# Preliminary analyses of interaction between common minke whales and fisheries off Kushiro region

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**ABSTRACT**

The stomach contents of common minke whale *Balaenoptera acutorostrata* sampled off Kushiro region from June to October in a part of the 1996 JARPN–2002 JARPN II, were analyzed. The dominant prey species consisted of one krill (*Euphausia pacifica*), three fish (Japanese anchovy *Engraulis japonicus*, Pacific saury *Cololabis saira* and walleye pollock *Theragra chalcogramma*) and one squid (Japanese common squid *Todarodes pacificus*). All these prey species are targeted by local fisheries. The annual prey consumption of Japanese anchovy, Pacific saury, walleye pollock and Japanese common squid by common minke whales were estimated as 10,000–15,000 tons, 3,500–5,000 tons, 6,000–10,000 tons and 1,600–2,500 tons, respectively. Based on these results, there is a possibility of direct competition between common minke whale and the fisheries for these resources in this region. To evaluate this competition, more information of accurate abundance in prey species and common minke whales, and resident period of common minke whale off Kushiro region are needed.

KEYWORDS: COMMON MINKE WHALE; NORTH PACIFIC; FISHERIES INTERACTION, SCIENTIFIC PERMIT

## INTRODUCTION

The common minke whale *Balaenoptera acutorostrata* is widely distributed in the world. In the western North Pacific two stocks have been recognized: one in the Sea of Japan - Yellow Sea - East China Sea (J stock) and the another in the Sea of Okhotsk – West Pacific (O stock) (IWC, 1983). The abundance of common minke whales was estimated to be 19,209 animals with 95 % confidence interval (10,069 – 36,645) in the Sea of Okhotsk and 5,841 animals with 95 % confidence interval (2,835 – 12,032) in the Northwest Pacific during August and September in 1989 and 1990 (IWC, 1992). In the western North Pacific, common minke whales are opportunistic feeders consuming a broad of prey with flexible feeding habits. According to previous reports, they consume several prey species such as pelagic schooling fish and zooplankton (Kasamatsu and Hata, 1985; Kasamatsu and Tanaka, 1992; Tamura *et al*., 1998).

The Japanese Whale Research Program under Special Permit in the Western North Pacific (JARPN) and JARPN II feasibility study showed that they fed on various prey species such as Japanese anchovy *Engraulis japonicus*, Pacific saury *Cololabis saira*, walleye pollock *Theragra chalcogramma* and Japanese common squid *Todarodes pacificus*. Furthermore, most of common minke whales pursued single prey species aggregations and the main prey species changed seasonally and geographically. For example, they feed on Japanese anchovy in May/June and Pacific saury in July/August (Tamura and Fujise, 2000a, 2002a). The estimated prey consumption by common minke whales was comparable to that of the commercial fisheries (Tamura and Fujise, 2000b, 2002b). It was thought that there was the competition between the common minke whales and fisheries in the coastal area.

However, our interests of coastal matter, the *Nisshin-Maru* and large sighting/sampling vessels can not be operated in the near shore area because of various restrictions and obstacles. Furthermore, these vessels can not join survey from late autumn to early spring for operational reason.

In order to cover the geographical and seasonal gaps of JARPN and JARPN II feasibility study, sampling of common minke whales in the coastal area using small type whaling catcher boats was planed in 2002 (Government of Japan,

2002). These coastal surveys were conducted off Kushiro in 2002, off Sanriku in 2003.The detail of these surveys were reported in Kishiro *et al*. (2003) and Yoshida *et al* (2004).

In previous report, krill, squid, Japanese sardine *Sardinops melanostictus*, Japanese anchovy, Chub mackerel *Scomber japonicus*, walleye pollock *Theragra chalcogramma*, cod, sand lance *Ammodytes personatus*, Pacific saury and so on were prey species of minke whales off the Pacific coast of Hokkaido (a part of sub-area 7W) from April to October (Kasamatsu and Tanaka, 1992; Tamura and Fujise, 2000a, 2002a). Kishiro *et al* (2003) reported that the dominant prey species of common minke whales sampled off Kushiro region were krill, Japanese anchovy, Pacific saury, walleye pollock and Japanese common squid in the coastal area of Kushiro.

In this document, the abundance of common minke whales and the consumption of targeted fisheries species consumed by common minke whales off Kushiro region were calculated using some assumption. Then, the interaction was evaluated by means of comparison between the prey consumption by common minke whales and fisheries catches.

## MATERIALS AND METHODS

### The abundance of common minke whales off Kushiro region

The study area was set off Kushiro region, which covered north of 41N and longitude from 143.15E (Erimo cape) to 146E. The area covered 7,307 $nml^2$. Three data sets were used for estimates of common minke whale distributed off Kushiro region (Fig. 1).

1. Data were obtained from sighting survey conducted by *Syunyo Maru* in September in 1991 and 1992. *g(0)* assumed 0.787 (Data for calculating *g(0)* were obtained from sighting survey in Okhotsk area in 1999 and 2000). The estimated abundance of common minke whales off Kushiro region was 821 individuals (95% confidence interval: 284 – 2,369 individuals).
2. Data were obtained from sighting survey conducted by *Kyoshin Maru No.2* in July in 1999. *g(0)* assumed 0.787 (Data for calculating *g(0)* were obtained from sighting survey in Okhotsk area in 1999 and 2000). The estimated abundance of common minke whales off Kushiro region was 1,194 individuals (95% confidence interval: 443 – 3,215 individuals).
3. Data were obtained from sighting survey conducted by *Kyoshin Maru No.2* in September in 2002. *g(0)* assumed 0.787 (Data for calculating *g(0)* were obtained from sighting survey in Okhotsk area in 1999 and 2000). The estimated abundance of common minke whales off Kushiro region was 803 individuals (95% confidence interval: 451 – 1,428 individuals).

### Sighting and sampling of common minke whales

1. JARPN 1996, 1999, JARPN II 2000, 2001 and offshore component of JARPN II in 2002

Sighting and sampling methods of common minke whales and research summary were described in Fujise *et al*. (1997, 2001, 2002, 2003) and Fujise (2000).

2. Coastal component of JARPN II in 2002

Sighting and sampling methods of common minke whales and research summary were described in Kishiro *et al*. (2003). Three small-type whaling catcher boat, *Taisho Maru* No. 28, *Sumitomo Maru* No. 31 and *Katsu Maru* No.7 were used. All common minke whales sighted excluding the cow-calf pair were targeted for sampling. When a school size was more than one animal, sampling target was selected randomly from the school. After the target was sampled by harpoon, she moved to the Kushiro port as soon as possible, to land research station.

The sample size of common minke whales, which were used for stomach contents analyses, was listed in Table 1.

### Sampling of the stomach contents

Biological research such as measurement of body proportion were conducted for all common minke whales sampled. The stomach contents were all removed. After that the stomach contents were all removed. The contents from each stomach were weighed to the nearest 0.1 kg, and sub-sample were removed from all individuals and frozen for later examination. The contents were first classified to major prey groups, such as euphausiids, copepods, fish and others. The freshness of stomach contents was categorized into four classes (1 = fresh, 2 = lightly digested, 3 = moderately digested, 4 = heavily digested).

The sub-samples were identified to the lowest taxonomic level as much as possible. When undigested fishes were found, standard lengths and weight were measured to the nearest 1 mm and 1 g, respectively. When fishes occurred in the sub-samples, the total number of each prey species was estimated by adding the number of undigested specimens and the number of intact skulls. The total weight of each prey species was estimated by using the average weight of fresh

specimens. The total number and weight of each prey species were estimated by using the results from the sub-samples. Then, the relative prey importance by weight of each prey species (*RW*) was calculated as follows:

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

$W_i$ = the weight of contents containing prey group *i*

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

**The consumption by common minke whales**

The seasonal diet composition (*RW*) of common minke whales was listed in Table 2. The maturity composition of common minke whales was listed in Table 3.

The daily prey consumptions by both immature and mature common minke whales were calculated with the assumptions below.

a. Mean body weight（Tamura and Fujise, 2002b）: Immature male: 2,500 kg

Immature female: 2,600 kg

Mature male: 4,800 kg

Mature female: 5,900 kg

These weights were obtained from JARPN and JARPNII survey data.

b. The residence time of the common minke whale off Kushiro region: 180 days (from May to October)

Off Kushiro region, common minke whales mainly distribute from May to October (Hatanaka and Miyashita, 1997). And past commercial whaling season off Kushiro region was from May to October. Between 1994 and 1999 JARPN surveys, common minke whales distribute off Kushiro region in June and August (Matsuoka *et al*, 2000). Therefore, residence time of the common minke whale off Kushiro region was assumed to be 180 days.

c. Field metabolism Immature male or female: 1.58×80×body weight（kg） KJ / day (Markussen *et al*., 1992)

Mature male or female: 1.25×80×body weight（kg） KJ / day (Nordoy *et al*, 1995)

The average field metabolism used in these calculations was obtained from Blix and Folkow (1995). The value of 80 kJ/kg per day is based on indirect determination of oxygen consumption from studies of the respiratory rates.

d. Average caloric value of prey species: 6,000 KJ / kg

Stomach content analyses show much variation in the diet of common minke whales in the western North Pacific (Kasamatsu and Tanaka, 1992; Tamura *et al.*, 1998, Tamura and Fujise, 2000a, 2002a). In the North Atlantic, the energy contents of the prey species varies from 3,720 kJ / kg when feeding on *Parathemisto* spp. to as high as 12,500 kJ / kg when feeding on herring (Markussen *et al*., 1992). In this study, the mean caloric value of krill, Japanese anchovy, Pacific saury, walleye pollock and Japanese common squid *Todarodes pacificus* were calculated using bomb caloric meter. The mean caloric value of krill, Japanese anchovy, Pacific saury, walleye pollock and Japanese common squid were calculated to be 3,600 kJ / kg, 6,400 kJ / kg, 13,000 kJ / kg, 6,200 kJ / kg and 6,600 kJ / kg, respectively (Tamura and Fujise, 2002b). Total prey species were assumed to be 6,000 kJ / kg by average of above values.

e. Assimilation efficiency: 80 %

The assimilation efficiency of the common minke whales is assumed to be 80 % (Markussen *et al*., 1992).

f. Reproduction cost: 20kg / day

The total reproductive cost for the female common minke whale was re-calculated to be $1.9 \times 10^7$ kJ (Lockyer, 1981), assuming a length at birth fetus of 280 kg (Christensen, 1981). The pregnancy rate is 95 % for mature. All energy related to reproduction costs as obtained during the residence (feeding) time in the western North Pacific (180 days) were assumed.

The each calculated prey consumption by common minke whales from May to October is shown in Table 5.

**The fisheries catches of Pacific saury, walleye pollock and Japanese common squid off Kushiro region from May to October**

Fisheries Catch data (2002) of several main ports off eastern Hokkaido from May to October ware provided from the Fishing Information Service Centre in Japan (Table 6). The catches in 2002 of Pacific saury, walleye pollock and Japanese common squid were 105,000 tons, 23,000 tons and 1,000 tons, respectively.

**The biomass of prey species off Kushiro region**

The results of the biomass of each prey species off Kushiro region from prey survey of JARPN II in 2000 and 2001 are shown in Table 7 (Murase *et al*., 2002).

**Interaction index between common minke whales and fisheries catch**

The interaction was evaluated by means of comparison between the prey consumption by common minke whales and fisheries catches as follows:

$$I \text{ index} = C_{all} / F \times 100$$

$I$ index = Interaction index between common minke whales and fisheries

$C_{all}$ = Consumption by common minke whales (tons)

$F$ = Fisheries catch (tons)

## RESULTS

The dominant prey species consisting of 1 krill (*Euphausia pacifica*), 3 fish (Japanese anchovy, Pacific saury, and walleye pollock) and 1 squid (Japanese common squid) were identified in common minke whales caught off Kushiro region based on from 1996 JARPN to 2002 JARPNII (Table 2). In early season (from may to June), Japanese anchovy and walleye pollock were dominant prey species and composed 58.3 % and 35.2 % in wet weight (%), respectively. In late season (from August to September), walleye pollock, Pacific saury, krill and Japanese anchovy were dominant prey species and composed of 26.1 %, 24.6 %, 19.9 % and 18.3 % in wet weight (%), respectively (Table 3).

The estimated daily prey consumption weights during feeding period off Kushiro region were 120 kg and 125 kg for immature male and female, and 183 kg and 244 kg for mature male and female, respectively.

The total prey consumption by common minke whales off Kushiro region from May to October was estimated to be approximately 24,000 – 35,000 tons. The prey consumption of economically important Pacific saury, walleye pollock and Japanese common squid by common minke whales were estimated as 3,000 – 5,000 tons, 6,000 – 9,000 tons and 1,500 – 2,000 tons, respectively (Table 5A, 5B, 5C, 5D, 5E and 5F).

The body length of Japanese anchovy (A), Pacific saury (B), walleye pollock (C) and Japanese common squid (D) ingested ranged from 100 to 156 mm, 141 to 342 mm, 177 to 530 mm, and 127 to 296 mm, respectively (Fig. 2).

The $I$ index were 2.9 – 4.8 in Pacific saury, 26 – 39 in walleye pollock and 100< in Japanese common squid, respectively. Sighting positions of common mink whales were overlapped to fisheries ground of Pacific saury (Fig. 3).

The biomass of Japanese anchovy and walleye pollock estimated by echo-sounder and trawling results were 150,000 tons (June in 2001) and 4,000 (June in 2001) – 27,000 tons (August in 2000), respectively (Table 7).

## DISCUSSION

The present study indicates that there is some impact of predation by common minke whale on some fish resources off Kushiro region.

Kasamatsu and Tanaka (1992) analysed the yearly change of prey species of common minke whale off Kushiro region during 1948 to 1987. Commercial whaling was made from April to October with peaks from July to September. After 1982, two peaks were observed in July and September. The dominant prey species were krill, Japanese sand lance, chub mackerel, *iwashi* (Japanese sardine and/or Japanese anchovy), walleye pollock, pacific saury and Japanese common squid. They pointed out that the yearly change of Japanese sardine in the stomach contents were similar to the annual trend of abundance of Japanese sardine in this area. In the results of JARPN and JARPN II, the dominant prey species of common minke whales sampled off Kushiro region from June to October were krill, Japanese anchovy, Pacific saury, walleye pollock and Japanese common squid. This result was similar to the previous report.

The maximum stomach contents weight was 154.3 kg (2.6 % of body weight). Our daily estimated prey consumption was from 120 kg to 244 kg (from 3.8 % to 4.8 % of body weight). Common minke whale should take on prey at several times due to meet a demand for their energy requirement in a day. Based on diurnal change in feeding activity of common minke whale in the western North Pacific, Tamura and Fujise (2000c) pointed out that common minke whales feed on prey at several time throughout the day at the surface. Our results supported their consideration.

The seasonal consumption of 803-1,194 common minke whales distributed off Kushiro during May and October (180 days) was approximately 24,000 – 35,000 tons. The prey consumption of economically important Pacific saury, walleye pollock and Japanese common squid by common minke whales were calculated as 3,000 – 5,000 tons, 6,000 – 9,000 tons and 1,500 – 2,000 tons, respectively.

Based on results of the Pacific saury consumption by common minke whales and the degree of overlap between fisheries ground of Pacific saury and sighting position of common minke whales, it is conceivable that the possibility with direct competition between common minke whale and Pacific saury fisheries occurs. The fisheries season of Pacific saury is from August to October, and common minke whales also feed on Pacific saury in the same season. The catch quota and season of Pacific saury off the Kushiro region is regulated by the fisheries conference in order to protect the resources of Pacific saury and price control, however common minke whales feed on Pacific saury without restriction. Therefore, consumption by common minke whales should be taken into account for fishery management of Pacific saury off Kushiro region.

The *I* index shows the possibility of direct competition between common minke whale and some fisheries. The prey consumption of walleye pollock was amount to one-third of their estimated biomass off Kushiro region.

Furthermore, some fishermen indicate the fishing operation have interfered by common minke whales. Some minke whales attack and feed on the school of Pacific saury when fishermen attracted fishes around boat, causing dispersion of the schools of Pacific saury.

This preliminary analysis was based on the result of some part of JARPN and JARPN II between 1996 and 2002. Especially, the research of coastal area was only once in 2002.

To evaluate the competition between common minke whale and some fisheries, more information of accurate abundance in prey species and common minke whales, and the accurate resident period of common minke whale around the Kushiro region are needed. It needs the long-term monitoring research in this area in future.

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**REFERENCES**

Blix, A. S. and Folkow, L. P. 1995. Daily energy expenditure in free living minke whales. *Acta Physiol. Scand*., 153:61-6.

Christensen, I. 1981. Age, determination of minke whale, *Balaenoptera acutorostrata,* from laminated structures in the tympanic bullae. *Rep. int. Whal. Commn.* 31:245-53.

Fujise, Y., Shimada, H., Zenitani, R., Goto, M., Tamura, T., Lindstrom, U., Uchida, A., Yoshida, H., Shimamoto, K., Yuzu, S., Kasai, H., Kinoshita, T., Iwata, T. and Toyama, D. 1997. Cruise report of the Japanese Whale Research Program under a Special Permit in the North Pacific (JARPN) in 1996 with some preliminary analysis of data collected during the 1994 – 1996 JARPN surveys. Paper SC/49/NP8 presented to the IWC Scientific Committee, September 1997 (unpublished). 38pp.

Fujise, Y. 2000. Outline of the research activities under the Japanese Whale Research Program under a Special Permit in the North Pacific (JARPN) from 1994 to 1999. Paper SC/F2KJ8 presented to the JARPN review meeting, February 2000 (unpublished). 30pp.

Fujise, Y., Zenitani, R., Tamura, T., Bando, T., Ohtani, S., Takeda, S., Kitajima, A., Kimura, T., Masaki, T. and Tohyama, D. 2000. Cruise report of the Japanese whale research program under special permit in the North Pacific (JARPN) in 1999. Paper SC/F2K/J9 presented to the JARPN review meeting, February 2000 (unpublished). 32pp.

Fujise, Y., Pastene, L.A, Tamura, T., Bando, T., Murase, H., Kawahara, S., Watanabe, H., Ohizumi, H., Mogoe, T., Kiwada, H., Nemoto, K. and Narita, H. 2001. Progress Report of the Feasibility study of the Japanese whale research program under special permit in the western North Pacific-Phase II (JARPN II) in 2000. Paper SC/53/O10 presented to the IWC Scientific Committee, July 2001 (unpublished). 77pp.

Fujise, Y., Tamura, T., Bando, T., Hikaru Watanabe, Hiroshi Kiwada, Otani, S., Kanda, N., Yasunaga, G., Mogoe, T., Konishi, K., Inamori, M., Shigemune, H. and Tohyama, D. 2002. Cruise report of the feasibility study of the Japanese whale research program under special permit in the western North Pacific – Phase II (JARPNII) in 2001. Paper SC/54/O16 presented to the IWC Scientific Committee, May 2002 (unpublished). 51pp.

Fujise, Y., Tamura, T., Bando, T, Yasunaga, G., Konishi, K., Murase, H., Yoshida, T., Itoh, S., Ogawa, R., Oka, T., Sasaki, T., Fukutome, K., Isoda, T., Birukawa, N., Horii, N., Zharikov, K.A., Park, K.J., Toyama, D and Kawahara, S. 2003. Cruise report of the Japanese Whale Research Program under a Special Permit in the North Pacific –Phase II (JARPN II) in 2002 (part I) offshore component-. Paper SC/55/O7 presented to the IWC Scientific Committee, June 2003 (unpublished). 41pp.

Government of Japan, 2002. Research Plan for Cetacean Studies in the Western North Pacific under Special Permit (JARPN II). Paper SC/54/O2 presented to the IWC Scientific Committee, May 2002 (unpublished). 115pp.

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* 47:557-67.

International Whaling Commission. 1983. Report of the Sub-Committee on minke whales. *Rep. int. Whal. Commn.* 33:91-122.

International Whaling Commission. 1992. Report of the Sub-Committee on North Pacific minke whale. *Rep. int. Whal. Commn.* 42:156-77.

Kasamatsu, F and Hata, T. 1985. Notes on minke whales in the Okhotsk Sea -West Pacific area. *Rep. int. Whal. Commn*. 35:299-304.

Kasamatsu, F. and Tanaka, S. 1992. Annual changes in prey species of minke whales taken off Japan 1948-87. *Nippon Suisan Gakkaishi*. 58:637-51.

Kishiro, T, Kato, H., Ohizumi, H., Yoshida, H., Saito, T., Isoda, T., Tabata, S., 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 Meeting, 26pp.

Lockyer, C. 1981. Estimation of the energy costs of growth, maintenance and reproduction in the female minke whale, (*Balaenoptera acutorostrata*), from the southern hemisphere. *Rep. int. Whal. Commn* 31:337-43.

Markussen, N. H., Ryg, M. and Lydersen, C. 1992. Food consumption of the NE Atlantic minke whale (*Balaenoptera acutorostrata*) population estimated with a simulation model. *ICES J. mar. Sci*. 49:317-23.

Matsuoka, K., Hakamada, T., Fujise, Y. and Miyashita, T. 2000. Distribution pattern of minke whales based on sighting data during 1994-1999 JARPN surveys. Paper SC/F2K/J16 presented to the IWC Scientific Committee Workshop to Review the Japanese Whale Research Programme under Special Permit for North Pacific Minke Whales (JARPN), Tokyo, 7-10 February 2000 (unpublished). 17pp.

Murase, H., Tamura, T., Kiwada, H., Fujise, Y., Watanabe, H., Ohizumi, H. and Kawahara, S. Preliminary estimation of prey preference of minke whale and Bryde's whales based on JARPN II. Appendux.5. pp 97-117. *In*: Government of Japan (Fujise, Y., Kawahara, S., Pastene, L.A. and Hatanaka, H. eds.), 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 Meeting

Nordøy, E.S., Folkow, L.P., Mårtensson, P.E. and Blix, A.S. 1995. Food requirements of Northeast Atlantic minke whales. pp. 307-17. In: A.S. Blix, L.Walløe and Ø. Ulltang (eds.) *Whales, seals, fish and man.* Elsevier. [*Developments in Marine Biology*] 4:720pp.

Tamura, T., Fujise, Y. and Shimazaki, K. 1998. Diet of minke whales *Balaenoptera acutorostrata* in the Northwestern part of the North Pacific in summer, 1994 and 1995. *Fisheries Science* 64(1): 71-6.

Tamura, T. and Fujise, Y. 2000a. Geographical and seasonal changes of prey species in the western North pacific minke whale. Paper SC/F2K/J22 presented to the JARPN review meeting, February 2000 (unpublished). 26pp.

Tamura, T. and Fujise, Y. 2000b. Daily and seasonal food consumption by the western North Pacific minke whale Paper SC/F2KJ24 presented to the JARPN review meeting, February 2000 (unpublished). 18pp.

Tamura, T. and Fujise, Y. 2002a. Food habit of common minke whales based on JARPN II. Apendix 4, pp 47-63. *In*: Government of Japan (Fujise, Y., Kawahara, S., Pastene, L.A. and Hatanaka, H. Eds.) 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 Meeting (Available from the IWC Secretariat).

Tamura, T and Fujise, Y. 2002b. Daily and seasonal prey consumption by common minke whale and Bryde's whale in the western North Pacific. Appendix 4. pp 85-96. *In*: Government of Japan (Fujise, Y., Kawahara, S., Pastene, L.A. and Hatanaka, H. eds.), 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 Meeting (Available from the IWC Secretariat).

Yoshida, H., Kato, H., Kishiro, T., Miyashita, T., Ryono, T., Tabata, S., Sakakibara, M., Saino, S., Hara, T., Hayashi, T., Tomizawa, Y., Tamai, K., Okamoto, R., Fukuoka, M., Watanabe, H., Tsunekawa, M. and Kawahara, S. 2004. Report of the coastal survey on common minke whales off Sanriku coast, northeast Japan: the Japanese Whale Rsearch Program under Special Permit in the western North Pacific-Phase II (JARPN II) in 2003 (Part II) – Coastal component. Paper SC/56/O14 submitted to the 56th IWC Scientific Committee Meeting, XXpp.

Table 1. Sample size of common minke whale off Kushiro region

| Year | Month | Number | Empty | Broken | Comment |
|---|---|---|---|---|---|
| 1996 | Aug. | 15 | 0 | 1 | |
| | Sept. | 15 | 0 | 0 | |
| 1999 | June | 44* | 0 | 0 | 3 Fundus broken |
| 2000 | Aug. | 1 | 0 | 0 | |
| | Sept. | 17 | 0 | 1 | 2 Fundus broken |
| 2001 | June | 10 | 0 | 0 | |
| 2002 | Aug. | 6 | 0 | 0 | |
| | Sept. | 54 | 1 | 3 | 6 Fundus broken |
| 2002C | Sept. | 37 | 0 | 2 | |
| | Oct. | 13 | 0 | 0 | 1 Fundus broken |

*3 inds. Out of research area.

Table 2. Wet weight composition (%) in the stomach contents of common minke whales off Kushiro region

| Month | Year | N | Pollock | Krill | Anchovy | Saury | Squid | Others |
|---|---|---|---|---|---|---|---|---|
| May-June | Average | | 35.2 | 6.5 | 58.3 | 0.0 | 0.1 | 0.0 |
| Aug.-Sept. | Average | All | 26.1 | 19.9 | 18.3 | 24.6 | 10.7 | 0.3 |

Table 3. Sex and maturity composition of common minke whales off Kushiro region

| Month | Sex and maturity | N | % |
|---|---|---|---|
| June | Immature male | 9 | 15.3 |
| | Immature female | 43 | 72.9 |
| | Mature male | 5 | 8.5 |
| | Mature female | 2 | 3.4 |
| Aug.-Oct. | Immature male | 45 | 28.5 |
| | Immature female | 87 | 55.1 |
| | Mature male | 9 | 5.7 |
| | Mature female | 17 | 10.8 |

Table 4. Estimated field metabolism and daily consumption during feeding period of common minke whales

| Sex maturity | Body weight (kg) | Field metabolism (KJ/day) | Daily consumption (Feeding period: kg) |
|---|---|---|---|
| Inmature male | 2,500 | 395,000 | 120.1 |
| Inmature female | 2,600 | 410,800 | 125.0 |
| Maturre male | 4,800 | 600,000 | 182.5 |
| Maturre female | 5,900 | 737,500 | 244.3 |

Table 5. Estimated seasonal consumption during feeding period (from May to October) of common minke whales off Kushiro Region

A. Total

| Abundance of common minke whale (individuals) | | Consumption (tons) | References |
|---|---|---|---|
| 821 | Best estimate | 25,631 | Miyashita, 1991,1992 (Sept.) |
| 284 | 95% confidence lower level | 8,866 | |
| 2,369 | 95% confidence upper level | 73,958 | |
| 1,194 | Best estimate | 37,275 | Hakamada and Matsuoka, 1999 (July) |
| 443 | 95% confidence lower level | 13,830 | |
| 3,215 | 95% confidence upper level | 100,369 | |
| 803 | Best estimate | 25,069 | Hakamada and Matsuoka, 2002 (Sept.) |
| 451 | 95% confidence lower level | 14,080 | |
| 1,428 | 95% confidence upper level | 44,581 | |

B. Krill

| Abundance of common minke whale (individuals) | | Consumption (tons) | References |
|---|---|---|---|
| 821 | Best estimate | 3,008 | Miyashita, 1991,1992 (Sept.) |
| 284 | 95% confidence lower level | 1,040 | |
| 2,369 | 95% confidence upper level | 8,679 | |
| 1,194 | Best estimate | 4,374 | Hakamada and Matsuoka, 1999 (July) |
| 443 | 95% confidence lower level | 1,623 | |
| 3,215 | 95% confidence upper level | 11,778 | |
| 803 | Best estimate | 2,942 | Hakamada and Matsuoka, 2002 (Sept.) |
| 451 | 95% confidence lower level | 1,652 | |
| 1,428 | 95% confidence upper level | 5,231 | |

C. Japanese anchovy

| Abundance of common minke whale (individuals) | | Consumption (tons) | References |
|---|---|---|---|
| 821 | Best estimate | 10,926 | Miyashita, 1991,1992 (Sept.) |
| 284 | 95% confidence lower level | 3,779 | |
| 2,369 | 95% confidence upper level | 31,526 | |
| 1,194 | Best estimate | 15,890 | Hakamada and Matsuoka, 1999 (July) |
| 443 | 95% confidence lower level | 5,895 | |
| 3,215 | 95% confidence upper level | 42,785 | |
| 803 | Best estimate | 10,686 | Hakamada and Matsuoka, 2002 (Sept.) |
| 451 | 95% confidence lower level | 6,002 | |
| 1,428 | 95% confidence upper level | 19,004 | |

D. Pacific saury

| Abundance of common minke whale (individuals) | | Consumption (tons) | References |
|---|---|---|---|
| 821 | Best estimate | 3,486 | Miyashita, 1991,1992 (Sept.) |
| 284 | 95% confidence lower level | 1,206 | |
| 2,369 | 95% confidence upper level | 10,059 | |
| 1,194 | Best estimate | 5,070 | Hakamada and Matsuoka, 1999 (July) |
| 443 | 95% confidence lower level | 1,881 | |
| 3,215 | 95% confidence upper level | 13,652 | |
| 803 | Best estimate | 3,410 | Hakamada and Matsuoka, 2002 (Sept.) |
| 451 | 95% confidence lower level | 1,915 | |
| 1,428 | 95% confidence upper level | 6,064 | |

E. Walleye pollock

| Abundance of common minke whale (individuals) | | Consumption (tons) | References |
|---|---|---|---|
| 821 | Best estimate | 6,495 | Miyashita, 1991,1992 (Sept.) |
| 284 | 95% confidence lower level | 2,247 | |
| 2,369 | 95% confidence upper level | 18,742 | |
| 1,194 | Best estimate | 9,446 | Hakamada and Matsuoka, 1999 (July) |
| 443 | 95% confidence lower level | 3,505 | |
| 3,215 | 95% confidence upper level | 25,435 | |
| 803 | Best estimate | 6,353 | Hakamada and Matsuoka, 2002 (Sept.) |
| 451 | 95% confidence lower level | 3,568 | |
| 1,428 | 95% confidence upper level | 11,297 | |

F. Japanese common squid

| Abundance of common minke whale (individuals) | | Consumption (tons) | References |
|---|---|---|---|
| 821 | Best estimate | 1,678 | Miyashita, 1991,1992 (Sept.) |
| 284 | 95% confidence lower level | 580 | |
| 2,369 | 95% confidence upper level | 4,841 | |
| 1,194 | Best estimate | 2,440 | Hakamada and Matsuoka, 1999 (July) |
| 443 | 95% confidence lower level | 905 | |
| 3,215 | 95% confidence upper level | 6,570 | |
| 803 | Best estimate | 1,641 | Hakamada and Matsuoka, 2002 (Sept.) |
| 451 | 95% confidence lower level | 922 | |
| 1,428 | 95% confidence upper level | 2,918 | |

Table 6. Fish catches of Pacific saury, walleye pollock and Japanese common squid off Kushiro region from May to October in 2002

- A. Pacific saury

| Month/Location | Nemuro | Attkeshi | Kushiro | Hiroo | Total |
|---|---|---|---|---|---|
| May | | | | | |
| June | | | | | |
| July | 286 | 248 | 8 | 0 | 542 |
| August | 8,541 | 5,327 | 6,886 | 32 | 20,786 |
| September | 18,986 | 11,267 | 11,978 | 14 | 42,245 |
| October | 19,415 | 10,514 | 11,908 | 17 | 41,854 |
| Total | 47,228 | 27,356 | 30,780 | 63 | 105,427 |

- B. Walleye pollock

| Month/Location | Nemuro | Attkeshi | Kushiro | Hiroo | Total |
|---|---|---|---|---|---|
| May | 1 | | 1,836 | | 1,837 |
| June | | | 99 | | 99 |
| July | | | 7 | | 7 |
| August | 1 | | 4 | | 5 |
| September | 2 | | 15,044 | 4 | 15,050 |
| October | 3 | | 7,451 | 7 | 7,461 |
| Total | 6 | 0 | 22,506 | 11 | 22,523 |

- C. Japanese common squid

| Month/Location | Nemuro | Attkeshi | Kushiro | Hiroo | Total |
|---|---|---|---|---|---|
| May | | | | | 0 |
| June | | | | | 0 |
| July | 24 | | | 47 | 71 |
| August | 87 | 1 | 5 | 68 | 161 |
| September | | 4 | 277 | 106 | 387 |
| October | | 2 | 300 | 56 | 358 |
| Total | 111 | 7 | 582 | 277 | 977 |

Table 7. Estimated biomass of each prey off Kushiro region using by echo sounder (from Murase *et al*. 2002)

A. June (2001 JARPN II (19-24 Jun.))

| Prey species | Estimated biomass ($10^3$ tons) |
|---|---|
| Krill | 101.9 |
| Japanese anchovy | 3.5 |
| Walleye pollock | 152.3 |

B. August (2000 JARPN II (5-7 Aug.))

| Prey species | Estimated biomass ($10^3$ tons) |
|---|---|
| Krill | 349.0 |
| Japanese anchovy | 26.9 |
| Walleye pollock | - |

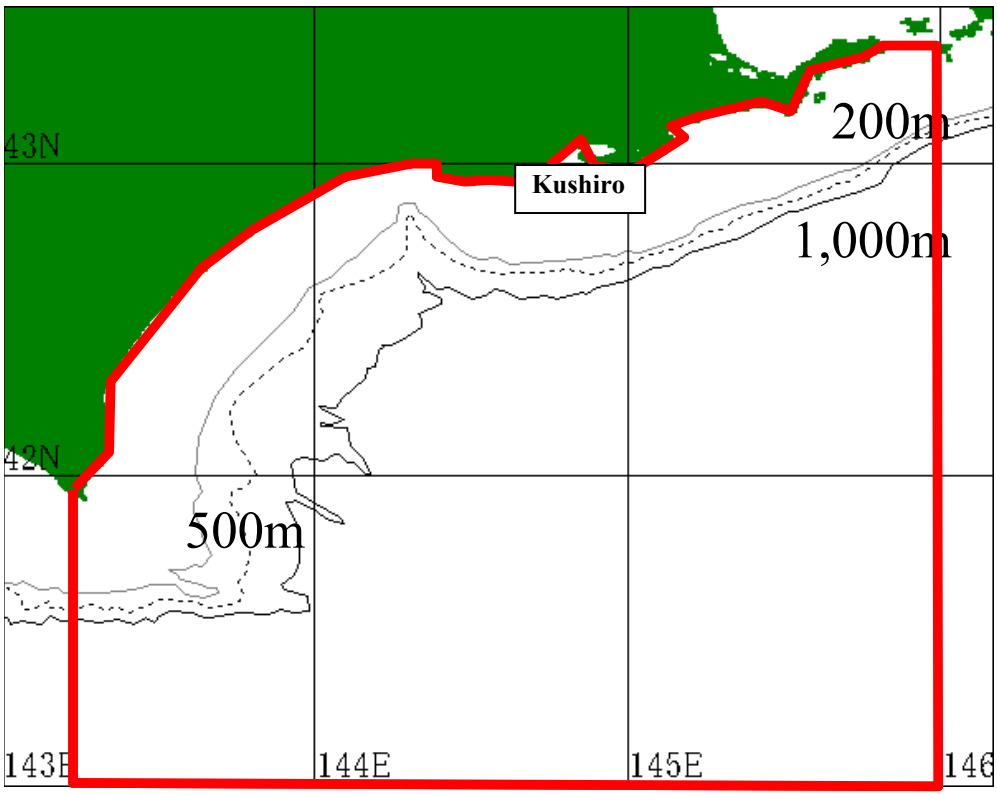
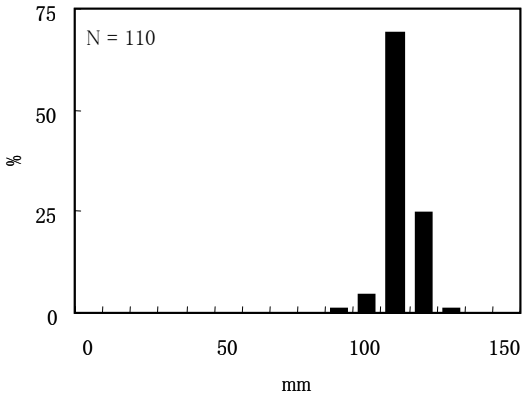


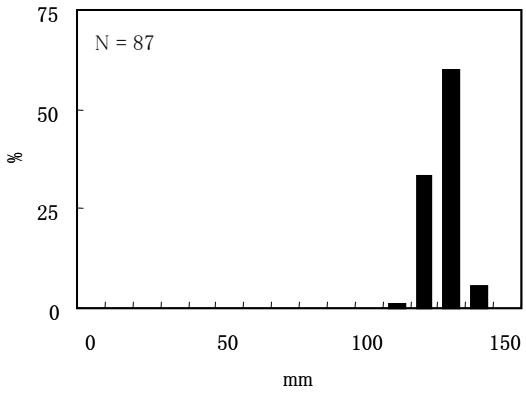

Fig. 1. Research area off Kushiro region

(A) Japanese anchovy

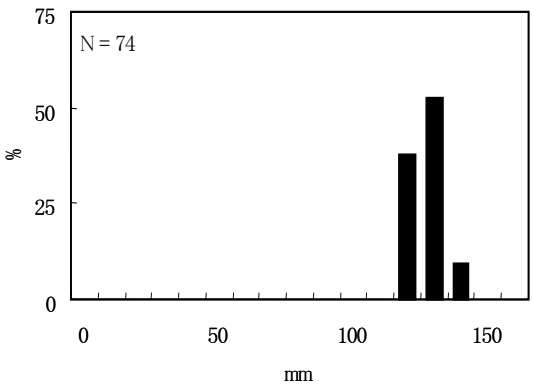
- (a). 1999 JARPN (June)




(b). 2000 JARPN II (August and September)




- (c). 2001 JARPN II (May and July)




(d). 2002 JARPN II (August and September)

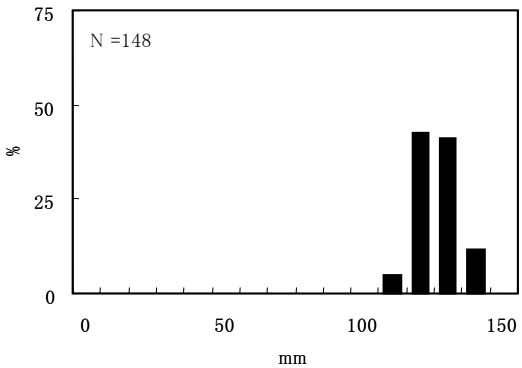
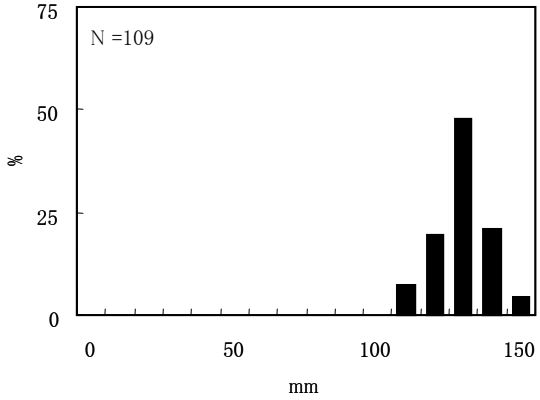


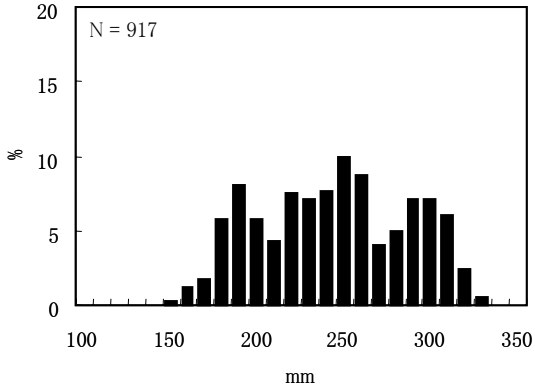

Fig. 2. Body length of distribution in the stomachs of common minke whales off Kushiro region.

- (e). 2002 JARPN II coastal (September and October)

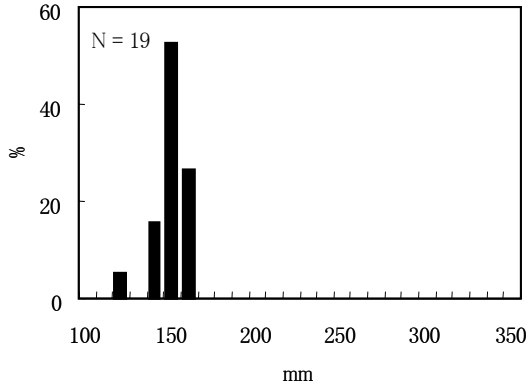



(B) Pacific saury

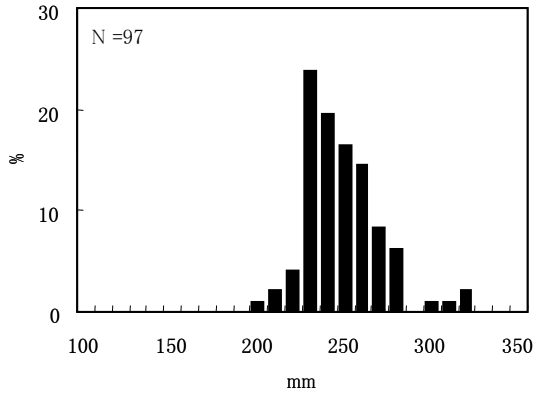
- (a). 1996 JARPN (August and September)




- (b). 2000 JARPN II (August)




- (c). 2002 JARPN II (August and September)




- (d). 2002 JARPN II coastal (September and October)

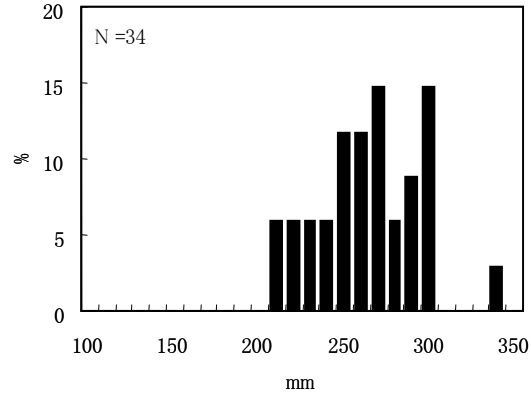
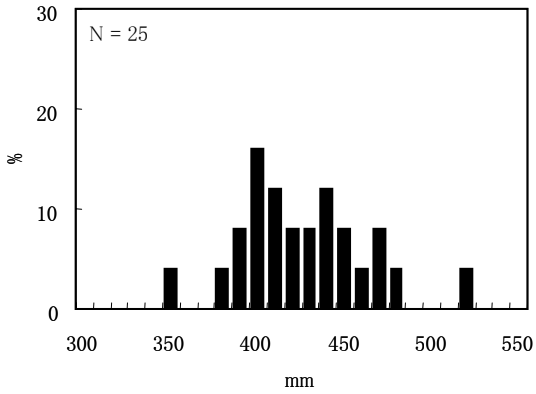


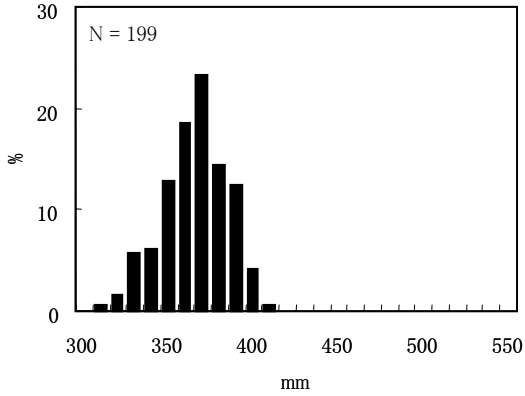

Fig. 2. Continued

(C) Walleye pollock

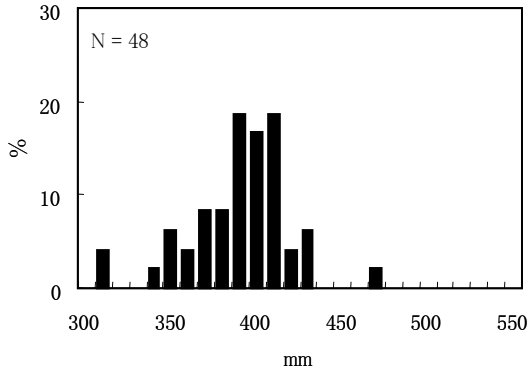
- (a). 1996 JARPN (September)



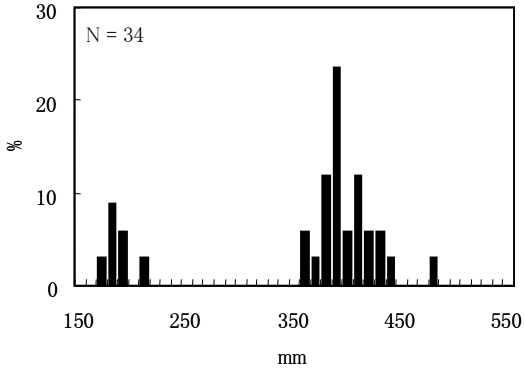

- (b). 1999 JARPN II (June)



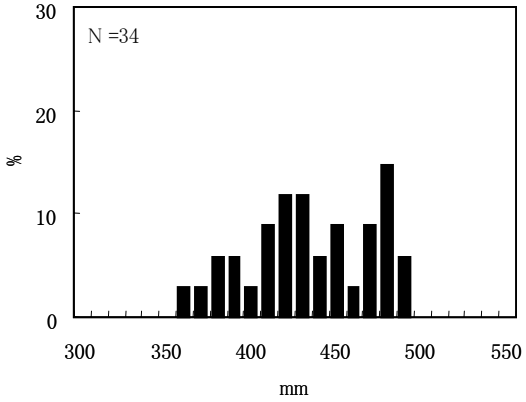

- (c). 2000 JARPN II (August and September)




- (d). 2001 JARPN II (June)

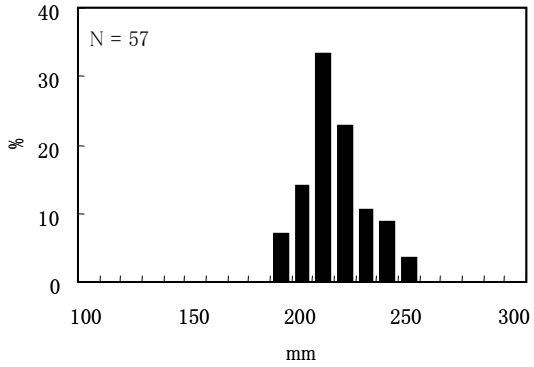



- (e). 2002 JARPN II coastal (September and October)




(D) Japanese common squid

- (a). 2000 JARPN II (September)




- (b). 2002 JARPN II coastal (September and October)

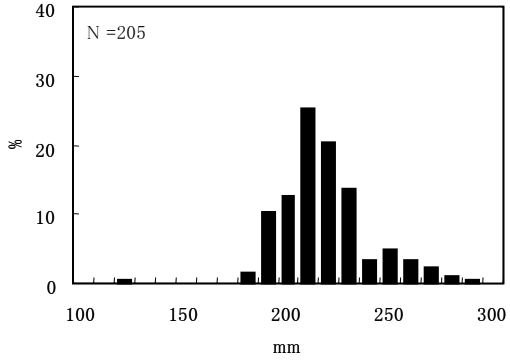
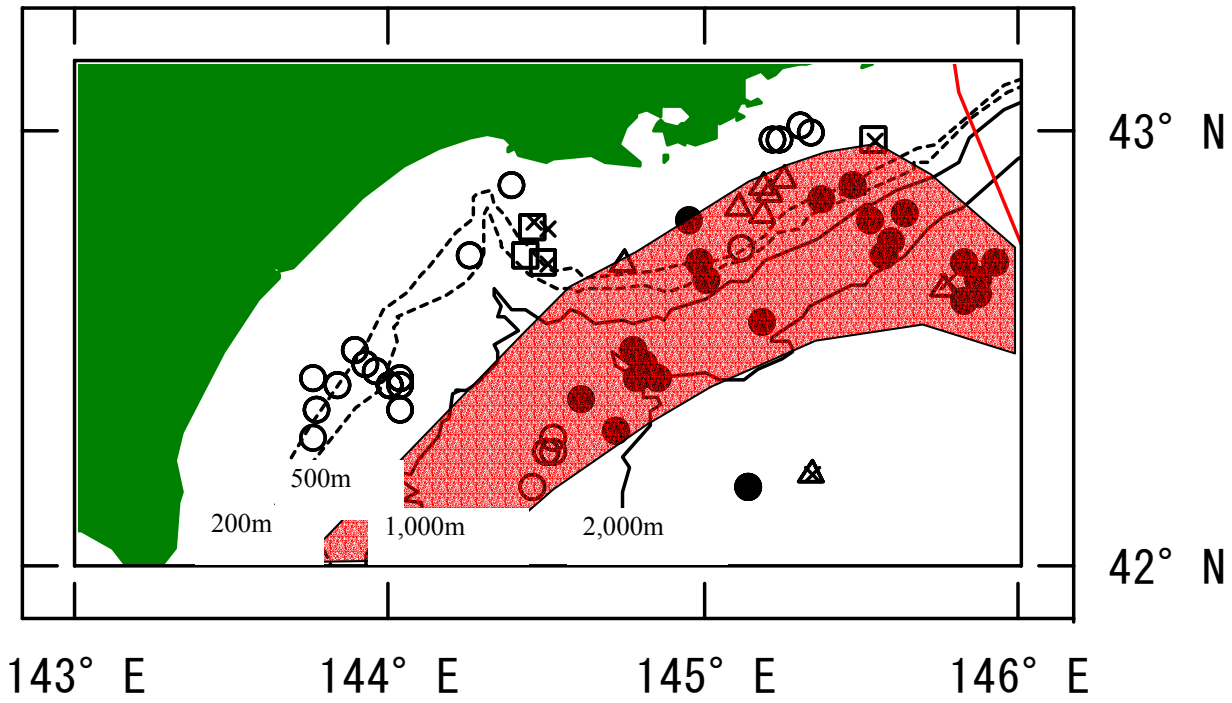



Fig. 2. Continued




△: Krill; ○: Japanese anchovy; ●: Pacific saury; □: Walleye pollock; ×: Japanese common squid

Fig. 3. Sighting positions and stomach contents of common minke whales sampled in JARPNII 2002.

（Fishing ground (shaded areas) of Pacific saury off Kushiro region during 18 to 24 September 2002. The information was obtained from telex No. 1801 relating to the fishing ground supplied to the Fishing Service Centre in Japan.）