

W_i = the apparent wet weight of contents containing prey species i

W_{all} = the total wet weight of contents analyzed.

The estimated proportion of squids living in surface layer to those migrating to surface during night time occurring in the stomachs of sperm whales.

The estimated proportion of squids living in surface layer to those migrating to surface during night time occurring in the stomachs of sperm whales (*PS*) was calculated as follows:

$$PS = (PSW_i / WW_{all}) \times 100 \quad (3)$$

PSW_i = the proportion of stomach contents weight of surface organisms as prey in each whale I

WW_{all} = the total wet weight of contents analyzed.

RESULTS

Diversity of prey species

Thirty-two prey species consisting of 28 squid, 1 octopus and 3 fish were identified in sperm whales caught between 2000 and 2003 as part of JARPNII (Table 2).

Composition of prey species
The occurrence (%) and apparent wet weight composition (%) of prey species consumed by sperm whales caught between 2000 and 2003 is shown on Table 3. They fed mainly on 5 squid species (*Taningia danae*, *Histioteuthis dofleini*, *Belonella pacifica borealis*, *Ancistrocheirus lesueu* and Neon flying squid). The apparent wet weight composition (%) of fish was 4.2 % in sub-area 7. The estimated proportion of squids living in surface layer to those migrating to surface during night time occurring in the stomachs of sperm whales ranged from 0.0 to 11.4 %.

Size frequency of prey species
The size frequency of *B. pacifica borealis*, *H. dofleini* and *G. borealis* is shown in Fig.2.

Belonella pacifica borealis
The dorsal mantle length of *B. pacifica borealis* ingested by sperm whales ranged from 360 to 612 mm with a single mode at 495 mm (Fig. 2A).

Histioteuthis dofleini
The dorsal mantle length of *H. dofleini* ingested by sperm whales ranged from 107 to 210 mm with a single mode at 154 mm (Fig. 2B).

Gonatopsis borealis
The dorsal mantle length of *G. borealis* ingested by sperm whales ranged from 261 to 298 mm with a single mode at 284 mm (Fig. 2C).

Weight and freshness of stomach contents (Table 1)
The stomach contents weight of sperm whales caught between 2000 and 2003 as part of JARPN II ranged from 9.0 kg to 265.5 kg. The maximum stomach contents weight was equivalent to 1.2% of body weight. The freshness of stomach contents were categorized as follows: F (6 inds., 27.3%),), fff (6 inds., 27.3%), ff (5 ind., 22.7%) and f (5 inds., 22.7%).

DISCUSSION

Diversity of prey species
Sperm whales caught between 2000 and 2003 as part of JARPN II fed mainly on various mesopelagic squids. Thirty-two prey species consisting of 28 squid, 1 octopus and 3 fish were identified. The most important prey species were 5 squid species (*Taningia danae*, *Histioteuthis dofleini*, *Belonella pacifica borealis*, *Ancistrocheirus lesueu* and Neon flying squid). This is very different from past records (*i.e.* Kawakami, 1980).

It seems that there are geographical, seasonal and yearly changes of prey species in the research area. The past samples were concentrated around inshore area (Joban-Sanriku area) during winter (*i.e.* Kawakami, 1976; Okutani *et al.*, 1976; Okutani and Satake, 1978). Our sample concentrated on the inshore area (sub-area 7), which is not different from past record, but seasons were during spring and summer. Additional samples are therefore needed to clarify these food habits, especially offshore area (such as sub-areas 8 and 9).

Daily prey consumption and feeding activity
The weight of stomach contents of sperm whales may be different according to the size of whales, although it is considered to be less than 300 kg. In Kurile Island, it was found that they did not consume more than 200 kg (Betesheva and Akimushkin, 1955). The stomach contents weight of the sperm whale in the Cook Strait region of New Zealand was reported to have varied from 12.7 to 105 kg (Gaskin and Cawthorn, 1967). Clarke (1977) considered the amount of daily prey consumed by sperm whales would be from 2 to 4 % of their body weight and calculated as 300 kg and 200 kg for males and females, respectively. Tamura (2003) calculated their dairy consumption using three different equations. The calculated daily prey consumption of sperm whale (average body weight 18.5 tons) in North Pacific was ranged from 304 to 648 kg (from 1.6 to 3.5%). Based on JARPNII data, the stomach contents weight ranged from 9.0 kg to 265.5 kg. The maximum stomach contents weight was equivalent to 1.2% of their body weight. According to Tamura (2003)'s calculation, the sperm whale must feed several times in a day.

In the Antarctic, they generally feed on prey near the surface during nighttime (Matsushita, 1955). However, in the western North Pacific, as some prey species in stomach contents of whales caught in the daytime were very fresh (no digestion), sperm whales apparently also feed during daytime.

The impact on resources of neon flying squid

In sub-area 7, two sperm whales fed on neon flying squids. Their average weight of stomach contents was 95.8% and 18.5% of body weight. The average proportion of neon flying squids consumed by sperm whales sampled was estimated as 5.0% of their total prey consumption in the western North Pacific during the research season.

The neon flying squid is a very important target species for fisheries in the western North Pacific. Recent fisheries catch was reported as one hundred thousand tons per year in western North Pacific (Fisheries Agency, 2002). They are widely distributed in both the coastal and offshore areas (Naito *et al.*, 1977).

An earlier report shows that sperm whales fed mainly on neon flying squids (20%:occurrence of squids) around Joban area (sub-area 7) in winter (Okutani *et al.*, 1976). In the case that the sperm whales feed on neon flying squid as 5 % of their prey consumption, the total consumption was estimated to be eight hundreds thousand tons, equivalent to roughly eight times the total estimated recent fisheries catch of this species in the western North Pacific.

It is necessary to collect more data regarding their feeding habits to consider the impact of sperm whale predation for the resources of neon flying squids.

Application to ecosystem models

The sperm whales were considered to be mesopelagic squid feeders in our research area. However, it was reported that they fed mainly on mesopelagic and/or bottom fishes in other region (Iceland, Bering Sea, West of Canada and New Zealand) (Pike, 1950; Okutani and Nemoto, 1964; Gaskin and Cawthorn, 1967; Roe, 1969).

Furthermore, sperm whales also fed on some squids related to surface layer such as *Onychoteuthis borealijaponica*, *O. banksi*, *Moroteuthis loennbergi*, eight armed squid (*Gonatopsis borealis*) and neon flying squid. The estimated proportion of squids living in surface layer to those migrating to surface during night time occurring in the stomachs of sperm whales ranged from 0.0 to 11.4 %. It is therefore considered that the influence on surface ecosystem by sperm whale predation can not be disregarded, because the biomass of sperm whales is huge.

In the future, these data will be imputed to Ecopath & Ecosym type models to better understand the role of sperm whales in the marine ecosystem.

The neon-flying squid, which were found in the sperm whale stomach contents is one of the important commercially utilized squids, and therefore there is a possibility of direct competition with this fishery. The data collected by JARPN II will be useful for at least single-species management of neon flying squid in the western North Pacific in the future.

This report provides results from the very small-scale sampling of sperm whales from 2000 to 2003. The stomach contents of 28 sperm whales sampled in the western North Pacific from May to September of these years were analyzed. However, these samples are concentrated in inshore area (Sub-area 7). To elucidate the food habits of sperm whales (especially, offshore area such as sub-areas 8 and 9) and to understand the relation of sperm whale predation to the surface ecosystem, more data is needed. These data will contribute to the design of a long-term research program and the consideration of a more realistic strategy for building ecosystem models in future.

ACKNOWLEDGEMENT

We are indebted to T. Bando, T. Mogoe, S. Otani, N. Kanda and G. Yasunaga of the Institute of Cetacean Research (ICR) who collected and weighed the stomach contents during the JARPNII surveys. We would like to thank all captains, crews and researchers, who were involved in the JARPNII surveys between 2000 and 2003. We appreciate very much the helpful sorting and analyses done by Ms. I. Kouda. Our sincere thanks to Dr. H. Hatanaka, Dr. D. Goodman and Dr. Luis A. Pastene of the ICR for their valuable suggestions and useful comments on this paper.

REFERENCES

Betesheva, F. I. and Akimushkin, I.I 1955. Food of the sperm whale (*Physeter catodon* L.) in the Kurile Island region. *Trudy Inst. Okeamol.* 18: 86-94. (in Russian)

Berzin, A. 1971. The sperm whale (translated into English in 1972). Israel Program for Scientific translation. 394pp.

Clarke, M. R. 1977. Beaks, nets and numbers. *Sym. Zool. Soc. London*, 38: 89-126.

Gaskin, D. E. and Cawthorn, N. W. 1967. Diet and feeding habits of the sperm whales (*Physeter catodon* L.) in the Cook Strait region of New Zealand. N. Z. J. mar. Freswat. Res. 1 (2) 159-79.

Kato, H. and Miyashita, T. 1998. Current status of the North Pacific sperm whales and its preliminary abundance estimates. Paper SC/50/CAWS2 presented to the IWC Scientific Committee, May 1998 (unpublished). 13pp. [Available from the author].

Kawakami, T. 1980. A review of food of sperm whale food. *Sci. Rep. Whales Res. Inst.* 32:199-218.

Kubodera, T. and Furuhashi, M. 1987. Inaiyoubutu tyuuno ikarui oyobi hadakaiwasikagyorui no syusateinikannsuru manyuaru [Guide to the identification of lantern fishes and cephalopods in the stomach contents]. Appendix document of the report on the modeling of ecosystem in northern North Pacific. Fisheries Agency of Japan. 65pp. [In Japanese].

Matsushita, T. 1955. Dairy rhythmic activity of the sperm whales in the Antarctic Ocean. *Bull. Japanese Society of Scientific Fisheries*, 20: 770-3

Murata, M. and Shimazu, Y. 1982. On some population parameters of flying squid, *Ommastrephes bartrami* (LESUEUR) in the Northwest Pacific. *Bull. Hokkaido Reg. Fish. Res. Lab.* 47. 1-10

Okutani, T. and Nemoto, T. 1964. Squids as thefood of sperm whale in the Bering Sea and Alaskan Gulf. *Sci. Rep. Whales Res. Inst.* 18: 111-121.

Okutani, T., Satake, Y., Ohsumi, S. and Kawakami, T. 1976. Squids eaten by sperm whales caught off Joban district, Japan, during January-February 1976. *Bull. Tokai Reg. Fish. Res. Lab.*, 87. 67-113.

Okutani, T. and Satake, Y. 1978. Squids in the diet of 38 sperm whales caught in the Pacific waters off northeastern Honshu, Japan, February 1977. *Bull. Tokai Reg. Fish. Res. Lab.*, 93. 13-23.

Okutani, T. 1980 Biology of cephalopoda-9 Systematics and life history of enoploteuthidae (2). *Aquabiology*, Vol2, No. 4, 278-282.

Okutani, T. 1995. Cuttlefish and squids of the world in color. *National Cooperative Association of Squid Processors*. 185pp.

Pike, G. C. 1950. Stomach contents of whales caught off the coast of British Columbia. *Prog. Rep. Pacif. Cst. Stns*, 83: 27-8.

Roe, H. S. J. 1969. The food and feeding habits of sperm whales (*Physeter catodon* L.) taken off the west coast of Iceland. *J. Cons. Int. Explor. Mer.*, 33 (1): 93-102.

Tamura, T. 2003. Regional assessments of prey consumption and competition by marine cetaceans in the world. pp.143-70. *In:* M. Sinclair and G. Valdimarsson (Eds) *Responsible Fisheries in the Marine Ecosystem*. FAO and CABI Publishing, Roma and Oxon. 448pp

Table 1. Biological and stomach contents data of sperm whales sampled in JARPN II surveys from 2000 to 2003.

Sub area	N		Body length (m)			Stomach contents (kg)			Ratio of body weight (%)			Frequency of freshness of stomach contents					
	Male	Female	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	F	fff	ff	f	Empty	Broken
7	7	15	10.1	8.2	12.8	103.5	9.0	242.2	0.5	0.1	1.2	6	5	3	5	1	2
8	1	2	8.7	7.9	9.9	60.7	18.9	137.4	0.2	0.0	0.5	0	1	0	0	2	0
9	0	3	11.0	10.4	11.5	168.0	106.4	265.5	0.4	0.1	0.7	0	0	2	0	0	1

Table 2. Prey species of sperm whales taken in the western North Pacific from 2000 to 2003.

	Scientific name	English name	Occurences in previous report	Ref.	Remarks
Cephalopoda					
	Enoploteuthis chuni			3	Day time: 300-900 m; Nigh ttime: Upper 200m
	Ancistrocheirus lesueuri		□ >	1	Night time: Upper 100m (DML is u<0.01er 35mm)
	Taningia danae		□ >	1	Night time: Upper 180m (Sub-adult); Upper 1,200m (Adult)
	Octopoteuthis sicula		□ >	1	Day time: Lower 200m, especially 300-400m, Night time: Lower 500m (DML is u<0.01er 15mm)
	O deletron			1	Day time: Lower 200m, especially 300-400m, Night time: Lower 500m (DML is u<0.01er 15mm)
	O. megaptera			2	Day time: Mid-bottom water; Night time: Surface layer
	O. sp. (Type M)				
	O. sp. (Type L)				
**	*Onychoteuthis borealijaponica*			2	Surface layer
**	*O. banksi*			1	Upper 150 m
*	*Moroteuthis loennbergi*		□ >	2	From surface layer to bottom layer
	M. robusta	Giant squid	□ >	1	U<0.01er 100m of bottom layer
	Gonatus berryi			1	Day time: 500-800 m; Nigh ttime: 400-800m (Sub-adult)
	G. pyros			1	Day time: 400-700m, Night time: 100-500m especially 300-400m (DML is u<0.01er 20mm)
	G. middendorffi			1	Day time: 400-800m, Night time: Upper 500m (DML is u<0.01er 21mm)
	Eogonatus tinro			2	From surface layer to bottom layer
	G. ,?□□				
*	*Gonatopsis borealis*	Eight-armed squid	□ >	1	Day time: 400-800m (DML is 16-47mm), Night time: 0-400m
	Histioteuthis dofleini		□ >	1	Day time: 500m, Night time: 50m (DML is 12-14mm)
	H. corona inermis			1	Day time: 600m (DML is 25-27mm)
	H. sp.				
	H. meleagroteuthis			1	Day time: 700m, Night time: 400m (DML is 16-32mm)
	Architeuthis martensi			1	From 200-1200 m
*	*Ommastrephes bartrami*	Neon flying squid	□ >	4	Day time: 300-400m, Night time: Surface layer .
	Pholidoteuthis sp.			1,2	Day time: Bottom layer (400-2,000m), Night time: Mid layer
	Discoteuthis discus			1	Day time: upper 750m, Night time: upper 400m (DML is u<0.01er 53mm)
	Cycloteuthis akimushkini			1	Day time: Upper 650m, Night time: Upper 200m
	Chiroteuthis imperator			2	From mid layer to bottom layer
	C. calyx		□ >	1	Day time: 500-800m, Night time: 0-500m (Sub-adult)
	Asperoteuthis acanthoderma			2	From mid layer to bottom layer
	Galiteuthis pacifica			1	Day time: lower 900m, Night time: 0-1200m (Sub-adult)
	Galiteuthis sp.				
	Belonella pacifica borealis		□ >	1	Day time: 600-800m (DML is u<0.01er 60mm)
	Megalocranchia maxima			2	Mid layer
	Megalocranchia sp.				
	Cranchidae sp.				
	Alloposus mollis			1	0-3,200 m, especially 0-200m, 450-1,000m
Pisces					
	Trachipterus ishikawae	King of salmon			
	Laemonema longipes	Threadfin hakeling	□ >		
	Theragra chalcogramma	Walleye pollock	□ >		

*: Surface migration during night; **: Surface distribution in a day

1: Roper, C. F. E. and R. E. Young (1975), 2: Nesis, K. N. (1987), 3: Okutani, T. (1980), 4: Tanaka (in Japanese: 2000)

(○ is shown in previous report as prey species of sperm whales around of Japan)

Table 3. Occurrence, number and wet weight composition (%) of each prey species consumed by sperm whales in each sub-area. *: Surface migration during night; **: Surface distribution in a day

Prey species	7 N=19 (N=3: Empty) Occurrence %	Number of squids %	Weight of squids %	8 N=3 Occurrence %	Number of squids %	Weight of squids %	9 N=3 Occurrence %	Number of squids %	Weight of squids %
Cephalopoda									
Enoploteuthis chuni	5.3	<0.01	<0.01						
Ancistrocheirus lesueuri	57.9	6.4	6.6						
Taningia danae	47.4	15.3	24.1	100.0	23.8	83.4	100.0	74.1	97.5
Octopoteuthis sicula	15.8	0.2	0.03						
Octopoteuthis deletron	21.1	1.6	0.5						
O. megaptera	10.5	0.4	0.1						
O. sp. (Type M)	21.1	2.2	1.6						
O. sp. (Type L)	10.5	0.6	3.8						
** *Onychoteuthis borealijaponica*	15.8	0.2	0.6						
** *O. banksi*	5.3	<0.01	<0.01						
* *Moroteuthis loennbergi*	15.8	1.5	0.5						
M. robusta	15.8	0.5	5.2						
Gonatus berryi	26.3	1.2	0.2				33.3	0.9	<0.01
G. pyros	15.8	1.6	<0.01	100.0	4.8	0.1			
G. middendorffi	15.8	0.2	0.03						
Eogonatus tinro	5.3	0.1	<0.01						
G. ,;0	63.2	4.2	0.4				33.3	0.9	<0.01
* *Gonatopsis borealis*	42.1	3.7	4.6						
Histioteuthis dofleini	84.2	26.2	26.1	100.0	61.9	16.6	66.7	24.1	2.5
H. corona inermis	10.5	0.2	0.04						
H. sp.	26.3	3.1	1.0	100.0	9.5	<0.01			
H. meleagroteuthis	5.3	<0.01	<0.01						
Architeuthis martensi	5.3	0.03	0.5						
* *Ommastrephes bartrami*	10.5	1.8	6.4						
Pholidoteuthis sp.	5.3	0.3	0.8						
Discoteuthis discus	10.5	0.3	0.1						
Cycloteuthis akimushkini	10.5	0.2	0.3						
Chiroteuthis imperator	15.8	0.2	0.01						
C. calyx	21.1	0.5	0.7						
Asperoteuthis acanthoderma	5.3	0.1	0.2						
Galiteuthis pacifica	63.2	8.6	1.2						
Galiteuthis sp.	10.5	0.1	0.01						
Belonella pacifica borealis	57.9	15.3	9.3						
Megalocranchia maxima	5.3	0.8	0.3						
Megalocranchia sp.	5.3	0.1	0.03						
Cranchidae sp.	5.3	0.3	0.04						
Unidentified squids	26.3	1.5	0.02						
Alloposus mollis	5.3	0.1	0.2						
Pisces									
Trachipterus ishikawae	15.8	0.2	4.3						
Laemonema longipes	5.3	0.03	<0.01						
Theragra chalcogramma	5.3	0.03	<0.01						
Unidentified fish	5.3	0.1	0.2						
Estimated contribution rate of surface *		7.1	10.8		0.0	0.0		0.0	0.0
Estimated contribution rate of surface *+**		7.3	11.4		0.0	0.0		0.0	0.0

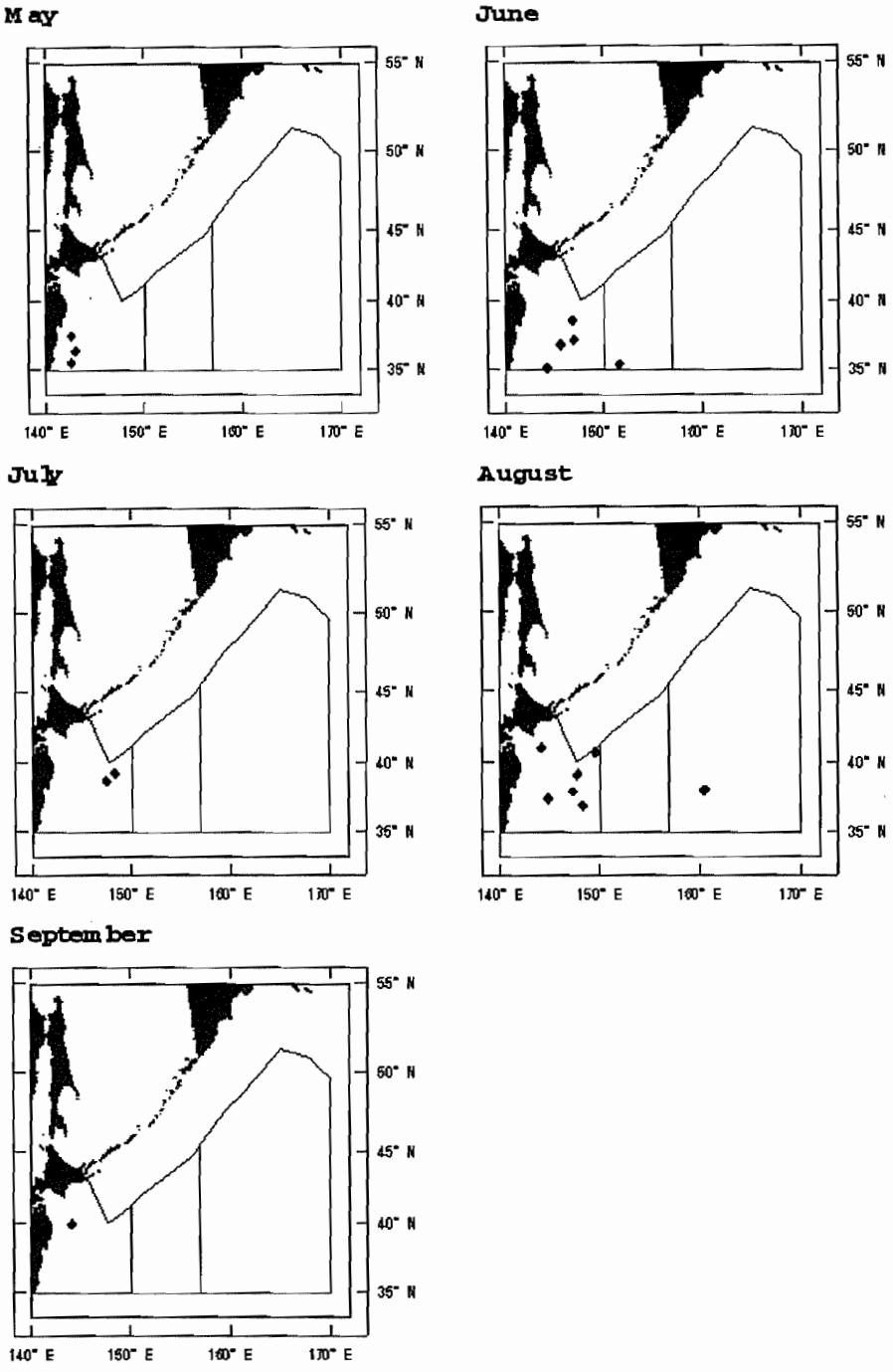
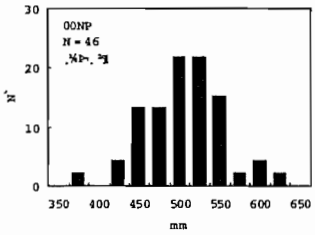
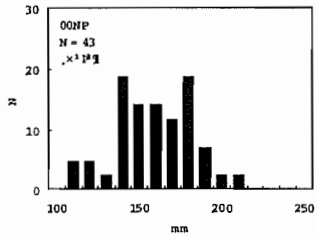


Fig. 1. Sighting positions of sperm whales sampled in each month from May through September (combined data for the years 2000, 2001, 2002 and 2003).

(A) *Belonella pacifica borealis*,



(B) *Histioteuthis dofleini*



(C) *Gonatopsis borealis*

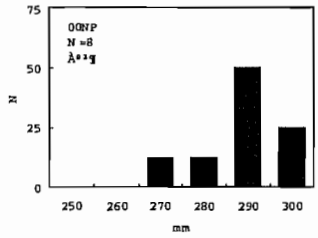


Fig. 2. The body length of dominant prey species consumed by sperm whale in 2000 JARPNII.