Relationship between body size, maturity, and feeding habit of common minke whales off Kushiro in autumn season, from 2002-2007 whale sampling surveys under the JARPN II coastal components off Kushiro

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ABSTRACT

The relationship between body size, maturity and feeding habit of common minke whales in the coastal waters off Kushiro, northeast Japan, was examined using data obtained from the whale sampling surveys under the JARPN II coastal component off Kushiro conducted in 2002 to 2007. The surveys were carried out in the autumn season (September and October). A total of 254 common minke whales (182 males and 72 females) were sampled. Ratio of sexually mature individuals was 0.58 for males and 0.15 for females, respectively. Immature whales were abundantly distributed near the coast or the continental shelf region whilst mature males were distributed in a wider area including the offshore waters. In the continental shelf and slope regions with water depths of less than 1,000m, occurrences of prey species found in stomachs differed significantly with maturity stage of the whales ($p<0.001$). Smaller and immature whales tend to take walleye pollock and krill whilst larger and mature whales tend to take Pacific saury. Japanese flying squid was consumed by only mature whales. Japanese anchovy was evenly consumed by both immature and mature whales. For the coastal waters off Kushiro in the autumn season, the results suggest that migration and prey preference of common minke whales differed with maturity stage and that on the continental shelf and slope regions immature whales preferred to take walleye pollock and krill than mature whales. These results implied that migration and feeding strategies of common minke whales might change with growth whereby immature whales take more stable preys and mature whales seek nutritionally more valuable preys. It was thought to be important to take account of this point in estimating the local prey consumptions and constructing the ecosystem models for restricted coastal small area, especially in the coastal waters off Kushiro.

KEYWORDS: COMMON MINKE WHALE; NORTH PACIFIC; COASTAL WATERS OF JAPAN; SCIENTIFIC PERMITS; PREY PREFERENCE; MATURITY; FEEDING HABIT

INTRODUCTION

Common minke whale *Balaenoptela acutorostrata*, is known to be widely distributed throughout the offshore to the coastal waters in the western North Pacific and feed on various prey species including commercially important species such as Japanese anchovy *Engraulis japonicus,* Pacific saury *Cololabis saira,* and walleye pollock *Theragra chalcogramma.* (Tamura and Fujise, 2002). The coastal waters off Kushiro, southeastern part of the Pacific coast of Hokkaido, northern Japan, is one of the major migrating grounds of common minke whales in autumn season (Hatanaka and Miyashita, 1997), and also important fishing grounds. The possible competitions between the whales and the fisheries has been suggested in those areas (Tamura and Fujise, 2002), and development of new management measures such as a multi stock management based on the ecosystem models has been required (Government of Japan, 2002a).

Under these situations, the whale sampling surveys in the coastal components off Kushiro was started in 2002 (Kishiro, *et. al.*, 2003) and carried out in every year from 2004 to 2007 (Kishiro, *et.al*., 2005; 2006; 2008, Yoshida, *et. al*., 2007), under the full JARPN II research plan (Government of Japan, 2002b; 2004). Background and details of the surveys were summarized in Kishiro, *et. al*. 2009. The objectives of the JARPN II are: i) feeding ecology and ecosystem studies, involving prey consumption by cetaceans, prey preferences of cetaceans and ecosystem modeling, ii) monitoring environmental pollutants in cetaceans and marine ecosystem, and iii) stock structure of whales. Among them, prey preference of cetaceans is one of the important factors in considering the feeding ecology and the ecosystem modeling.

Based on the results of the 2007 survey off Kushiro, Kishiro, *et. al*. 2008 suggested possibility of the presence of difference in prey preference within a species of common minke whale as larger and mature whales tend to take Pacific saury whilst immature whales mainly took walleye Pollock. Such difference might affect not only modeling but also estimating the prey consumption of the whales in the local area, such as the coastal waters off Kushiro. However, sample size was small and further analysis was needed. The present study examined these aspects further, using data of whole 2002-2007 whale sampling surveys off Kushiro.

MATERIAL AND METHODS

The present study used data and samples obtained from the whale sampling surveys in the 2002-2007 coastal components off Kushiro, under the JARPN II. These surveys were carried out in autumn season (September to October) in the coastal waters within a maximum of 50 nautical miles radius from the Kushiro port (Fig.1), and a total of 254 common minke whales were sampled during the period from 2002 to 2007. Distribution of sampled whales is shown in Fig.2. Methodology and

details of these surveys were described in Kishiro, *et.al*., 2009.

Body length and maturity of common minke whales

Body length of all sampled common minke whales were measured to the nearest 1cm on a straight and parallel to the body axis from the tip of upper jaw to the notch of flukes by researches at the research land station. Each side of testis was weighed after separated from the epididymis and histological samples were collected from the center of the right testis. Male with a single testis weight of 290g or more was tentatively determined as sexually mature based on the histological observation of the seminiferous tubules, spermatocyte, spermatid or spermatozoa using hematoxylin and eosin stained sections. In females, both side of ovaries were collected and examined. Female had at least one corpus luteum or albicans in their ovaries was determined as sexually mature.

Prey species in the stomach

At the research land station, stomach contents of the whales were weighted to the nearest 0.1 Kg by each four chamber in both cases of including and excluding liquid. Prey species was tentatively recorded using morphological characters. Then, a sub-sample (1-5Kg) of forestomach contents was collected and frozen for the laboratory works. In the laboratory, detailed species identification and restoring stomach contents weight were made by Tamura, *et al*., 2009 as follows. Prey species was identified to the lowest taxonomic level as possible using morphological characters for undigested preys or the otoliths and jaw plate for digested preys. The total wet weight of each prey species in the forestomach was estimated by multiplying average weight of fresh prey specimens by the number of preys (including undigested full bodies, undigested skulls, and half the total number of free otoliths) in the sub-sample and multiplying ratio of the weight of sub-sample for the total weight of forestomach contents. Details of the methods were described in Tamura, *et.al*., 2009. Occurrence of the prey species was calculated as the ratio of the number of whales counted by the prey species found in their forestomach for the total number of whales counted. When plural prey species were found simultaneously in a stomach, the number of whales was counted as one for every prey species. Mean composition of the restored wet weight by prey species was calculated as an average of the ratio of restored weights by prey species in respective whales.

Individual identification of the stocks of common minke whales

Skin samples of all whales were collected and preserved in ethanol for the laboratory DNA analysis. In this study, results of the individual identification of the stocks (J or O stocks) made by Kanda *et al*., 2009 by the microsatellite analysis were used for the comparison of the features of maturity and feeding habit between J and O stock individuals. Details of the genetic identification methods were described in Kanda, *et.al*., 2009.

RESULTS

Sex ratio, body length and maturity of common minke whales

A total of 254 sampled whales were consisted of 182 males and 72 females (sex ratio of males was 0.72). Statistics and frequency of body length are shown in Table 1 and Fig. 3. Average body length in respective year ranged from 6.60m to 6.87m for males, and 5.48m to 6.39m for females, respectively. Males with body length of 7 to 7.5m were most frequent, and distinct yearly change was not observed. Compositions of sex and sexual maturity of the whales is listed in Table 2. Sex ratio (ratio of males) in respective year ranged from 0.64 to 0.80. In males, ratio of sexually mature individuals ranged from 0.45 to 0.68 (total of all years: 0.58). Five males could not be determined their maturity status due to the anomaly in both side of the testis. In females, only 11 individuals or 15% of total 72 females were sexually mature, which consisted of 4 pregnant and 7 resting individuals. Fig. 4 shows geographical distribution of the whales by sex and maturity status, and Fig. 5 indicates sex ratio and maturity ratio by 10 minutes square latitude-longitude in the research area. Both sex and maturity ratios of males were lower in near shore area compared with those in the waters far from the shore. These figures suggested that immature whales tend to be distributed near the coast while mature males were mainly distributed in the offshore or waters far from the shore.

Prey species in the stomach

Five prey species, walleye pollock, krill Euphasusiiids, Japanese anchovy, Pacific saury, and Japanese flying squid *Todarodes pacificus* (hereafter referred as common squid) were found in the stomach as the major preys in both occurrence and the restored wet weighs (Table 3 and 4). 'Others' consisted of Japanese pomfret, *Brama japonica*, unidentified Salmonidae, unidentified fish, and unidentified squid, but all of those 'Others' species were found only one individual simultaneously with major prey species such as Japanese anchovy and Krill in the stomach, thus they were thought to be incidentally consumed by the whales. Most dominant prey species was Japanese anchovy in the occurrence (46.2%), and walleye pollock in the weight (38.1%).

Relationship between body lengths of the whales with prey species in the stomach

Fig.6 shows relationship between body lengths of the whales with the occurrence of prey species in their stomach. In both males and females, the occurrence of walleye pollock was high in small sized whales, and decreased with increasing the body size. The occurrence of krill was also decreased with body length. On the other hand, the occurrence of Pacific saury was increased with the body length. Common squid was only found in the whales with body length of 6.5m or more.

Relationship between whales' maturity with prey species in the stomach

Comparison of the occurrence of prey species between immature and mature whales was made in

Table 5. Most dominant prey species was Japanese anchovy in regardless of the maturity, but in both males and females, the occurrence of walleye pollock and krill in immature whales was higher than that of mature whales while the occurrence of Pacific saury in immature whales was lower than that of mature whales. Common squid was only found in mature whales. Table 6 shows the comparison of the mean compositions of prey species between immature and mature whales based on the restored wet weight of their stomach contents. Result was almost same with Table 5, i.e. ratio of the weights of walleye pollock and krill in immature whales was higher than that of mature whales, and ratio of the weight of Pacific saury in immature whales was lower than that of mature whales. Maturity ratio of the whales by their prey species is shown in Table 7. In both males and females, maturity ratio of the whales fed on walleye pollock and krill were lower than that of the whales fed on Pacific saury, and highest value (1.0) was in the whales fed on common squid. Maturity ratio of Japanese anchovy was located in between that of walleye pollock and Pacific saury. Fig.7 shows frequency distributions of body length and maturity of the whales by their prey species found in the stomach. Although some variations were observed in respective year due to the small sample size, in generally, frequency of the whales fed on walleye pollock and krill were higher in smaller and immature whales while those of Pacific saury and common squid were higher in larger and mature whales.

Comparison between J and O stocks

Around the coastal waters off Japan including the research area in this study, two stocks (J stock: mainly distributed in the Sea of Japan; O stock: mainly distributed in the western North Pacific) of common minke whales are known to be existed, and genetically identified by Kanda, *et. al*., 2009. If the feeding habit were clearly different between stocks, results of this study were possibly affected by the difference of stocks in the samples. Therefore, samples were divided to respective stock using genetic identification results made by Kanda, *et. al*., 2009, and the comparisons between stocks were made. The number of identified whales was 38 for J stock and 190 for O stock. Table 8 shows the compositions of sex and sexual maturity of the whales by the stocks. Ratio of males in samples was almost same between J stock (0.76) and O stocks (0.70) but maturity ratio of males in J stock (0.39) was lower than that of O stock (0.65). Comparisons of the occurrence and the ratio of restored weight of prey species between stocks and maturity status are shown in Table 9 and 10. Maturity ratio of the whales by their prey species is shown in Table 11. Both J and O stocks (except for females of J stock which sample size was too small), same results were obtained i.e., ratio of walleye pollock and krill in immature whales was higher than that of mature whales while ratio of Pacific saury in immature whales was lower than that of mature whales. These results suggested that there was no difference between the stocks.

Geographic comparisons of the preys in the research area

Distributions of the whales by their prey species found in the stomach are shown in Fig. 8. Although the positions of the whales were somewhat dispersed, the whales fed on walleye pollock and common squids were relatively concentrated in the continental shelf and slope regions of the water depth shallower than 1,000m. On the other hand, distributions of the whales fed on Japanese anchovy and Pacific saury were more spread, and widely distributed in the offshore area. Walleye pollock and common squids are known to be demersal or mesopelagic species while Japanese anchovy and Pacific saury are pelagic fishes. Those differences in distribution of preys also affect the difference of stomach contents of the whales between immature and mature, because immature whales are abundant in near shore areas while mature males are mainly distributed in the offshore waters as revealed in the previous section. To eliminate the effect of the difference of distributions, samples were divided to three geographic groups based on the catch positions of the whales as follows; 'Continental shelf': water depth shallower than 200m; 'Continental slope'; water depth from 200m to 1,000m; 'Offshore': water depth of 1,000m or more; and comparisons by maturity status was independently made in each group. Table 12 indicates the compositions of sex and sexual maturity of the whales by the geographic groups. Ratio of males and maturity ratio were lowest in 'Continental shelf' region and highest in 'Offshore' region. Comparisons of the occurrence and the ratio of restored weight of prey species by maturity status in each group are shown in Table 13 and 14. In both the 'Continental shelf' and 'Continental slope' groups, ratio of walleye pollock and krill in immature whales were higher than that of mature whales while ratio of Pacific saury in immature whales was lower than that of mature whales. In the 'Offshore' group, the whales fed on walleye pollock and common squid were not observed, and ratio of Japanese anchovy and Pacific saury were similar between immature and mature whales. Fig.9 shows frequency distributions of body length and maturity of the whales by their prey species in respective geographic groups and Fig. 10 indicates compositions of the occurrence of the preys by the groups. Compositions of the preys in the 'Continental shelf' was significantly different between immature and mature whales (x square test, $p<0.001$), and those of the 'Continental slope' was also significantly different (x square test, $p<0.001$), but in the 'Offshore' group, significant difference was not observed between maturity status (x square test, $p>0.5$). The differences by maturity status observed in at least the continental shelf and slope regions were thought to be indicated the presence of the difference in prey preference between immature and mature whales.

DISCUSSION

The differences observed between immature and mature whales in the coastal waters off Kushiro in autumn season can be summarized as follows.

(1) Immature whales are more frequently distributed near the coast or the continental shelf region while mature males are distributed in a wider area including the offshore waters.
(2) At least in the continental shelf and slope regions with water depths of less than 1,000m, smaller and immature whales tend to take walleye pollock and krill while larger and mature whales tend to take Pacific saury and common squid.
(3) Common squid is consumed by only mature whales. Japanese anchovy is evenly consumed by both immature and mature whales.

These results suggested that migration and prey preference of common minke whales in the coastal waters off Kushiro in autumn season possibly differed with their maturity stage, and immature whales more prefer to take walleye pollock on the continental shelf and slope regions than mature whales. One of the reasons of these differences might be explained by the availability of species as a prey for the whales (such as distribution, migration, and shoaling behavior of respective prey species) and the caloric value of species as a food. Walleye pollock is stably and restrictively distributed in the continental shelf and slope regions, and it is possibly easy to find by the whales, but the caloric value contained in this species (1,480Kcal/Kg: Tamura *et al*., 2009) is low compared with that of Pacific saury (3,140Kcal/Kg: Tamura *et al*., 2009). On the other hand, because Pacific saury is a large migratory species and their distribution is not stable, the whales have to search for wider areas to find and take this species. It is expected that mature whale has higher capability of swimming and experience to seek the prey, but required more energy cost than immature whales. These imply that migration and feeding strategies might change with growth whereby immature whales take more stable preys and mature whales seek nutritionally more valuable preys. Since, Japanese anchovy is distributed widely throughout the coastal area and sporadically shoaling, both immature and mature whales possibly can take this species easily.

In the coastal waters off the Sanriku district, northeastern part of the Japanese main island, in spring season, three species (krill, Japanese anchovy, and sand lance, *Ammodytes personatus*) were found as major prey species of common minke whales, but change of prey species by maturity stage was not detected (Yoshida, *et al*., 2009). However, this may be due to the difference of the locality and season of the surveys. Sampling positions of the whales off Sanriku were concentrated in the Sendai Bay on the continental shelf region less than 200m water depth. In this area, topography of sea bottom is monotonous compared with those off Kushiro, and sand lance is dominantly distributed and abundant especially in spring season. Thus, sand lance is thought to be fed easily by both immature and mature whales as well as Japanese anchovy. Walleye pollack, common squid, and Pacific saury are not distributed in the Bay in spring. Furthermore, compositions of sex and

reproductive status of common minke whales off Sanriku in spring season are also different from that off Kushiro in autumn season. Ratio of males off Sanriku (0.40) is lower than that off Kushiro (0.72), and the number of mature pregnant females in the samples is higher in Sanriku (31 out of 136 females or 22.8%) than those off Kushiro (4 out of 72 females or 5.6%). Apparent low ratio of mature females in both areas indicates that only some part of the population of the whales migrate to each coastal area in respective season, and the differences of those ratios between Kushiro and Sanriku are seems to be indicated seasonal difference of the migration of the whales to respective areas. Minke whale is well known to have segregation in their migration as the predominance of females around the northern limit of their distribution in both the Southern Hemisphere (Kato, *et al*., 1990) and off northern Japan (Wada, 1989), and coastal waters off Japan is thought to be located in the migration corridor of their north-south migration. The whale off Sanriku in spring is thought to be on the way to the northward migration after the breeding season, and the whale off Kushiro in autumn is thought to be on the way to the southward migration from the northern feeding areas. In the case of Gary whales, it is known that females generally migrate earlier than males and adults earlier than sexually immature whales in their coastal north-south migration (Wolman, 1985). Seasonal migration route of common minke whales is also known to be different between sex and maturity status (Hatanaka and Miyahita, 1997). These appeared that the feeding strategy of common minke whales might be also changed to adapt the local environments along with their respective migration route in respective season.

From the viewpoint of the ecosystem modeling and multi stock managements, the difference in prey preference by maturity stage may be affect to the local inshore ecosystem and coastal fisheries. Thus, it is thought to be important to take account of this point in estimating the local prey consumptions and constructing the models for restricted coastal small area, especially in the coastal waters off Kushiro.

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REFERENCES

Government of Japan (Fujise, Y., Kawahara, S., Pastene, L.A. and Hatanaka, H. eds.), 2002a. Report of 2000 and 2001 feasibility study of the Japanese Whale Research Program under Special Permit

in the western North Pacific-Phase II (JARPN II). Paper SC/54/O17 submitted to the 54th IWC Scientific Committee, 202pp.

Government of Japan, 2002b. Research plan for cetacean studies in the western North Pacific under special permit (JARPN II). Paper SC/54/O2 submitted to the 54th IWC Scientific Committee.

Government of Japan, 2004. Revised research plan for cetacean studies in the western North Pacific under special permit (JARPN II). Paper SC/56/O1 submitted to the 56th IWC Scientific Committee, 14pp.

Hatanaka, H. and Miyashita, T. 1997. On the feeding migration of the Okhotsk Sea-West Pacific Stock of minke whales, estimates based on length composition data. *Rep.int. Whal. Commn* 47:557-564.

Kanda, N., Goto, M., Kishiro, T., Yoshida, H., Kato, H. and Pastene, L.A.. 2009. Individual identification and mixing of the J and O stocks around Japanese waters examined by microsatellite analysis. Paper SC/J09/JR26 presented to the JARPN II Review Workshop, Tokyo, January 2009 (unpublished). 9pp.

Kato, T., Kishino, H. and Fujise, Y. 1990. Some analyses on age composition and segregation of southern minke whales using samples obtained from the Japanese feasibility study in 1987/88. *Rep. int. Whal. Commn* 40: 249-256.

Kishiro, T., Kato, H., Ohizumi, H., Yoshida, H., Saito, T., Isoda, T., Tabata, T., Sakakibara, M., Saino, S., Hara, T., Hayashi, T., Miyashita, T., Fukudome, K., Kiwada, H. and Kawahara, S. 2003. Report of the 2002 JARPN II survey in the western North Pacific. Part II: Coastal component – Coastal survey off Kushiro, northeast Japan. Paper SC/55/O8 submitted to the 55th IWC Scientific Committee, 26pp.

Kishiro, T., Kato, H., Yoshida, H., Miyashita, T., Ryono, T., Tabata, S., Okamoto, R., Yasui, K., Sato, H., Morita, Y., Saino, S., Hara, T., Ebisui, T., Kuroishi, H., Nishiwaki, S. and Kawahara, S. 2005. Cruise report of the coastal survey on common minke whales off Kushiro, northeast Japan: the 2004 JARPN II survey (Part II)-Coastal component. Paper SC/57/O4 submitted to the 57th IWC Scientific Committee, 37pp.

Kishiro, T., Kato, H., Yoshida, H., Miyashita, T., Ryono, T., Tabata, S., Yasui, K., Sato, H., Morita, Y., Kumagaya, K., Tokuda, D., Nakai, K., Funabashi, N., Ebiui, T., Wakatsuki, T., Sakaguchi, M., Houhana, T., Nishiwaki, S. and Kawahara, S. 2006. Cruise report of the Second phase of the Japanese Whale Research Program under Special Permit in the western North Pacific (JARPN II) in 2005 – Coastal component off Kushiro. Paper SC/58/O10 submitted to the 58th IWC Scientific Committee, 32pp.

Kishiro, T., Kato, H., Yoshida, H., Miyashita, T., Iwasaki, T., Kanaji, Y., Ryono, T., Tabata, S., Morita, Y., Okamoto, R., Maeda, H., Nagatsuka, S., Ogawa, N., Nakai, K., Ebisui, T., Matsumoto, A., Gokita, A., Kiwada, H. and Kawahara, S. 2008. Cruise report of the Second phase of the

Japanese Whale Research Program under Special Permit in the western North Pacific (JARPN II) in 2007 – Coastal component off Kushiro. Paper SC/60/O7 submitted to the 60th IWC Scientific Committee, 33pp.

Kishiro, T., Yoshida, H., Goto, M., Bando, T., Kato, T. 2009. Methodology and survey procedure under the JARPN II-coastal component of Sanriku and Kushiro-, with special emphasis on whale sanpling prodedures. Paper SC/J09/JR3 presented to the JARPN II Review Workshop, Tokyo, January 2009 (unpublished). 27pp.

Tamura, T. and Fujise, Y. 2002. Geographical and seasonal changes of the prey species on minke whale in the Northwestern Pacific. ICES Journal of Marine Science, 59:516-528.

Tamura, T., Konishi, K., Goto, M., Bando, T., Kishiro, T., Yoshida, H., Okamoto, R. and Kato, H. 2009. Prey consumption and feeding habits of common minke whales in coastal areas off Sanriku and Kushiro. 18pp. Paper SC/J09/JR9 presented to the JARPN II Review Workshop, Tokyo, January 2009 (unpublished). 18pp.

Wada, S. 1989. Latitudinal segregation of the Okhotsk Sea-West Pacific stock of minke whales. *Rep.int. Whal. Commn* 39: 229-233.

Wolman, A. A. 1985. Gray whale *Eschrichtius robustus* (Lilljeborg, 1861), Pp.67-90. *In*: S. H. Ridgway and R. J. Harrison (edc.), Handbook of Marine Mammals Vol.3. The Sirenians and Baleen Whales. Academic Press, London. 362pp.

Yoshida, H., Kato, H., Kishiro, T., Miyashita, T., Iwasaki, T. Minamikawa, S., Ryono, T., Tabata, Morita, Y., Sato, H., Okamoto, R., Toyoda, Y., Nakamura, G., Ebisui, T., Nakai, K., Matsumoto, A., Nishiwaki, S. and Kawahara, S. 2007. Cruise report of the Second phase of the Japanese Whale Research Program under Special Permit in the western North Pacific (JARPN II) in 2006 – Coastal component off Kushiro. Paper SC/59/O7 submitted to the 59th IWC Scientific Committee, 43pp.

Yoshida, H., Kishiro, T., Goto, M., Bando, T., Tamura, T., Konishi, K., Okamoto, R. and Kato, H. 2009. Relationship between body size, maturity, and feeding habit of common minke whales off Sanriku in spring season, from 2003-2007 whale sampling surveys under the JARPN II coastal component off Sanriku. Paper SC/J09/JR12 presented to the JARPN II Review Workshop, Tokyo, January 2009 (unpublished). 20pp.

Table 1. Body length (m) of common minke whales sampled by the 2002-2007 coastal components off Kushiro in the JARPN II.

	Male					Female				
Year	Mean	S.D.	Min.	Max.	n	Mean	S.D.	Min.	Max.	n
2002	6.28	1.13	4.51	7.98	32	6.39	1.39	4.53	8.27	18
2004	6.87	0.80	4.65	7.95	47	6.00	1.09	4.27	8.07	12
2005	6.77	1.07	4.12	8.29	45	5.48	0.60	4.66	6.45	15
2006	6.60	1.02	4.61	8.12	25	6.05	1.31	4.62	8.33	10
2007	6.45	1.10	4.31	7.83	33	5.49	0.81	4.23	7.43	17
Total	6.63	1.03	4.12	8.29	182	5.88	1.11	4.23	8.33	72

Table 2. Composition of sex and sexual maturity of common minke whales sampled by the 2002-2007 coastal components off Kushiro in the JARPN II.

	Male			Female					Maturity ratio		
Year	Imm.	Mat.	Unk.	Imm.	Peg.	Rest.	Total	Sex ratio*	Male	Female	Total
2002	16	16	0	11	3	4	50	0.64	0.50	0.39	0.46
2004	15	32	0	10	0	2	59	0.80	0.68	0.17	0.58
2005	15	29	1	15	0	0	60	0.75	0.66	0.00	0.49
2006	12	11	2	8	1	1	35	0.71	0.48	0.20	0.39
2007	17	14	2	17	0	0	50	0.66	0.45	0.00	0.29
Total	75	102	5	61	4	7	254	0.72	0.58	0.15	0.45

*Ratio of males

Table 3. Occurrence of prey species in the stomach of common minke whales sampled by the 2002-2007 coastal components off Kushiro in the JARPN II.

	No. of whales (% Occurrence)								
Year	Walleye pollock	Krill	Japanese anchovy	Pacific saury	Common Squid	Others	Empty	Unknown[1]	Total
2002	12 (16.4)	4 (5.5)	27 (37.0)	19 (26.0)	8 (11.0)	2 (2.7)	0 (0.0)	1 (1.4)	73
2004	4 (5.5)	1 (1.4)	42 (57.5)	23 (31.5)	1 (1.4)	1 (1.4)	0 (0.0)	1 (1.4)	73
2005	19 (24.1)	18 (22.8)	32 (40.5)	5 (6.3)	4 (5.1)	0 (0.0)	1 (1.3)	0 (0.0)	79
2006	7 (17.1)	1 (2.4)	29 (70.7)	3 (7.3)	1 (2.4)	0 (0.0)	0 (0.0)	0 (0.0)	41
2007	21 (32.3)	7 (10.8)	23 (35.4)	10 (15.4)	2 (3.1)	1 (1.5)	1 (1.5)	0 (0.0)	65
Total	63 (19.0)	31 (9.4)	153 (46.2)	60 (18.1)	16 (4.8)	4 (1.2)	2 (0.6)	2 (0.6)	331

1: Broken by harpoon

Table 4. Restored weights of prey species in the stomach of common minke whales sampled by the 2002-2007 coastal components off Kushiro in the JARPN II.

		Restored wet weight of stomach contents in Kg (% of total weight)						
Year	n	Walleye pollock	Krill	Japanese anchovy	Pacific saury	Common Squid	Others	Total
2002	47	306.9 (19.7)	169.7 (10.9)	296.4 (19.0)	259.2 (16.6)	527.2 (33.8)	0.9 (0.1)	1560.3
2004	54	51.6 (4.0)	26.9 (2.1)	714.2 (55.1)	499.3 (38.5)	1.6 (0.1)	2.3 (0.2)	1295.8
2005	58	2037.0 (70.6)	390.2 (13.5)	292.0 (10.1)	35.5 (1.2)	130.8 (4.5)	0.0 (0.0)	2885.4
2006	34	152.9 (24.8)	3.3 (0.5)	376.0 (61.1)	47.0 (7.6)	36.4 (5.9)	0.0 (0.0)	615.7
2007	37	398.7 (29.1)	46.3 (3.4)	509.1 (37.2)	220.2 (16.1)	193.0 (14.1)	1.2 (0.1)	1368.5
Total	230	2947.1 (38.1)	636.4 (8.2)	2187.7 (28.3)	1061.2 (13.7)	888.9 (11.5)	4.4 (0.1)	7725.7

Table 5. Occurrence of prey species in the stomach of common minke whales by sex and maturity status.

Sex		No. of whales (% Occurrence)								
		Walleye pollock	Krill	Japanese anchovy	Pacific saury	Common squid	Others	Empty	Unknown	Total
Male	Immature whales	25 (23.1)	15 (13.9)	47 (43.5)	19 (17.6)	0 (0.0)	2 (1.9)	0 (0.0)	0 (0.0)	108
	Mature whales	10 (7.8)	6 (4.7)	66 (51.2)	34 (26.4)	11 (8.5)	2 (1.6)	0 (0.0)	0 (0.0)	129
	Total[1]	36 (14.9)	21 (8.7)	116 (47.9)	53 (21.9)	12 (5.0)	4 (1.7)	0 (0.0)	0 (0.0)	242
Female	Immature whales	25 (33.8)	10 (13.5)	30 (40.5)	5 (6.8)	0 (0.0)	0 (0.0)	2 (2.7)	2 (2.7)	74
	Mature whales	2 (13.3)	0 (0.0)	7 (46.7)	2 (13.3)	4 (26.7)	0 (0.0)	0 (0.0)	0 (0.0)	15
	Total	27 (30.3)	10 (11.2)	37 (41.6)	7 (7.9)	4 (4.5)	0 (0.7)	2 (2.2)	2 (2.2)	89
Total	Immature whales	50 (27.5)	25 (13.7)	77 (42.3)	24 (13.2)	0 (0.0)	2 (1.1)	2 (1.1)	2 (1.1)	182
	Mature whales	12 (8.3)	6 (4.2)	73 (50.7)	36 (25.0)	15 (10.4)	2 (1.4)	0 (0.0)	0 (0.0)	144
	Total[1]	63 (19.0)	31 (9.4)	153 (46.2)	60 (18.1)	16 (4.8)	4 (1.2)	2 (0.6)	2 (0.6)	331

1: Includes amimals of unkown maturity

Table 6. Mean compositions of restored weights of prey species in the stomach of common minke whales by sex and maturity status.

Sex			Mean of % wet weight					
		n	Walleye pollock	Krill	Japanese anchovy	Pacific saury	Common squid	Others
Male	Immature whales	71	23.6	16.3	50.4	9.6	0	0.1
	Mature whales	91	6.8	5.3	57.5	25.7	4.6	0.1
	Total[1]	167	14.3	9.9	54.5	18.1	3.1	0.1
Female	Immature whales	47	30.2	16.3	48.4	5.1	0	0
	Mature whales	11	9.3	0	46.5	8.2	36.1	0
	Total	58	26.2	13.2	48.0	5.6	6.8	0
Total	Immature whales	118	26.2	16.3	49.6	7.8	0	0.1
	Mature whales	102	7.0	4.8	56.3	23.8	8.0	0.1
	Total[1]	225	17.4	10.7	52.8	14.9	4.1	0.1

1: Includes amimals of unkown maturity

Table 7. Maturity ratio of common minke whales by prey species found in their stomaches.

	Male				Female				Total			
Prey species	Imm.	Mat.	Total	Maturity	Imm.	Mat.	Total	Maturity	Imm.	Mat.	Total	Maturity
Walleye pollock	25	10	35	0.29	25	2	27	0.07	50	12	62	0.19
Krill	15	6	21	0.29	10	0	10	0.00	25	6	31	0.19
Japanese anchovy	47	66	113	0.58	30	7	37	0.19	77	73	150	0.49
Pacific saury	19	34	53	0.64	5	2	7	0.29	24	36	60	0.60
Common squid	0	11	11	1.00	0	4	4	1.00	0	15	15	1.00
Total	106	127	233	0.55	70	15	85	0.18	176	142	318	0.45

Table 8. Composition of sex and sexual maturity by stocks of common minke whales sampled by the 2002-2007 coastal components off Kushiro in the JARPN II.

		Male			Female					Maturity ratio		
Stock	Year	Imm.	Mat.	Unk.	Imm.	Peg.	Rest.	Total	Sex ratio[1]	Male	Female	Total
J stock	2002	2	2	-	2	-	1	7	0.57	0.50	0.33	0.43
	2004	-	3	-	1	-	-	4	0.75	1.00	0.00	0.75
	2005	7	3	-	2	-	-	12	0.83	0.30	0.00	0.25
	2006	3	-	1	-	-	-	4	1.00	0.00	-	0.00
	2007	5	3	-	3	-	-	11	0.73	0.38	0.00	0.27
	Total	17	11	1	8	0	1	38	0.76	0.39	0.11	0.32
O stock	2002	13	14	-	8	3	3	41	0.66	0.52	0.43	0.49
	2004	11	24	-	8	-	2	45	0.78	0.69	0.20	0.58
	2005	6	25	-	12	-	-	43	0.72	0.81	0.00	0.58
	2006	8	10	1	8	1	1	29	0.66	0.56	0.20	0.43
	2007	8	11	2	11	-	-	32	0.66	0.58	0.00	0.37
	Total	46	84	3	47	4	6	190	0.70	0.65	0.18	0.50

1: Ratio of males

Table 9. Occurrence of prey species in the stomach of common minke whales by stocks, sex and maturity status.

			No. of whales (% Occurrence)								
Stocks	Sex		Walleye pollock	Krill	Japanese anchovy	Pacific saury	Common squid	Others	Empty	Unknown	Total
J stock	Male	Immature whales	7 (28.0)	6 (24.0)	10 (40.0)	2 (8.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	25
		Mature whales	2 (15.4)	0 (0.0)	7 (53.8)	3 (23.1)	1 (7.7)	0 (0.0)	0 (0.0)	0 (0.0)	13
		Total[1]	9 (23.1)	6 (15.4)	18 (46.2)	5 (12.8)	1 (2.6)	0 (0.0)	0 (0.0)	0 (0.0)	39
	Female	Immature whales	5 (45.5)	3 (27.3)	2 (18.2)	0 (0.0)	0 (0.0)	0 (0.0)	1 (9.1)	0 (0.0)	11
		Mature whales	1 (100.0	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1
		Total	6 (29.7)	3 (21.6)	2 (43.2)	0 (5.4)	0 (0.0)	0 (0.0)	1 (0.0)	0 (0.0)	12
	Total	Immature whales	12 (33.3)	9 (25.0)	12 (33.3)	2 (5.6)	0 (0.0)	0 (0.0)	1 (2.8)	0 (0.0)	36
		Mature whales	3 (21.4)	0 (0.0)	7 (50.0)	3 (21.4)	1 (7.1)	0 (0.0)	0 (0.0)	0 (0.0)	14
		Total[1]	15 (29.4)	9 (17.6)	20 (39.2)	5 (9.8)	1 (2.0)	0 (0.0)	1 (2.0)	0 (0.0)	51
O stock	Male	Immature whales	15 (22.4)	7 (10.4)	30 (44.8)	14 (20.9)	0 (0.0)	1 (1.5)	0 (0.0)	0 (0.0)	67
		Mature whales	8 (7.4)	6 (5.6)	53 (49.1)	29 (26.9)	10 (9.3)	2 (1.9)	0 (0.0)	0 (0.0)	108
		Total[1]	23 (12.8)	13 (7.3)	86 (48.0)	43 (24.0)	11 (6.1)	3 (1.7)	0 (0.0)	0 (0.0)	179
	Female	Immature whales	19 (33.9)	6 (10.7)	26 (46.4)	3 (5.4)	0 (0.0)	0 (0.0)	0 (0.0)	2 (3.6)	56
		Mature whales	1 (7.1)	0 (0.0)	7 (50.0)	2 (14.3)	4 (28.6)	0 (0.0)	0 (0.0)	0 (0.0)	14
		Total	20 (29.7)	6 (21.6)	33 (43.2)	5 (5.4)	4 (0.0)	0 (0.0)	0 (0.0)	2 (0.0)	70
	Total	Immature whales	34 (27.6)	13 (10.6)	56 (45.5)	17 (13.8)	0 (0.0)	1 (0.8)	0 (0.0)	2 (1.6)	123
		Mature whales	9 (7.4)	6 (4.9)	60 (49.2)	31 (25.4)	14 (11.5)	2 (1.6)	0 (0.0)	0 (0.0)	122
		Total[1]	43 (17.3)	19 (7.6)	119 (47.8)	48 (19.3)	15 (6.0)	3 (1.2)	0 (0.0)	2 (0.8)	249

1: Includes amimals of unkown maturity

Table 10. Mean compositions of restored weights of prey species in the stomach of common minke whales by stocks, sex and maturity status.

Stocks	Sex		n	Mean of % wet weight: Walleye pollock	Krill	Japanese anchovy	Pacific saury	Common squid	Others
J stock	Male	Immature whales	14	25.8	31.4	41.2	1.5	0	0
		Mature whales	10	20.0	0	59.0	20.7	0.3	0
		Total[1]	25	22.5	17.6	50.7	9.1	0.1	0
	Female	Immature whales	5	41.9	37.4	20.8	0	0	0
		Mature whales	1	100.0	0	0	0	0	0
		Total	6	51.5	31.2	17.3	0	0	0
	Total	Immature whales	19	30.0	33.0	35.8	1.1	0	0
		Mature whales	11	27.3	0	53.7	18.8	0.3	0
		Total[1]	31	28.1	20.2	44.2	7.4	0.1	0
O stock	Male	Immature whales	45	24.5	12.2	51.1	12.2	0	0.05
		Mature whales	74	5.6	6.6	54.6	27.4	5.6	0.2
		Total[1]	122	12.5	8.5	53.6	21.1	4.2	0.1
	Female	Immature whales	38	31.9	12.7	52.2	3.2	0	0
		Mature whales	10	0.2	0	51.1	9.0	39.7	0
		Total	48	25.3	10.0	52.0	4.4	8.3	0
	Total	Immature whales	83	27.9	12.4	51.6	8.1	0	0.03
		Mature whales	84	5.0	5.8	54.2	25.2	9.7	0.1
		Total[1]	170	16.1	8.9	53.2	16.4	5.4	0.1

1: Includes amimals of unkown maturity

Table 11. Maturity ratio of common minke whales by sex, stocks and prey species found in their stomaches.

Sex	Prey species	J stock: Imm.	Mat.	Total	Maturity	O stock: Imm.	Mat.	Total	Maturity
Male	Walleye pollock	7	2	9	0.22	15	8	23	0.35
	Krill	6	0	6	0.00	7	6	13	0.46
	Japanese anchovy	10	7	17	0.41	30	53	83	0.64
	Pacific saury	2	3	5	0.60	14	29	43	0.67
	Common squid	0	1	1	1.00	0	10	10	1.00
	Total	25	13	38	0.34	66	106	172	0.62
Female	Walleye pollock	5	1	6	0.17	19	1	20	0.05
	Krill	3	0	3	0.00	6	0	6	0.00
	Japanese anchovy	2	0	2	0.00	26	7	33	0.21
	Pacific saury	0	0	0	-	3	2	5	0.40
	Common squid	0	0	0	-	0	4	4	1.00
	Total	10	1	11	0.09	54	14	68	0.21
Total	Walleye pollock	12	3	15	0.20	34	9	43	0.21
	Krill	9	0	9	0.00	13	6	19	0.32
	Japanese anchovy	12	7	19	0.37	56	60	116	0.52
	Pacific saury	2	3	5	0.60	17	31	48	0.65
	Common squid	0	1	1	1.00	0	14	14	1.00
	Total	35	14	49	0.29	120	120	240	0.50

Table 12. Geographical comparison of the composition of sex and sexual maturity of common minke whales sampled by the 2002-2007 coastal components off Kushiro in the JARPN II.

Area	Water depth	Male			Female			Total	Sex ratio[1]	Maturity ratio		
		Imm.	Mat.	Unk.	Imm.	Peg.	Rest.			Male (n)	Female (n)	Total (n)
Continental shelf	200m <	35	24	1	30	2	5	97	0.62	0.41 (59)	0.19 (37)	0.32 (96)
Continental slope	200-1,000m	34	63	4	29	2	2	134	0.75	0.65 (97)	0.12 (33)	0.52 (130)
Offshore	< 1,000m	6	15	0	2	0	0	23	0.91	0.71 (21)	0.00 (2)	0.65 (23)
Total		75	102	5	61	4	7	254	0.72	0.58 (177)	0.15 (72)	0.45 (249)

1: Ratio of males

Table 13. Geographical comparison of the occurrence of prey species in the stomach of common minke whales by their maturity status.

Area	Water depth		No. of whales (% Occurrence)							
			Walleye pollock	Krill	Japanese anchovy	Pacific saury	Common squid	Others	Empty	Total
Continental shelf	200m <	Immature whales	19 (23.5)	12 (14.8)	41 (50.6)	7 (8.6)	0 (0.0)	0 (0.0)	2 (2.5)	81
		Mature whales	5 (12.5)	1 (2.5)	20 (50.0)	5 (12.5)	9 (22.5)	0 (0.0)	0 (0.0)	40
		Total	24 (19.8)	13 (10.7)	61 (50.4)	12 (9.9)	9 (7.4)	0 (0.0)	2 (1.7)	121
Condinental slope	200-1,000m	Immature whales	31 (35.2)	12 (13.6)	32 (36.4)	11 (12.5)	0 (0.0)	2 (2.3)	0 (0.0)	88
		Mature whales	7 (8.1)	5 (5.8)	46 (53.5)	21 (24.4)	6 (7.0)	1 (1.2)	0 (0.0)	86
		Total	38 (21.8)	17 (9.8)	78 (44.8)	32 (18.4)	6 (3.4)	3 (1.7)	0 (0.0)	174
Offshore	< 1,000m	Immature whales	0 (0.0)	1 (9.1)	4 (36.4)	6 (54.5)	0 (0.0)	0 (0.0)	0 (0.0)	11
		Mature whales	0 (0.0)	0 (0.0)	7 (38.9)	10 (55.6)	0 (0.0)	1 (5.6)	0 (0.0)	18
		Total	0 (0.0)	1 (3.4)	11 (37.9)	16 (55.2)	0 (0.0)	1 (3.4)	0 (0.0)	29

Table 14. Geographical comparison of the mean compositions of restored weights of prey species in the stomach of common minke whales by their maturity status.

Area	Water depth		n	Mean of % wet weight					
				Walleye pollock	Krill	Japanese anchovy	Pacific saury	Common squid	Others
Continental shelf	200m <	Immature whales	52	17.9	17.9	61.4	2.8	0	0
		Mature whales	30	14.5	2.1	60.8	7.0	19.2	0
		Total	82	16.7	11.9	60.1	4.3	7.0	0
Condinental slope	200-1,000m	Immature whales	58	37.3	15.8	40.2	6.5	0	0.2
		Mature whales	58	4.9	7.6	58.8	24.6	4.1	0.05
		Total	116	21.1	11.7	49.5	15.6	2.1	0.1
Offshore	< 1,000m	Immature whales	8	0	10.1	40.7	49.3	0	0
		Mature whales	14	0	0	42.6	56.8	0	0.6
		Total	22	0	3.7	41.9	54.1	0	0.4

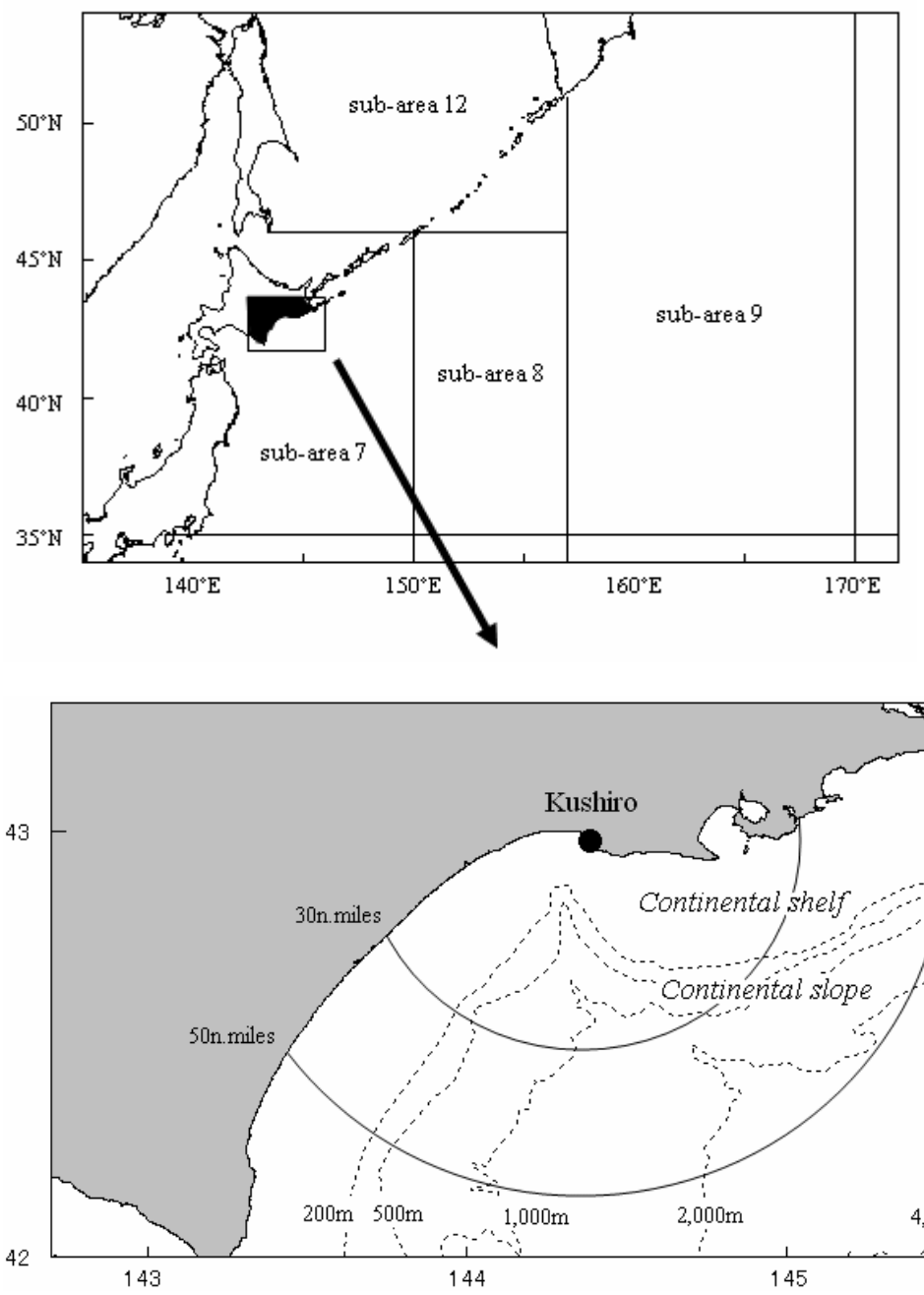

Fig.1. The IWC sub-area for western North Pacific minke whales (upper) and research area of the whale sampling surveys in the coastal component off Kushiro, under the JARPN II (lower)

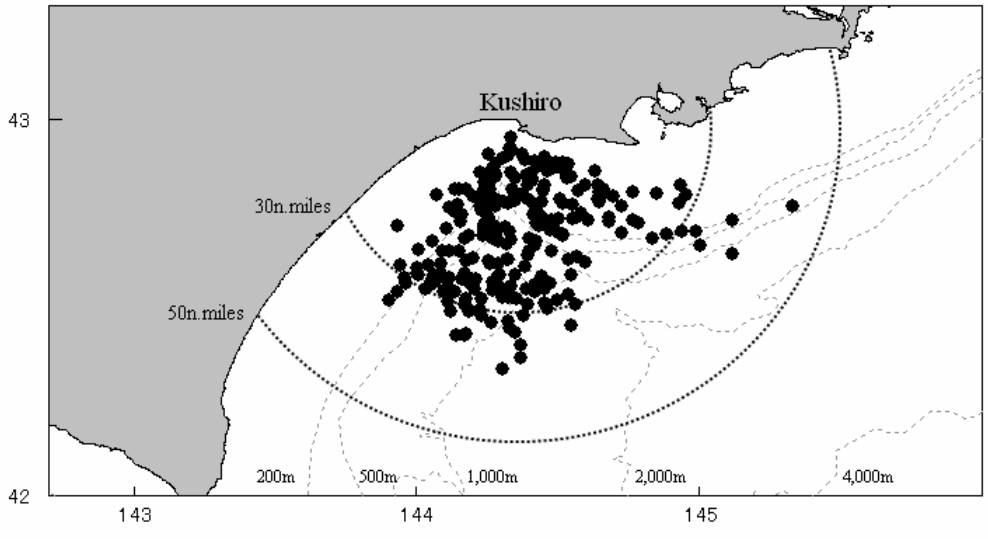

Fig.2. Distribution of common minke whales sampled by the coastal component off Kushiro in 2002 to 2007.

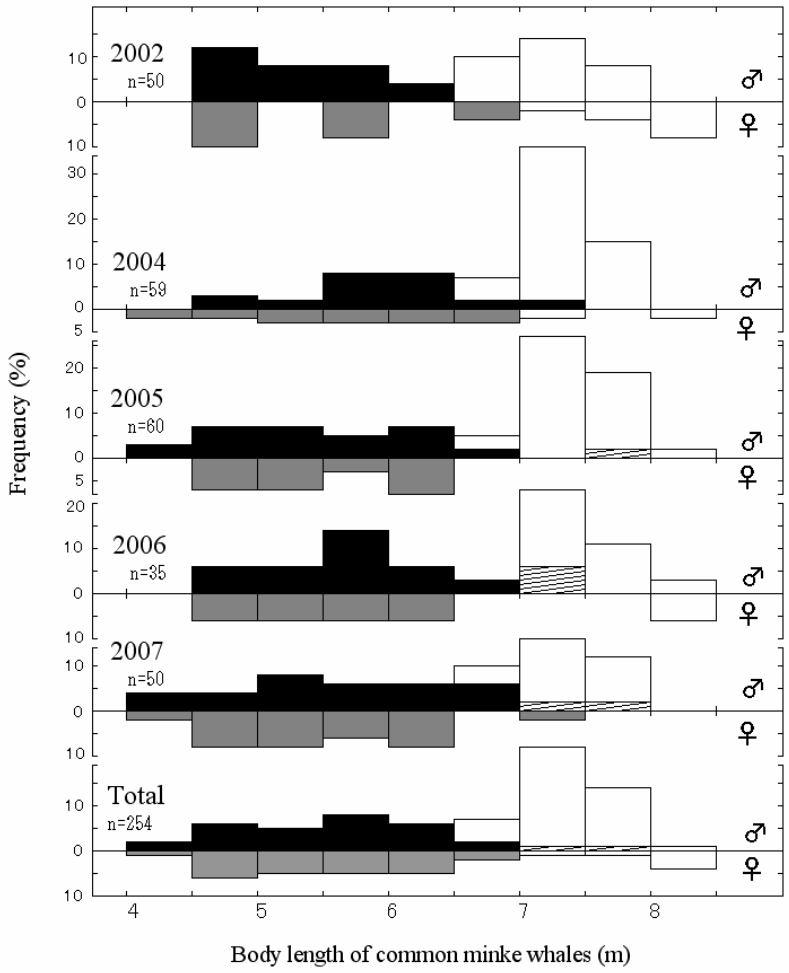

Fig.3. Body length frequency of common minke whales sampled by the coastal component off Kushiro in 2002 to 2007. ■: Immature (males); ■: immature (females); □: mature; ◪: unknown maturity.

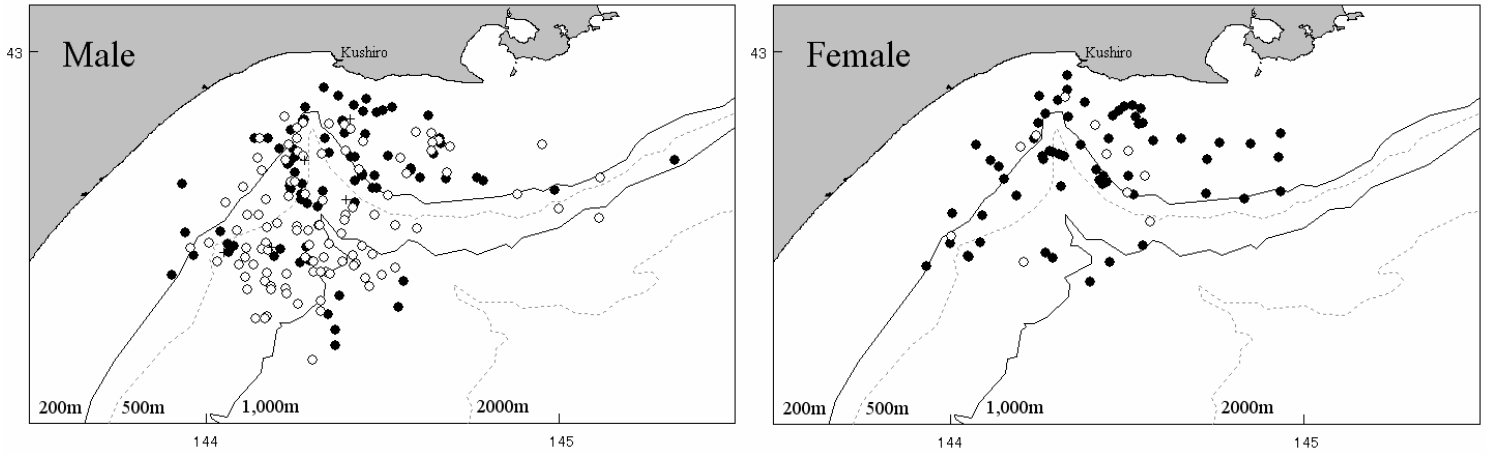

Fig.4. Distribution of males and females common minke whales sampled by the coastal component off Kushiro in 2002 to 2007. ●: Immature; ○: mature; ＋: unknown maturity

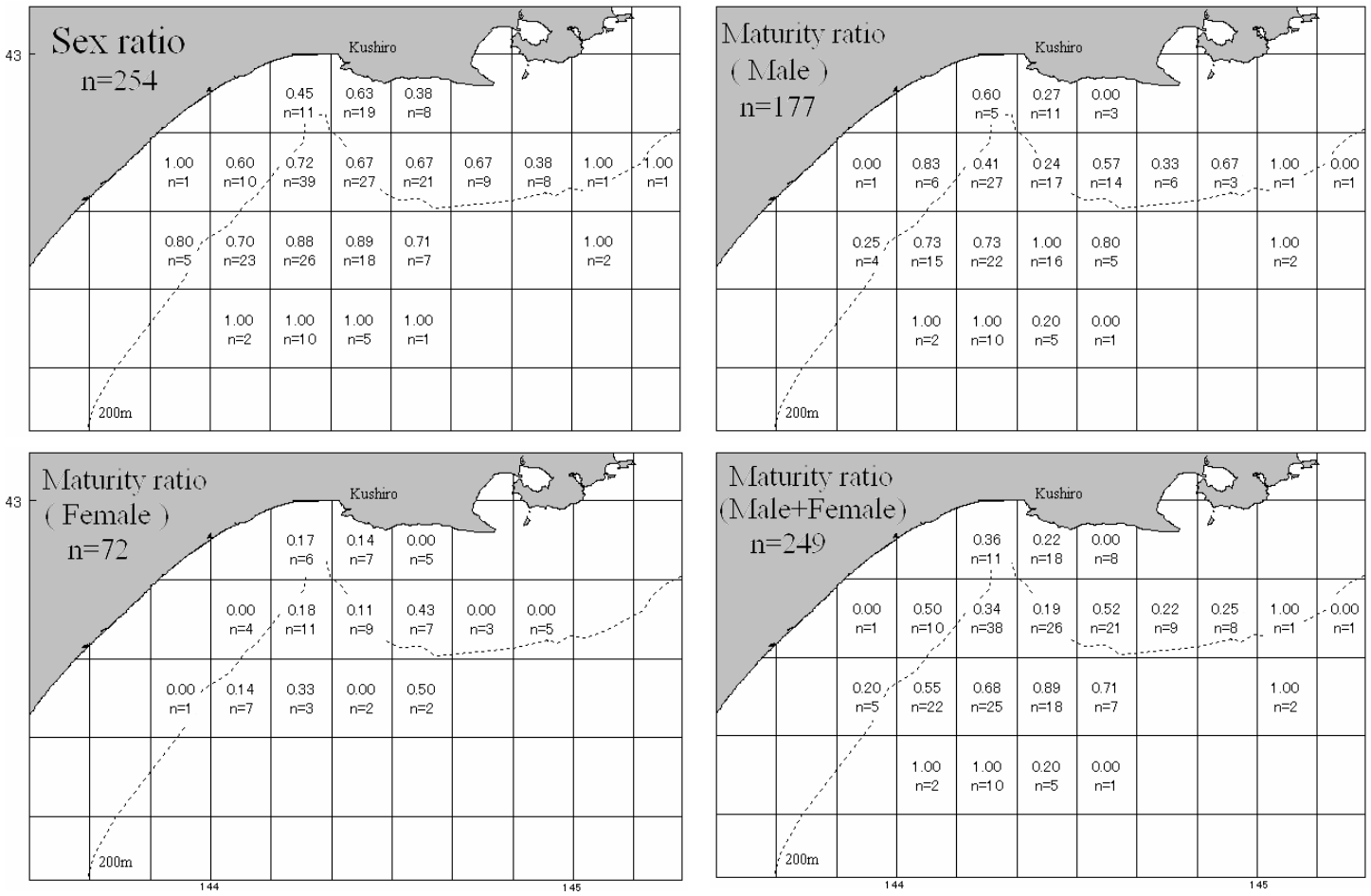

Fig.5. Sex and maturity ratio of common minke whales by 10 minutes square latitude-longitude.

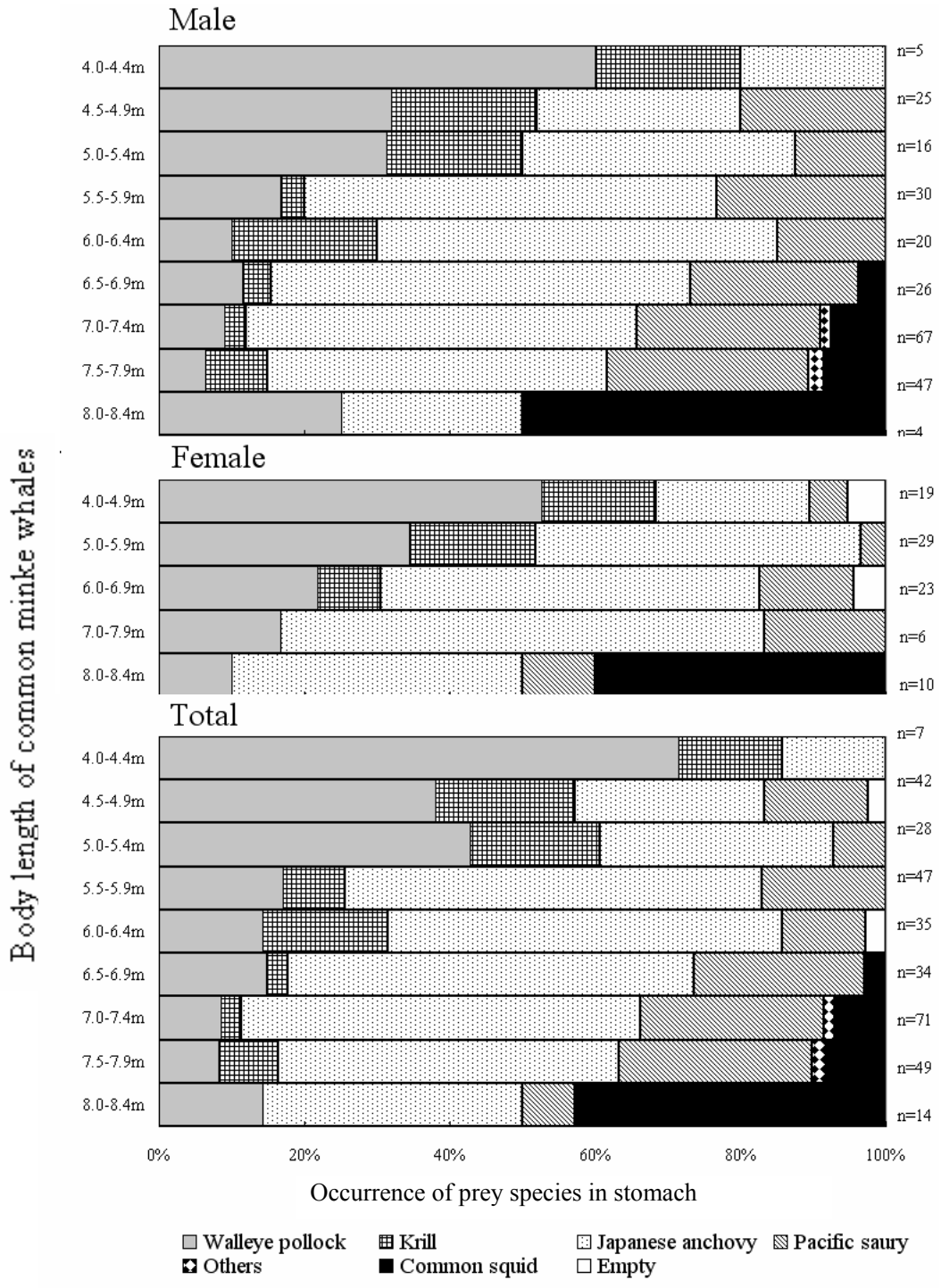

Fig.6. Relationship between body lengths of common minke whales with compositions of the occurrence of prey species in their stomach in 2002 to 2007 off Kushiro.

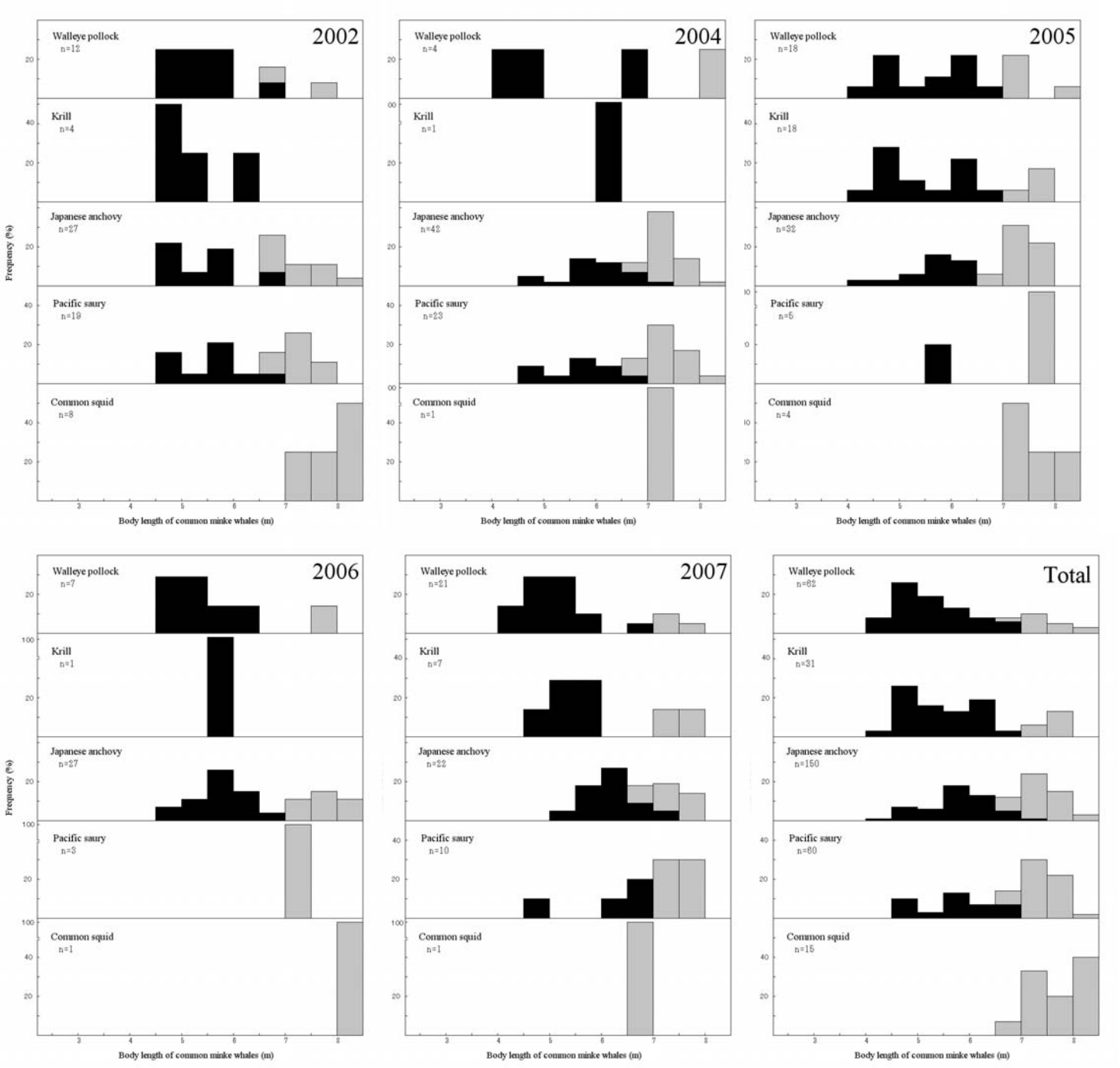

Fig.7. Yearly change in maturity and body length frequency of common minke whales with their prey species found in the stomach in 2002 to 2007 coastal components off Kushiro.
■: Immature whales; ■: mature whales.

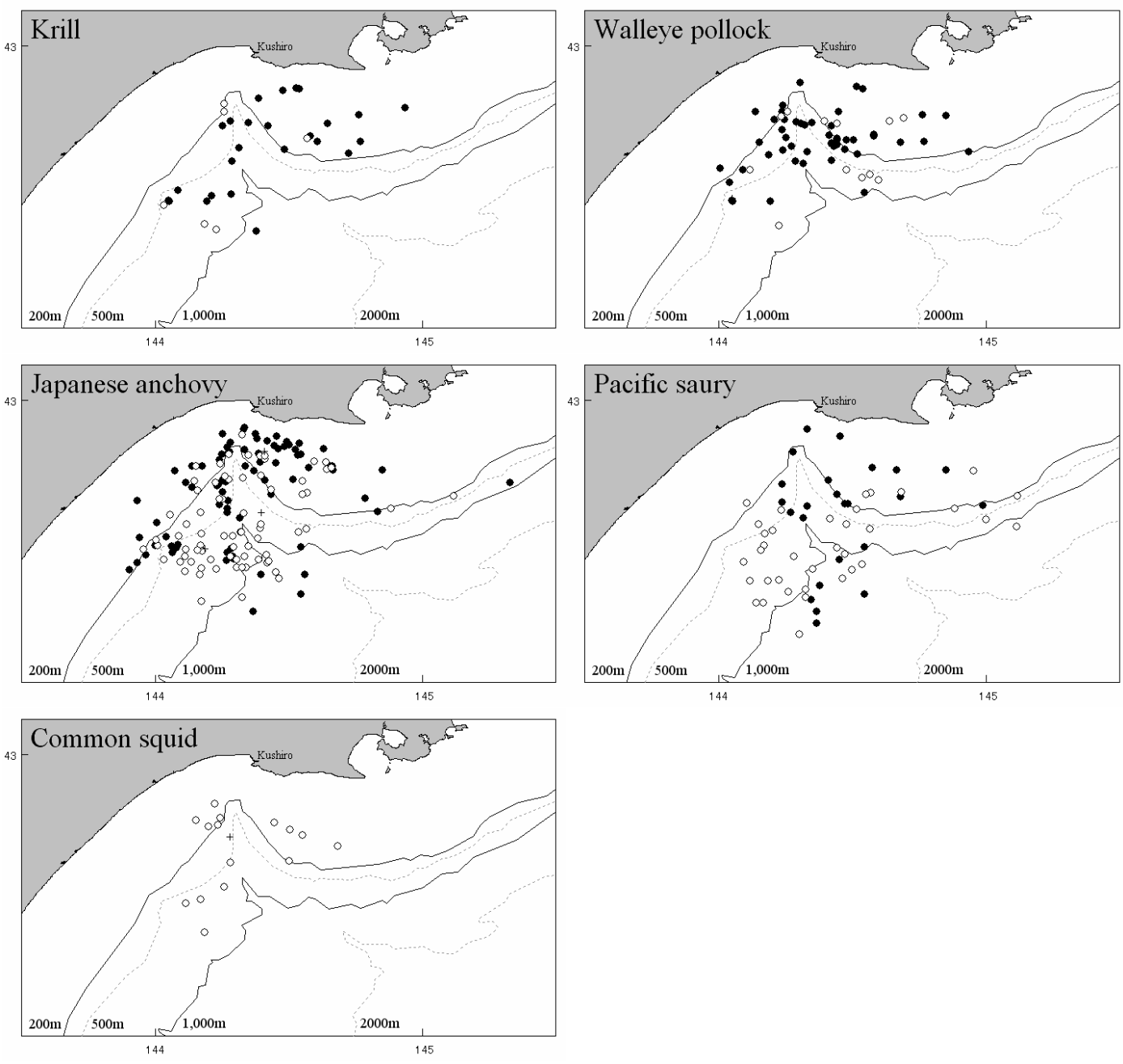

Fig.8. Distribution of sampled common minke whales by prey species found in their stomach in 2002 to 2007 coastal components off Kushiro.
●: Immature whales; ○: mature whales; ＋: unknown maturity

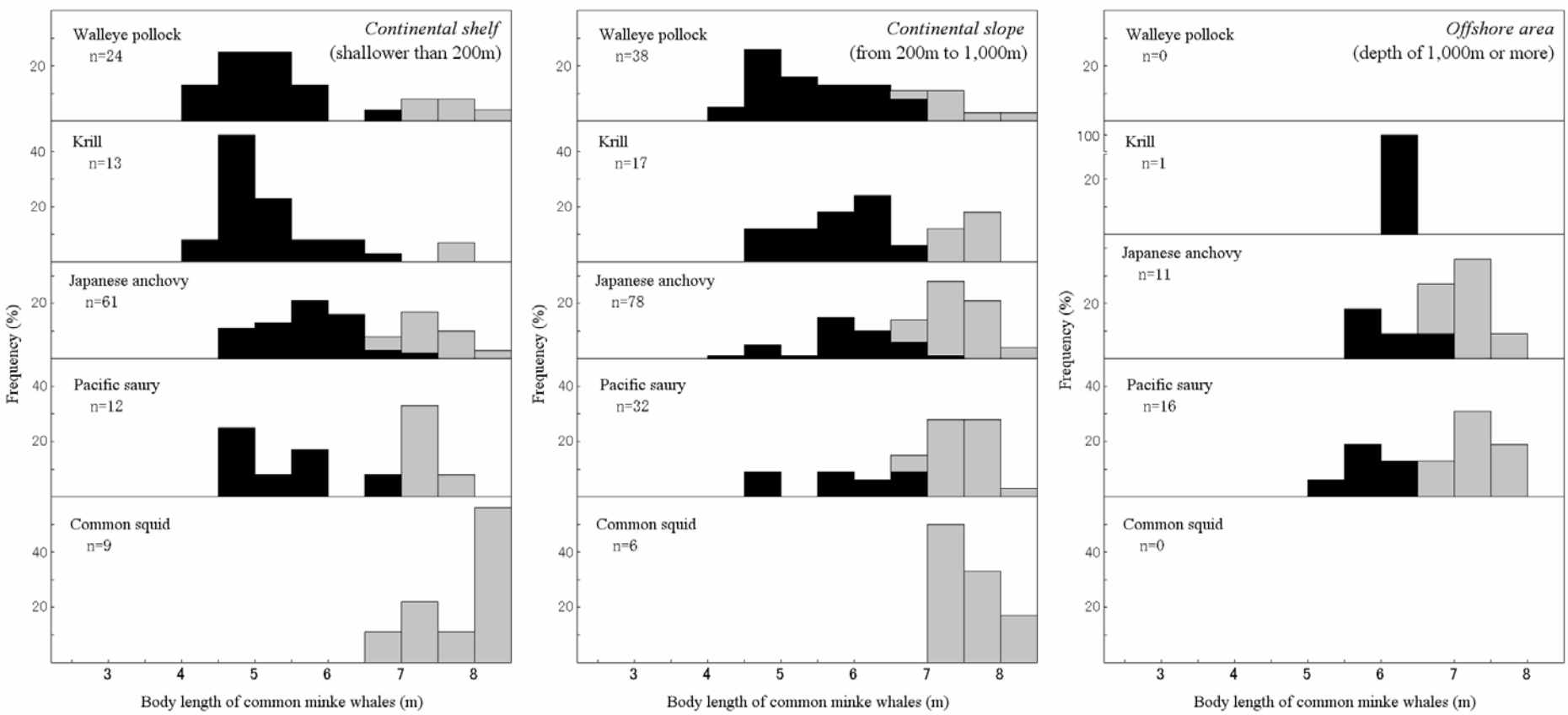

Fig.9. Geographical comparison of maturity and body length frequency of common minke whales with their prey species found in the stomach in 2002 to 2007 coastal components off Kushiro. ■: Immature whales; ■: mature whales.

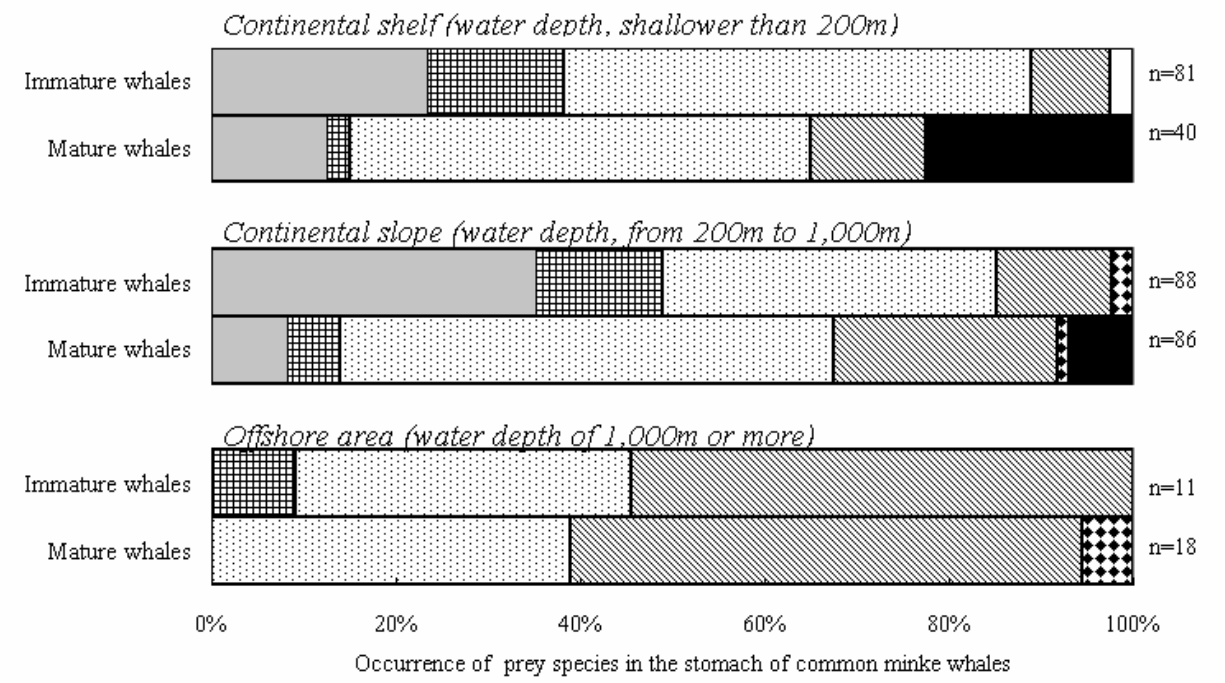

Table 10. Geographical comparison of the occurrence of prey species in the stomach of common minke whales by their maturity status.