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 –

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ABSTRACT

The seventh 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 6 June to 29 August 2008 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 seven research vessels was used: one trawl survey vessel equipped with scientific echo sounder (TSV), two dedicated sighting vessel (SVs), three sighting/sampling vessels (SSVs) and one research base vessel. A total of 5,147.1n.miles was surveyed in a period of 122 days by SVs. During that period nine common minke, 140 sei, 292 Bryde's and 291 sperm whales were sighted by the SVs. A total of 5,757.6n.miles was surveyed in a period of 80 days by SSVs. During that period 66 common minke, 386 sei, 234 Bryde's and 277 sperm whales were sighted by the SSVs. A total of 59 common minke, 100 sei, 50 Bryde's and 2 sperm whales was sampled by the SSVs. All whales sampled were examined on board the research base vessel. One Bryde's whale was tracked by satellite tag in the western North Pacific during July. Data transmission was received for three weeks (SC/61/O7). 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 krill and Japanese anchovy. Sei whales fed mainly on copepods, krill and Japanese anchovy. Dominant preys in the stomach of two sperm whales 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; SATELLITE TAGGING; 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 2008 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). These results will reflect to the next research activities of JARPN II.

In this paper, we present an outline of the seventh full-scale survey of the JARPN II -offshore component-, which was conducted from 6 June to 29 August 2008.

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, 7SO) stratified for taking into account satellite information on water temperature.

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

Research vessels

Seven research vessels were used.

The research base vessel *Nisshin Maru* (NM: 8,030GT) commanded the research and was the platform for biological examination of whale samples and processing of by-products. The *Yushin Maru* (YS1: 720GT), *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 *Kyoshin Maru* No. 2 (KS2: 372GT) was used as dedicated sighting vessel (SV). The *Kaiko-maru* (KK1: 860.25GT) was engaged the cetacean prey species survey and whale sighting survey (TSV and/or SV) using midwater trawl, Issaces Kidd Midwater Trawl (IKMT), NORPAC net and Oceanographic observations. 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 the cooperative survey.

Whale survey

Vessels: Four research vessels (NM, YS1, 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 6 June and 24 August

Dedicated Sighting survey

Vessels: Two research vessel (KS2, KK1)

Research area: Sub-areas 7, 8 and 9

Research period:

KS2: Between 1 July and 29 August

KK1: Between 27 July and 31 August

Cooperative survey on the prey species and whale sampling

Vessels: Six research vessels (NM, YS1, YS2, YS3, KK1 and SYO)

Research area:

First period (Eastern block) : A part of sub areas 8 and 9 (NM, YS1, YS2, YS3, KK1)

Second period (Western block): A part of sub area 7 (NM, YS1, YS2, YS3, SYO)

Research period:

First period (Eastern block) : Between 1 July and 26 July (NM, YS1, YS2, YS3, KK1)

Second period (Western block): Between 18 July and 5 August (NM, YS1, YS2, YS3, 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, 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. Three 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 two parallel tracks 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, Matsuoka *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 2008 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 trackline 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 (*YS1*, *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. Preliminary experiments on attachment of satellite tagging to sei and Bryde's whales.
5. Feeding behaviour patterns of large whale species (blue, fin, sei, Bryde's, common minke, humpback, right and sperm whales).

On board the SV (*KS2*, *KK1*), 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.

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*, *KK1*), 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, IKMT net and plankton net.
3. Oceanographic observations using CTD, TDR, EPCS and OPCS.

RESULTS AND DISCUSSIONS

Searching distance

Track line covered by the three sighting/sampling vessels (SSVs) is shown in Fig. 2. The total searching distance for SSVs was 5,757.6n.miles.

Track line covered by the dedicated sighting vessels (SVs) is shown in Fig. 3. The total searching distance was 5,147.1n.miles.

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

Sighting and sampling vessels (SSVs)

A total of 64 schools (66 individuals) of common minke whales was sighted, consisting of 21 schools (21 individuals) of primary and 43 schools (45 individuals) of secondary sightings. For sei whale, 229 schools (386 individuals) were sighted, consisting of 137 schools (230 individuals) of primary sightings and 92 schools (156 individuals) of secondary sightings. For Bryde's whale, 170 schools (234 individuals) were sighted, consisting of 134 schools (186 individuals) of primary sightings and 36 schools (48 individuals) of secondary sightings. For sperm whale, 141 schools (277 individuals) were observed, consisting of 97 schools (162 individuals) of primary sightings and 44 schools (115 individuals) of secondary sightings (Table 1).

Fig 4. shows the distribution of common minke, sei, Bryde's and sperm whales sighted by the SSVs in the sub-areas 7, 8 and 9. Common minke whales and sei whales were sighted mainly in offshore of sub-areas 8 and 9. But, Bryde's whales were sighted mainly in southern part of sub-areas 7 and 8. Sperm whales were widely distributed in sub-areas 7, 8 and 9.

Dedicated sighting vessels (SVs)

During the research cruise, 11 schools (11 individuals) of common minke whales were sighted, consisting of 9 schools (9 individuals) of primary sightings and 2 schools (2 individuals) of secondary sightings. For sei whale, 71 schools (139 individuals) were sighted, consisting of 69 schools (136 individuals) of primary sightings and 2 schools (3 individuals) of secondary sightings. For Bryde's whale, 193 schools (292 individuals) were sighted, consisting of 188 schools (285 individuals) of primary sightings and 5 schools (7 individuals) of secondary sightings. For sperm whale, 134 schools (294 individuals) were sighted, consisting of 127 schools (283 individuals) of primary sightings and 7 schools (11 individuals) of secondary sightings (Fig. 5, 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 (15 schs./22 inds.), fin (39 schs./46 inds.), and humpback whales (17 schs./27 inds.).

Dedicated sighting vessels (SVs)

Large baleen whales such as blue (18 schs. /23 inds.), fin (51 schs./75 inds.), humpback whales (10 schs./10 inds.) and right whale (5 schs./6 inds.) were found in the sub-areas 7, 8 and 9 (Table 1).

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

A total of 59 common minke whales (Male: 53 individuals, Female: 6 individuals) was sampled. A total of 100 sei whales (Male: 44 individuals, Female: 56 individuals) was sampled. A total of 50 Bryde's whales (Male: 30 individuals, Female: 20 individuals) were sampled. Two male sperm whales were sampled. Table 2 summarizes the biological data and samples collected from whales. A total of 52 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 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 7.37 m and 7.96 m for males and females, respectively. For sei whales, those were 13.42 m and 13.89 m for males and females, respectively. For Bryde's whales, those are 12.02 m and 12.55 m for males and females, respectively. For sperm whale, the statistics of body length are shown also in Table 4. Mean body length is 11.48 m.

Geographical distribution of common minke, sei, Bryde's and sperm whale samples are also shown in Fig. 6 based on the sighting positions.

Distribution and food habit

During the research season (from June to August) in the offshore area, common minke whales fed mainly on Pacific saury, and they also fed on krill (Table 5). Sei whales were distributed widely in the offshore area. From June to August, they fed mainly on copepods and Japanese anchovy (Table 5). Bryde's whales were distributed in the southern part of the research area. They fed mainly on Japanese anchovy and krill (Table 5). Sperm whales were also distributed widely in the research area. They fed mainly on deep sea squids in entire area.

Experiments

Biopsy sampling trial

Table 6 shows the results of biopsy skin sampling. A total of eleven blue whales, one humpback whale, one sei whale and four right whales was targeted for biopsy sampling by the SV s and SSVs. As a result, four blue whales, one humpback whale, one sei whale and four right whale biopsy skin samples were collected.

Natural marks (photo ID) for blue, humpback, sei and right whales

Table 7 shows the results of the photo-ID experiments for blue whales, humpback whales, sei and right whales. A total of eleven blue whales, one humpback whale, one sei whale and five right whales was targeted by the SVs and SSVs.

Feeding and excretion behaviour for large baleen whales

The SVs and SSVs had planned to conduct recording of the feeding and excretion behaviour of large baleen whales using a photograph. As a result, 36 sei whales and four Bryde's whale were observed, and took 17 photographs.

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

The SSVs had planned to try attaching satellite tags to sei and Bryde's whales. A total of four sei and 14 Bryde's whales was targeted by the SSVs. As a result, one satellite tag was attached to a Bryde's whale. The satellite tracking data was received for a period of three weeks (See Appendix 1.).

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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., Lindstrøm, 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. 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/52/01 presented to the IWC Scientific meeting, 68pp.

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.

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

Government of Japan. 2004b. Some considerations of the feasibility components of the JARPN II research plan. Paper SC/56/O2 presented to the IWC Scientific Committee, May 2004 (unpublished). 36pp

International Whaling Commission. 2001. Report of the workshop to review the Japanese Whale Research Programme under Special Permit for North Pacific minke whales (JARPN), Tokyo, 7-10 February 2000. J. Cetacean Res. Manage. (*Suppl.*) 3: 377-413.

International Whaling Commission. 2009. The report of the Expert Workshop to review the ongoing JARPN II Programme. Paper SC/61/Rep 1 presented to this meeting.

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.

Kawamura, A. 1980. A review of food of Balaenopterid whales. Sci. Rep. Whales Res. Inst., Tokyo, 32: 155-197.

Omura, H. and Nemoto, T. 1955. Sei whales in the adjacent waters of Japan III. Relation between movement and water temperature of the Sea. Sci. Rep. Whales Res. Inst. 10: 79-87.

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.

Nemoto, T. 1959. Food of baleen whales with reference to whale movements. Sci. Rep. Whales Res. Inst., Tokyo, 14: 149-291.

Tamura, T. and Fujise, Y. 2002. Appendix 1. Food habit of common minke whales based on JARPN II., 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.

Tamura, T. and Fujise, Y. 2002. Appendix 2. Food habit of Bryde's whales based on JARPN II., pp 64-74. 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.

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., Konishi, K., Isoda, T., Okamoto, R. and Bando, T. 2009. 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

Yatsu, A., Nishida, H., Tomosada, A., Kinoshita, T. and Wada, T. 2001. Trajectories of catch and stock abundance of dominant small pelagic fishes and common squid with some related environmental indices around Japan. PICES Sci. Rep. 18: 175-8.

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 (YS1, YS2 and YS3)

Species	Primary		Secondary		Total	
	Sch.	Ind.	Sch.	Ind.	Sch.	Ind.
Common minke whale	21	21	43	45	64	66
Like minke whale	1	1	10	10	11	11
Sei whale	137	230	92	156	229	386
Bryde's whale	134	186	36	48	170	234
Sperm whale	97	162	44	115	141	277
Blue whale	12	18	3	4	15	22
Fin whale	28	34	11	12	39	46
Humpback whale	9	16	8	11	17	27

Dedicated sighting vessel (KS2)

Species	Primary		Secondary		Total	
	Sch.	Ind.	Sch.	Ind.	Sch.	Ind.
Common minke whale	8	8	2	2	10	10
Sei whale	56	116	0	0	56	116
Bryde's whale	94	141	0	0	94	141
Sperm whale	79	205	5	9	84	214
Blue Whale	12	17	0	0	12	17
Fin Whale	35	55	1	1	36	56
Humpback whale	8	8	1	1	9	9
Right whale	5	6	0	0	5	6

Dedicated sighting vessel (KK1)

Species	Primary		Secondary		Total	
	Sch.	Ind.	Sch.	Ind.	Sch.	Ind.
Common minke whale	1	1	0	0	1	1
Like minke whale	1	1	0	0	1	1
Sei whale	13	20	2	3	15	23
Bryde's whale	94	144	5	7	99	151
Sperm whale	48	78	2	2	50	80
Blue whale	5	5	1	1	6	6
Fin whale	15	19	0	0	15	19
Humpback whale	1	1	0	0	1	1

Table 2. Summary of biological data and samples obtained.

Samples and data	Common minke			Sei whale			Bryde's whale			Sperm whale		
	M	F	T	M	F	T	M	F	T	M	F	T
Body length and sex	53	6	59	44	56	100	30	20	50	2	0	2
External body proportion	53	6	59	44	56	100	30	20	50	2	0	2
Photographic record and external character	53	6	59	44	56	100	30	20	50	2	0	2
Diatom film record	53	6	59	44	56	100	30	20	50	2	0	2
Standard measurements of blubber thickness (five points)	53	6	59	44	56	100	30	20	50	2	0	2
Detailed measurements of blubber thickness (eleven points)	8	1	9	5	10	15	6	2	8	2	0	2
Body weight	53	6	59	28	14	42	30	20	50	1	0	1
Body weight*	-	-	-	16	42	58	-	-	-	-	-	-
Body weight by parts	8	1	9	5	10	15	6	2	8	2	0	2
Blubber tissues for DNA study	53	6	59	44	56	100	30	20	50	2	0	2
Blubber, muscle, liver and kidney tissues for heavy metal analysis	53	6	59	44	56	100	30	20	50	2	0	2
Blubber, muscle, liver and kidney tissues for organochlorines analysis	53	6	59	44	56	100	30	20	50	2	0	2
Blubber, muscle tissues for by-product inspection	53	6	59	44	56	100	30	20	50	2	0	2
Blubber, muscle tissues for ingredient analysis	2	0	2	2	3	5	3	2	5	2	0	2
Lung tissue for atmospheric analysis	2	0	2	10	0	10	7	0	7	2	0	2
Tissues for lipid analysis	9	1	10	6	11	17	7	2	9	2	0	2
Tissues for various analysis	53	6	59	44	56	100	30	20	50	2	0	2
Tissues for virus test	53	5	58	44	36	80	30	9	39	2	0	2
Mammary grand; lactation status, measurement and histological sample	-	6	6	-	56	56	-	20	20	-	0	0
Collection of spermaceti sample	-	-	-	-	-	-	-	-	-	2	0	2
Collection of maternal milk sample	-	6	6	-	1	1	-	0	0	-	0	0
Uterine horn; measurement and endometrium sample	-	6	6	-	55	55	-	20	20	-	0	0
Collection of ovary	-	6	6	-	56	56	-	20	20	-	0	0
Photographic record of foetus	3	2	5	12	24	36	5	4	9	0	0	0
Foetal sex (identified by visual observation)	3	2	5	12	24	36	5	4	9	0	0	0
Foetal length and weight	3	2	5	12	24	36	5	4	9	0	0	0
External measurements of foetus	3	2	5	12	24	36	5	4	9	0	0	0
Foetal blubber tissues for DNA study	3	2	5	12	24	36	5	4	9	0	0	0
Foetal tissues for various analysis	3	2	5	12	24	36	5	4	9	0	0	0
Foetal lens for age determination	3	2	5	12	24	36	5	4	9	0	0	0
Testis and epididymis; weight and histological sample	52	-	52	44	-	44	30	-	30	2	-	2
Collection of plasma sample	53	6	59	44	56	100	30	20	50	2	0	2
Collection of whole blood sample	53	6	59	44	56	100	30	20	50	2	0	2
Whole blood samples from umbilical cord	-	0	0	-	27	27	-	8	8	-	0	0
Plasma samples from umbilical cord	-	3	3	-	33	33	-	9	9	-	0	0
Stomach content, conventional record	53	6	59	44	56	100	30	20	50	2	0	2
Volume and weight of stomach content in each compartment	53	6	59	44	56	100	30	20	50	2	0	2
Stomach contents for feeding study	50	6	56	37	40	77	12	6	18	2	0	2
Record of external parasites	53	6	59	44	56	100	30	20	50	2	0	2
Collection of external parasites	0	1	1	2	2	4	2	3	5		0	0
Record of internal parasites	53	6	59	44	56	100	30	20	50	2	0	2
Collection of internal parasites	0	0	0	4	5	9	1	0	1	2	0	2
Earplug for age determination	53	6	59	44	56	100	30	20	50	-	-	-
Tympanic bulla for age determination	53	6	59	43	56	99	30	20	50	-	-	-
Maxillally teeth for age determination	-	-	-	-	-	-	-	-	-	2	0	2
Lens for age determination	53	6	59	44	56	100	30	20	50	-	-	-
Largest baleen plate for morphologic study and age determination	53	6	59	44	56	100	30	20	50	-	-	-
Baleen plate measurements (length and breadth)	53	6	59	43	56	99	29	19	48	-	-	-
Length of each baleen plate series	52	5	57	36	56	92	30	20	50	-	-	-
Vertebral epiphyses sample	53	6	59	44	56	100	30	20	50	2	0	2
Number of vertebrae	0	0	0	5	11	16	6	2	8	2	0	2
Number of ribs	53	6	59	44	56	100	30	20	50	2	0	2
Brain weight	8	1	9	5	11	16	6	2	8	2	0	2
Skull measurement (length and breadth)	48	5	53	32	52	84	22	20	42	2	0	2

*divided by some parts because the whale was too big to measure the whole body weight with the scale

Table 3. Compositon of sex and sexual maturity of three baleen whales collected

Common minke whale

Sub-area	Male				Female				Combined	Sex ratio	Maturity		Pregnancy
	Imm.	Mat.	Unknown	Total	Imm	Rest.	Preg.	Total		(% males)	Male	Female	rate*)
7	1	4	0	5	0	0	0	0	5	100.0	80.0	0.0	0.0
	(20.0)	(80.0)	(0.0)	(100.0)	(0.0)	(0.0)	(0.0)	(0.0)	(100.0)				
8	0	3	1	4	0	0	0	0	4	100.0	75.0	0.0	0.0
	(0.0)	(75.0)	(25.0)	(100.0)	(0.0)	(0.0)	(0.0)	(0.0)	(100.0)				
9	2	38	4	44	0	1	5	6	50	88.0	86.4	100.0	0.0
	(4.0)	(76.0)	(8.0)	(88.0)	(0.0)	(2.0)	(10.0)	(12.0)	(100.0)				
Combined	3	45	5	53	0	1	5	6	59	89.8	84.9	100.0	83.3
	(5.1)	(76.3)	(8.5)	(89.8)	(0.0)	(1.7)	(8.5)	(10.2)	(100.0)				

*) Apparent pregnancy rate

Sei whale

Sub-area	Male			Female							Combined	Sex ratio	Maturity		Pregnancy
	Imm.	Mat.	Total	Imm	Ovu	Rest.	Preg.	Lact.	Preg&Lact	Total		(% males)	Male	Female	rate*)
7	0	0	0	0	0	0	0	0	0	0	0	-	-	-	-
8	5	18	23	6	0	1	13	1	0	21	44	52.3	78.3	71.4	86.7
	(11.4)	(40.9)	(52.3)	(13.6)	(0.0)	(2.3)	(29.5)	(2.3)	(0.0)	(47.7)	(100.0)				
9	5	16	21	11	0	1	22	0	1	35	56	37.5	76.2	68.6	95.8
	(8.9)	(28.6)	(37.5)	(19.6)	(0.0)	(1.8)	(39.3)	(0.0)	(1.8)	(62.5)	(100.0)				
Combined	10	34	44	17	0	2	35	1	1	56	100	44.0	77.3	69.6	92.3
	(10.0)	(34.0)	(44.0)	(17.0)	(0.0)	(2.0)	(35.0)	(1.0)	(1.0)	(56.0)	(100.0)				

*) Apparent pregnancy rate

Bryde's whale

Sub-area	Male				Female							Combined	Sex ratio	Maturity		Pregnancy
	Imm.	Mat.	Unknown	Total	Imm	Ovu	Rest.	Preg.	Lact.	Preg&Lact	Total		(% males)	Male	Female	rate*)
7	4	10	1	15	1	0	5	5	0	0	11	26	57.7	66.7	90.9	50.0
	(15.4)	(38.5)	(3.8)	(57.7)	(3.8)	(0.0)	(19.2)	(19.2)	(0.0)	(0.0)	(42.3)	(100.0)				
8	1	12	0	13	3	0	2	4	0	0	9	22	59.1	92.3	66.7	66.7
	(4.5)	(54.5)	(0.0)	(59.1)	(13.6)	(0.0)	(9.1)	(18.2)	(0.0)	(0.0)	(40.9)	(100.0)				
9	1	1	0	2	0	0	0	0	0	0	0	2	100.0	50.0	#DIV/0!	#DIV/0!
	(50.0)	(50.0)	(0.0)	(100.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(100.0)				
Combined	6	23	1	30	4	0	7	9	0	0	20	50	60.0	76.7	80.0	56.3
	(12.0)	(46.0)	(2.0)	(60.0)	(8.0)	(0.0)	(14.0)	(18.0)	(0.0)	(0.0)	(40.0)	(100.0)				

*) Apparent pregnancy rate

Table 4. Statistics of body length (m) of four whale species collected

Common minke whale

Sub area	Male					Female				
	Mean	S.D.	Min	Max	n	Mean	S.D.	Min	Max	n
7	6.89	1.25	4.66	7.56	5	-	-	-	-	-
8	7.24	0.30	6.80	7.47	4	-	-	-	-	-
9	7.44	0.43	5.20	8.07	44	7.96	0.55	7.09	8.69	6
Combined	7.37	0.56	4.66	8.07	53	7.96	0.55	7.09	8.69	6

Sei whale

Sub area	Male					Female				
	Mean	S.D.	Min	Max	n	Mean	S.D.	Min	Max	n
7	12.05	0.68	10.53	12.95	15	12.80	0.50	11.69	13.49	11
8	12.21	1.03	9.10	13.55	13	12.24	1.92	8.78	13.76	9
9	10.63	2.70	8.72	12.54	2	-	-	-	-	0
Combined	12.02	1.03	8.72	13.55	30	12.55	1.33	8.78	13.76	20

Bryde's whale

Sub area	Male					Female				
	Mean	S.D.	Min	Max	n	Mean	S.D.	Min	Max	n
7	-	-	-	-	-	-	-	-	-	-
8	13.46	0.69	11.58	14.54	23	13.98	1.33	10.61	15.83	21
9	13.38	0.99	10.63	14.46	21	13.83	1.20	10.49	15.93	35
Combined	13.42	0.84	10.63	14.54	44	13.89	1.24	10.49	15.93	56

Sperm whale

Sub area	Male					Female				
	Mean	S.D.	Min	Max	n	Mean	S.D.	Min	Max	n
7	9.24	-	9.24	9.24	1	-	-	-	-	-
8	-	-	-	-	-	-	-	-	-	-
9	13.72	-	13.72	13.72	1	-	-	-	-	-
Combined	11.48	3.17	9.24	13.72	2	-	-	0.00	0.00	0

Table 5. Prey species and stomach contents weight (1st. + 2nd. stomachs) found in stomach of common minke, Bryde's, sei whales sampled

Common minke whale

Prey species		N (Dominant)	Range of weigth (kg) in the stomachs
Krill		5	0.86-77.40
Copepods	Neocalanus spp.	1	1.02
Fish	Pacific saury	36	0.48-118.20
	Japanese anchovy	1	5.66
	Pink salmon	3	1.72-25.88
	Oceanic lightfish	1	0.92
	Pacific pomfret	3	17.56-61.72

Sei whale

Prey species		N (Dominant)	Range of weigth (kg) in the stomachs
Copepods	Neocalanus spp.	61	0.18-333.65
Krill		2	0.14-0.78
Fish	Pacific saury	3	0.28-58.80
	Japanese anchovy	7	0.36-382.66
	Oceanic lightfish	2	5.70-10.70
	Chub mackerel*	1	-
	Japanese sardine*	1	-
Jellyfish	Unidentified*	1	0.20
Squid	Japanese flying squid*	1	-
	Unidentified*	1	-

*: Minor prey species

Bryde's whale

Prey species		N (Dominant)	Range of weigth (kg) in the stomachs
Krill		7	0.12-12.28
Fish	Japanese anchovy	17	0.70-317.10
	Oceanic lightfish	2	0.16-0.26
	Chub mackerel *	3	-
	Japanese sardine*	7	-

*: Minor prey species

Table 6. Summary of biopsy skin sampling for baleen whales in the 2008 JARPN II

Whale species	Ship	Number of experiments (A)	Targeted individuals (B)	Number of shoots (C)	Number of hits (D)	Number of samples (E)	Effort (hr) (F)	sample per trial (E)/(C)	sample per hit (E)/(D)
Blue whale	SSVs	4	7	3	2	1	1:43	0.33	0.50
Blue whale	SVs	4	4	7	2	2	1:59	0.29	1.00
Humpback whale	SSVs	1	1	1	1	1	0:05	1.00	1.00
Right whale	SVs	4	5	9	4	4	1:59	0.44	1.00
Sei whale	SVs	1	1	1	1	1	0:15	1.00	1.00

Table 7. Summary of photo ID for baleen whales in the 2008 JARPN II

Whale species	Ship	Number of experiments (A)	Targeted individuals (B)	Number of photos (C)
Blue whale	SSVs	2	3	2
Blue whale	SVs	4	4	2
Right whale	SSVs	1	1	1
Right whale	SVs	3	4	3

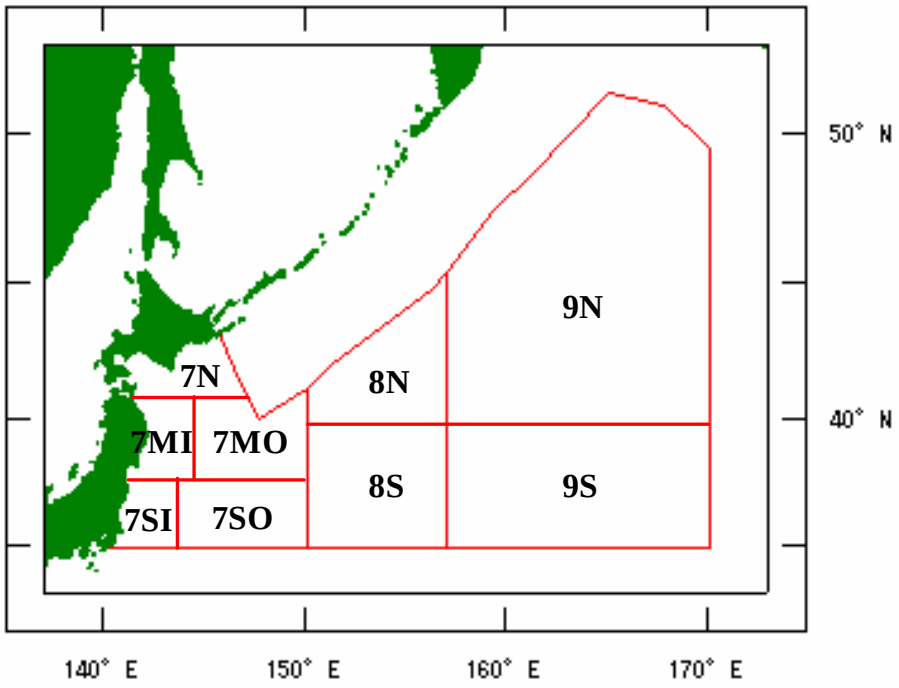

Fig 1. Map showing the research area and strata of the JARPN II full-scale program.

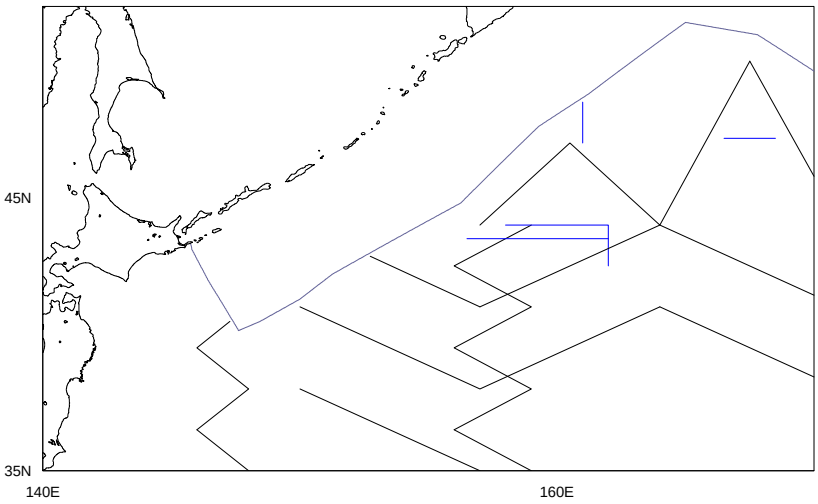

Fig. 2. Track-line covered by the three sighting/sampling vessels (SSVs)
Blue lines were SMS.

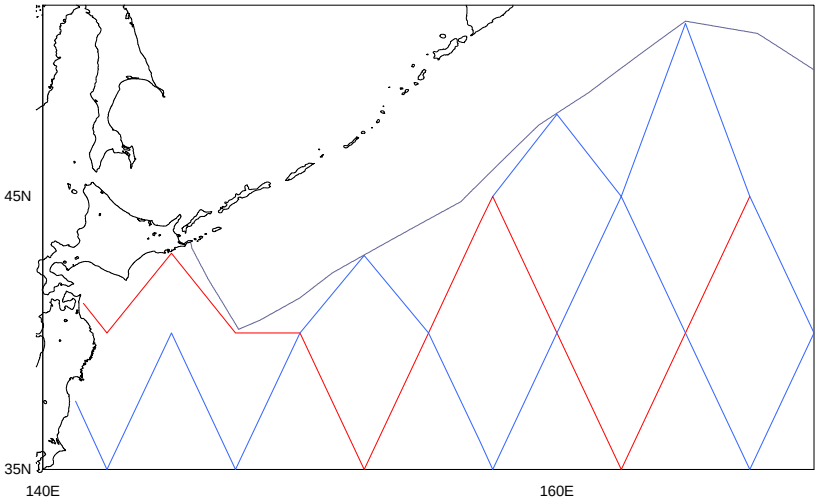

Fig. 3. Track-line covered by the sighting vessel (SVs: KS2 and KK1)
(Blue line KS2, Red line KK1).

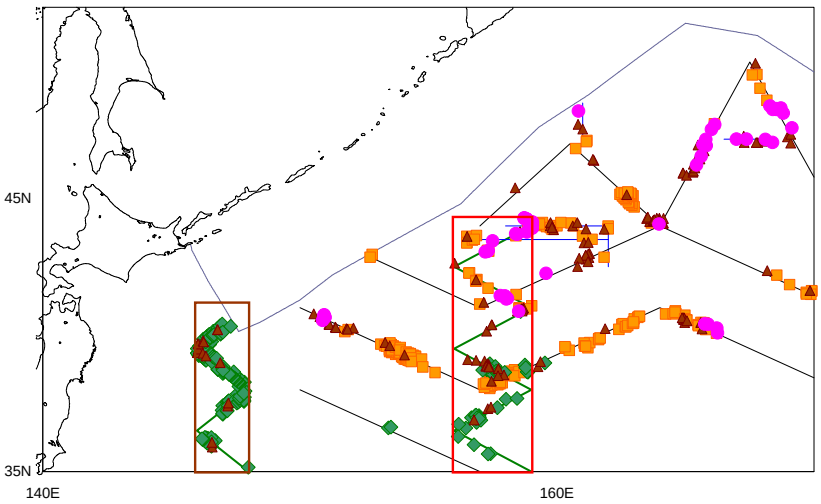

Fig. 4. The positions of the sightings of common minke whale (pink circle), sei (orange square), Bryde's (green diamond) and sperm (brown triangle) whales by the three sighting/sampling vessels (SSVs)

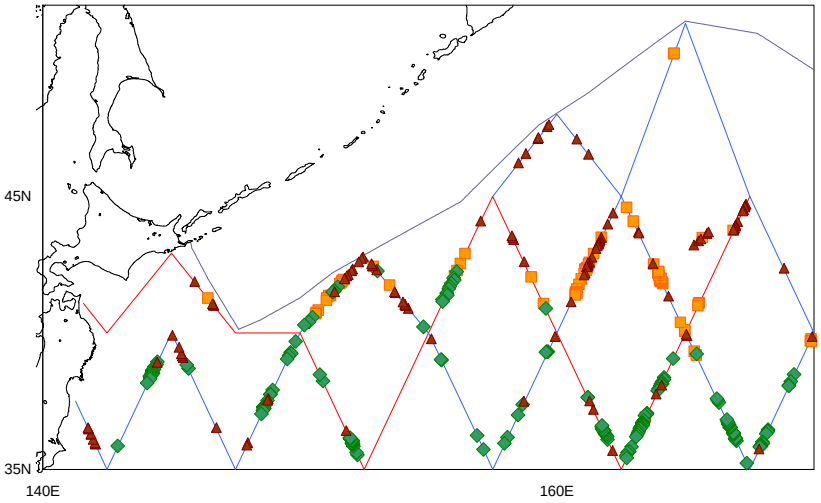

Fig. 5. The positions of the sightings of common minke whale (pink circle), sei (orange square), Bryde's (green diamond) and sperm (brown triangle) whales by the two dedicated sighting vessels (SVs). Blue line KS2, Red line KK1

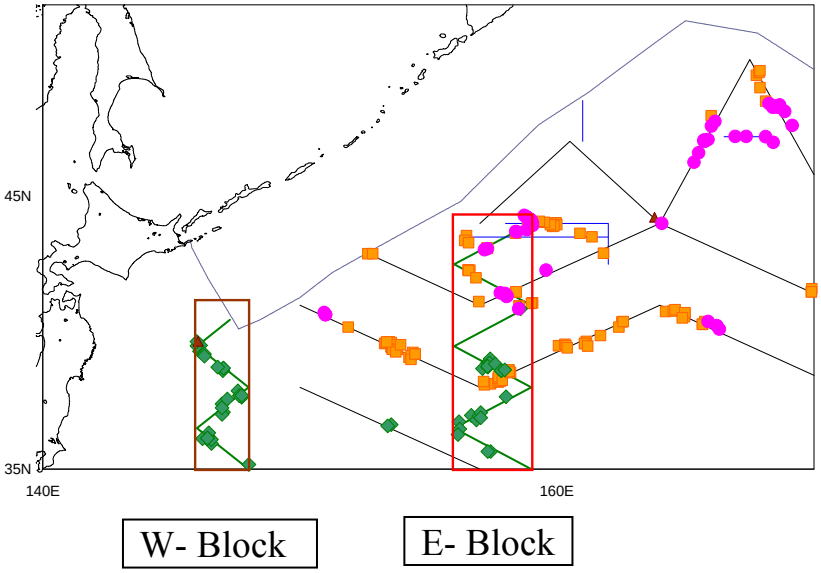

Fig. 6. The positions of the samplings of common minke whale (pink circle), sei (orange square), Bryde's (green diamond) and sperm (brown triangle) whales by the three sighting/sampling vessels (SSVs).

Two blocks (Western and Eastern block) show the cooperative surveys on the prey species and whale sampling areas.

Appendex.1.

The information of satellite tagging of a Bryde's whale in the western North Pacific

(Tamura, T. and Nishiwaki, S)

Abstract

One Bryde's whale tagged with an Argos transmitter (Telonics, INC. USA) was tracked in the western North Pacific from 24 July to 13 August. The Bryde's whale with an estimated body length of 12.6m, was tagged on 24 July 2008, at 38-01N, 147-52E from the *Yushin Maru* No.2. We received their position information from the satellite for a period of three weeks. After the satellite tag was attached, the animal moved southeast. The travelling distance was estimated to be approximately 1,200 naut. miles in the three weeks. The detail of this result was shown in SC/61/O7.

Fig. 1. The Bryde's whale with the satellite tag attached.

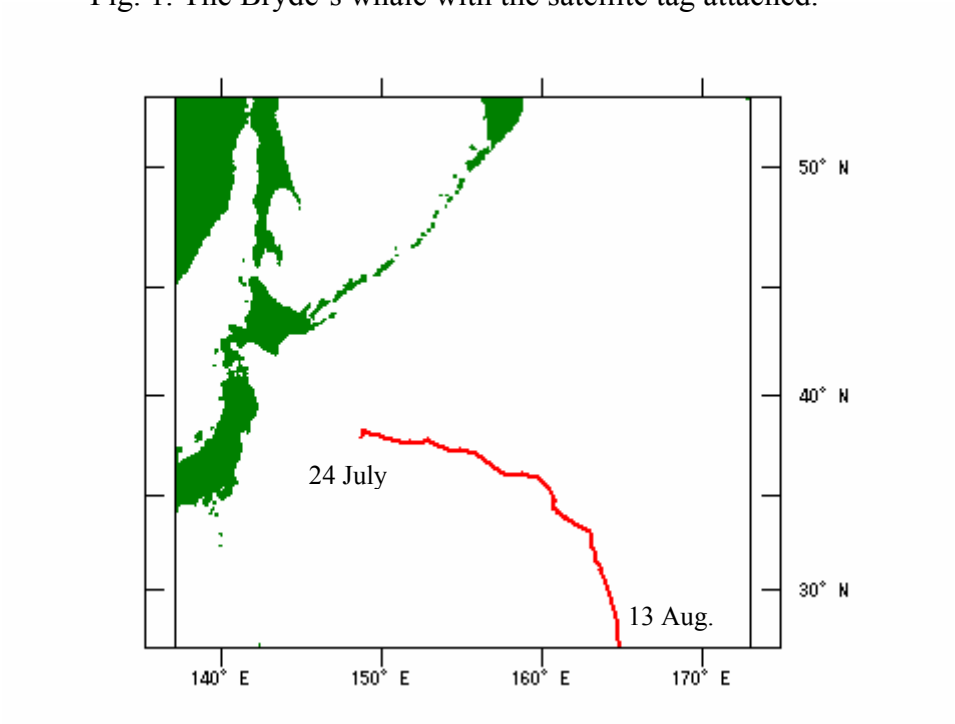

Fig. 2. Track of the Bryde's whale 24 July to 13 August 2008 in the western North Pacific.

Appendix 2.

Cruise report of the cetacean prey species survey of JARPN II (offshore component) in 2008

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ABSTRACT

A whale prey species survey was conducted concurrently with a whale sampling survey as a part of the offshore component of JARPN II in 2008. The primary objective of the concurrent study was estimation of prey selection of whales. Survey block with zigzag track lines was set within the survey area of JARPN II. The survey was conducted from 5 to 25 July. A trawler-type survey vessel, Kaiko-Maru (860 ton, KK1), equipped with the quantitative echo sounder dedicated to the prey survey. KK1 also conducted cetacean sighting survey while she steamed on the track lines. The acoustic survey using a Simrad EK 500 echo sounder with operating frequencies at 38 and 120 kHz was carried out to quantify prey abundance as well as to elucidate the distribution patterns. Species compositions of acoustical backscatterings were identified using midwater trawl and plankton nets. In addition, trawls were towed at predetermined stations independently from the acoustic survey. IKMT and Twin – NORPAC were used to collect zooplanktons. Midwater trawl, IKMT, and Twin – NORPAC were towed at 22, 2, and 23 stations, respectively. Oceanographic observations were conducted using CTD at 25 stations. Total surveyed distance of cetacean sighting survey was 690.17 n.miles. Primary sightings of common minke, sei and Bryde's whales were one group / one individual, one group / one individual, 23 groups / 24 individuals, respectively.

INTRODUCTION

The Japanese Whale Research Program under Special Permit in the North Pacific (JARPN) was conducted between 1994 and 1999. The main objective was to clarify the stock structure of common minke whale (*Balaenoptera acutorostrata*) in the western North Pacific. As it proved that minke whales feed on a good deal of fisheries resources such as Japanese anchovy (*Engraulis japonicus*) and Pacific saury (*Cololabis saira*) (Tamura and Fujise, 2002), the feeding ecology was added in 1996 as a feasibility study. At the JARPN review meeting held in February 2000, the workshop agreed that the sampling regime must be designed to allow for a more quantitative estimation of temporal and geographical variation in diet, and recommended that acoustic and trawl surveys should be conducted cooperatively with whale survey (IWC, 2001). In response to the recommendation, 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 52nd IWC / SC (Government of Japan, 2002). Some outcome of the results of JARPN feasibility study related to feeding ecology of cetacean was published in peer reviewed scientific journal (Murase *et al*., 2007). Based on successful results of the feasibility study, the study was expanded to full scale in 2002 (Government of Japan, 2002). Sei whale (*B. borealis*) was added as target cetacean species with minke, Bryde's (*B. edeni*), and sperm (*Physeter macrocephalus*) whales in the full-scale study. The full-scale study in 2008 was

conducted in Sub-areas 8 and 9, off the coast of eastern Honshu, Japan in July. The whale survey is conducted to collect diet data as well as other biological parameters of sei, Bryde's, minke, and sperm whales, whereas the prey survey was conducted to collect data on prey species of former three baleen whale species. This paper presented the cruise report of the prey species survey as a part of offshore component of JARPN II in 2008.

MATERIALS AND METHODS

The area of the cooperative whale and prey surveys was in Sub-areas 8 and 9 off the coast of eastern Honshu, Japan (Fig. 1). A zigzag track lines were set independently from whale sampling survey. Waypoints were listed in Table 1. The research vessel, *Kaiko-maru* (KK1, 860 GT), departed Sendai-Shiogama port on 1 July, 2008. Prey distribution and abundance surveys using the quantitative echo sounder, midwater trawl, Isaacs Kidd Midwater Trawl (IKMT) and Twin – NORPAC were conducted by KK1. In addition to the prey survey, KK1 conducted cetacean sighting survey. During the daytime, KK1 steamed at about 10.5 knots along track lines to conduct cetacean sighting and acoustic survey. Research hour was from an hour after sunrise to an hour before sunset while the maximum research hours were set at 13 hours. Generally, the survey started at 5:00 and end at 18:00 at local time.

A quantitative echo sounder (Simrad EK 500) with operating frequencies at 38 and 120 kHz was used on board KK1 to acquire acoustic data. The transducers were hull-mounted at the depth of 4.3 m from the surface. Calibrations were carried out at off the coast of Sendai-Shiogama before the prey species survey using the copper sphere technique described in the EK 500 manual (Simrad, 1997). Acoustic data were recorded while the KK1 steamed on the track lines. Acoustic data were also recorded during net samplings.

The midwater trawl net was 86.3 m long with a mouth opening of ca. 900 m^2 and a 6.0 m cod end with a 17.5 x 17.5 mm mesh inner. The sampling depth and, the height and width of the mouth of the net were monitored with Simrad PI32 Catch Monitoring System. Towing speed of the trawl net was 4 – 5 knots. Surface and midwater trawl was towed at predetermined and target trawl stations. Surface trawls were conducted using the midwater trawl net with the floats attached the bridle so that the trawl could be towed at the surface. Surface trawl was designed for collecting mainly Pacific saury. Target trawls were conducted to identify the species and size compositions of biological backscattering detected by the quantitative echo sounder. Another type of trawling was also conducted at predetermined stations in this survey. The purpose of the predetermined trawls was to estimate the abundance and distribution patterns of cephalopods and neustonic organisms such as Pacific saury that are difficult to detect by the echo sounder. Two different depth layers were sampled at predetermined trawl stations; 0 – 30 m (surface) and 0 – 100 m (midwater). Midwater predetermined trawl was towed for 10 minutes at each depth layer, 0 – 30 m, 30 – 60 m, and 60 – 100 m whereas surface predetermined trawl was towed for 30 minutes. All samples were identified to the species as much as possible and wet weight of each species was measured aboard the ship. For the major species, lengths of 100 individuals were measured to examine their size composition. A part of samples were frozen for further analysis in the laboratory. In addition to the trawl net, IKMT was used to identify the species and size compositions of macro and meso zooplanktons detected by the quantitative echo sounder. Mouth opening of the IKMT was about 3.7 x 3.1 m and mesh size of cod end was 1.9 mm. The samples were preserved in 10 % formalin for species identification at the laboratory. A small plankton net, Twin – the North Pacific standard net (NORPAC), equipped with flow meter was towed at most of trawl stations to estimate abundance of copepods. The mouth opening of Twin – NORPAC are 45 cm, and mesh size of that 0.33 mm and 0.15 mm, respectively. Twin – NORPAC was towed from 150 m to surface but it was towed various depth range in some cases to identify species compositions of acoustical backscattering.

Water temperature and salinity profiles at sampling stations were recorded by Conductivity – Temperature – Depth profiler (CTD, SBE – 19 – 01, Seabird, USA). CTD data were recorded from surface to 500 m.

Cetacean sighting survey was conducted by KK1 while she steamed on the track lines. Primary observers were allocated to the top barrel (3 observers) and the upper bridge (2 observers). Sighting survey was conducted in passing mode though abeam closing was conducted if the sightings were baleen whales but the species was uncertain. Abeam closing was conducted on sightings at a distance of 2 n.miles perpendicular to track lines.

RESULTS AND DISCUSSION

Most of track lines were surveyed by the quantitative echo sounder. Predetermined surface and midwater trawling was conducted at 11 and 11 stations, respectively. Target trawl were conducted at 2 stations. Positions of surface and midwater trawling were shown in Fig. 2. Summary of the results of trawling was shown in Table 2. Pink salmon (*Oncorhynchus gorbuscha*) and Japanese anchovy were dominant among sampled species. IKMT was towed at two stations (Table 3, Fig. 3). Twin – NORPAC was towed at 23 stations (Table 4, Fig. 4). CTD cast was carried out 25 stations (Table 5, Fig. 5). Surveyed distance of cetacean sighting survey was 690.17 n.miles. About 57.2 % of planned surveyed distance was surveyed in this survey. Primary sightings of common minke, Bryde's, and sei whales were one group / one individual, 23 groups / 24 individuals, and one group / one individual, respectively (Table 6, Figs. 6 - 10).

REFERENCES

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 Committee Meeting.

International Whaling Commission. 2001. Report of the workshop to review the Japanese whale research programme under special permit for North Pacific minke whales. *J. Cetacean Res. Manage.* (Suppl.) 3: 377-413.

Murase, H., Tamura, T., Kiwada, H., Fujise, Y., Watanabe, H., Ohizumi, H., Yonezaki, S., Okamura, H., and Kawahara, S. 2007. Prey selection of common minke and Bryde's whales in the western North Pacific in 2000 and 2001. *Fish. Ocenog*. 16: 186-201.

Tamura, T., and Fujise, Y. 2002. Geographical and seasonal changes of the prey species of minke whale in the Northwestern Pacific. *ICES J. Mar. Sci.* 59: 516-528.

Table 1. Positions of waypoints in this survey

Waypoint	Latitude				Longitude				Course	Distance (n.mile)
612	46	·	00	N	158	·	00	E	223	123.4
611	44	·	30	N	156	·	00	E	109	91.2
610	44	·	00	N	158	·	00	E	236	105.8
609	43	·	00	N	156	·	00	E	124	106.9
608	42	·	00	N	158	·	00	E	236	108.1
607	41	·	00	N	156	·	00	E	123	109.2
606	40	·	00	N	158	·	00	E	237	110.4
605	39	·	00	N	156	·	00	E	122	111.5
604	38	·	00	N	158	·	00	E	238	112.5
603	37	·	00	N	156	·	00	E	122	113.6
602	36	·	00	N	158	·	00	E	239	114.6
601	35	·	00	N	156	·	00	E		
									Total	1207.2

Table 2. Summary of the results of surface and midwater trawls

ST	Latitude (N)	Longitude (E)	P / T *1	M / S *2	SST (°C)	Target depth (m)	Towing duration (min)	Catch (kg)											Total (kg)
								Japanese anchovy	Japanese sardine	Chub mackerel	Blue mackerel	Pacific pomfret	Pink salmon	Chum salmon	Oceanic lightfish	Other fishes	Japanese flying squid	Other squids	
01	46-00.0	158-00.0	P	S	7.9	0−30	30						24.85					+	25.78
02	45-15.3	157-00.0	P	M	9.1	0−100	30						5.75					+	6.80
03	44-30.0	156-00.0	P	S	9.7	0−30	30						8.85	1.65		+		+	10.54
04	44-15.0	157-00.0	P	S	10.8	0−30	40						12.50			+		+	13.70
05	44-00.0	158-00.0	P	S	10.0	0−30	30						9.10			+		+	9.35
06	43-30.1	157-00.0	P	M	11.6	0−100	30					6.90	1.80			0.09		+	11.70
07	43-00.0	155-59.8	P	S	13.7	0−30	30											+	0.51
08	42-30.1	157-00.2	P	M	14.8	0−100	30									+		+	0.17
09	42-23.1	157-14.0	T	S	16.1	0−30	45	0.02								+	0.07	+	0.21
10	42-00.0	158-00.0	P	S	15.7	0−30	30									+			<0.001
11	41-30.1	156-59.8	P	M	17.1	0−100	30	0.01								0.01		0.02	0.16
12	41-00.1	156-00.2	P	S	18.7	0−30	40	18.90	0.02		11.49	+				+		+	31.46
13	40-30.0	157-00.2	P	M	18.5	0−100	30	1.50	+		0.08	0.08				+		+	2.70
14	40-00.1	158-00.0	P	S	19.6	0−30	30	+				0.27				0.07		+	2.80
15	39-30.0	157-00.1	P	M	19.8	0−100	30					0.05						+	0.56
16	39-12.4	157-24.7	T	S	20.7	0−30	30	7.30	+	+						0.07			8.67
17	39-00.0	155-59.8	P	M	20.4	0−100	30	0.02								+		+	0.27
18	38-30.1	157-00.0	P	S	21.1	0−30	30												0.74
19	37-59.8	158-00.4	P	M	22.3	0−100	30					+				+		+	0.52

Table 2. Continued

ST	Latitude (N)	Longitude (E)	P / T *1	M / S *2	SST (°C)	Target depth (m)	Towing duration (min)	Catch (kg)											Total (kg)
								Japanese anchovy	Japanese sardine	Chub mackerel	Blue mackerel *	Pacific pomfret	Pink salmon	Chum salmon	Oceanic lightfish	Other fishes	Japanese flying squid	Other squids	
20	37-30.0	156-59.8	P	S	21.5	0−30	30												0.31
21	37-02.2	155-59.9	P	M	23.8	0−100	30									+		+	0.61
22	36-28.8	156-59.9	P	S	23.5	0−30	30									+		+	0.13
23	35-59.7	158-00.6	P	M	24.2	0−100	30									+		+	0.62
26	34-59.4	155-58.7	P	M	24.3	0−100	30								0.07	+		+	0.68

1: P = predetermined trawl, T = target trawl

2: M = midwater trawl, S = surface trawl

Table 3. Summary of the results of IKMT

ST	Latitude (N)	Longitude (E)	SST (°C)	Target depth (m)
05	44-01.0	158-05.5	10.3	30-40
25	35-01.3	156-12.1	23.8	170

Table 4. Summary of the results of Twin – NORPAC

ST	Latitude (N)	Longitude (E)	SST (°C)	Target depth (m)	Filtered volume (m^3)	
					Mesh size 0.35 mm	Mesh size 0.10 mm
01	45-57.5	157-55.5	7.9	150	30.6	28.2
02	45-10.6	156-54.8	9.0	150	25.4	26.4
03	44-29.1	156-05.5	9.5	150	23.7	22.6
04	44-15.3	157-07.6	9.9	150	29.3	27.9
05	44-01.0	158-06.4	9.9	150	18.4	29.7
06	43-27.0	156-52.8	11.3	150	51.3	49.2
07	43-04.0	155-57.1	13.8	150	36.2	33.9
08	42-36.3	156-59.3	14.3	150	29.0	24.3
10	41-56.7	158-02.8	14.1	150	27.8	19.9
11	41-35.5	157-02.3	16.1	150	23.9	16.7
12	41-02.9	156-05.3	18.8	150	28.1	19.3
13	40-32.8	156-53.8	18.4	150	28.3	18.9
14	40-00.3	158-06.0	20.0	150	38.0	28.3
15	39-33.5	157-08.6	19.8	150	32.7	24.1
17	39-05.8	156-02.1	20.6	150	33.9	23.4
18	38-34.4	156-59.1	20.9	150	21.2	31.7
19	38-05.2	158-03.7	22.1	150	41.8	34.7
20	37-28.1	156-56.4	21.8	150	65.4	51.5
21	36-54.4	156-01.5	23.7	150	57.3	49.5
22	36-32.0	156-59.6	23.3	150	32.9	27.3
23	36-02.0	157-55.9	24.9	150	24.8	22.3
24	35-30.0	157-00.0	24.0	150	26.7	24.6
26	35-01.7	156-03.5	24.1	150	42.9	39.3

Table 5. List s of oceanographic observation stations

ST	Latitude (N)	Longitude (E)	Water temperature (°C)		
			0 m	100 m	200 m
01	45-54.7	157-53.0	7.8	1.7	3.3
02	45-10.6	156-54.8	9.2	3.2	3.0
03	44-29.3	156-05.5	9.8	2.7	3.3
04	44-15.4	157-08.1	10.0	2.2	3.1
05	44-01.0	158-06.2	9.9	2.2	3.1
06	43-26.8	156-52.4	11.3	2.7	3.2
07	43-03.9	155-57.0	13.9	6.8	5.5
08	42-36.5	156-59.0	14.3	4.9	3.9
09	42-22.6	157-15.3	16.3	7.9	5.5
10	41-56.7	158-03.0	15.7	10.4	6.6
11	41-35.5	157-02.3	16.2	10.4	7.3
12	41-03.1	156-05.1	18.9	8.6	5.4
13	40-30.2	157-00.1	18.8	10.5	7.1
14	40-00.4	158-06.1	19.8	10.8	6.1
15	39-33.8	157-08.7	19.8	13.7	10.6
16	39-15.2	156-28.7	20.8	12.4	9.8
17	39-06.1	156-02.1	20.5	8.6	5.7
18	38-34.5	156-58.9	20.9	12.4	9.8
19	38-05.5	158-04.1	22.1	12.4	9.6
20	37-28.5	156-56.5	21.7	11.7	9.7
21	36-53.6	156-02.0	23.7	16.2	13.7
22	36-31.6	156-59.7	23.4	14.3	10.9
23	36-02.0	157-56.0	23.9	16.8	12.4
24	35-30.0	157-00.0	23.3	16.1	14.2
26	35-01.8	156-03.4	24.1	16.1	13.7

Table 6. Summary of cetacean sightings

Species	Primary		Secondary	
	School	Individual	School	Individual
Common minke whale	1	1	0	0
Bryde's whale	23	24	1	2
Sei whale	1	1	2	3
Sperm whale	19	43	1	1
Like common minke whale	1	1	0	0
Unidentified large whale	5	6	6	7

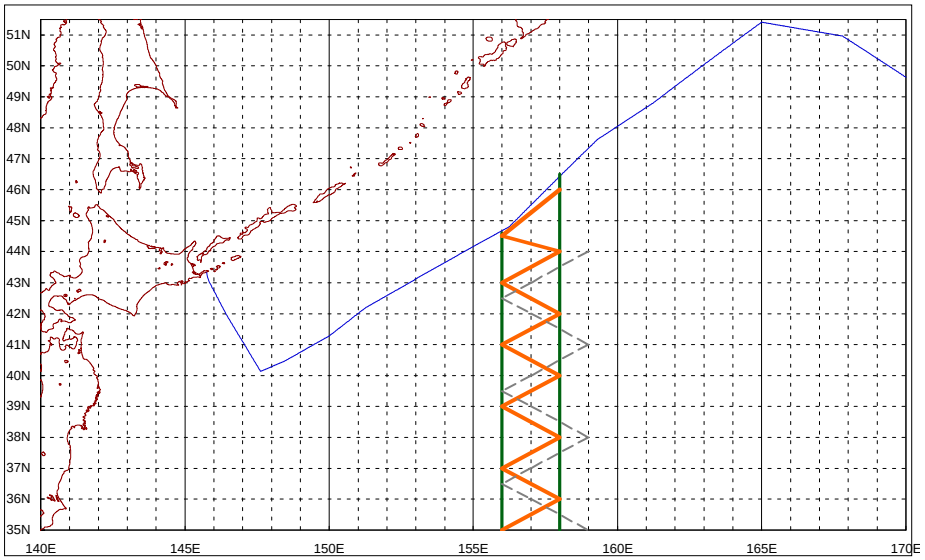

Fig 1. Survey area and the planned track lines. Orange thick line and broken gray line represented the track lines of KK1 and whale sampling line, respectively.

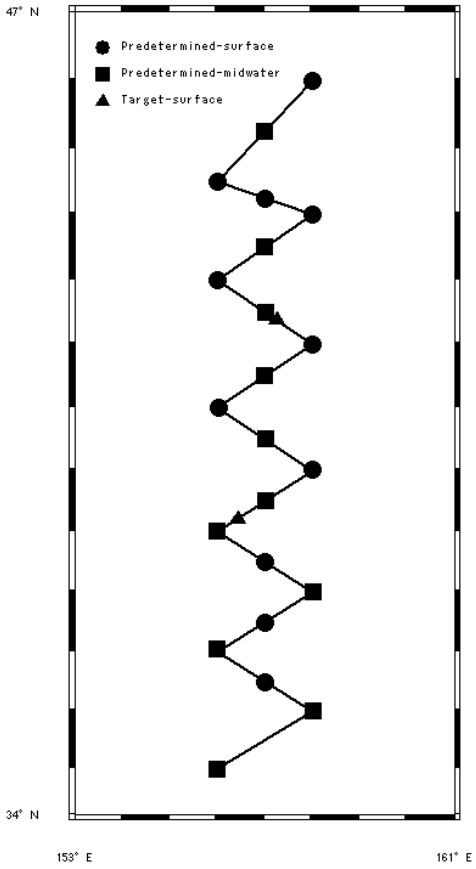

Figure 2. Positions of trawling stations.

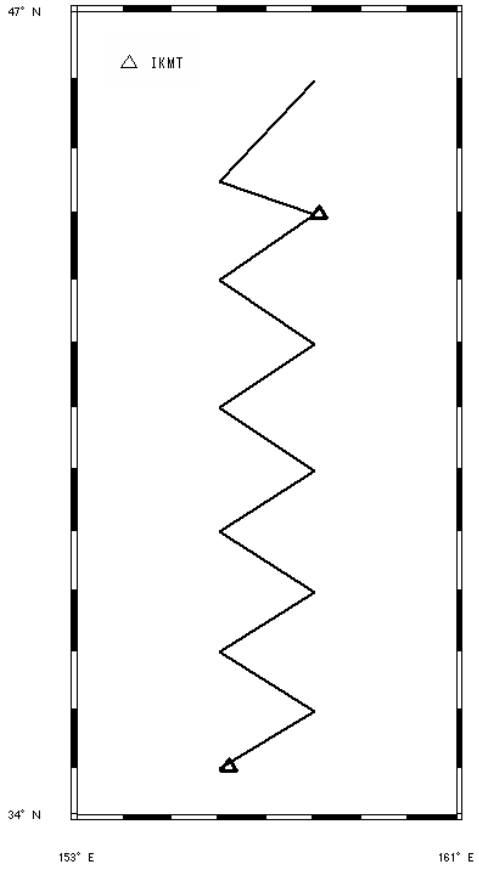

Figure 3. Positions of IKMT trawling.

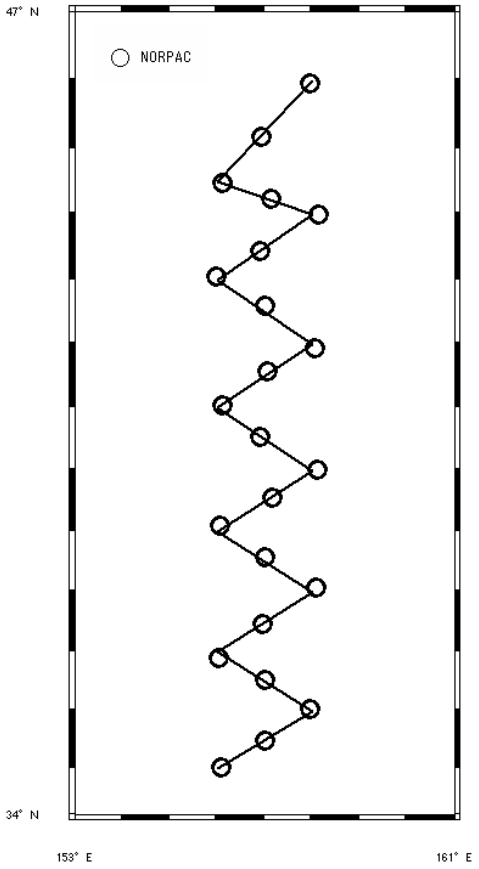

Figure 4. Positions of Twin – NORPAC towing.

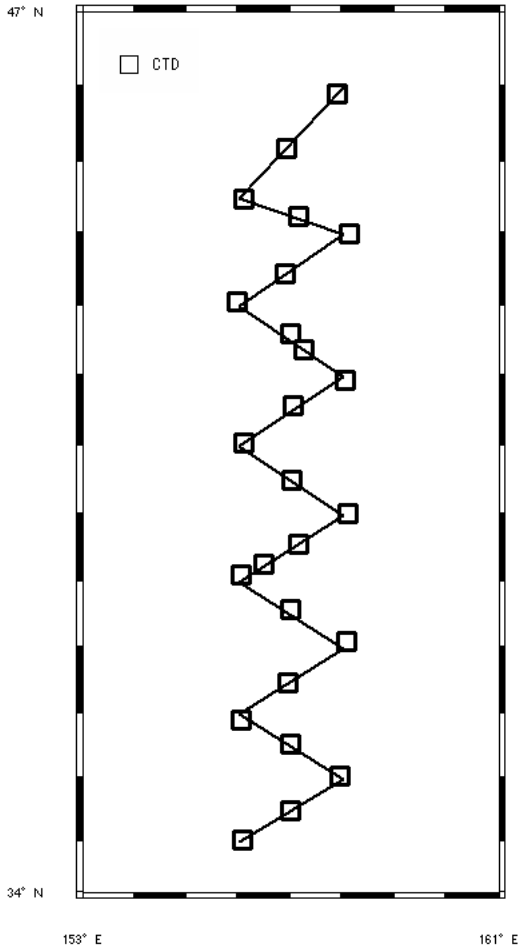

Figure 5. Positions of CTD stations.

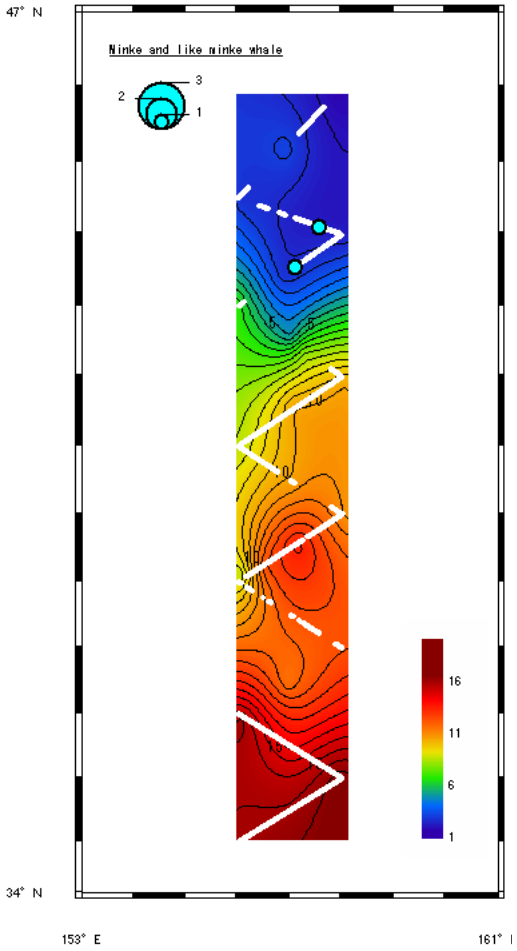

Figure 6. Primary and secondary sighting positions of Common minke and like minke whales were overlaid on contour map of water temperature at 100 m.

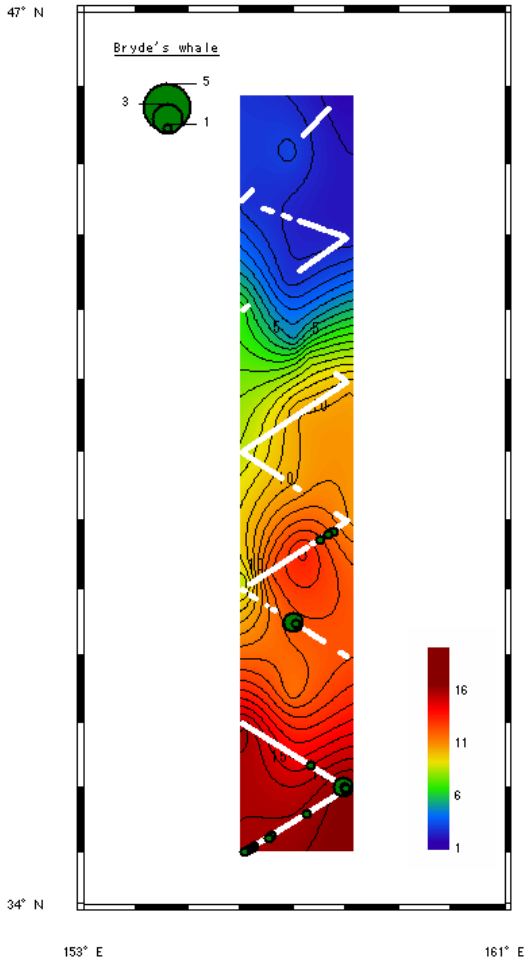

Figure 7. Primary and secondary sighting position of Bryde's whales were overlaid on contour map of water temperature at 100 m.

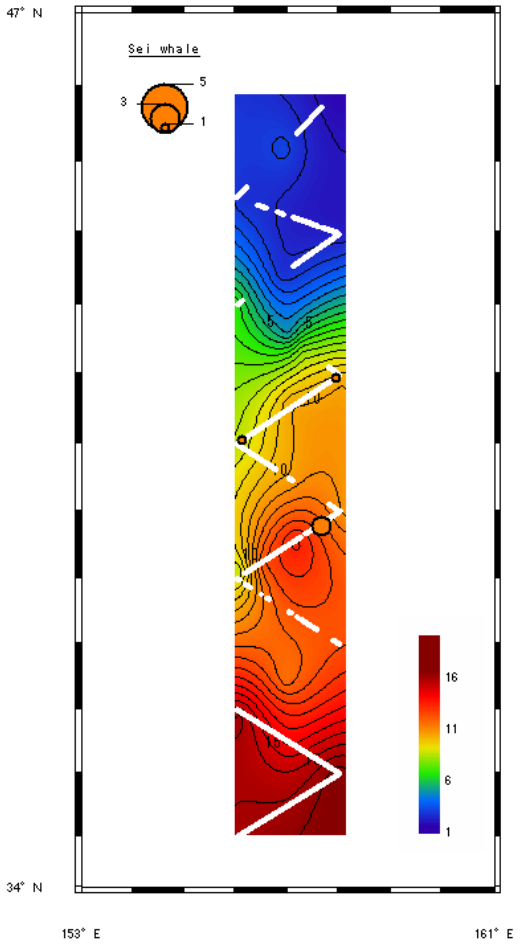

Figure 8. Primary and secondary sighting positions of sei whales were overlaid on contour map of water temperature at 100 m.

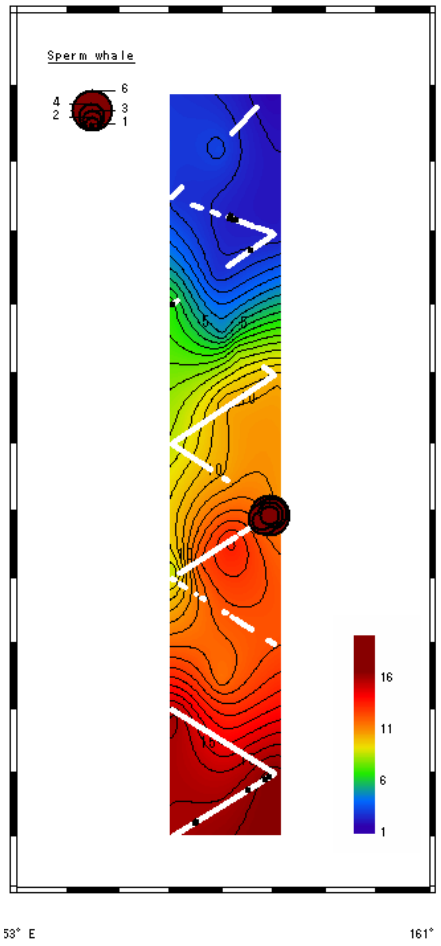

Figure 9. Primary and secondary sighting positions of sperm whales were overlaid on contour map of water temperature at 100 m.

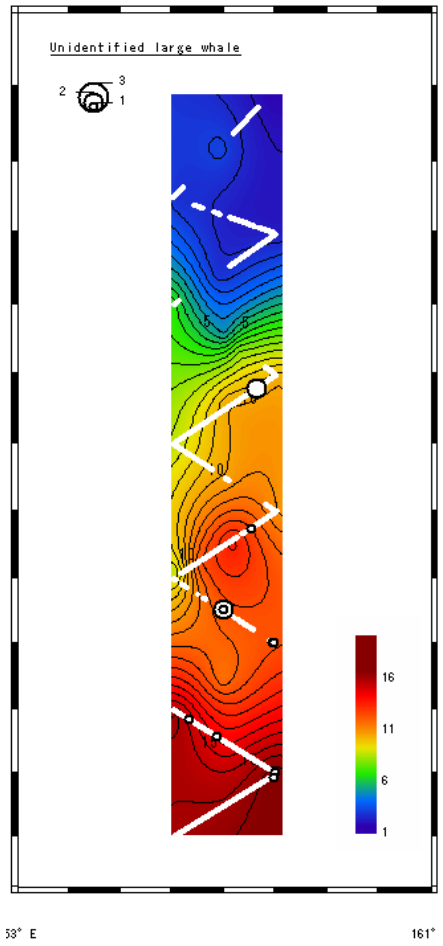

Figure 10. Primary and secondary sighting positions of unidentified large whales were overlaid on contour map of water temperature at 100 m.

Appendix 3.

Preliminary result of prey species survey in the offshore component of JARPN II in 2008 conducted by Shunyo Maru

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ABSTRACT

Prey species survey by Shunyo Maru was conducted in July and August 2008 in the Kuroshio and transition regions of the western North Pacific. The objective of this survey is to examine prey environment and prey preference of Bryde's whale *Balaenoptera edeni* in cooperation with the sampling survey of the whale by Nisshin Maru and whale catcher boats. The distribution, abundance, and size composition of the prey species were investigated with the midwater trawl, MOCNESS, Twin NORPAC net, and quantitative echosounder in the daylight period. Euphausiiids and Japanese anchovy *Engraulis japonicus* were the most and second most abundant prey species in the most part of the study area except for the northernmost area close to the subarctic front, where euphausiids and mackerels were abundant. Euphausiids and Japanese anchovy were generally distributed in the 100-200 and 0-30 m layers, respectively, and there distributions greatly overlapped horizontally. Bryde's whales were mainly distributed in the area where these two prey species were abundantly distributed and this whale mainly fed on Japanese anchovy, suggesting prey preference for Japanese anchovy.

KEY WORDS: Prey species survey, offshore component, shunyo maru, JARPN II, prey biomass, prey preference, Bryde's 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 to examine feeding habits of major cetacean species and ecosystem studies, including studies on prey

consumption by cetaceans, prey preference of cetaceans, and ecosystem model. In JARPN II program, prey species surveys have been conducted in cooperation with the whale sampling surveys to estimate the abundance of each prey species and prey preference of cetaceans. In 2008, prey species surveys were conducted in the offshore region of the western North Pacific by the two stern trawler-type research vessels, Shunyo Maru (887 GT, National Research Institute of Far Seas Fisheries) and Kaiko Maru (860 GT, Kaiko Senpaku Co., Ltd.). This appendix presents results of prey species survey conducted by Shunyo Maru attempting to quantify the prey environment and prey preference of Bryde's whale *Balaenoptera edeni* during summer.

MATERIALS AND METHODS

Prey species survey was conducted from 21 July to 3 August 2008 in the Kuroshio and Kuroshio-Oyashio transition regions between 35˚N to 41ºN, and 146ºE and 148ºE in Sub-area 7 except for Russian EEZ (Fig. 1). In this area, zigzag track lines were set and distribution and abundance of the prey species were investigated with the midwater trawl, MOCNESS, Twin NORPAC net, and quantitative echosounder on these lines. The waypoints of planned track lines are shown in Table 1. During the survey from 21 to 27 July, sampling survey of Bryde's whale was also conducted on the same track lines from WP1 to WP 5 and time difference between the prey and whaling surveys was less than two days, indicating that both surveys were conducted concurrently in this period. All prey surveys were conducted in the daylight period from one hour after sunrise to one hour before sunset (generally from 05:00 to 17:00 in local time).

Midwater trawl sampling

The midwater trawl adopted in this study had a mouth opening of about 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. 21 midwater trawl surveys were conducted (Table 2). Of these, the target trawls were made two times to identify species and size compositions of acoustic backscatters of the fish. Target trawls were continued until targeted schools were captured through or maximum trawling duration reaches at 60 minutes. The results of target trawls were shown in Table 2 (Stations 12 and 16), indicating that the acoustic backscattering detected in this study was Japanese anchovy *Engraulis japonica*. Other 19 trawls were so-called 'predetermined trawling' (Table 2). Those were aimed to examine the distribution and abundance of squids and neustonic organisms like Pacific saury, which are difficult to detect by the echosounder. This trawling was made generally every 20 to 30 nautical miles on the track lines regardless of acoustic backscatters. At each predetermined station, a trawl net was towed at 0-100 (oblique tow) or 0-30 m for 30 to 60 minutes in principal. 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, body length of each individual was measured from randomly selected 100 individuals. When sample size was less than 100 individuals, body length was measured for

all individuals. 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. The mouth opening and mesh size of this net were 1 m^2 and 0.33 x 0.33 mm, respectively. At the eight predetermined stations, this net 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) in the daytime (Table 2). 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 at sea for further analysis in the laboratory ashore.

Twin NORPAC net sampling

We conducted Twin NORPAC net samplings in the 0-150 m layer at each trawl and MOCNESS sampling station to estimate abundance of micro- and meso-zooplanktons 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 operated the quantitative echsounders, SIMRAD ER60, by moving at about 10.5 knots on the track lines to acquire acoustic data with operating frequency at 38, 70, and 120 kHz. Calibrations were carried out in the Kuroshio extension region off Tateyama on 19 July using copper sphere technique. Acoustic data will be analyzed with an aid of SonarData Echoview (Sonar Data Co., Ltd.) software.

Oceanographic observation

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

RESULTS and DISCUSSION

In this study, planned track lines were completely surveyed. Acoustic data, plankton samples, and oceanographic conditions are being analyzing now, the preliminary results are as follows. CTD and SST data indicated that the southernmost region of the study area between 35˚N and 35˚30'N were located in the Kuroshio region, the northernmost area north of 40˚N were in the transitional domain between

subarctic boundary and subarctic front, and other region was in the transition zone south of the subarctic boundary.

According to Tamura (unpubl. data), hot spot of Bryde's whale was found in the southern transition region between 35˚30'N and 36˚30'N and northern transition region between 38˚30'N and 39˚30'N, where were located in or close to the Kuroshio front and the subarctic boundary, respectively. The result of our prey species survey indicated that these two oceanographic front areas were prey rich environment for the whale because juvenile and adult Japanese anchovy were abundantly distributed in the former and the latter regions, respectively, and euphausiids were abundantly distributed in the both regions (Figs. 2, 3, and 4). Generally, both juvenile and adult Japanese anchovy were mainly distributed at 0-50 m and distribution centre of euphausiids were found at 100-200 m (Figs. 2 and 4). Bryde's whale fed mainly on juvenile and adult Japanese anchovy in the southern and northern transition region, respectively (Tamura unpubl. data), suggesting that this whale preferred both juvenile and adult sized Japanese anchovy and avoid euphausiids. This indicates that Bryde's whale possibly affects the fluctuations of both recruitment success and adult biomass of Japanese anchovy. These results also suggest that Bryde's whale prefer prey rich environment in or close to the Kuroshio front and subarctic boundary where small epipelagic fishes are abundantly distributed in the transition zone.

In the Kuroshio region south of 35˚30'N and transition zone between 36˚30'N and 38˚30'N, both potential prey species like anchovy, saury, and euphausiids and Bryde's whale were rarely distributed and stomach contents of the whale captured in these regions were almost empty (Tamura unpubl. data). In the northernmost part of the study area located between the subarctic boundary and subarctic front, euphausiids were abundantly distributed in the 100-200 m depth layer but Japanese anchovy almost disappeared and replaced by mackerel *Scomber* spp. (see Stations 13 and 15 in Table 2). Bryde's whales were frequently found in this region, but sampling survey of the whale was not conducted (Tamura unpubl. data).

Acknowledgement

A special thank is given to Captain Y. Terada and crews of Shunyo Maru for their assistance in collecting data.

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)	Lingitude (E)
1	35ū00.0'	148ū00.0'
2	36ū30.0'	146ū00.0'
3	38ū00.0'	148ū00.0'
4	39ū30.0'	146ū00.0'
5	40ū25.0'	147ū12.0'
6	41ū00.0'	146ū00.0'
7	39ū30.0'	148ū00.0'
8	38ū00.0'	146ū00.0'
9	36ū30.0'	148ū00.0'
10	35ū00.0'	146ū00.0'

Table 2. Sampling data of midwater trawl and MOCNESS surveys. P: predetermined trawl; T: targeting trawl; +: 0.01 kg < CPUE.

Midwater trawl

															CPUE (kg/h)					
					SST	Latitude			Longitude			Sampling depth (m)		Sampling duration	Japanese	Mackerel	Other	Pacific	Common	Other
Stn	P/T	Year	Month	Day	(ūC)	Degree	Minute	N/S	Degree	Minute	E/W	Shallowest	Deepest	(min)	anchovy		fishes	pomfret	squid	squids
1	P	2008	7	21	25.9	35	15.9	N	147	38.8	E	0	90	60	0	0	0	0	+	0
3	P	2008	7	22	25.6	36	12.4	N	146	25.5	E	0	30	60	1.9	0.28	0.02	0	0	0
4	P	2008	7	22	24.1	36	45.4	N	146	20.3	E	0	90	60	0.01	0	0	0	0	0
6	P	2008	7	23	23.5	37	44.9	N	147	40.6	E	0	30	60	+	0	0	0	0	+
7	P	2008	7	24	23.9	38	4.5	N	147	54	E	0	90	60	0.02	0	0	0	0	0
8	P	2008	7	24	23.2	38	35.5	N	147	12.7	E	0	30	60	0.53	0	0	0	0	0
9	P	2008	7	25	23.2	38	57.7	N	146	44.1	E	0	30	60	+	0	0	0	0	0
11	P	2008	7	26	20.9	39	54.3	N	146	31.5	E	0	90	60	0.01	0	0	0.08	0	0
12	T	2008	7	26	19.4	40	5.5	N	146	46.1	E	0	30	60	0.42	0	0	0	0	0
13	P	2008	7	27	17.5	40	24.5	N	147	12.7	E	0	30	60	0.12	28.0	0	0	0.18	0
15	P	2008	7	28	18.2	40	38.3	N	146	29.3	E	0	30	60	0	565.73	0.14	0	5.52	0
16	T	2008	7	28	21.7	40	16.4	N	147	2	E	0	30	60	0.4	0	0	0	0	0
17	P	2008	7	29	22.3	40	4.2	N	147	14.6	E	0	90	60	0.08	0	0.39	0	0	0
19	P	2008	7	30	22.2	39	8.7	N	147	30.6	E	0	30	60	0.40	0	0	0	0	0
20	P	2008	7	30	24.3	38	27.6	N	146	36	E	0	90	60	+	0	0	0	0	0
21	P	2008	7	31	24.6	38	6.8	N	146	8.6	E	0	30	60	+	0	0	0	0	0
23	P	2008	8	1	24	37	13.0	N	147	2.8	E	0	30	60	0.3	+	0	0	0	0
24	P	2008	8	1	27.3	36	50.1	N	147	36.1	E	0	90	60	0.39	+	0.09	0	0	+
25	P	2008	8	2	27.9	36	32.5	N	147	58.2	E	0	30	60	0	0	0	0	0	0
27	P	2008	8	3	28.4	35	40.3	N	146	52.1	E	0	30	60	0	0	0	0	0	+
28	P	2008	8	3	27.6	35	8.1	N	146	8.9	E	0	90	60	2.52	0	0	0	0	0.02

MOCNESS

					SST	Latitude			Longitude			Sampling depth (m)	
Stn	P/T	Year	Month	Day	(ūC)	Degree	Minute	N/S	Degree	Minute	E/W	Shallowest	Deepest
2	P	2008	7	21	26.9	35	52.5	N	146	55.3	E	0	250
5	P	2008	7	23	24.7	37	5.1	N	146	46.8	E	0	250
10	P	2008	7	25	19.2	39	31.7	N	146	1.8	E	0	250
14	P	2008	7	27	22.8	39	56.0	N	146	33.6	E	0	250
18	P	2008	7	29	21.8	39	30.1	N	147	59.8	E	0	250
22	P	2008	7	31	24.5	37	29.3	N	146	39.6	E	0	250
26	P	2008	8	2	28.3	35	58.8	N	147	18.4	E	0	250
29	P	2008	8	4	26.7	35	0.0	N	146	0.0	E	0	250

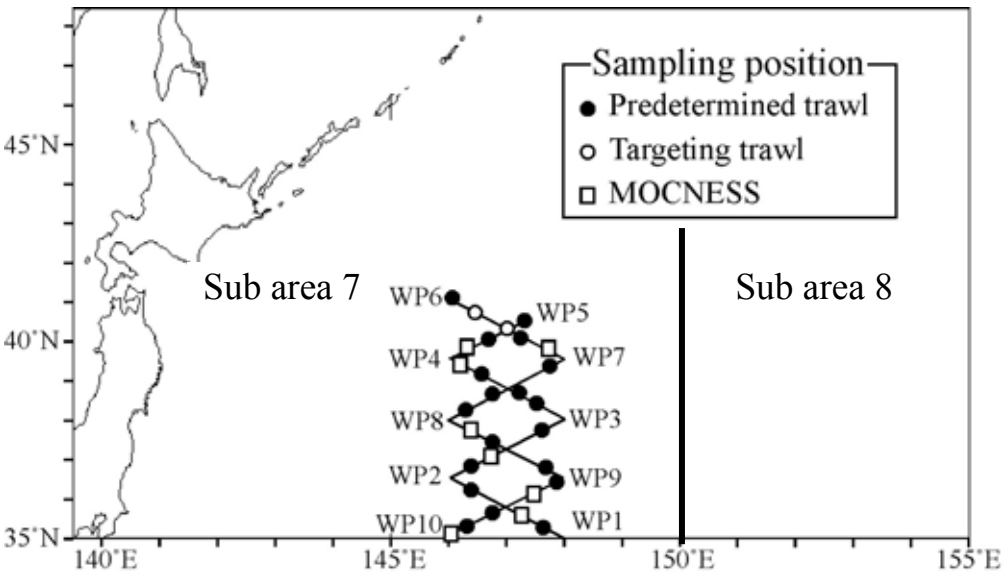

Fig 1. Research area, planned track lines, and sampling positions of offshore prey species survey in 2008.

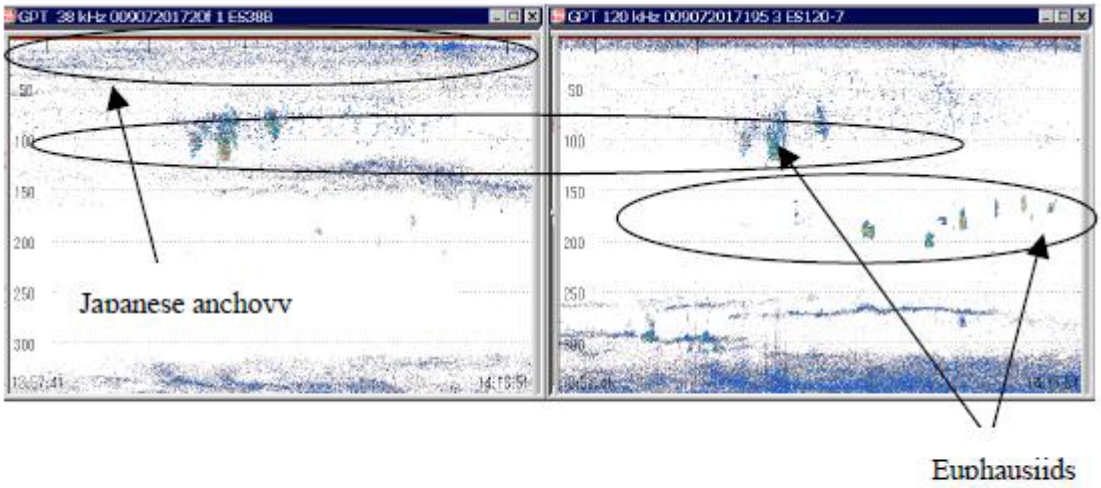

Fig 2. Typical acoustic backscatterings around at Station 3 in the southern transition region close to the Kuroshio front where Bryde's whale was densely distributed.

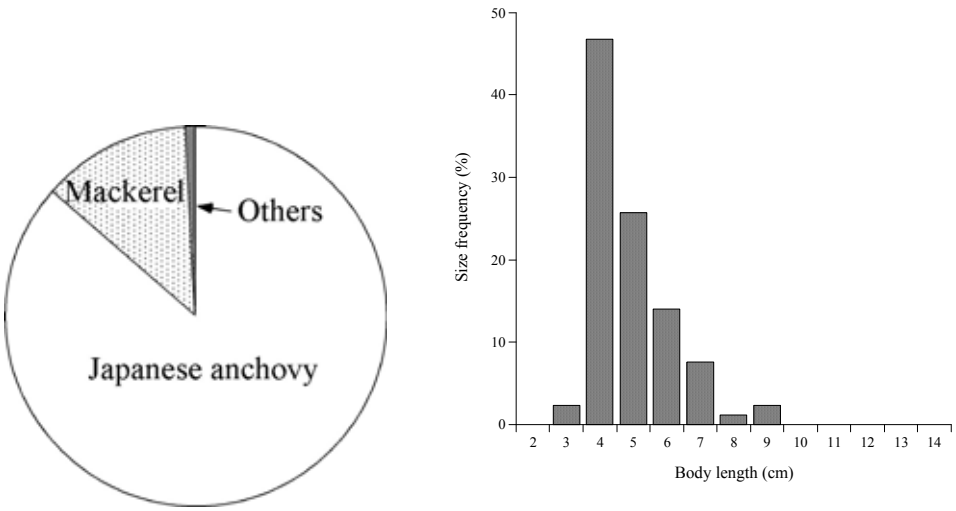

Fig 3. Species composition of predetermined trawl samples and size distribution of Japanese anchovy at Station 3 located in the southern transition region where hot spot of Bryde's whale was found. Bryde's whale fed mainly on juvenile of Japanese anchovy around this station.

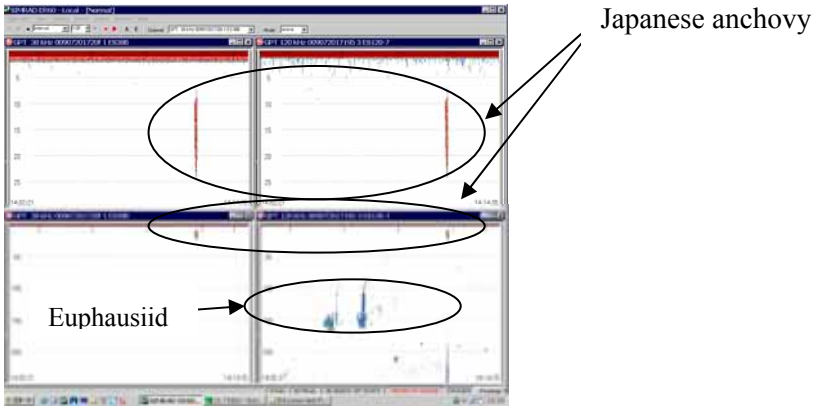

Fig. 4. Typical acoustic backscatterings around at Station 8 in the northern transition region close to the subarctic boundary where Bryde's whale was densely distributed.

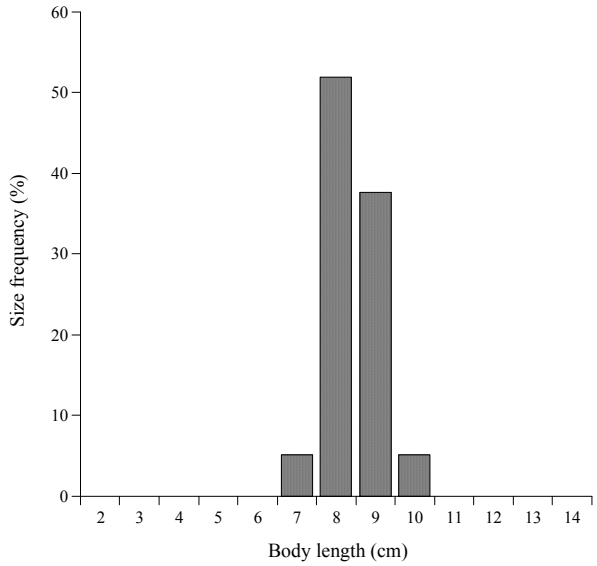

Fig. 5. Size distribution of Japanese anchovy at Station 8 located in the northern transition region where hot spot of Bryde's whale was found. All samples collected at this station were Japanese anchovy. Bryde's whale fed mainly on adult sized Japanese anchovy around this station.

Appendix 4.

Oceanographic conditions in the survey area of offshore compoent of JARPN II in the western North Pacific from July to August 2008

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ABSTRACT

A prey species survey was conducted in July-August 2008 using *Kaiko-Maru, Kyoshin-Maru No.2* and *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 and XCTD was made to make clear the environment of the prey. The survey area was located between the Kuroshio Extension and the Subarctic Front, The water mass was characterized by the subarctic water, subtropical water and mixed water.

Introduction

A prey species survey was conducted in the offshore area of the western North Pacific in July-August 2008 using *Kaiko-Maru,* and *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 ºC) 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) and expendable CTD (XCTD) were carried out in the survey area from July to August 2008 (Table 1 and Fig. 1). Three research vessels, *Kaiko-Maru*, *Kyoshin-Maru No.2* and *Shunyo-Maru* conducted the hydrographic observations. Salinity correction for CTD data was not done using water sampling data. 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-August 2008 are detected by 100m and 200m temperature maps using our observation data by three vessels 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 ºC isotherm at the depth of 200m (Kawai, 1969). The warm water spread from Kuroshio Extension is defied by temperature more than 10 ºC at the depth of 100 m. The first and the second Oyashio Intrusions are defined by temperature lass than 5 ºC at the depth of 100 m (Murakami, 1994). Subarctic front and the Subarctic Boundary is defined by 4 ºC temperature front and 34.0psu salinity front, respectively (Favorite *et al*. 1976).

Oceanographic conditions in the survey area

Fig. 2 shows the Temperature-Salinity diagrams in the survey area. There is typical Kuroshio water characterized by high salinity profile around 34.5 psu, especially in warm upper layer (over 10 ºC).

Oyashio water (colder than 5 ºC) and Subarctic waters characterized by cold profile less than 4 ºC is shown in lower part of Fig. 2. The mixed water is distributed between both of the Oyashio and the Kuroshio waters.

Figure 3 shows a schematic hydrographic map with isotherms of 100 m temperature in July-August 2008. The cold water less than 5 ºC at 100 m depth was distributed in a northern part of the survey area. The Subarctic Front (defined by 4 ºC isotherm) was observed from 41° N, 150° E to 43° -30' N, 165° E in Fig. 3. In 100 m salinity map (lower panel in Fig. 4), a salinity front around 34.0 psu is shown along 40° N line in the western part of the survey area, and it meandered around 42° N line in the middle and eastern part of this area. The warmest temperature at the 200 m depth is observed at south western part of this area, and 14 ºC isotherm, which is an index of the Kuroshio Extension, is observed along 35° N line (upper panel in Fig. 4).

Figure 5 shows temperature, salinity and density anomaly sections between 146° E-148° E. The Subarctic Water (colder than 4 ºC) and 4 ºC isotherm (index of the subarctic front) is observed around 40° 30'N. The salinity front around 34 psu (index of the subarctic boundary) is shown around 40° N nearby the subarctic front. The Kuroshio Extension is appeared around 35° 30'N (westward flow) and 36° 45'N (eastward flow) according to meandering of the current in this section.

Figure 6 shows the vertical sections of temperature, salinity and density anomaly along the cruise track of *Kaiko-Maru* along 157° E. The Subarctic Water colder than 4 ºC is observed in the northern area, north of 42° 30'N, where the 4 ºC isotherm observes vertically from 50 m depth to 400 m depth. It indicates that there is the subarctic front around 42° 30'N in this section. A surface low salinity water less than 33.5psu is also observed in the northern area, north of 43° N. The isohaline of 34 psu, which is the index of the subarctic boundary, is shown at a surface layer around 42° N, a little southern area of the subarctic front (middle panel in Fig. 6). In this section, isotherms between 5 ºC and 10 ºC are running vertically and show an existence of a temperature front around 42° N. As there is high-salinity water over 34.7 psu is observed around 35° 30'N, isotherms around 35° 30'N are running vertically and 14 ºC isotherm cross at the depth of 200 m around 35° 30'N, the Kuroshio Extension flows at 35° 30'N in this section.

Figure 7 shows temperature, salinity and density anomaly sections between 165° E-170° E, eastern part of our survey area. The Subarctic Water is observed in the northern area, north of 42° 30'N where is 4 ºC isotherm (index of the subarctic front) running vertically from 50 m to 500 m depth. The high-salinity water greater than 34 psu is shown at a surface layer in the southern area, south of 41° 30'N, and the isohaline of 34 psu (index of the subarctic boundary) was observed around 41° 30'N with a typical salinity front (33 to 34.4 psu). The Kuroshio Extension is not appeared in this section.

These figures show that the survey area is located between the Kuroshio Extension and the Subarctic Front.

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
Kaiko-Maru	CTD: SBE 19 XCTD: TSK MK-130	5 July to 29 August	50
Kyoshin-Maru No.2	CTD: SBE 19	7 July to 29 August	35
Shunyo-Maru	CTD: BE 9plus	21 July to 4 August	29

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

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

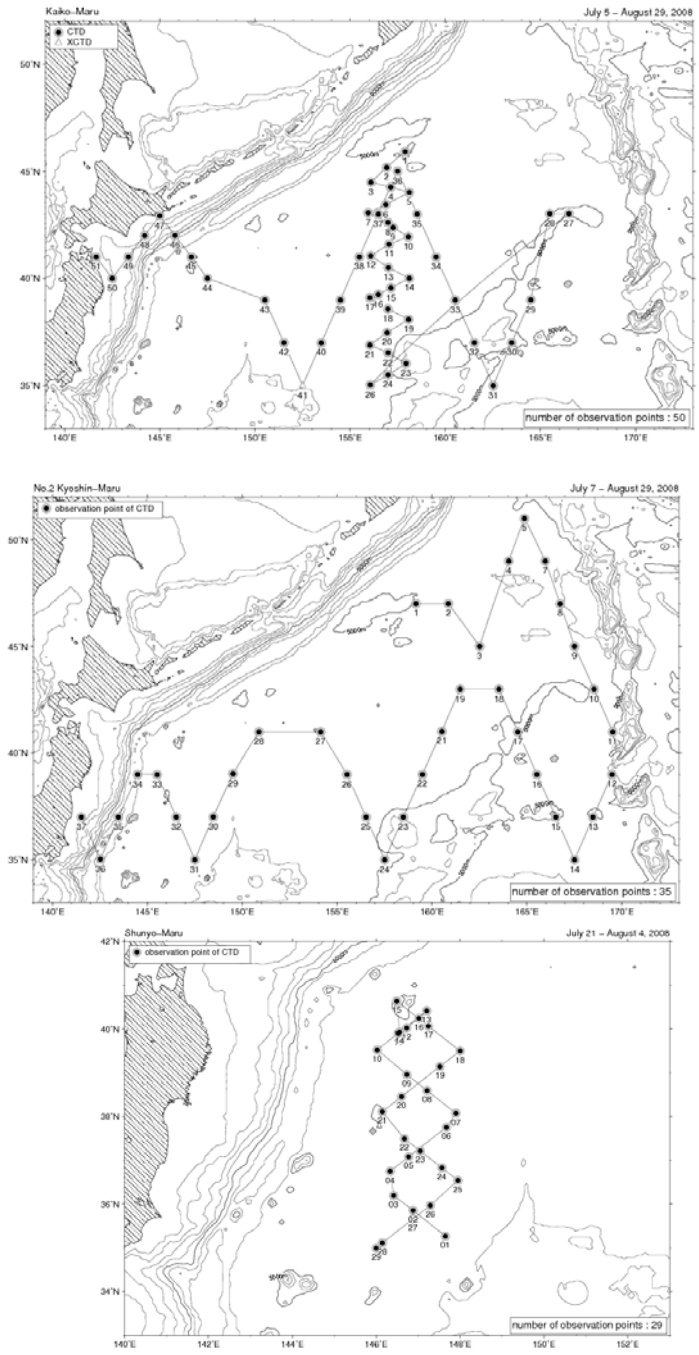

Fig. 1. Station map observed by *Kaiko-Maru* in 5th July to 29th August 2008 (upper panel), *Kyoshin-Maru No.2* in 7th July to 29th August 2008 (middle panel) and *R/V Shunyo-Maru* 21st July to 4th August 2008 (lower panel).

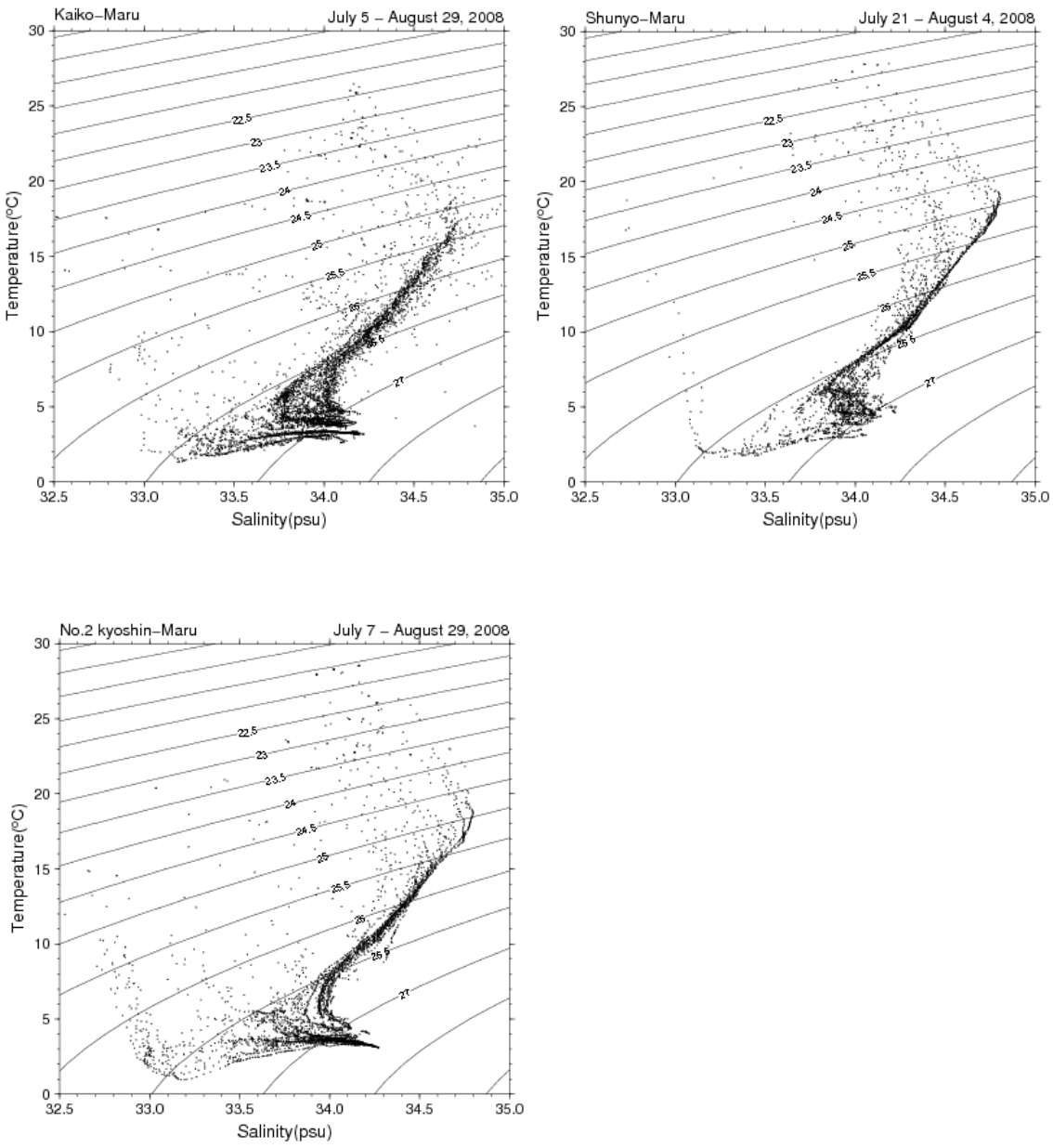

Fig. 2. Temperature-Salinity diagrams using CTD and XCTD station data observed by *Kaiko-Maru* (left upper panel), *Kyoshin-Maru No.2* (left lower panel) and *R/V Shunyo-Maru* (right upper panel). Each thin line in this figure denotes a density line of sigma-t.

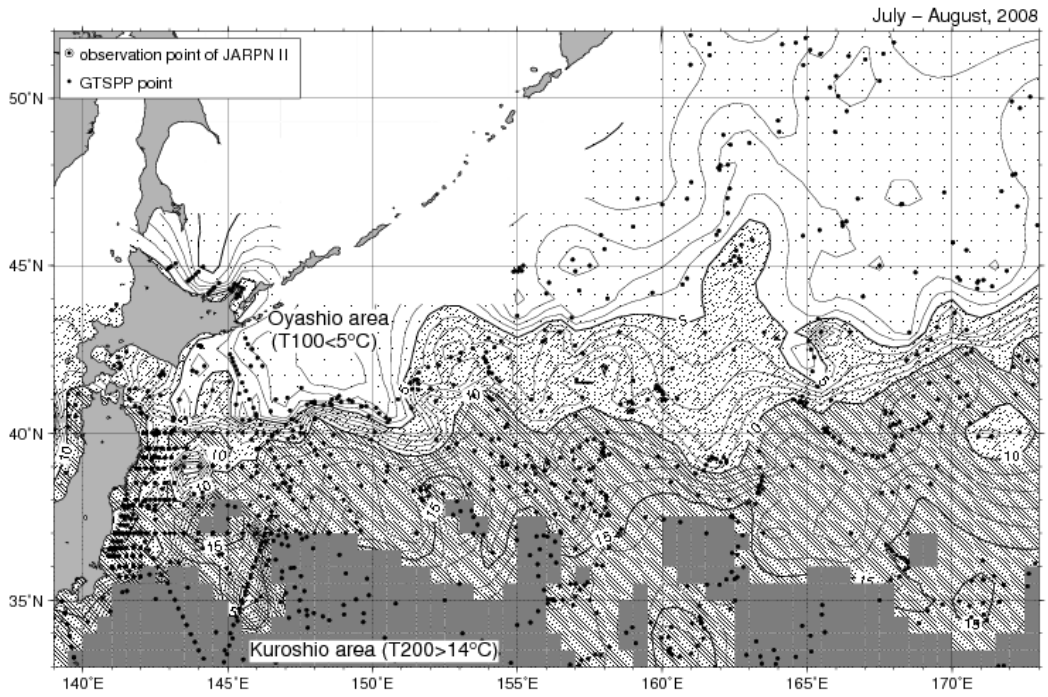

Fig. 3. Schematic hydrographic map in the western North Pacific in July-August 2008 with station map observed by *Kaiko-Maru*, *Kyoshin-Maru No.2, R/V Shunyo-Maru* and reported to GTSPP.

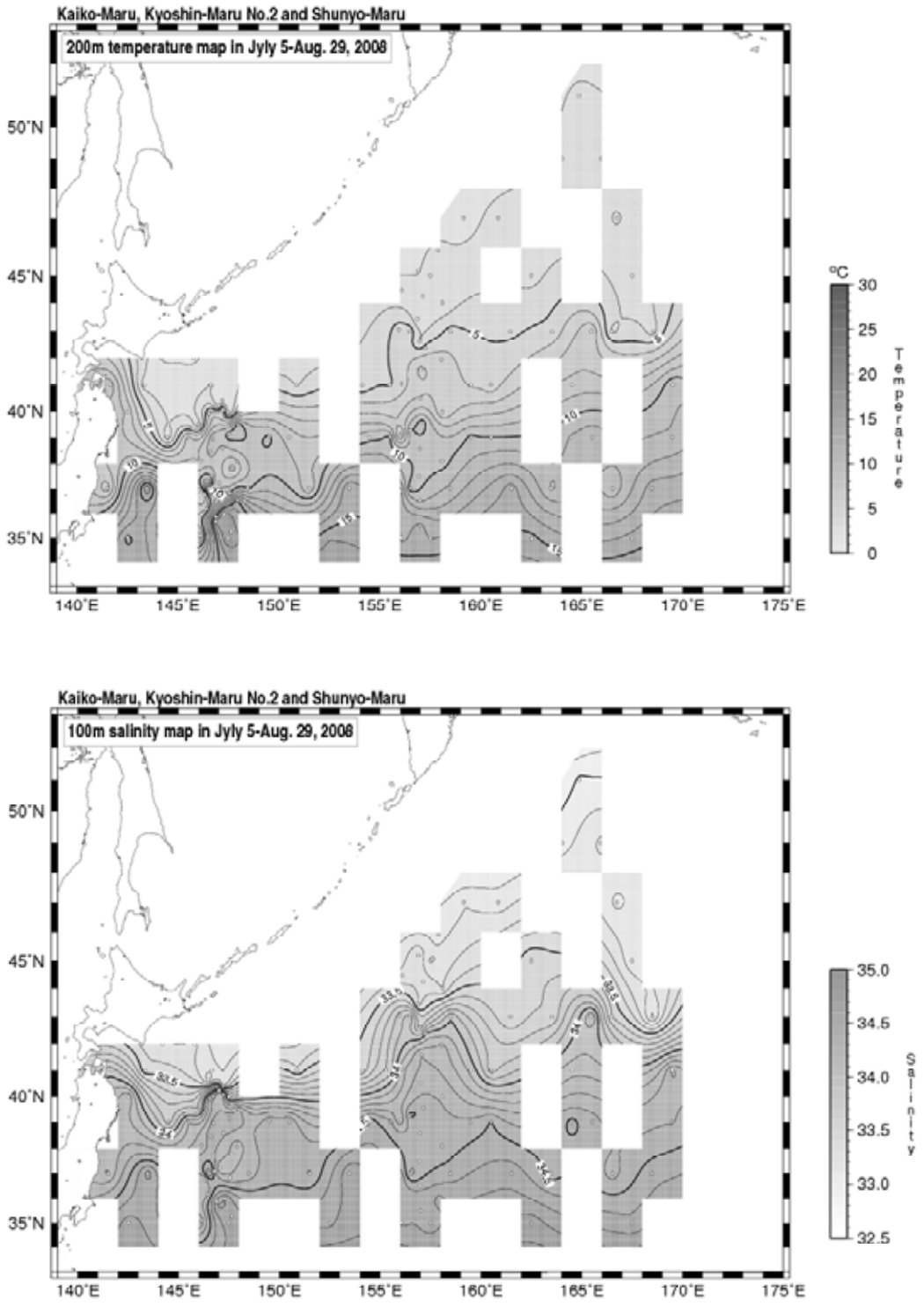

Fig.4. Temperature at 200 m depth (upper panel) and salinity map at 100 m depth (lower panel), observed by *Kaiko-Maru, Kyoshin-Maru No.2* and *R/V Shunyo-Maru* in July 5 to August 29.

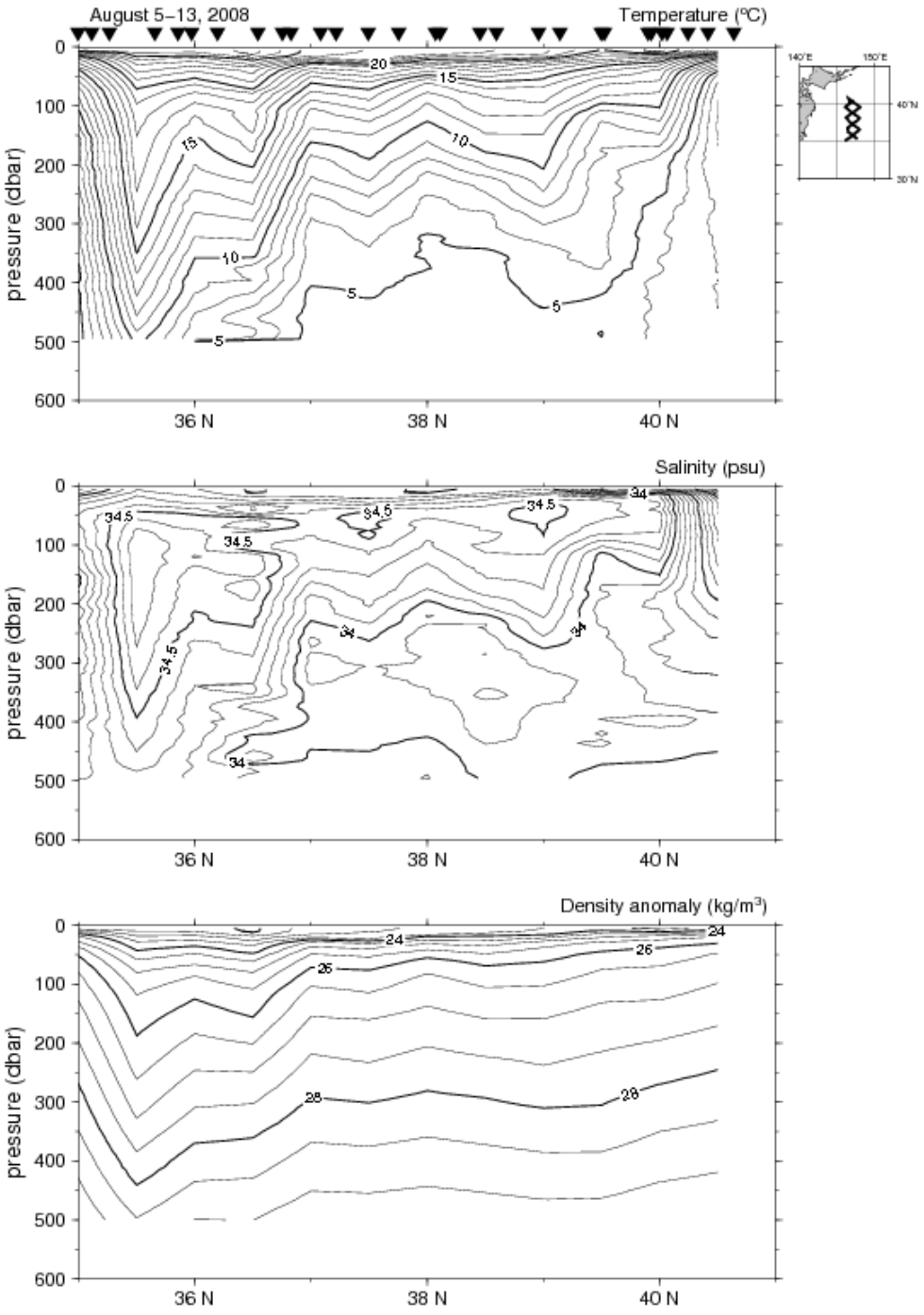

Fig. 5. Vertical sections of temperature (upper panel), salinity (middle panel) and density anomaly (lower panel) observed by *R/V Shunyo-Maru* in August 5 to 13 (western part of our survey area).

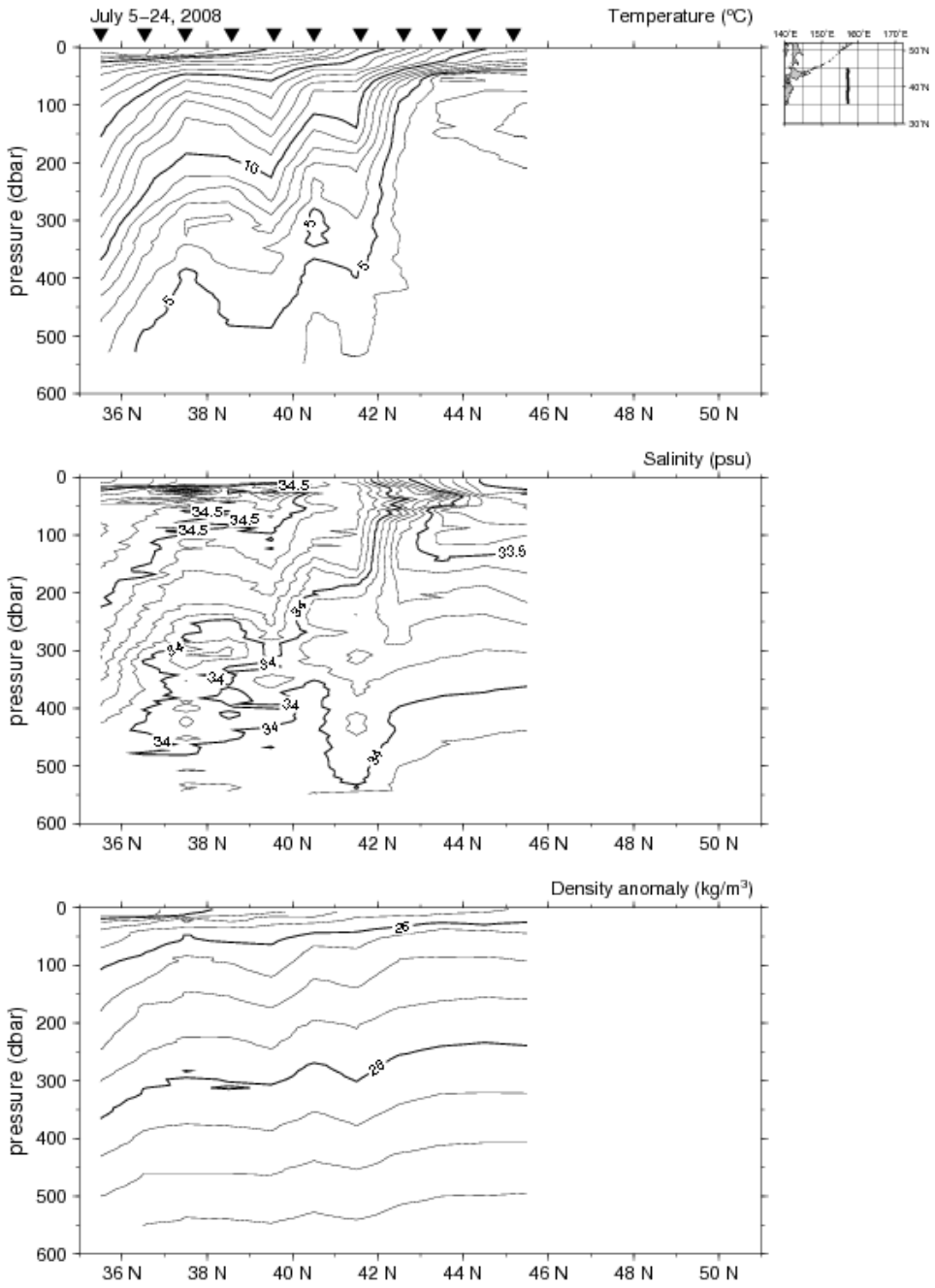

Fig. 6. Vertical sections of temperature (upper panel), salinity (middle panel) and density anomaly (lower panel) observed by *Kaiko-Maru* along 157 ° E (middle part of our survey area).

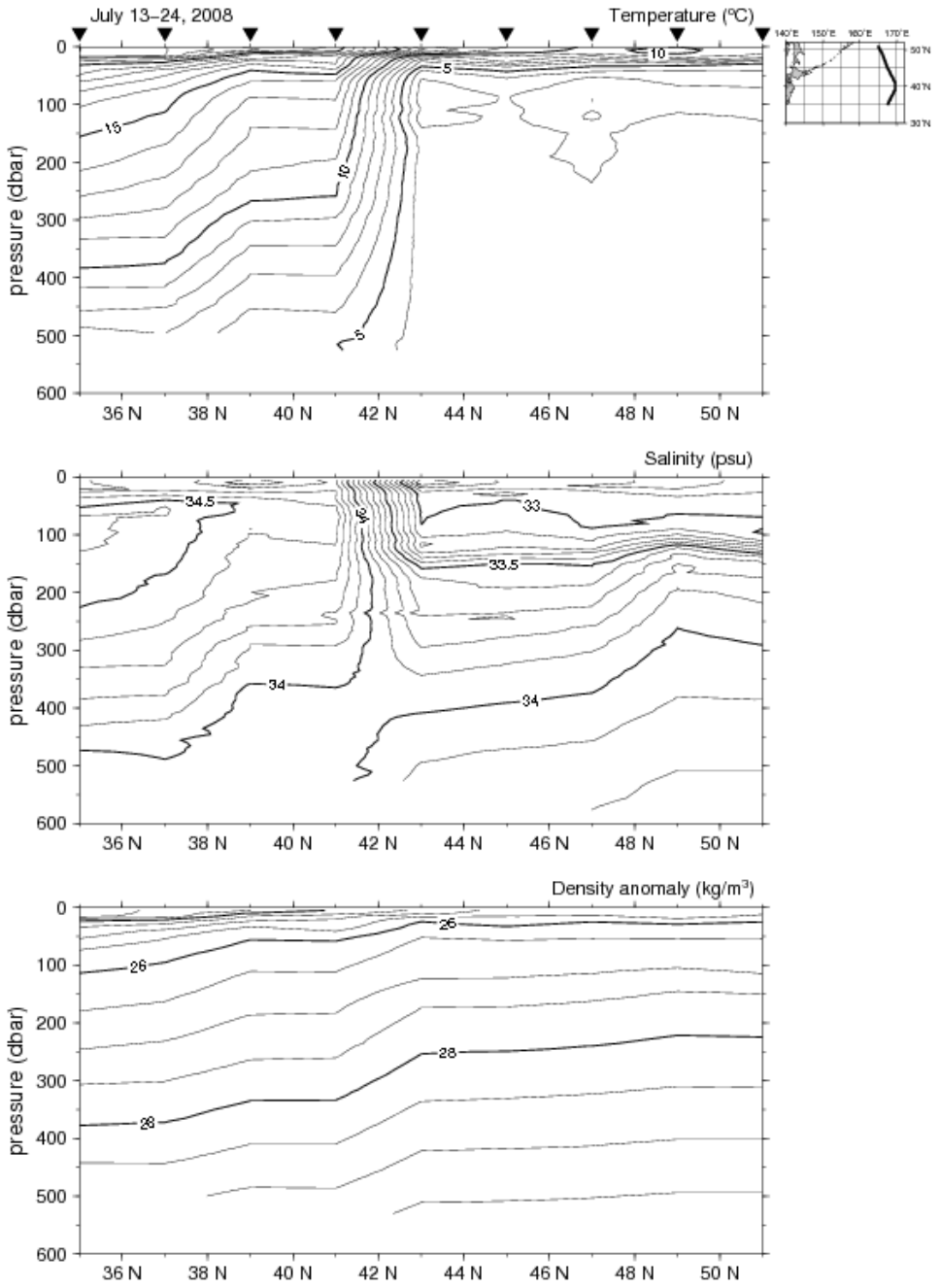

Fig. 7. Vertical sections of temperature (upper panel), salinity (middle panel) and density anomaly (lower panel) observed by *Kyoshin-Maru No.2* in July 13 to 24 between 149° E-151° E (eastern part of our survey area).