

Cruise Report of the second phase of the Japanese Whale Research Program under Special Permit in the Western North Pacific (JARPN II) in 2009 (part I) - Offshore component –

BANDO, T. ¹⁾, KIWADA, H. ¹⁾, MOGOE, T. ¹⁾, ISODA, T. ¹⁾, MORI, M. ²⁾, TSUNEKAWA, M. ²⁾, YOSHIMURA, I. ²⁾, NAKAI, K. ¹⁾, SATO, H. ¹⁾, TANAKA, H. ¹⁾, INAGAKI, M. ¹⁾, TAMAHASHI, K. ²⁾, YOSHIDA, K. ²⁾, MORINE, G. ²⁾, WATANABE, H. ³⁾, FUJIWARA, G. ³⁾, EGUCHI, K. ²⁾, AND TAMURA, T. ¹⁾

1) *The Institute of Cetacean Research, 4-5, Toyomi-cho, Chuo-ku, Tokyo, 104-0055, Japan,*

2) *Kyodo Senpaku Co. Ltd., 4-5, Toyomi-cho, Chuo-ku, Tokyo, 104-0055, Japan,*

3) *National Research Institute of Far Seas Fisheries, 2-12-4, Fukuura, Kanazawa, Yokohama, Kanagawa 212-0055, Japan*

Contact e-mail: bando@cetacean.jp

ABSTRACT

The eighth cruise of the full-scale survey of the second phase of the Japanese Whale Research Program under Special Permit in the Western North Pacific (JARPN II) -offshore component- was conducted from 10 May to 29 July 2009 in sub-areas 7, 8 and 9 of the western North Pacific. The objectives of the JARPN II are (a) feeding ecology and ecosystem studies, (b) monitoring environmental pollutants in cetaceans and the marine ecosystem and (c) elucidation of stock structure. Target species in the whale component of the programme are common minke whale *Balaenoptera acutorostrata*, sei whale *B. borealis*, Bryde's whale *B. edeni* and sperm whale *Physeter macrocephalus*. A total of five research vessels was used: one trawl survey vessel equipped with scientific echo sounder (TSV), one dedicated sighting vessel (SV), two sighting/sampling vessels (SSVs) and one research base vessel. A total of 2,617 n.miles was surveyed in a period of 27 days by SV. During that period 11 common minke, 96 sei, 6 Bryde's and 120 sperm whales were sighted by the SV. A total of 3,757 n.miles was surveyed in a period of 71 days by SSVs. During that period 52 common minke, 386 sei, 87 Bryde's and 167 sperm whales were sighted by the SSVs. A total of 43 common minke, 100 sei, 50 Bryde's and one sperm whales was sampled by the SSVs. All whales sampled were examined on board the research base vessel. As in previous surveys, common minke whales fed mainly on Pacific saury (*Cololabis saira*) and Japanese anchovy (*Engraulis japonicus*). Bryde's whales fed mainly on Japanese anchovy and Oceanic lightfish. Sei whales fed mainly on copepods, Japanese anchovy and mackerels. Dominant preys in the stomach of one sperm whale were various kinds of squids, which inhabit the mid- and deep-waters. These data will be used in the development of ecosystem modelling.

KEYWORDS: PACIFIC OCEAN; COMMON MINKE WHALE; BRYDE'S WHALE; SEI WHALE; SPERM WHALE; MONITORING; FOOD/PREY; ECOSYSTEM; SCIENTIFIC PERMITS

BACKGROUND

After the Japanese Whale Research Program under Special Permit in the Western North Pacific (JARPN) from 1994 to 1999, the second phase of Japanese Whale Research Program under Special Permit in the Western North Pacific (JARPNII) was started in the 2000 summer season as a two-year feasibility study. Based on the success of the feasibility study (Government of Japan, 2002a) and increasingly strong support from international fisheries organizations, including FAO, for research to improve multi-species approaches to management, JARPN II started as a full-scale research program in 2002. The full-scale study aimed mainly i) to evaluate the feeding ecology and ecosystem studies, ii) to monitor environmental pollutants in cetaceans and the marine ecosystem and iii) to elucidate the stock structure (Government of Japan, 2002b).

The full-scale JARPN II plan involved two survey components: the 'offshore' survey was covered by the *Nisshin Maru* research unit and the two 'coastal' surveys (Sanriku and Kushiro) were covered by catcher boats of small type whaling. The coastal component was necessary to cover the temporal and spatial gaps, which could not be covered by the *Nisshin Maru* unit (Government of Japan, 2002b).

The research area of offshore component was set in sub-areas 7, 8 and 9, and the target species and sample sizes in 2009 were set as follows: 100 common minke whales (in addition, 120 were to be sampled by the coastal survey); 100 sei whales, 50 Bryde's whales and 10 sperm whales.

In January 2009 IWC/SC conducted the Expert Workshop to review the ongoing JARPN II Programme (IWC, 2009). The results presented on the three main objectives of JARPN II (Feeding ecology and ecosystem studies, marine pollutants and stock structure) were discussed by the Independent Expert Panel (IEP). Constructive discussions were

conducted and some recommendations were derived from the IEP. These recommendations will be reflected to the future research activities of JARPN II.

In this paper, we present an outline of the eighth full-scale survey of the JARPN II -offshore component-, which was conducted from 10 May to 29 July 2009.

MATERIALS AND METHODS

Research area

Sub-areas 7, 8 and 9, excluding the EEZ zones of foreign countries, were the research area (Fig. 1). These sub-areas were further divided as follows:

Sub-area 7: Five small blocks (7N, 7MI, 7MO, 7SI and 7SO) stratified for taking into account satellite information on water temperature.

Sub-areas 8 and 9: Four small blocks were divided at latitude of 40°N in each sub area (8N and 8S, 9N and 9S).

Research vessels

Five research vessels were used. The research base vessel *Nisshin Maru* (NM: 8,044GT) commanded the research and was the platform for biological examination of whale samples and processing of by-products. The *Yushin Maru* No.2 (YS2: 747GT) and *Yushin Maru* No.3 (YS3: 742GT) were used as the sighting/sampling vessels (SSVs), which conducted sighting activities, sampling of targeted whale species and various experiments and observations. The *Yushin Maru* (YS1: 720GT), was used as dedicated sighting vessel (SV). The *Shunyo Maru* (SYO: 887GT) was engaged in trawl surveys and echo sounder surveys. This vessel also conducted the mid-water trawl net and MOCNESS net sampling. Furthermore, this vessel conducted the oceanographic observations using CTD.

Survey components

The survey was composed of three main components: whale survey, sighting survey and prey species survey.

Whale survey

Vessels: Three research vessels (NM, YS2 and YS3)

Research area: Sub-areas 7, 8 and 9. In addition, a ‘special monitoring survey’ (SMS) was undertaken in some areas where the number of common minke, Bryde’s and sei whales was expected to be abundant.

Research period

Between 16 May and 25 July

Dedicated Sighting survey

Vessels: One research vessel (YS1)

Research area: Sub-areas 8 and 9

Research period:

Between 24 May and 19 June

Cooperative survey on the prey species and whale sampling

Vessels: Four research vessels (NM, YS2, YS3 and SYO)

Between 23 May and 23 June another vessel conducted sighting and experiment activities in the western North Pacific (*Kaiko Maru*). Because the survey plan for this vessel was made independently from the other vessels in JARPN II, results for *Kaiko Maru* are not presented here. Instead they are presented in the Japan Progress Report of Cetacean Research presented to the 2010 IWC SC meeting.

Research area:

First period (Southern block) : A part of sub areas 8 and 9 (NM, YS2, YS3 and SYO)

Second period (Northern block) : A part of sub areas 8 and 9 (NM, YS2, YS3 and SYO)

Research period:

First period (Southern block) : Between 5 July and 16 July (NM, YS2, YS3 and SYO)

Second period (Northern block) : Between 17 July and 22 July (NM, YS2, YS3 and SYO)

Methods for setting cruise track line

Whale survey

Track lines and allocation of vessels were made as in previous JARPN and JARPN II surveys (Fujise *et al.*, 1995, 1996, 1997, 2000, 2001, 2002, 2003; Ishikawa *et al.*, 1997; Zenitani *et al.*, 1999; Tamura *et al.*, 2004, 2005, 2006, 2009a, 2009b, Matuoka *et al.*, 2007). The zigzag-shaped track line was established on an arbitrary basis in each sub-area. Furthermore, some 'special monitoring surveys' (SMS) were conducted in areas where the abundance of common minke whales, Bryde's and sei whales was expected to be high. Track line in the SMS was designed separately from the original track line. Two SSVs were allocated to these tracks with the allocation being changed every day. The research course for the SSVs consisted of one main track and one parallel track established in 7 n.miles apart from main course.

Dedicated Sighting survey

Apart from the sampling activities, an independent track line for dedicated sighting survey was designed in the research area.

Sighting surveys

Sighting procedure both for the whale survey and dedicated sighting survey was similar to the previous surveys of JARPN and JARPN II (Fujise *et al.*, 1995, 1996, 1997, 2000, 2001, 2002, 2003; Ishikawa *et al.*, 1997; Zenitani *et al.*, 1999; Tamura *et al.*, 2004, 2005, 2006, 2007, 2009a, 2009b, Matuoka *et al.*, 2008). In the research area sighting was conducted mainly under closing mode. Furthermore two modalities of sighting in closing mode were adopted, *NSC* and *NSS modes*, by taking into consideration weather and sea conditions. The *NSC* and *NSS modes* were the same as *BC* and *BS modes* in the previous JARPN surveys, respectively. The conditions to conduct surveys under *NSC mode* were similar to those established in Japanese sighting surveys conducted by the National Research Institute of Far Seas Fisheries (*i.e.* visibility of 2 n.miles or more and wind force of 4 or below). The *NSS mode* was used under bad weather conditions such as heavy rain and fog when the collection of whale samples was still possible. This *NSS mode* was used only by SSV vessels. These two mode surveys were recorded separately for future analysis. Also an *ASP mode* was used (closing mode survey without sampling activities under normal sighting conditions).

During the transit from homeport (HP) to research area (RA) and from RA to HP, the *NSP mode* was adopted (passing mode without sampling activities under normal sighting conditions).

Closing was performed mainly on sightings of common minke, Bryde's, sei and sperm whales. Furthermore closing was made on sightings of large whales, such as blue, humpback, right and fin whales. In these cases, closing was done in order to confirm species and school size and in order to conduct some experiments.

Sampling of common minke, Bryde's, Sei and sperm whales

The target species and sample sizes in 2009 JARPN II offshore component were set as follows: 100 common minke whales; 100 sei whales, 50 Bryde's whales and 10 sperm whales.

Most of the target whales sighted on the track line was approached for sampling. Furthermore sampling effort was applied outside the established research hours (Main time: 07:00-19:00 (12 hrs)), if collection of whale samples was considered possible.

For schools consisting of two or more animals, numbering was made for all the whales in the school; to set sampling order randomly in accordance with the table of random numbers (Kato *et al.*, 1989). Cow and calf pairs were not targeted for sampling.

Sampled whales were immediately transported to a research base vessel, where biological measurements and sampling were carried out.

Experiments

The following experiments and observations were conducted by the sighting/sampling vessels (YS2 and YS3):

1. Sighting distance and angle experiments to examine the precision of sighting data.
2. Biopsy sampling on gray, blue, fin, humpback and right whales.
3. Photographic records of natural marks on blue, humpback and right whales.
4. Feeding behaviour patterns of large whale species (blue, fin, sei, Bryde's, common minke, humpback, right and sperm whales).

On board the SV (*YSI*), the following experiments and observations were conducted:

1. Sighting distance and angle experiment to examine the precision of sighting data.
2. Biopsy sampling on gray, blue, fin, sei, Bryde's, minke, humpback, right and sperm whales.
3. Photographic records of natural marks on blue, humpback and right whales.
4. Feeding behaviour patterns of large whales.
5. Preliminary experiments on attachment of satellite tagging to sei and Bryde's whales.

On board the research base vessel (*NM*), the following experiments and observations were conducted:

1. Observations of marine debris in the sea were conducted from the wheelhouse (during transit cruises)

On board the prey survey vessel (*SYO*), the following experiments were conducted:

1. Estimate abundance of prey species of common minke and other large whale species using an echo sounder system.
2. Prey survey using echo sounder, Mid-water trawl net, MOCNESS net and plankton net.
3. Oceanographic observations using CTD, TDR, and OPCS.

RESULTS AND DISCUSSIONS

Searching distance

Track line covered by the two sighting/sampling vessels (SSVs) is shown in Fig. 2. The total searching distance for SSVs was 3,757 n.miles.

Track line covered by the dedicated sighting vessel (SV) is shown in Fig. 4. The total searching distance was 2,617 n.miles.

Sightings of common minke, Bryde's, sei and sperm whales

Sighting and sampling vessels (SSVs)

A total of 51 schools (52 individuals) of common minke whales was sighted, consisting of 9 schools (10 individuals) of primary and 42 schools (42 individuals) of secondary sightings. For sei whale, 213 schools (386 individuals) were sighted, consisting of 93 schools (161 individuals) of primary sightings and 120 schools (225 individuals) of secondary sightings. For Bryde's whale, 72 schools (87 individuals) were sighted, consisting of 47 schools (59 individuals) of primary sightings and 25 schools (28 individuals) of secondary sightings. For sperm whale, 82 schools (167 individuals) were observed, consisting of 39 schools (84 individuals) of primary sightings and 43 schools (83 individuals) of secondary sightings (Table 1).

Fig. 3 shows the distribution of common minke, sei, Bryde's and sperm whales sighted by the SSVs in the sub-areas 7, 8 and 9. Sei whales and Bryde's whales were sighted mainly in offshore of sub-areas 8 and 9. On the other hand, common minke whales were sighted mainly in sub-areas 7 and 8. Sperm whales were widely distributed in research area.

Dedicated sighting vessels (SV)

During the research cruise, 9 schools (11 individuals) of common minke whales were sighted, all sighting consisting of primary sightings. For sei whale, 52 schools (96 individuals) were sighted, consisting of 51 schools (95 individuals) of primary sightings and 1 school (1 individual) of secondary sightings. For Bryde's whale, 6 schools (6 individuals) were sighted, all sighting consisting of primary sightings. For sperm whale, 37 schools (120 individuals) were sighted, consisting of 35 schools (103 individuals) of primary sightings and 2 schools (17 individuals) of secondary sightings (Fig. 4, Table 1).

Sightings of other large cetacean species

Sighting and sampling vessels (SSVs)

Table 1 also shows the number of sightings for other large whale species made by the SSVs, including large baleen whales such as blue (13 schs./15 inds.), fin (34 schs./44 inds.), and humpback whales (19 schs./21 inds.).

Dedicated sighting vessel (SV)

Large baleen whales such as fin (4 schs./6 inds.) and humpback whales (2 schs./2 inds.) were found in the sub-areas 8 and 9 (Table 1).

Sampling numbers and biological research for common minke, Bryde's, sei and sperm whales

A total of 43 common minke whales (Male: 36 individuals, Female: 7 individuals), 100 sei whales (Male: 46 individuals, Female: 54 individuals), 50 Bryde's whales (Male: 18 individuals, Female: 32 individuals) and one female sperm whale were sampled. Struck and lost occurred in one case for sei whale. Table 2 summarizes the biological data and samples collected from whales. A total of 53 research items was covered. These items are related to the studies conducted under the three main objectives of the JARPN II: study on feeding ecology of whales and marine ecosystem, pollution studies and elucidation of stock structure.

Composition of sex and sexual maturity status of common minke, sei and Bryde's whales are shown in Table 3. Statistics of body length of common minke, sei, Bryde's and sei whales is shown in Table 4. Mean body length of common minke whales is 7.28 m and 6.86 m for males and females, respectively. For sei whales, those were 13.37 m and 14.11 m for males and females, respectively. For Bryde's whales, those are 11.79 m and 12.02 m for males and females, respectively. For sperm whale, body length of collected female was 10.26m.

Geographical distribution of common minke, sei, Bryde's and sperm whale samples are also shown in Fig. 5 based on the sighting positions.

Distribution and food habit

During the research season (from May to July), common minke whales fed mainly on Pacific saury and Japanese anchovy (Table 5). Sei whales were distributed widely in the offshore area. From May to July, they fed mainly on copepods, Japanese anchovy and mackerels (Table 5). Bryde's whales were distributed in the southern part of the research area. In this survey, Bryde's whales were firstly sampled from offshore area (sub-area 9) in June. They fed mainly on Japanese anchovy and Oceanic lightfish (Table 5). Sperm whales were also distributed widely in the research area. They fed mainly on deep sea squids.

Experiments*Biopsy sampling trial*

Table 6 shows the results of biopsy skin sampling. A total of nine blue whales, fifty-two sei whales, two Bryde's whales and eighteen sperm whales were targeted for biopsy sampling by the SV and SSVs. As a result, six blue whales, nine sei whales and one sperm whale biopsy skin samples were collected.

Natural marks (photo ID) for large whales

Table 7 shows the results of the photo-ID experiments for large whales. A total of eight blue whales were targeted by the SSVs. No experiment was conducted in the SV.

Feeding and excretion behaviour for large baleen whales

The SV and SSVs had planned to conduct recording of the feeding and excretion behaviour of large baleen whales using a photograph. No case was observed in this survey.

Examination of attachment of satellite tag to sei and Bryde's whale

The SV had planned to try attaching satellite tags to sei and Bryde's whales. A total of seven sei whales were targeted and one satellite tag was attached, however, no data was obtained.

ACKNOWLEDGMENTS

The authors are greatly indebted to Joji Morishita and Shigeki Takaya of the Fisheries Agency of Japan, Hidehiro Kato, Tokyo University of Marine Science and Technology, and Hiroshi Hatanaka, Seiji Ohsumi, Yoshihiro Fujise, Tsutomu Tamura, L.A. Pastene, and Shigetoshi Nishiwaki of The Institute of Cetacean Research (ICR) for their guidance in the design and implementation of the research. We thank all crew of the research vessels (NM, YS1, YS2, YS3 and SYO) and the staff of the ICR, Kyodo-Senpaku Co. Ltd and NRFSF. The present research project (JARPN II) was funded by a subsidy from the Ministry of Agriculture, Forestry and Fisheries, Government of Japan.

REFERENCES

- Fujise, Y., Kishiro, T., Zenitani, R., Matsuoka, K., Kawasaki, M. and Shimamoto, K. 1995. Cruise report of the Japanese whale research program under a special permit for North Pacific minke whales in 1994. Paper SC/47/NP3 presented to the IWC Scientific Committee, May 1995 (unpublished). 29pp.
- Fujise, Y., Iwasaki, T., Zenitani, R., Araki, J., Matsuoka, K., Tamura, T., Aono, S., Yoshida, T., Hidaka, H., Nibe, T. and Tohyama, D. 1996. Cruise report of the Japanese whale research program under a special permit for North Pacific minke whales in 1995 with the results of a preliminary analysis of data collected. Paper SC/48/Np13 presented to the IWC Scientific Committee, June 1996 (unpublished). 39pp.
- Fujise, Y., Shimada, H., Zenitani, R., Goto, M., Tamura, T., Lindström, U., Uchida, A., Yoshida, H., Shimamoto, K., Yuzu, S., Kasai, H., Kinoshita, T., Iwata, T. and Tohyama, 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., 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., Tohyama, D. and Kawahara, S. 2003. Cruise report of the Japanese whale research program under special permit in the western North Pacific – Phase II (JARPNII) in 2002 (Part I). Paper SC/55/O7 presented to the IWC Scientific Committee, May 2003 (unpublished). 41pp.
- Government of Japan. 2002a. Report of the 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 presented to the IWC Scientific Committee, May 2002 (unpublished). 202pp.
- Government of Japan. 2002b. 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.
- International Whaling Commission. 2009. The report of the Expert Workshop to review the ongoing JARPN II Programme. Paper SC/61/Rep 1 presented the IWC Scientific Committee, May 2009 (unpublished). 57pp.
- Ishikawa, H., Yuzu, S., Shimamoto, K., Bando, T., Ohshima, K., Kasai, H., Kinoshita, T., Mizushima, Y., Iwakami, H., Nibe, T., Hosoyama, T., Kuramochi, T., Numano, K. and Miyamoto, M. 1997. Cruise report of the Japanese Whale Research Program under a Special Permit in the North Pacific (JARPN) in 1997. Paper SC/49/NP9 presented to the IWC Scientific Committee, September 1997 (unpublished). 28pp.
- Kato, H., Hiroyama, H., Fujise, Y. and Ono, K. 1989. Preliminary report of the 1987/88 Japanese feasibility study of the special permit proposal for Southern Hemisphere minke whales. Report of the International Whaling Commission, 39: 235-248.
- Matsuoka, K., Otani, S., Isoda, T., Wada, A., Kumagai, S., Ohshima, T., Yoshimura, I., Sugiyama, K., Aki, M., Kato, K., Bhuiyan M.M.U., Funasaka, N., Suzuki, Y., Sudo, R., Motohashi, Y., Mori, M., Tsunekawa, M., Inagake, D., Murase, H. and Ogawa, T. 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 - Offshore component -. Paper SC/60/O5 submitted to the 60th IWC Scientific Committee Meeting.
- Tamura, T., Fujise, Y., Bando, T., Yasunaga, G., Konishi, K., Kiwada, H., Isoda, T., Itoh, S. Machida, S., Tsunekawa, M., Konagai, T., Takamatsu, T., Ohshima, T., Honjo, K., Matsuoka, T., Zharikov, K.A., Yong, Rock AN, Tohyama, D. and Kawahara, S. 2004. Cruise Report of the Japanese Whale Research Program under Special Permit in the western North Pacific -Phase II (JARPN II) in 2003 (part I) – Offshore component –. Paper SC/56/O13 presented to the IWC Scientific Committee, June 2004 (unpublished). 46pp.

- Tamura, T., Fujise, Y., Mogoe, T., Kanda, N., Yasunaga, G., Konishi, K., Kiwada, H., Ogihara, M., Hasegawa, A., Kitajima, M., Sugiyama, T., Sasaki, T., Mori, M., Teraoka, T., Tsunekawa, M., Fukutome, K., Zharikov, K.A., NA, Jong-Hun., Tohyama, D., Inagake, D. and Kawahara, S. 2005. Cruise Report of the Japanese Whale Research Program under Special Permit in the western North Pacific -Phase II (JARPN II) in 2004 (part I) – Offshore component –. Paper SC/57/O3 presented to the IWC Scientific Committee, June 2005 (unpublished). 33pp
- Tamura, T., Otani, S., Kiwada, H., Mori, M., Konishi, K., Isoda, T., Wada, A., Ogihara, M., Hasegawa, A., Kumagai, S., Komatsu, W., Hayasaka, K., Fukutome, M., Siozaki, M., Zharikov, K.A., NA, Jong-Hun., Ogawa, T., Watanabe, H., Yonezaki, S., Inagake, D. 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 – Offshore component –. Paper SC/58/O8 presented to the IWC Scientific Committee, June 2006 (unpublished). 52pp
- Tamura, T., Otani, S., Isoda, T., Wada, A., Yonezaki, S., Mori, M., Tsunekawa, M., Fukutome, K., Nakai, K., Satoh, H., Nomura, I., Nagatsuka, S., Umatni, M., Koyanagi, T., Takamatsu, T., Kawabe, S., Kandabashi, S., Watanabe, H., Kumagai, S., Sato, H. and Ogawa, T. 2009a. Cruise Report of the second phase of the Japanese Whale Research Program under Special Permit in the Western North Pacific (JARPN II) in 2008 (part I) - Offshore component –. Paper SC/61/O4 presented to the IWC Scientific Committee, May 2009 (unpublished). 49pp
- Tamura, T., Matsuoka, K. and Fujise, Y. 2009b. Methodology and survey procedure under the JARPN II - offshore component- with special emphasis on whale sampling procedures. Paper SC/J09/JR4 presented to the JARPN II review meeting, January 2009 (unpublished). 36pp
- Tamura, T., Konishi, K., Isoda, T., Okamoto, R. and Bando, T. 2009c. Prey consumption and feeding habits of common minke, sei and Bryde's whales in the western North Pacific. Paper SC/J09/JR16 presented to the JARPN II review meeting, January 2009 (unpublished). 36pp
- Zenitani, R., Fujise, Y., Matsuoka, K., Tamura, T., Bando, T., Ichihashi, H., Shimokawa, T., Krasnenko, A.S., Taguchi F., Kinoshita, T., Mori, M., Watanabe, M., Ichinomiya, D., Nakamura, M., Sakai, K., Matsuzaka, K., Kamei, H. and Tohyama, D. 1999. Cruise report of the Japanese Whale Research Program under a Special Permit in the North Pacific in 1998. Paper SC/51/RMP7 presented to the IWC Scientific Committee, May 1999 (unpublished). 20pp

Table 1. List of cetacean species and number of sightings (no. schools/no. individuals)

Sighting/sampling vessels (YS2 and YS3)

Species	Primary		Secondary		Total	
	Sch.	Ind.	Sch.	Ind.	Sch.	Ind.
Common minke whale	9	10	42	42	51	52
Like minke whale	0	0	7	7	7	7
Sei whale	93	161	120	225	213	386
Bryde's whale	47	59	25	28	72	87
Sperm whale	39	84	43	83	82	167
Blue whale	6	7	7	8	13	15
Fin whale	20	24	14	20	34	44
Humpback whale	11	12	8	9	19	21

Dedicated sighting vessel (YS1)

Species	Primary		Secondary		Total	
	Sch.	Ind.	Sch.	Ind.	Sch.	Ind.
Common minke whale	9	11	0	0	9	11
Sei whale	51	95	1	1	52	96
Bryde's whale	6	6	0	0	6	6
Sperm whale	35	103	2	17	37	120
Blue whale	0	0	0	0	0	0
Fin whale	4	6	0	0	4	6
Humpback whale	2	2	0	0	2	2

Table 2. Summary of collected biological data and samples.

Research items	Common minke			Sei whale			Bryde's whale			Sperm whale		
	F	M	T	F	M	T	F	M	T	F	M	T
Body length and sex	7	36	43	54	46	100	32	18	50	1	0	1
External body proportion	7	36	43	54	46	100	32	18	50	1	0	1
Photographic record and external character	7	36	43	54	46	100	32	18	50	1	0	1
Diatom film record	7	36	43	54	46	100	32	18	50	1	0	1
Standard measurements of blubber thickness (five points)	7	36	43	54	46	100	32	18	50	1	0	1
Detailed measurements of blubber thickness (eleven points)	4	13	17	9	8	17	5	4	9	1	0	1
Body weight	7	36	43	54	46	100	32	18	50	1	0	1
Body weight by parts	4	13	17	9	8	17	5	4	9	1	0	1
Blubber tissues for DNA study	7	36	43	54	46	100	32	18	50	1	0	1
Blubber, muscle, liver and kidney tissues for heavy metal analysis	7	36	43	54	46	100	32	18	50	1	0	1
Blubber, muscle, liver and kidney tissues for organochlorines analysis	7	36	43	54	46	100	32	18	50	1	0	1
Blubber, muscle tissues for ingredient analysis	7	36	43	54	46	100	32	18	50	1	0	1
Tissue for nutritional component analysis	0	5	5	2	3	5	3	2	5	1	0	1
Lung tissue for atmospheric analysis	0	5	5	0	11	11	0	3	3	1	0	1
Tissues for lipid analysis	4	13	17	9	8	17	5	4	9	1	0	1
Tissues for various analysis	7	36	43	54	46	100	32	18	50	1	0	1
Tissues for virus test	3	36	39	33	46	79	9	18	27	0	0	0
Mammary gland; lactation status, measurement and histological sample	7	0	7	54	0	54	32	0	32	1	0	1
Collection of spermaceti sample	0	0	0	0	0	0	0	0	0	1	0	1
Collection of maternal milk sample	0	0	0	2	0	2	2	0	2	0	0	0
Uterine horn; measurement and endometrium sample	7	0	7	54	0	54	32	0	32	1	0	1
Collection of ovary	7	0	7	54	0	54	32	0	32	1	0	1
Photographic record of foetus	3	0	3	17	15	35*	5	4	10*	0	0	0
Foetal sex (identified by visual observation)	3	0	3	17	15	32	5	4	9	0	0	0
Foetal length and weight	3	0	3	17	15	35*	5	4	10*	0	0	0
External measurements of foetus	3	0	3	17	15	33	5	4	9	0	0	0
Foetal blubber tissues for DNA study	3	0	3	17	15	34*	5	4	10*	0	0	0
Foetal tissues for various analysis	3	0	3	17	15	32	5	4	9	0	0	0
Foetal lens for age determination	3	0	3	17	15	32	5	4	9	0	0	0
Testis and epididymis; weight and histological sample	0	36	36	0	46	46	0	18	18	0	0	0
Collection of plasma sample	7	36	43	54	46	100	32	18	50	1	0	1
Collection of whole blood sample	7	36	43	54	46	100	32	18	50	1	0	1
Whole blood samples from umbilical cord	1	0	1	14	13	27	4	4	8	0	0	0
Plasma samples from umbilical cord	3	0	3	17	15	32	4	4	8	0	0	0
Stomach content, conventional record	7	36	43	54	46	100	32	18	50	1	0	1
Volume and weight of stomach content in each compartment	7	36	43	54	46	100	32	18	50	1	0	1
Stomach contents for feeding study	6	35	41	45	35	80	28	17	45	1	0	1
Record of external parasites	7	36	43	54	46	100	32	18	50	1	0	1
Collection of external parasites	1	1	2	2	1	3	2	1	3	0	0	0
Record of internal parasites	7	36	43	54	46	100	32	18	50	1	0	1
Collection of internal parasites	0	1	1	3	2	5	0	2	2	1	0	1
Earplug for age determination	7	36	43	54	46	100	32	18	50	0	0	0
Tympanic bulla for age determination	7	34	41	54	46	100	32	18	50	0	0	0
Maxillary teeth for age determination	0	0	0	0	0	0	0	0	0	1	0	1
Lens for age determination	7	36	43	54	46	100	32	18	50	1	0	1
Largest baleen plate for morphologic study and age determination	7	36	43	54	46	100	32	18	50	0	0	0
Baleen plate measurements (length and breadth)	7	35	42	54	46	100	31	18	49	0	0	0
Length of each baleen plate series	7	36	43	53	44	97	32	18	50	0	0	0
Vertebral epiphyses sample	7	35	42	54	46	100	32	18	50	1	0	1
Number of vertebrae	0	0	0	9	8	17	5	4	9	1	0	1
Number of ribs	7	36	43	54	46	100	32	18	50	1	0	1
Brain weight	4	11	15	9	8	17	5	4	9	1	0	1
Skull measurements (length and breadth)	7	36	43	53	45	98	28	18	46	1	0	1

*: Including fetus of sex unknown.

Table 3. Composition of sex and sexual maturity status of collected samples.

Species	Sub area	Male				Female							Total	Total
		Imm.	Mat.	Uk	Total	Imm.	Mat.					Total		
							Ovu.	Rest.	Preg.	Lact.	Preg. Lact.			
Common minke	SA7	3	13	2	18	1	0	0	0	0	0	0	1	19
	SA8	2	6	4	12	1	0	1	3	0	0	4	5	17
	SA9	1	5	0	6	1	0	0	0	0	0	0	1	7
	Combined	6	24	6	36	3	0	1	3	0	0	4	7	43
Sei	SA7	-	-	-	0	-	-	-	-	-	-	0	0	0
	SA8	4	11	0	15	3	0	7	5	1	0	13	16	31
	SA9	8	23	0	31	6	0	3	28	0	1	32	38	69
	Combined	12	34	0	46	9	0	10	33	1	1	45	54	100
Bryde's	SA7	-	-	-	0	-	-	-	-	-	-	0	0	0
	SA8	7	4	1	12	9	0	3	3	0	0	6	15	27
	SA9	2	4	0	6	5	0	4	6	2	0	12	17	23
	Combined	9	8	1	18	14	0	7	9	2	0	18	32	50
Sperm	SA7	-	-	-	0	-	-	-	-	-	-	0	0	0
	SA8	-	-	-	0	-	-	-	-	-	-	0	0	0
	SA9	0	0	0	0	0	1	0	0	0	0	1	1	1
	Combined	0	0	0	0	0	1	0	0	0	0	1	1	1

Table 4. Body length (m) of samples collected during 2009 JARPN II survey.

Species	Sub area	Male					Female				
		n	mean	S.D.	min	max	n	mean	S.D.	min	max
Common minke	SA7	18	7.45	0.55	5.94	8.12	1	5.68	-	-	-
	SA8	12	7.17	0.53	5.96	8.01	5	7.50	1.26	5.00	8.31
	SA9	6	6.98	1.03	4.80	7.82	1	4.88	-	-	-
	Combined	36	7.28	0.68	4.80	8.12	7	6.86	1.48	4.88	8.31
Sei	SA7	0	-	-	-	-	0	-	-	-	-
	SA8	15	13.57	0.66	11.83	14.59	16	14.07	0.74	12.77	15.19
	SA9	31	13.27	1.09	10.56	14.51	38	14.12	0.80	12.18	15.54
	Combined	46	13.37	0.98	10.56	14.59	54	14.11	0.79	12.18	15.54
Bryde's	SA7	0	-	-	-	-	0	-	-	-	-
	SA8	12	11.68	1.02	9.83	13.17	15	11.71	1.17	10.09	13.83
	SA9	6	12.01	1.29	9.15	12.84	17	12.28	1.26	9.41	13.62
	Combined	18	11.79	1.13	9.15	13.17	32	12.02	1.25	9.41	13.83
Sperm	SA7	0	-	-	-	-	0	-	-	-	-
	SA8	0	-	-	-	-	0	-	-	-	-
	SA9	0	-	-	-	-	1	10.26	-	-	-
	Combined	0	-	-	-	-	1	10.26	-	-	-

Table 5. Prey species and stomach contents weight (1st. + 2nd. stomachs) found in each whales.

Dominant prey species		N	Range of weight (kg)	
Common minke whale				
	Krill	2	3.4 - 40.4	
	Copepods	Neocalanus spp.	2	7.2 - 23.5
	Fish	Japanese anchovy	17	7.0 - 230.9
		Pacific saury	9	7.0 - 52.4
		Walleye pollock	3	10.4 - 71.8
		Mackerels	2	24.1 - 175.9
		Japanese sardine	1	51.0
Sei whale				
	Krill	3	72.4 - 464.4	
	Copepods	Neocalanus spp.	26	9.2 - 453.8
	Fish	Japanese anchovy	23	4.6 - 740.7
		Mackerels	10	55.6 - 627.6
		Pacific saury	4	55.4 - 336.3
Bryde's whale				
	Krill	2	95.4 - 166.1	
	Fish	Japanese anchovy	25	9.6 - 588.8
		Oceanic lightfish	7	61.0 - 254.0
		Mackerels	1	331.0
		Unidentified	1	25.0

Table 6. Summary of biopsy skin sampling experiment.

Whale Species	Ship	Number of experiments (A)	Targeted individuals (B)	Number of shoots (C)	Number of hits (D)	Number of samples (E)	Effort time (F)	Sample per trial (E)/(C)	Sample per hit (E)/(D)
Blue whale	SSVs	8	9	7	6	6	2:20	0.86	1.00
Sei whale	SSVs	13	41	10	7	7	3:35	0.70	1.00
	SV	5	11	3	2	2	1:35	0.67	1.00
Bryde's whale	SSVs	1	1	1	0	0	0:06	0.00	-
	SV	1	1	2	0	0	0:11	0.00	-
Sperm whale	SSVs	1*	1	1	1	1	0:11	1.00	1.00
	SV	1	17	1	0	0	0:18	0.00	-

*: Dead and floating individual

Table 7. Summary of Photo-ID experiment.

Whale Species	Ship	Number of experiments	Targeted individuals	Number of photographed individuals
Blue whale	SSVs	7	8	7

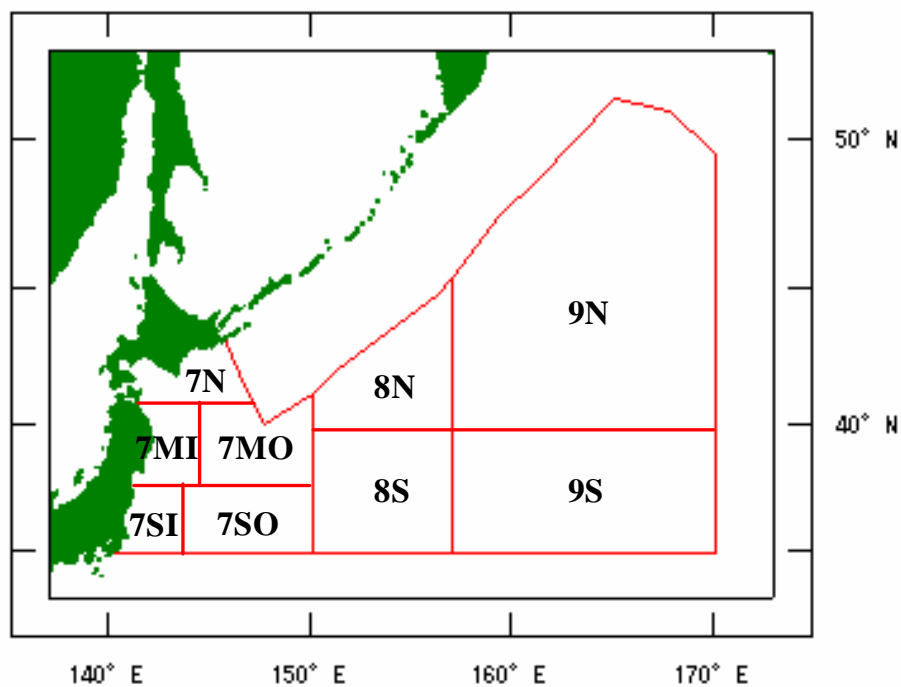


Fig 1. Map showing the research area and strata of the JARPN II full-scale program.

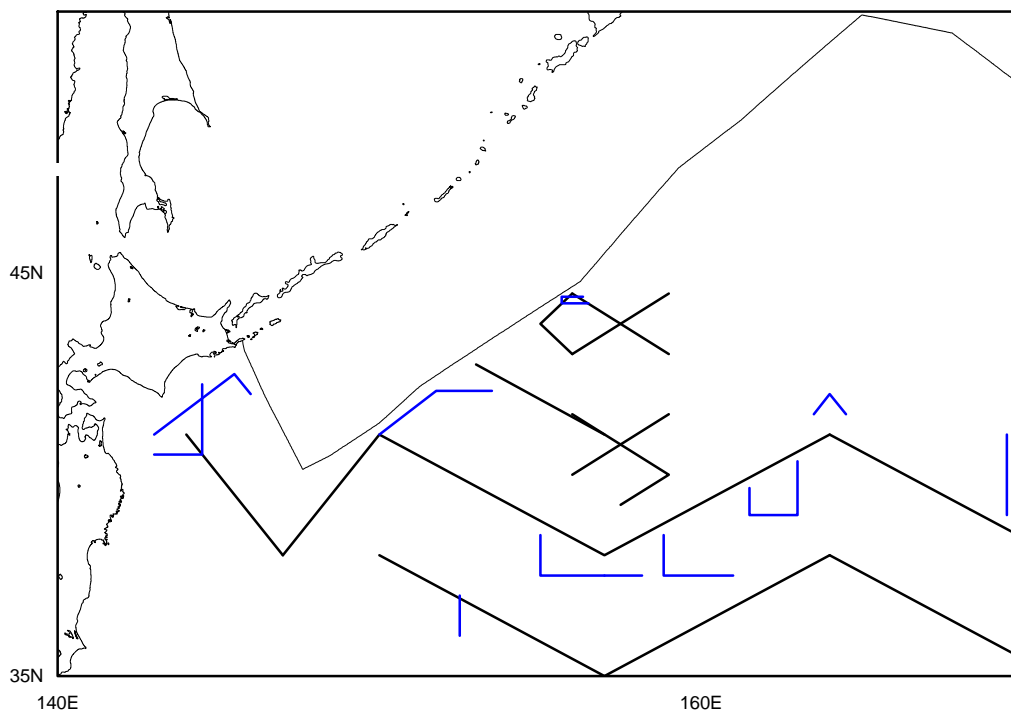


Fig. 2. Track-line covered by the two sighting/sampling vessels (SSVs). Blue lines were SMS.

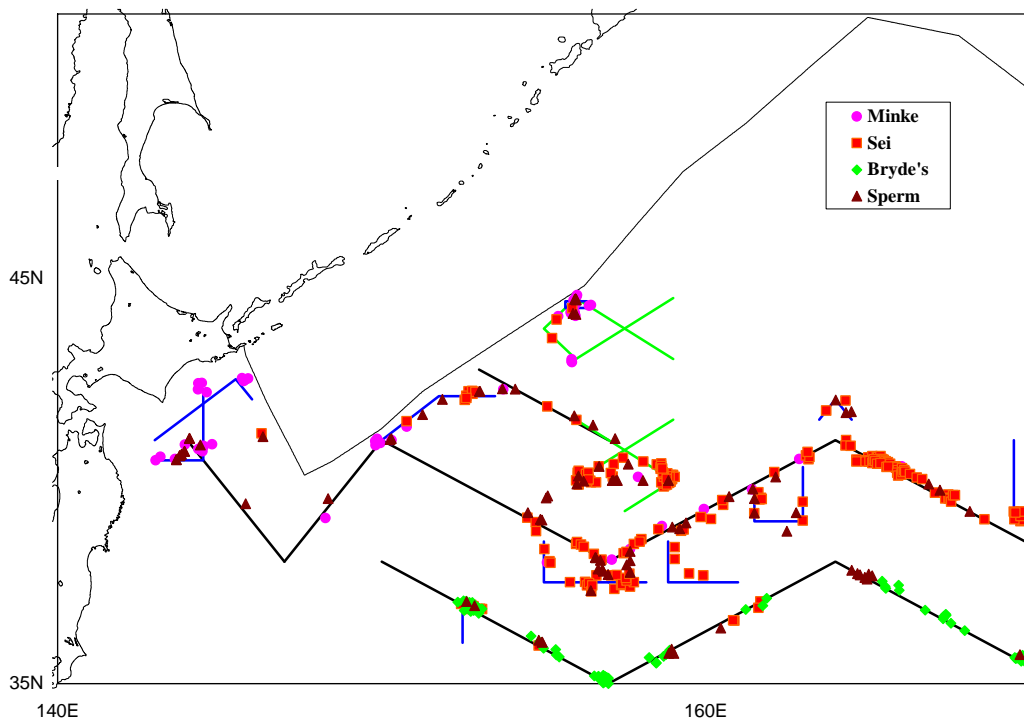


Fig. 3. The positions of the sightings of common minke whale (pink circle), sei (orange square), Bryde's (green diamond) and sperm (brown triangle) whales by the two sighting/sampling vessels (SSVs)

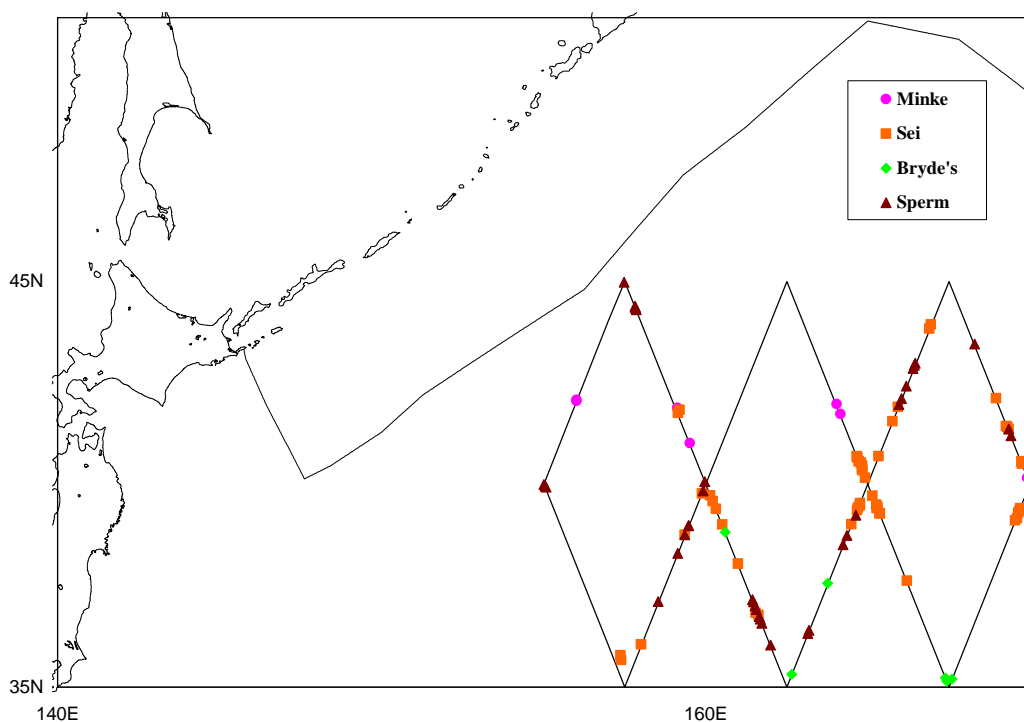


Fig. 4. The track-line and positions of the sightings of common minke whale (pink circle), sei (orange square), Bryde's (green diamond) and sperm (brown triangle) whales by dedicated sighting vessel (SV).

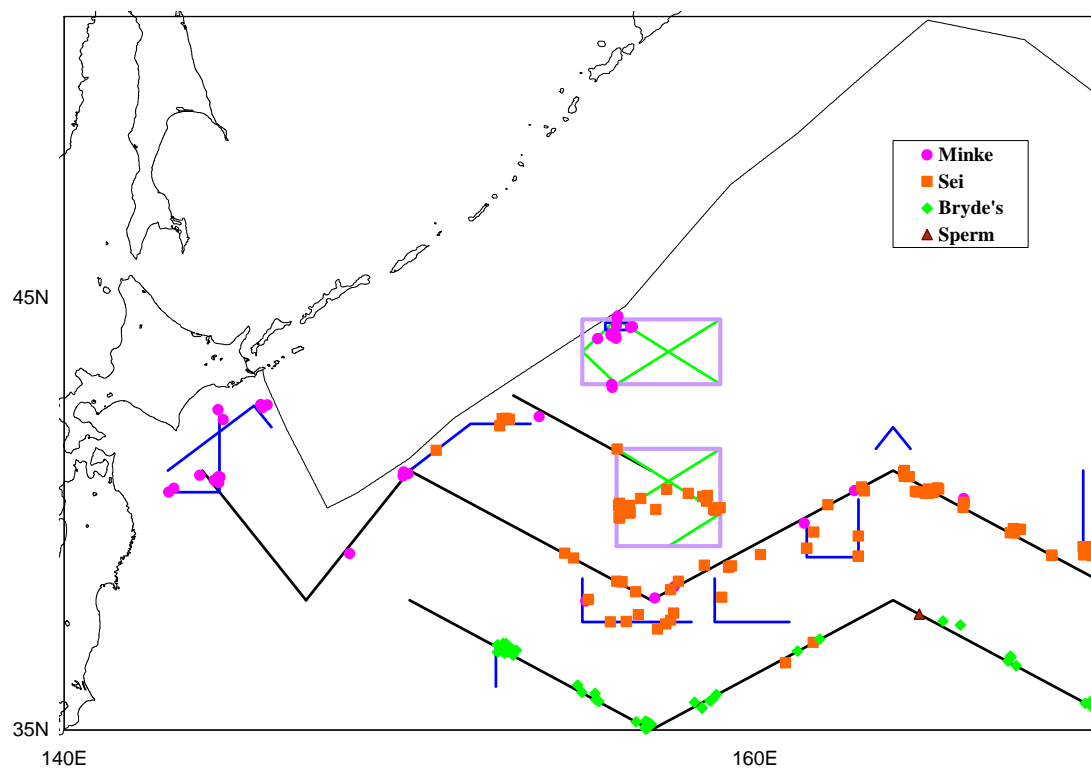


Fig. 5. The Sighting positions of the sampled common minke whale (pink circle), sei (orange square), Bryde's (green diamond) and sperm (brown triangle) whales. Two blocks show the cooperative survey areas of prey species and whale sampling surveys.

Appendix 1.

Preliminary result of whale prey species survey in the offshore component of JARPN II in 2009 conducted by Shunyo Maru

HIKARU WATANABE^{1*}, GENZABURO FUJIWARA¹, TAKEHARU BANDO², HIROSHI KIWADA², TSUTOMU TAMURA², AND TOMIO MIYASHITA¹

¹ National Research Institute of Far Seas Fisheries, 2-12-4 Fukuura, Kanazawa-ku, Yokohama, Kanagawa 236-8648, Japan

² The Institute of Cetacean Research, Toyomi-cho 4-5, Chuo-ku, Tokyo 104-0055, Japan

*Author in correspondence, e-mail: hikaru1@affrc.go.jp

ABSTRACT

Whale prey species survey in the transition regions of the western North Pacific was conducted in July 2009 by RV Shunyo Maru. The objective of this survey is to examine habitat and prey preference of sei whale *Balaenoptera borealis* and common minke whale *B. acutorostrata* in cooperation with the sampling and sighting survey of the whale by Nisshin Maru and two sighting/sampling vessels. The distribution, abundance, and size composition of the whale prey species were investigated with the midwater trawl, MOCNESS, twin NORPAC nets, and quantitative echosounder during the daylight period. “Hot spot” of the sei whale was found in the southern transition region where euphausiids and Japanese anchovy *Engraulis japonicus* were abundantly distributed at 100-200 m and 20-40 m, respectively. Of these, sei whales fed mainly on Japanese anchovy, suggesting prey preference for this species. Because relative abundance of Japanese anchovy was significantly higher in the main distribution area than its adjacent area of the whale, sei whale seems to select the habitat where Japanese anchovy was abundantly distributed. Common minke whale was densely distributed in the subarctic region and the subarctic frontal zone, where were the main habitat and main fishing ground of Pacific saury *Cololabis saira*. Euphausiids were frequently found both in and out of the hot spot area of the whale at 50-200 m. This whale fed mainly on Pacific saury, suggesting strong prey preference for this prey species. This also suggests that common minke whale selected the feeding ground where Pacific saury was abundantly distributed.

KEY WORDS: PREY SPECIES SURVEY, OFFSHORE COMPONENT, SHUNYO MARU, JARPN II, PREY PREFERENCE, SEI WHALE, COMMON MINKE WHALE

INTRODUCTION

The government of Japan submitted the Research Plan for Cetacean Studies in the Western North Pacific under Special Permit (JARPN II) (Feasibility Study Plan for 2000 and 2001) to the 52th IWC/SC (Government of Japan 2000). The objective of this program is (1) studying on

feeding ecology of cetaceans and ecosystem modelling, (2) monitoring environmental pollutants in cetaceans and the marine ecosystem, and (3) elucidating stock structure of whales in the western North Pacific, especially within Japan's EEZ (Government of Japan, 2002). This program would contribute to the conservation and sustainable use of marine living resources including marine mammals. The priority of this plan is the first objective above, including studies on prey consumption and prey preference of cetaceans, and collecting data for ecosystem models. In JARPN II, prey species surveys have been conducted in cooperation with stomach contents study of the whale sampling surveys. Combining data from these surveys, we can estimate prey preference of cetaceans. Prey preference study of the whale during 2002 and 2007 was highly evaluated at IWC/JARPN II review meeting in 2009 and 61th IWC/SC, and further progress of this study was expected. This paper will report some results of summer prey species survey of sei whale *Balaenoptera borealis* and common minke whale *B. acutorostrata* in the western North Pacific in 2009. This research was the first attempt to conduct prey and whale sampling surveys for these two whale species concurrently in the same area.

MATERIALS AND METHODS

Survey was conducted in the western North Pacific enclosed by latitude from 39°N to 40°N and longitude from 156°E and 149°E for sei whales and latitude from 43°N to 44°N, and longitude from 154°E and 157°E excluding Russian EEZ for common minke whale from 10 to 22 July 2009 by the trawler-type research vessels, Shunyo Maru (887 GT, National Research Institute of Far Seas Fisheries, Fig. 1). The waypoints of predetermined track lines are shown in Table 1. These prey surveys by Shunyo Maru and whale stomach content survey by Nisshin Maru and two sighting/sampling vessels were conducted concurrently at the same area within 24 h. All prey surveys were conducted during the daylight period from one hour after sunrise to one hour before sunset (usually from 04:00 to 17:00 in JST). Distribution and abundance of the prey species were investigated with the midwater trawl, MOCNESS (Multiple Opening/Closing Net and Environment Sampling System, Bess Co., Ltd.), twin NORPAC nets (North Pacific Standard net), and quantitative echosounder on the track lines as follows.

Midwater trawl sampling

The midwater trawl adopted in this study had a mouth opening of approximately 30 x 30 m with a 17.5 mm liner cod end. The sampling depths and the height of the net mouth were monitored by net monitor system (PI32, SIMRAD). Towing speed was 3-4 knots. In this prey survey, trawls were made to identify species and size compositions of acoustic backscatters in the echosounder and also aimed for collecting data on species difficult to detect by the echosounder such as squids and neustonic organisms like Pacific saury. Trawling station was predetermined at generally every 20 to 30 nautical mile apart on the track lines. At each predetermined station, a trawl net was towed at 0-100 m (oblique tow) or 0-30 m for 60 minutes (Table 2). All samples

were identified to the lowest taxonomic level possible and wet body weight of each species was measured aboard the ship. For the major species, individual body length was measured from randomly selected 100 samples. When sample size was less than 100 individuals, body length was measured for all. We also measured the total wet weight of these samples to estimate the total catch number for each sampling.

MOCNESS sampling

We used MOCNESS to examine species and size compositions and vertical distribution patterns of meso- and macro-zooplanktons, especially euphausiids (Table 2). The mouth opening and mesh size of this net were 1 m² and 0.33 x 0.33 mm, respectively. MOCNESS was towed at about 2 knots in eight target depths (0-20m, 20-40m, 40-60m, 60-80m, 80-100m, 100-150m, 150-200m, and 200-250m). The volume of seawater filtered by each net was measured with a flow meter mounted at the net mouth. Samples were preserved in 10 % formalin-buffered seawater for later analysis in the laboratory.

Twin NORPAC net sampling

We conducted twin NORPAC net samplings in the 0-150 m layer at all stations to collect data for abundance estimates of micro- and meso-zooplanktons, especially copepods, in the epipelagic zone. The mesh sizes of the net were 0.11 x 0.11 mm and 0.33 x 0.33 mm. A flow meter was attached to each net to measure the volume of seawater filtered. Samples were preserved in 10 % formalin-buffered seawater.

Quantitative echosounder survey

We collected acoustic data by quantitative echosounders, SIMRAD ER60 with operating frequency at 38, 70, and 120 kHz, by steaming at 10 knots on the track lines. Calibrations were carried out in the Tateyama Bay off Chiba prefecture (35°01'N, 139°49E) on 26 July using a copper sphere technique. Acoustic data will be analyzed with an aid of SonarData Echoview (Sonar Data Co., Ltd.) software in the future.

Oceanographic observation

A Conductivity-Temperature-Depth (CTD, Sea-Bird Co., Ltd.) profiler cast was made down to 500 m depth at each sampling station to determine the position of the subarctic boundary and subarctic front.

RESULTS AND DISCUSSION

While acoustic data, plankton samples, and oceanographic conditions are currently underway, the preliminary results are as follows.

CTD and surface seawater temperature data indicated that the southern area south of 41°N was located in the transition region between subtropical and subarctic fronts, and the northern area north of 43°N were in or close to subarctic region.

According to Bando (unpubl. data), “hot spot” of sei whale in southern prey species survey area was found in the region around WP1 and WP3 where SST range was 16 to 19°C (Fig. 1). The result of our prey species survey indicated that this area was prey rich environment for the sei whale, because juvenile and adult Japanese anchovy and euphausiids were abundantly distributed (see Stn 1 in Table 1 and Figs. 2 and 3). Generally, both juvenile and adult Japanese anchovy were mainly distributed at 20-40 m and distribution centre of euphausiids were found at 100-200 m (Figs. 2 and 3). Stomach content data showed that sei whale fed mainly on juvenile and adult Japanese anchovy (Bando unpubl. data), although euphausiids are abundant below Japanese anchovy schools. This therefore may indicate that sei whales preferred Japanese anchovy to euphausiids. In the northernmost region of southern research area around 40°45'N and 157°30'E, where SST was 14.9°C, sei whales were rarely found although mackerels and euphausiids were abundantly distributed in the surface and 100-200 m layers, respectively (Bando unpubl. data, see Stn 3 in Table 2). Furthermore, in the southern region south of 40°N, potential prey species like anchovy and euphausiids were rarely distributed (Fig. 4). Sei whales were also rarely seen in this region (Bando unpubl. data). Therefore, sei whale might select distribution centre of Japanese anchovy as their main habitat.

Common minke whales were abundantly distributed in or close to the subarctic region around 44°30'N and 156°E (Fig. 2). This area was the main commercial fishing ground of Pacific saury (Watanabe unpubl. data). The results of our prey survey indicated that Pacific saury and euphausiids were densely distributed in the surface and 150-200 m layers, respectively, and adult Japanese anchovy was also sometimes distributed in the 20-50 m layer of this area (Figs. 5 and 6). In the rest of the region, common minke whales were rarely found although euphausiids and adult Japanese anchovy were distributed (Bando unpubl. data, Fig. 7). These results, together with the result of whale sampling survey that common minke whale was fed mainly on Pacific saury (Bando unpubl. data), strongly suggest that this whale preferred Pacific saury and selected the feeding ground where Pacific saury was abundantly distributed.

ACKNOWLEDGEMENT

A special thank is given to Captain S. Sawadaishi and crews of Shunyo Maru for their assistance in collecting data. H. Kiwada, T. Tamura, and S. Kumagai of Institute of Cetacean Research, T. Miyashita of National Research Institute of Far Seas Fisheries, and K. Sawada of National

Research Institute of Fisheries Engineering gave valuable information and comments during the course of this research.

REFERENCES

Government of Japan. 2000. Research plan for cetacean studies in the western North Pacific under special permit (JARPN II) (Feasibility study plan for 2000 and 2001). Paper SC/52/O1 submitted to the 52th IWC Scientific meeting.

Government of Japan. 2002. 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 Meeting.

Table 1. Waypoints of planned track lines.

WP	Latitude (N)	Longitude (E)
Southern research area		
1	40-00.0	156-00.0
2	40-45.0	157-30.0
3	40-00.0	159-00.0
4	39-15.0	157-30.0
Northern research area		
5	43-45.0	154-30.0
6	44-30.0	156-00.0
7	43-45.0	157-30.0
8	43-00.0	156-00.0

Table 2. Sampling data of midwater trawl and MOCNESS surveys. +: 0.01 kg < CPUE.

Midwater trawl													CPUE (kg/h)											
Stn	Year	Month	Day	SST			Latitude			Longitude			Sampling depth (m)		duration (min)	Japanese anchovy	Japanese sardine	Mackerels	Pacific saury	Pink salmon	Chum salmon	Pacific pomfret	Other fishes	Common squid
				(°C)	Degree	Minute	N/S	Degree	Minute	E/W	Shallowest	Deepest												
Southern research area																								
1	2009	7	10	16.7	40	11.65	N	156	22.67	E	0	30	60	62.0	0.2		+	+	0	0	0	0	0	
2	2009	7	10	16.6	40	35.25	N	157	11.06	E	0	100	60	0	0	1.6	0	0	0	0	2.9	0	0	
3	2009	7	11	14.9	40	45.04	N	157	30.88	E	0	30	60	0	0	126.7	3.9	0	0	0	0	0	+	
4	2009	7	12	16.3	40	26.47	N	158	7.44	E	0	30	60	+	0	0	0	0	0	0	0	0	0	
5	2009	7	12	18.8	40	0.03	N	159	0.23	E	0	30	60	14.1	0.1	+	0	0	0	0	0	0	0	
6	2009	7	13	18.2	39	39.56	N	158	18.74	E	0	100	60	0.0	0	0	0	0	0	0	0	0	0	
Northern research area																								
8	2009	7	18	12.0	44	6.83	N	156	45.46	E	0	30	60	0	0	1.0	163.9	0	0	0	0	0	0	
9	2009	7	18	12.4	43	38.46	N	157	17.09	E	0	100	60	0	0	0	0	9.5	10.8	15.7	0	+	+	
10	2009	7	19	12.5	43	17.39	N	156	34.68	E	0	30	60	+	0	0	0	0	0	0	+	+	+	
11	2009	7	19	13.0	43	12.26	N	155	43.83	E	0	100	60	0	0	0	50.0	0	6.3	15.7	0	0	0	
12	2009	7	20	14.7	43	37.31	N	155	10.71	E	0	30	60	+	0	0	0	0	0	0	0	0	0.7	
13	2009	7	20	12.7	44	9.18	N	155	34.04	E	0	30	60	0.1	0	0	268.3	3.4	0	212.5	0	0.4	0.4	
14	2009	7	21	10.2	44	27.22	N	155	56.42	E	0	30	60	0.2	0	0	210.8	0	0	0	0	0	+	
15	2009	7	22	13.5	43	39.10	N	156	1.38	E	0	30	60	0.4	0	0	244.5	0	0	0	0	0	0.3	
16	2009	7	22	13.6	43	3.17	N	155	59.94	E	0	50	60	0	0	0	0	0	0	0	4.9	0	0	
MOCNESS																								
Stn	Year	Month	Day	SST			Latitude			Longitude			Sampling depth (m)											
				(°C)	Degree	Minute	N/S	Degree	Minute	E/W	Shallowest	Deepest												
Southern research area																								
7	2009	7	13	18.7	39	18.91	N	157	22.53	E	0	250												
Northern research area																								
14	2009	7	21	10.2	44	27.22	N	155	56.42	E	0	250												

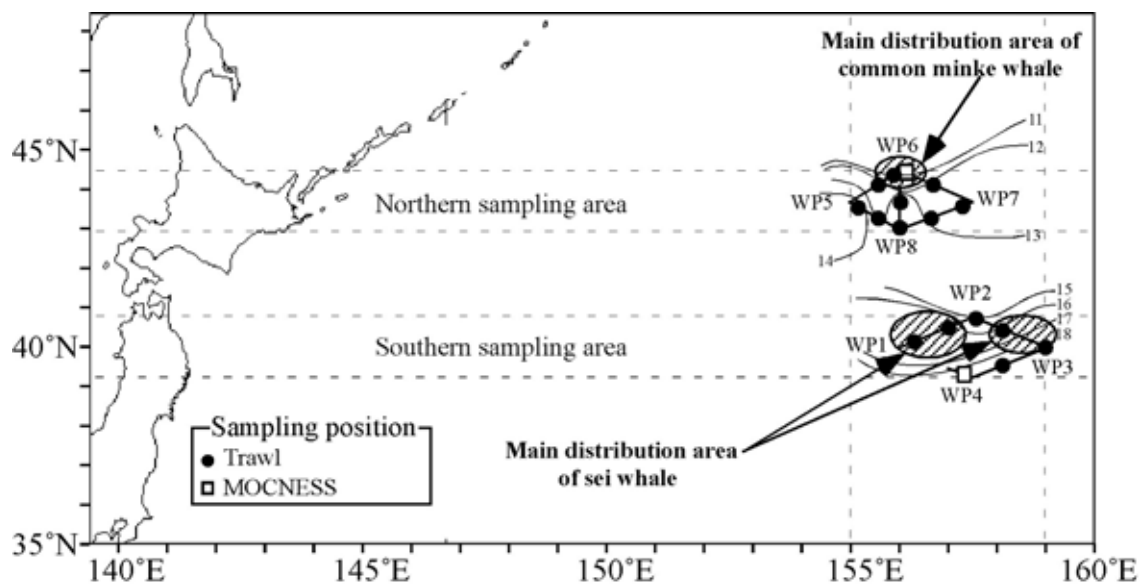


Figure 1. Research area, predetermined track lines, and sampling positions of offshore prey species survey in 2009. SST of each sampling area was also shown.

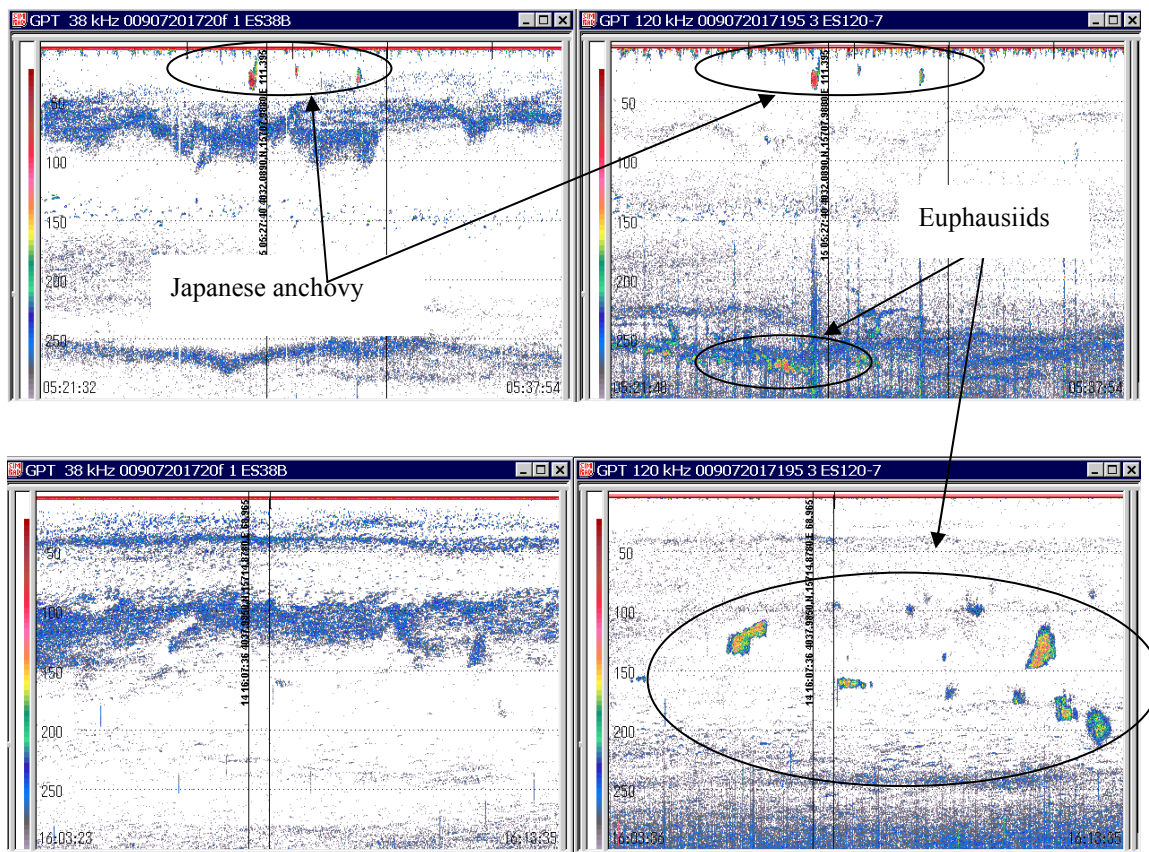


Figure 2. Typical acoustic back scatterings around at WP1 in the southern transition regions where sei whale was densely distributed.

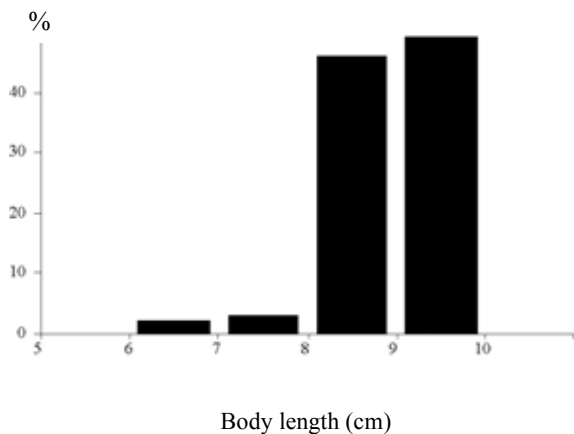


Figure 3. Size distribution of Japanese anchovy at Station 1 located in the southern transition zone where “hot spot” of sei whale was found. Sei whale fed mainly on juvenile and adult Japanese anchovy around this station (Bando unpubl. data).

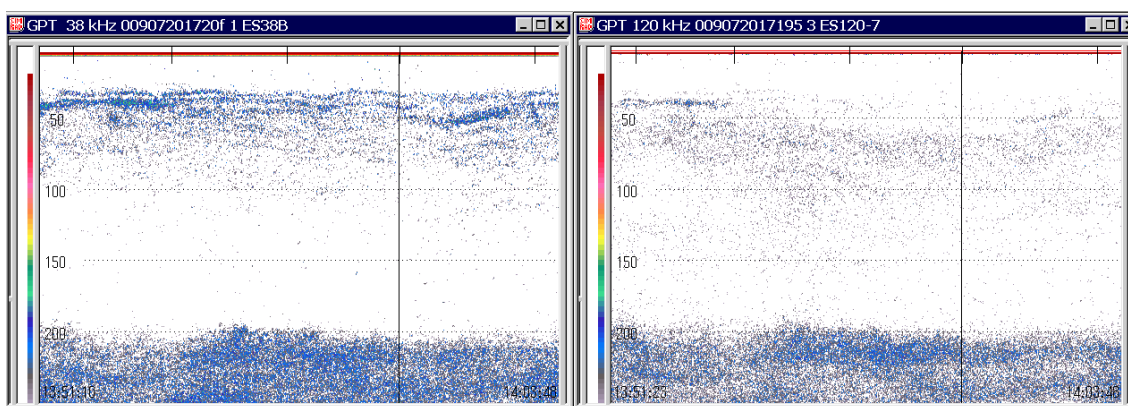


Figure 4. Typical acoustic back scatterings around at Station 3 in the northernmost region of the southern research area where sei whale was rarely distributed, showing that potential prey density was extremely low.

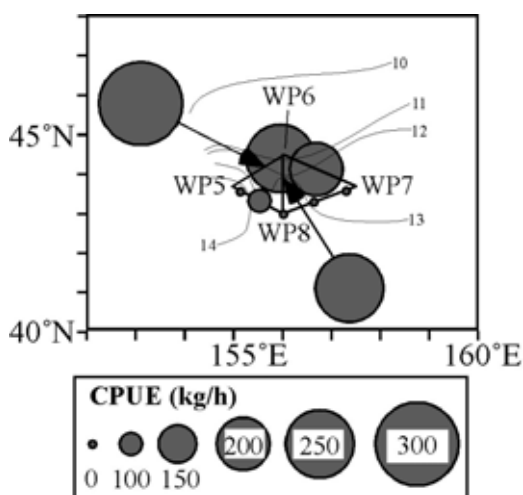


Figure 5. Geographical distributions of Pacific saury in the northern research area based on the result of predetermined trawl samplings in the 0-30 m layer. Pacific saury was densely distributed around WP6 in or close to the subarctic front, where hot spot of common minke whale was also found. Common minke whale fed mainly on Pacific saury in this area.

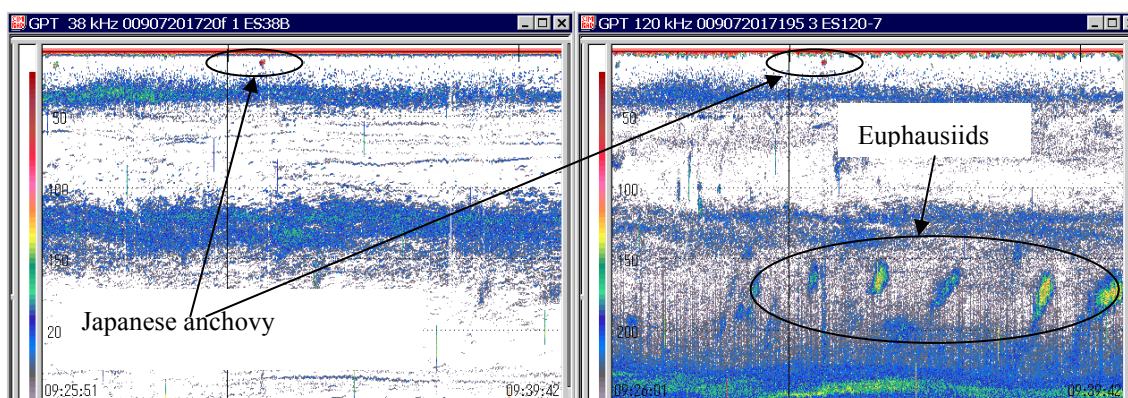


Figure 6. Typical acoustic back scatterings around at WP6, where common minke whale was densely distributed. Pacific saury could not be detected by echo sounder because this species is generally distributed in the surface layer shallower than 10 m depth (see Fig. 5).

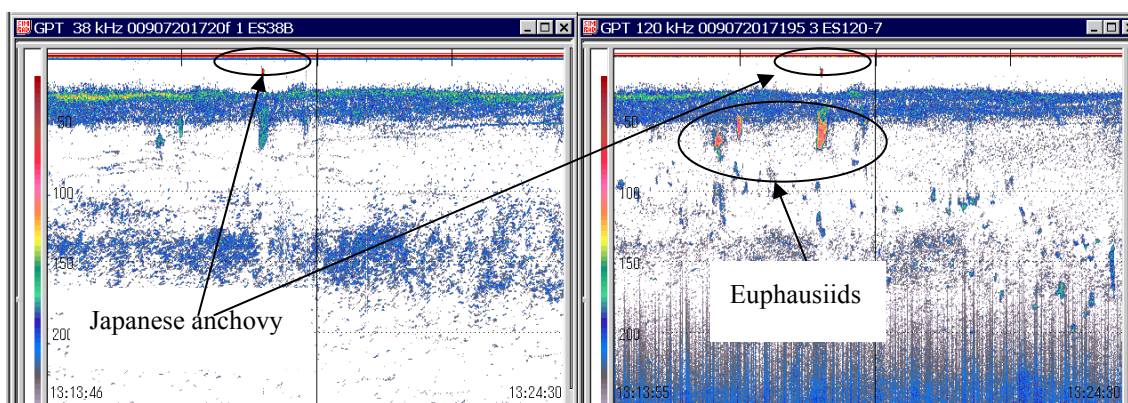


Figure 7. Typical acoustic back scatterings in the northern research area where common minke whale was rarely distributed.

Appendix 2

Oceanographic conditions in the survey area of offshore component of JARPN II in the western North Pacific from July 2009

Denzo Inagake*, Makoto Okazaki*, Hikaru Watanabe**,
and Tomio Miyashita **

*National Research Institute of Fisheries Science, 2-12-4 Fukuura, Kanazawa, Yokohama, Kanagawa, 236-8648, Japan

**National Research Institute of Far Seas Fisheries, 2-12-4 Fukuura, Kanazawa, Yokohama, Kanagawa, 236-8648, Japan

ABSTRACT

A prey species survey was conducted in July 2009 using *R/V Shunyo-Maru* as a part of offshore component of JARPN II. The survey covered from subarctic area to the adjacent area of the subtropical area in the western North Pacific where common minke, Bryde's and sei whales were found. During the survey, oceanographic observation with CTD was made to make clear the environment of the prey. The survey area was located in the Subarctic Domain and the Transition Domain. The water mass was characterized by the subarctic water and the mixed water between the subarctic water and the Kuroshio water.

Introduction

A prey species survey was conducted in the offshore area of the western North Pacific in July 2009 using *R/V Shunyo-Maru* (Fig. 1) in cooperation with the sampling survey by *Nisshin-Maru*. Common minke, Bryde's and sei whales were found in the survey blocks.

There are a lot of water masses and fronts in the western North Pacific. The Oyashio flows southwestward along the Kuril Islands and turns eastward from the northern coast of Japan. The Kuroshio flows northward from the tropical area to Tohoku area east of Japan, and reaches near the Oyashio front. The Kuroshio turns eastward from the northern coast of Japan, and the strong eastward flow is called the Kuroshio Extension. Both major current, the Kuroshio Extension and the Oyashio, form Kuroshio-Oyashio Inter-frontal Zone. Water masses originated in the Kuroshio and the Oyashio are mixed each other in this zone and form new water masses.

In the high sea of the North Pacific Ocean, there are Subarctic Front (temperature front defined by 4 °C) and the Subarctic Boundary (salinity front defined by 34.0psu) with a weak eastward flow. The Subarctic Front is south limit of the subarctic water and the Subarctic Boundary is north limit of the tropical water. The area between these fronts is called the Transition Domain (Favorite *et al.* 1976).

Each water mass in the western North Pacific has its own ecosystem, like a Kuroshio ecosystem, an Oyashio ecosystem, warm-core ring ecosystem, etc. So, we must make clear the oceanographic condition around whale's prey to build up a marine ecosystem model in this area. In this paper, distributions of water masses and fronts in the survey area will be described to make clear the environment of the prey of sei, Bryde's and common minke whales.

Methods

Hydrographic observations with a conductivity-temperature-depth profiler (CTD) were carried out in the survey area from July 10 to 22 in 2009 using *R/V Shunyo-Maru* (Table 1 and Fig. 1). Salinity correction for CTD data was not done using water sampling data. The survey area was separated to the northern part around 44° N, 156° E and the southern part around 40° N, 158° E

Locations of oceanic fronts and water masses are usually detected based on subsurface temperature map (see Table 2), because they are obscure in sea surface temperature distributions from summer to fall, and the Oyashio water spreads into the subsurface layer. The oceanographic conditions in July 2009 are detected by 100m and 200m temperature maps using our observation data by the vessel as well as NEAR-GOOS (the North-East Asian Regional-Global Ocean Observing System) database. We use following indices to know the distribution of water mass in the survey area. The Kuroshio Extension is defined by the 14 °C isotherm at the depth of 200m (Kawai, 1969). The warm water spread from Kuroshio Extension is defined by temperature more than 10 °C at the depth of 100 m. The Subarctic Front and the Subarctic Boundary is defined by 4 °C temperature front and 34.0 psu salinity front, respectively (Favorite *et al.* 1976).

Oceanographic conditions in the survey area

Figure 2 shows the Temperature-Salinity diagrams in the survey area. There is no typical Kuroshio water characterized by high salinity profile around 34.5 psu, but warm water spread from the Kuroshio with warm (over 10 °C) and high salinity (over 34 psu) water at the surface layer. Subarctic waters characterized by cold profile less than 4 °C is shown in lower part of Fig. 2. The mixed water in Transitional Domain is distributed between subarctic waters and warm water spread from the Kuroshio.

Figure 3 shows a schematic hydrographic map with isotherms of 100 m temperature in July 2009. The cold water less than 5 °C at 100 m depth was distributed in a northern part of the survey area. The Subarctic Front, which is defined by 4 °C isotherm and corresponds to 33.4psu isohaline in Fig. 5, was observed around 43° 40'N, 156° E in Figs. 3 and 4. In 100 m salinity map (middle panel in Fig. 5), a salinity front around 34.0 psu lies from 39° N, 157° E to 41° N, 158° E in the southern part of the survey area. The warmest temperature at the 200 m depth is 8 °C that is observed at southwestern part of this area (right panel in Fig. 4), and warm water spread from the Kuroshio is observed at only one station, Stn. 5 (middle panel in Fig. 4). The Kuroshio Extension (14 °C isotherm at 200 m depth) meanders along 36° N line, far from our survey area.

Figure 6 shows temperature, salinity and density anomaly sections in the eastern part of the northern survey area. A seasonal thermocline lies at the depth of 50m, and temperature at the surface mixing layer shallower than 30 m is warmer than 10 °C in this section. The Subarctic water (colder than 4 °C) is observed in almost all of this section, deeper than 150 m depth. A little warm and high salinity water is observed around 43° 30'N (Stn. 10) in Fig. 6. 4 °C isotherm (index of the Subarctic Front) shows like a bowl shape and 33.5psu isohaline looks a shape of dome around a

little warm and high salinity water. The salinity front around 34 psu (index of the Subarctic Boundary) is not appeared in this section.

In the western part of the northern survey area (Fig. 7), almost isotherms and isohalines lie similar to the section of the eastern part (Fig. 6), without the area around 43° 40'N, where are a little warm and high salinity were are observed at a surface mixing layer shallower than 50 m. While there is no typical Subarctic Front in this section, almost all stations along this section are in the Subarctic Domain.

In the southern survey area (Fig. 8), the seasonal thermocline lies around the depth of 25 m. The surface mixing layer in this section is over 15 , which is warmer than the temperature at the layer in the northern survey area. Surface salinity front around 34psu (index of the Subarctic Boundary) is observed around 40° 40'N.

These figures show that the survey area is located between the Subarctic Domain and the Transition Domain. The subarctic water occupied in Stn. 8-9 and 11-15. Stns. 2-4, 6-7 and 10 are in the Transition Domain. Stn. 5 is located in the warm water spread from the Kuroshio Extension.

REFERENCES

- Favorite, F., A. J. Dodimead and K. Nasu (1976): Oceanography of the subarctic Pacific region, 1960-71. Bull. International North Pacific Fisheries Commission, 33, 187 pp.
- Kawai, H. (1969): Statistical estimation of isotherms indicative of the Kuroshio axis, *Deep-Sea Res.*, Suppl. to **16**, 109-115.
- Murakami, M. (1994): On long-term variations in hydrographic conditions in the Tohoku area, *Bull. Tohoku Natl. Fish. Res. Inst.*, No. 56, 47-56 (in Japanese with English abstract).

Table 1. Observation summary.

Ship	Instrument	Date	Number of stations
<i>Shunyo-Maru</i>	CTD: BE 9plus	10 July to 22 July	15

Table 2. Extraction method from temperature map to determine the position of each water mass.

Target characteristics	Extraction method
Kuroshio Extension Axis	14 isotherm at 200 m
Warm-core ring	Temperature front at 200 m
Oyashio front	5 isotherm at 100 m
Oyashio water	Area with $T < 5$ at 100 m
Cold water	Area with $5 < T < 10$ at 100 m
Warm water	Area with $T > 10$ at 100 m and $T < 14$ at 200 m
Subarctic Boundary	Salinity front defined by 34.0 psu
Subarctic Front	Temperature front defined by 4
Subarctic Domain	North of Subarctic Front
Transition Domain	Between Subarctic Front and Subarctic Boundary.

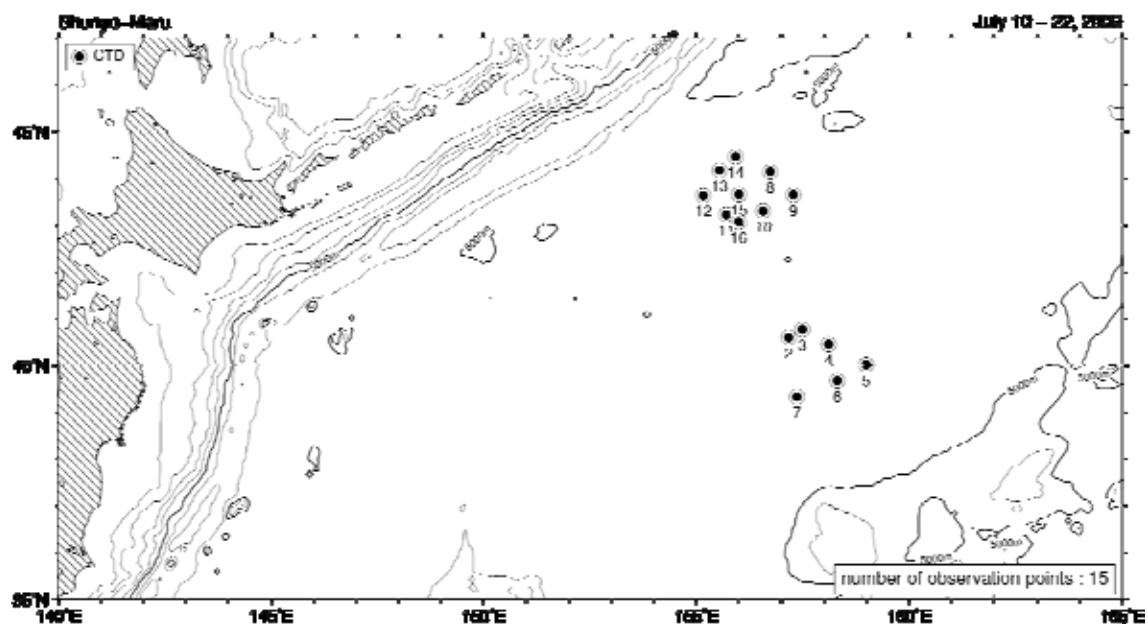


Fig. 1. Station map observed by *R/V Shunyo* in 10th to 22th July 2009.

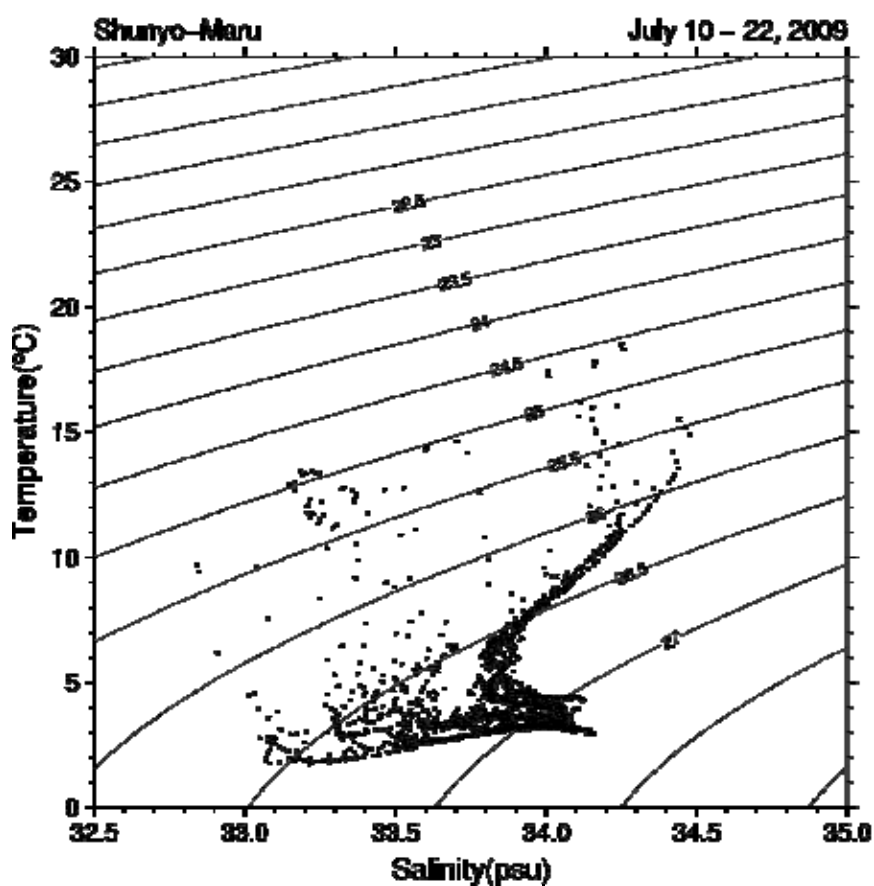


Fig. 2. Temperature-Salinity diagrams using CTD station data observed by *R/V Shunyo-Mar*. Each thin line in this figure denotes a density line of σ_t .

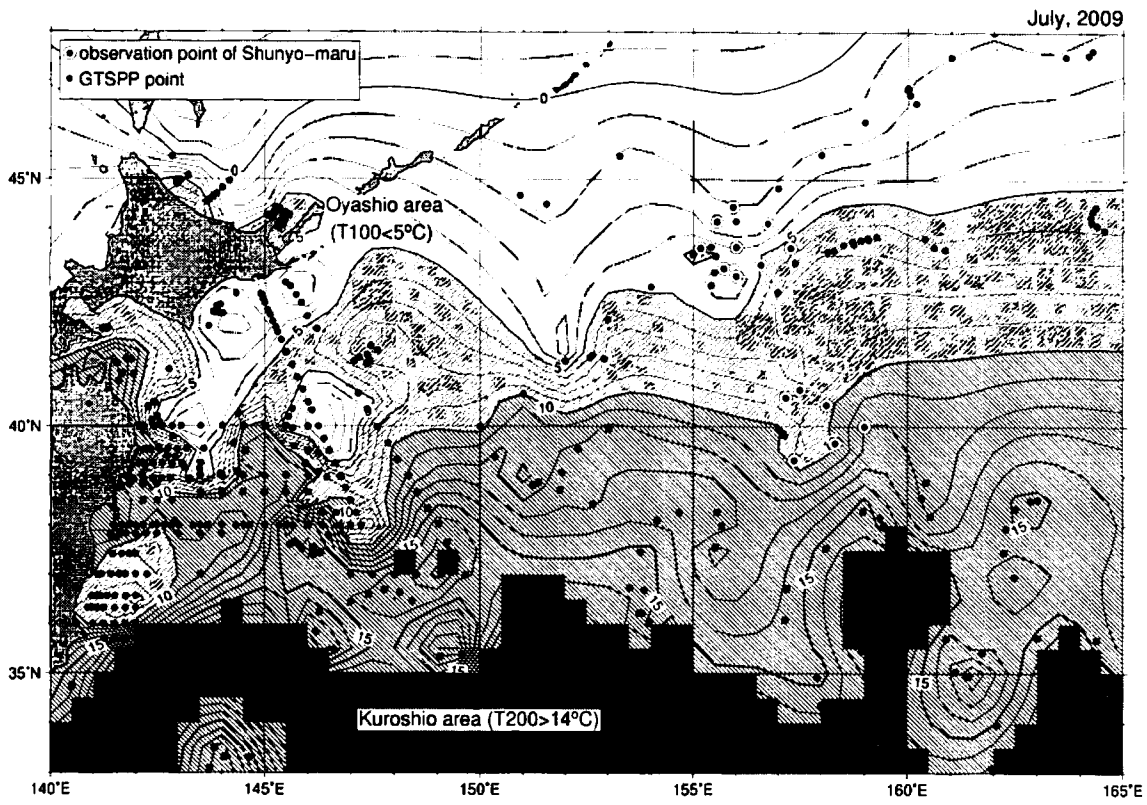


Fig. 3. Schematic hydrographic map in the western North Pacific in July 2009 with station map observed by *R/V Shunyo-Marui* and reported to GTSPPP.

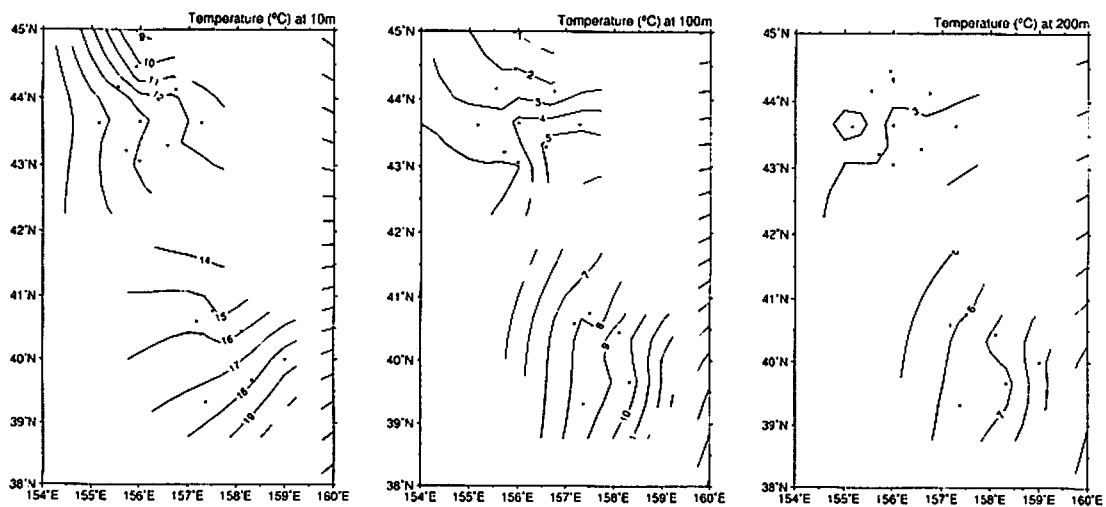


Fig. 4. Temperature at 10 m (left panel), 100 m (middle panel) and 200 m depth (right panel) observed by *R/V Shunyo-Maru* in July 2009.

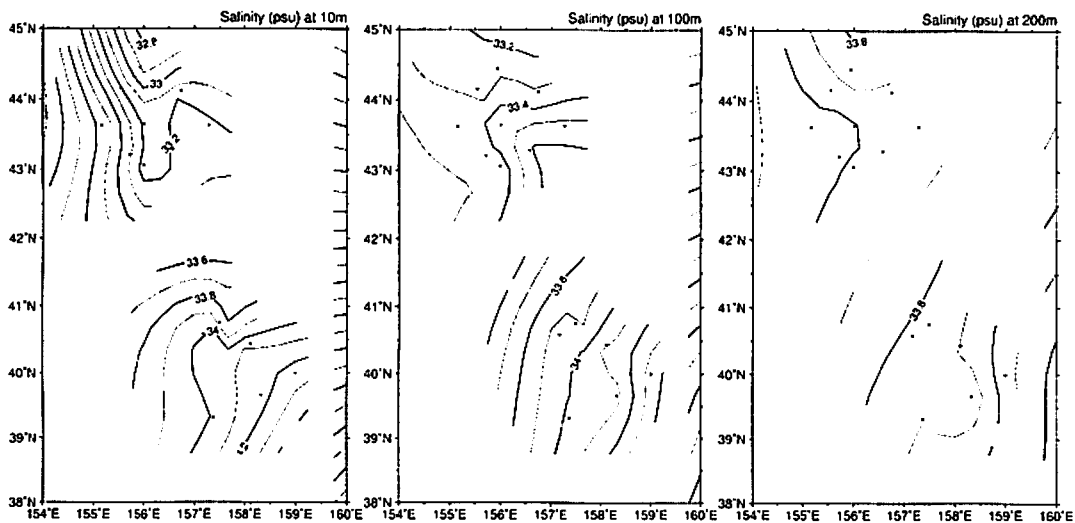


Fig. 5. Salinity at 10 m (left panel), 100 m (middle panel) and 200 m depth (right panel) observed by *R/V Shunyo-Maru* in July 2009.

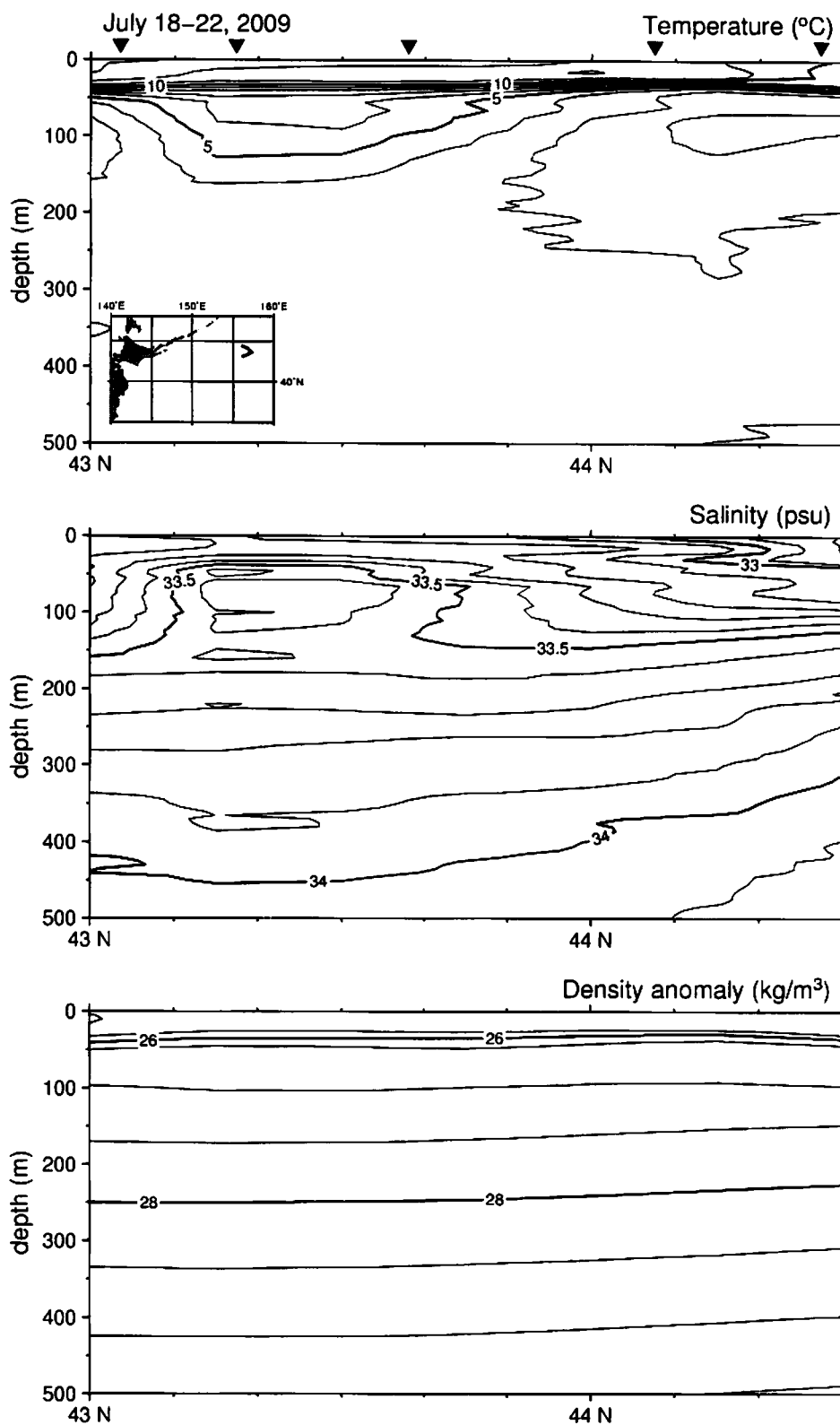


Fig. 6. Vertical sections (through Stns.14-8-9-10-16) of temperature (upper panel), salinity (middle panel) and density anomaly (lower panel) observed by *R/V Shunyo-Maru* in July 18-22, 2009.

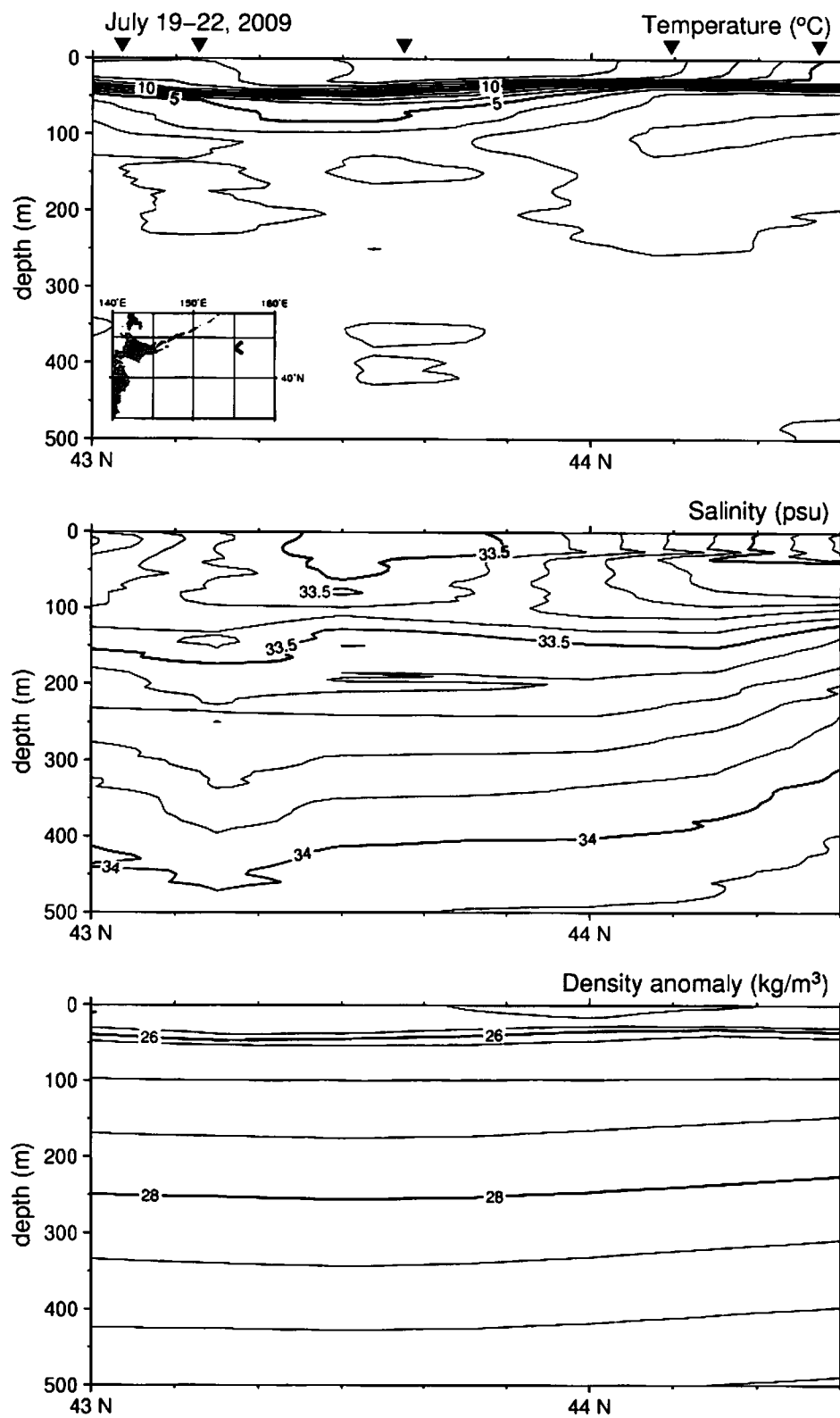


Fig. 7. Vertical sections (through Stns. 14-13-12-11-16) of temperature (upper panel), salinity (middle panel) and density anomaly (lower panel) observed by *R/V Shunyo-Maru* in July 19-22, 2009.

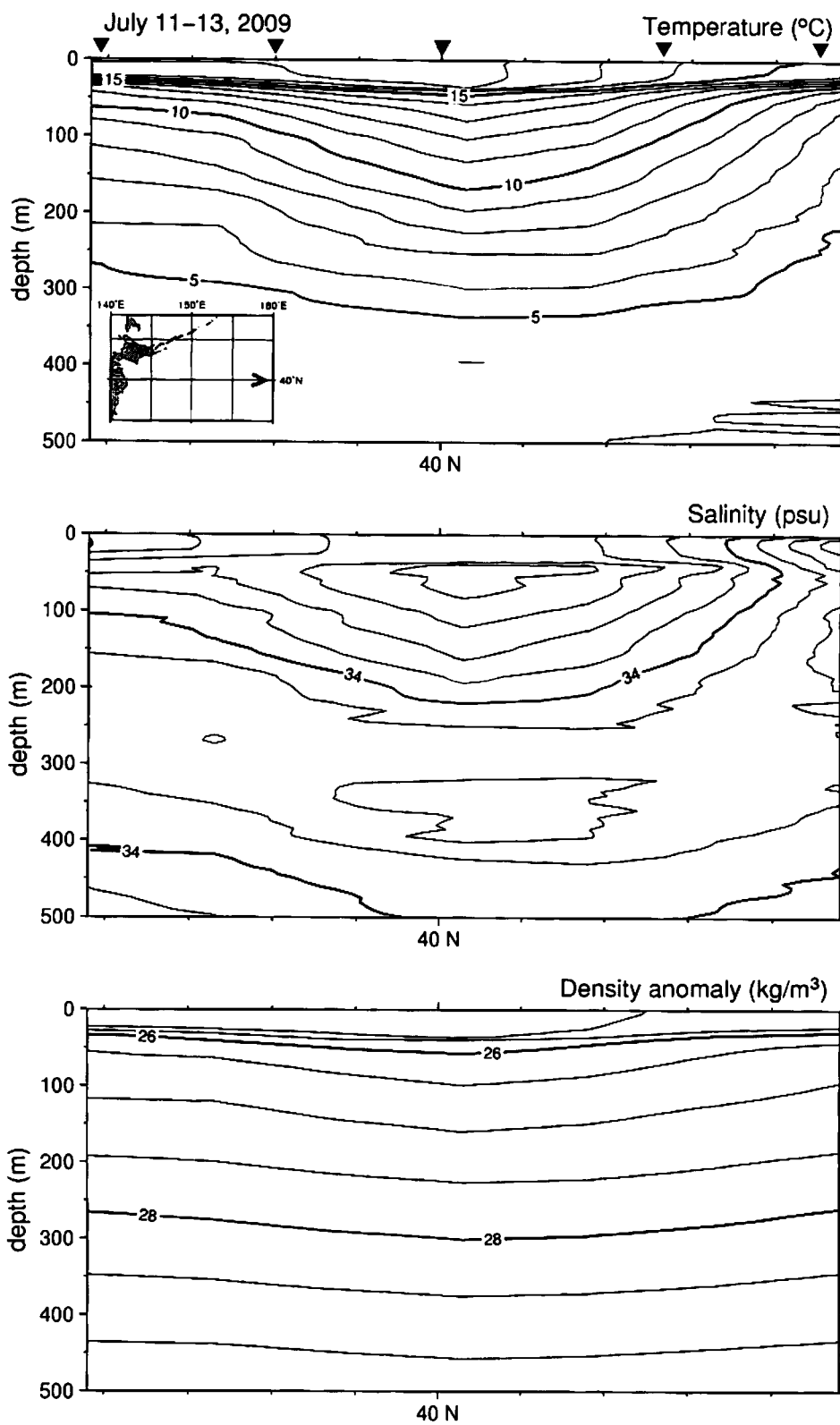


Fig. 8. Vertical sections (through Stns. 3-4-5-6-7) of temperature (upper panel), salinity (middle panel) and density anomaly (lower panel) observed by *R/V Shunyo-Maru* in July 11-13, 2009.