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 -

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ABSTRACT

The sixth 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 11 May to 6 September 2007 in sub-areas 7, 8 and 9 of the western North Pacific. The objectives of the full-scale research were (a) feeding ecology and ecosystem studies, (b) monitoring environmental pollutants in cetaceans and the marine ecosystem and (c) elucidation of stock structure. Target species were common minke whale (*Balaenoptera acutorostrata*), sei whale (*B. borealis*), Bryde's whale (*B. edeni*) and sperm whale (*Physeter macrocephalus*). A total of six research vessels were used: one dedicated sighting vessel (SV), three sighting/sampling vessels (SSVs), one trawl and dedicated sighting survey vessel (TSV) equipped with quantitative scientific echo sounder and one research base vessel. A total of 17,200.5 n.miles was surveyed in a period of 119 days. During that period 9 common minke, 52 sei, 235 Bryde's and 264 sperm whales were sighted by the SV. 148 common minke, 548 sei, 376 Bryde's and 620 sperm whales were sighted by the SSVs. And 5 "like common minke", 107 sei, 76 Bryde's and 87 sperm whales were sighted by the TSV. Biopsy samples were collected from 2 fin whales and 1 humpback whale. And 10 blue whales and 3 humpback whales were photographed. A total of 100 common minke, 100 sei, 50 Bryde's and 3 sperm whales was sampled by the SSVs. All whales sampled were examined on board the research base vessel. Common minke whales fed mainly on Pacific saury (*Cololabis saira*) and Mackerels in the sub-area 8 and 9 and on Japanese anchovy (*Engraulis japonicus*) in sub-area 7. Sei whales fed mainly on mackerels in May and June and on copepods and Japanese anchovy in August. Bryde's whales fed mainly on Japanese anchovy. Sperm whales fed mainly on various kinds of squids, which inhabit the mid- and deep-waters. The whale prey species surveys were conducted by TSV using midwater trawl, IKMT and NORPAC net, CTD and XCTD observations in a part of sub-area 7, 8 and 9. The cooperative survey on the prey species and whale sampling to compare with results of echo sounder and stomach contents were conducted with the participation of the five vessels in a part of sub-area 7 and 9 between 9 July and 13 August.

KEYWORDS: COMMON MINKE WHALE; BRYDE'S WHALE; SEI WHALE; SPERM WHALE; NORTH PACIFIC OCEAN; DISTRIBUTION; 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 IWC Scientific Workshop to review the survey results and data availability was held in February 2000. In that workshop, participants agreed that no sub-stock scenario existed within the O stock (Government of Japan, 1994) for common minke whale in western North Pacific but the hypothesis of whether the W-stock exist (western part of sub-area 9) was not resolved. Regarding the feasibility studies on feeding ecology, the workshop considered them as successful. The results showed that the main prey species of common minke whale changed seasonally and geographically. As most of these prey species are also the target species of Japanese commercial fisheries, possible competition between common minke whales and fisheries was postulated. The Workshop agreed that, if ecological studies are to be conducted in the area, the sampling regime must be designed to allow for a more quantitative estimation of temporal and geographical variation in diet. It was also recommended that acoustic and trawl surveys should be conducted concurrently with future whale surveys, if possible (IWC, 2001).

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 (Government of Japan, 2000). One of the major objectives of this research was to study the feeding ecology of whales and the marine ecosystem. During the previous JARPN surveys, it was revealed that common minke whales consumed various commercial fish species such as Pacific saury, Japanese anchovy. Japanese flying squids (*Todarodes pacificus*) and walleye pollock (*Theragra chalcogramma*) and that they ate considerable amounts of these prey species. The second objective of the feasibility survey of JARPNII is related to stock structure issues, and the third to pollution studies. Sampling of common minke, Bryde's and sperm whales was conducted in the feasibility research program.

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, as a full-scale research program, started from 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 'coastal' survey was covered by small type whaling catcher boats. 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).

Sampling of 100 minke, 50 Bryde's and 10 sperm whales as in the JARPN II feasibility study is continued in the full research program with the addition of 50 sei whales in each year and 50 common minke whales to be taken by small-type whaling catcher boats in 2002. Sei whale is selected as a target species as they feed on fisheries resources such as Japanese flying squid and the estimated biomass is larger than that of Bryde's and common minke whales. The additional 50 common minke whales provide full coverage of the spring and autumn seasons in coastal waters where the competition between cetaceans and fisheries is likely to be substantial. In the full JARPN II plan, the coastal survey component was presented as a two-year feasibility study to be conducted in 2002 and 2003. The plan also noted that in the case of the sei whale, 'the required sample size will be recalculated after the first two years making use of the data accumulated' (Government of Japan, 2002b).

In accordance with these provisions, a revised JARPN II research plan was presented for the period starting from 2004, which takes into consideration i) the results of the coastal survey component (feasibility surveys in 2002 and 2003) regarding logistic and sample size of the common minke whales and ii) the results of new calculations of required sample size for the sei whales based on the data accumulated in those two years. The research area was set in sub-areas 7, 8 and 9, and the target species and sample sizes in 2005 were set as follows: 160 common minke whales (100 were to be sampled by the offshore survey and 60 - by the coastal component); 100 sei whales (offshore component), 50 Bryde's whales (offshore component) and 10 sperm whales (offshore component) (Government of Japan, 2004a, 2004b).

In this paper, we present an outline of the sixth full-scale survey of the JARPN II -offshore component- with the cooperative survey on the prey and whale sampling, which was conducted between 11 May and 6 September 2007.

MATERIALS AND METHODS

Research area

Sub-areas 7, 8 and 9 constituted the research area (Fig. 1). Those sub-areas were further divided as follows:

Sub-area 7: Five small blocks (7N, 7MI, 7MO, 7SI, 7SO) were 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).

In the case of the cetacean prey survey, three blocks were predetermined in the survey areas which were set in the offshore area (see Appendix A).

Research vessels
Six research vessels were used. The research base vessel *Nisshin-Maru* (NM: 8,030GT) commanded the research and was used for conducting the biological examinations of whale samples and in the processing of by-products. The *Yushin-Maru* (YS1: 720GT), *Yushin-Maru No.2* (YS2: 747GT) and *Kyo-Maru No.1* (K01: 812.08GT) 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 a dedicated sighting vessel (SV). The *Kaiko-Maru* (KK1: 860.25 GT) was engaged the cetacean prey species and whale sighting surveys (TSV) using midwater trawl, Isaacs Kidd Midwater Trawl (IKMT), NORPAC net and Oceanographic observations.

Survey components
The survey was composed of three main components: (1) dedicated sighting survey, (2) whale survey and (3) the whale prey species survey (Table 1).

Dedicated sighting survey
Vessel: One research vessel (SV)

Research area: Sub-areas 7, 8 and 9

Research period: From 11 May to 1 August

Whale survey
Vessels: Four research vessels (three SSVs and NM)

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

Research period:

First period: From 11 May to 8 July.

Second period: From 9 July to 18 August.

Cooperative survey on the prey species and whale sampling
Vessels: Five research vessel (three SSVs, NM and TSV)

Research area: Three blocks (1, 2 and 3).

Research period: Block 1 (from 9 to 22 July), block 2 (from 3 to 5 August) and block 3 (from 11 to 13 August).

Methods for setting cruise track line for the 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 and 2007). The zigzag-shaped track line was established on an arbitrary basis in each sub-area and month, taking into consideration previous sighting information of target whales and sea conditions.

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 SSVs surveyed in the following manner: the research course consisted of one main track and two parallel tracks established in 7 n.miles apart from both sides. The track line of the TSV in the cooperative survey was determined and the zigzag-shaped track line was set independent of whale survey.

Apart from these sampling activities, an independent track line for dedicated sighting survey was determined 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. In the research area sighting survey was conducted mainly under closing modes (*NSC and NSS modes*) by the SSVs. Furthermore two modalities of sighting in closing mode by the SSVs were adopted, *NSC* and *NSS modes*, by taking into consideration weather and sea conditions mainly. The *NSC* and *NSS modes* were the same as *BC* and *BS modes* in the previous JARPN II surveys, respectively. The conditions to conduct sighting surveys by the SSVs 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* by the SSVs was used under more bad weather conditions such as heavy rain and fog but under this condition the collection of whale samples was possible. This *NSS mode* was used only by SSVs.

The *ASP* and *NSP modes* by the SV and TSV were used (*ASP*: closing mode under normal sighting conditions, *NSP:* passing mode 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

Most of the target whale species sighted on the trackline were approached for sampling. Furthermore sampling effort was applied outside the established research hours (SSV: 06:00-19:00, SV: 06:00-18:00), if collection of whale samples was considered as 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.

Cooperative survey on the prey species and whale sampling

Prey distribution and abundance surveys using the quantitative echo sounder, midwater trawl, IKMT and NORPAC with XCTD oceanographic observation were conducted by the TSV. In addition to the whale prey survey, TSV conducted dedicated sighting survey within the cooperative survey area. During the daytime, TSV steamed at about 10 knots along the tracklines 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. Detailed report on this activity is shown in Appendix A.

Experiments

The following experiments and observations were conducted on board the SSV:

1. Sighting distance and angle experiments to examine the precision of sighting data (YS1, YS2 and K01).
2. Biopsy sampling on gray, blue, fin, sei, Bryde's, minke, humpback, right, bowhead and sperm whales.
3. Photographic records of natural marks in blue, humpback and right whales.
4. Preliminary examination of attachment of satellite tag to common minke, sei and Bryde's whales.
5. Feeding behaviour observation of large whale species (blue, fin, sei, Bryde's, common minke, humpback, right and sperm whales).

On board the SV and TSV, 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, bowhead and sperm whales.
3. Photographic records of natural marks in blue, humpback and right whales.
4. Feeding behaviour patterns of large whales.
5. Oceanographic observations using EPCS (Electric particle counting and sizing system), CTD and XCTD.

Observations of marine debris in the research area were conducted from the wheelhouse of the research base vessel (NM) (mainly during transit cruises). Marine debris was also investigated in the stomach contents of common minke, Bryde's, sei and sperm whales sampled. Experiments on killing method were conducted onboard of both the research base vessel and the SSVs.

RESULTS

Searching distance

Track line covered by the SV is shown in Figs. 2a and 2b. Track line covered by the SSVs is shown in Fig. 3.The total searching distances were 4,042.5 n.miles by the SV, 11,416.4 n.miles by the SSVs and 1,741.6 n.miles by the TSV (Table 2).

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

Dedicated sighting survey

During the research cruise by the SV, 9 schools (9 individuals) of common minke whales were sighted, consisting of 8 schools (8 individuals) of primary sightings and 1 school (1 individual) of secondary sightings. For sei whale, 35 schools (52 individuals) were sighted, consisting of 34 schools (51 individuals) of primary sightings and 1 school (1 individual) of secondary sightings. For Bryde's whale, 152 schools (235 individuals) were sighted, consisting of 148 schools (229 individuals) of primary sightings and 4 schools (6 individuals) of secondary sightings. For sperm whale, 101 schools (264 individuals) were sighted, consisting of 90 schools (248 individuals) of primary sightings and 11 schools (16 individuals) of secondary sightings. Large baleen whales such as blue (2 schools /5 individuals), fin (20 schools /24 individuals) and humpback whales (8 schools /12 individuals) were found in the sub-areas 7, 8 and 9 (Table 3a, Fig. 2a and 2b).

Whale survey

During the research cruise by the SSVs, a total of 146 schools (148 individuals) of common minke whales were sighted, consisting of 63 schools (64 individuals) of primary and 83 schools (84 individuals) of secondary sightings. For sei whales, 298 schools (548 individuals) were sighted, consisting of 204 schools (398 individuals) of primary sightings and 94 schools (150 individuals) of secondary sightings. For Bryde's whales, 260 schools (376 individuals) were sighted, consisting of 215 schools (314 individuals) of primary sightings and 45 schools (62 individuals) of secondary sightings. For sperm whales, 231 schools (620 individuals) were observed, consisting of 173 schools (457 individuals) of primary sightings and 58 schools (163 individuals) of secondary sightings. Large baleen whales such as blue (14 schools / 17 individuals), fin (33 schools /42 individuals), humpback (46 schools /85 individuals) and North Pacific right whales (one school /one individual) were found in the sub-areas 7, 8 and 9 (Table 3b).

Cooperative survey on the prey species and whale sampling

During the research cruise by the TSV, a total of 5 schools (5 individuals) of like common minke whales were sighted, consisting of 3 schools (3 individuals) of primary sightings and 2 schools (2 individuals) of secondary sightings. For sei whale, 56 schools (107 individuals) were sighted, consisting of 55 schools (105 individuals) of primary sightings and 1 school (2 individuals) of secondary sightings. For Bryde's whale, 47 schools (76 individuals) were sighted, consisting of 42 schools (69 individuals) of primary sightings and 5 schools (7 individuals) of secondary sightings. For sperm whale, 60 schools (87 individuals) were observed, consisting of 59 schools (86 individuals) of primary sightings and 1 school (1 individual) of secondary sightings. Large baleen whales such as blue (2 schools / 3 individuals) and fin (5 schools /5 individuals) whales were found in the sub-areas 7, 8 and 9 (Table 3c).

List of cetacean species and number of sightings (no. schools/no. individuals) were made by all vessels in the 2007 JARPN II are shown in Table 3d.

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

This survey covered spatial and temporal gaps for studies on feeding ecology and stock structure. Table 4 shows the number of whales sampled in each sub-area or special block for each research component and period. A total of 100 common minke whales (Male: 86 individuals, Female: 14 individuals) were sampled. A total of 100 sei whales (Male: 54 individuals, Female: 46 individuals) were sampled. A total of 50 Bryde's whales (Male: 23 individuals, Female: 27 individuals) were sampled. A total of three sperm whales (Female: 3) were sampled during the whale survey component.

Geographical distribution of common minke, Bryde's, sei and sperm whale samples are also shown in Fig. 3 based on the sighting positions.

Cooperative survey on the prey species and whale sampling
During the cooperative survey on the prey species and whale sampling, a total of 18 sei, 28 Bryde's and one sperm whales were sampled in the block 1. A total of 5 sei and 2 Bryde's whales were sampled in the block 2. A total of 15 Bryde's whales were sampled in the block 3 (Table 4).

Biological research for common minke sei, Bryde's and sperm whales
Table 5 summarizes the biological data and samples collected from whale sampled such as the common minke, sei, Bryde's and sperm whales sampled. A total of 52 research items were 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 is shown in Tables 6a, 6b and 6c, respectively. The rate of mature males in common minke was higher than in Bryde's and sei whales.

Preliminary analyses of biological data and experiments

Body length of sampled whales
The statistics of body length of whales sampled are shown in Tables 7a, 7b, 7c and 7d. Mean body length of common minke whales is 7.25 m and 6.50 m for males and females, respectively. For sei whales, mean body length is 13.14 m and 13.84 m for males and females, respectively (Table 7b). Mean body length of Bryde's whales is 11.44 m and 11.93 m for males and females, respectively (Table 7c). For sperm whale, mean body length is 10.06 m for females (Table 7d).

Distribution and food habit
During research season (from May to August) in the offshore area, common minke whales fed mainly on Pacific saury. They also fed on mackerels. On the other hand, the common minke whales fed mainly on Japanese anchovy and walleye pollock in coastal area. The geographical changes of the prey species of the common minke whales seem to reflect changes in the distribution of prey species in feeding areas. The common minke whales seem to be opportunistic feeders with a broad diet and with flexible feeding habits in the research area (Table 8a). Sei whales were distributed widely in the research area. From May to August, they fed mainly on copepods, mackerels, Japanese anchovy and krill in the research area. The sei whales seem to be opportunistic feeders with a broad diet and with flexible feeding habits in the research area. There are geographical and seasonal changes of their prey species (Table 8b). Bryde's whales were distributed in the southern part of research area during research periods. They fed mainly on Japanese anchovy. They also fed on mackerels (Table 8c). Sperm whales were distributed widely in the research area. From three sperm whale samples, they fed mainly on deep sea squids in offshore area (sub-area 9).

Experiments, whale prey species surveys and oceanographic surveys

Biopsy sampling
Table 9 shows the results of biopsy skin sampling for blue, fin and humpback whales. A total of 3 blue, 4 fin and 3 humpback whales were targeted by the SV and SSVs. As a result, 2 fin and 1 humpback whale's skin samples were collected.

Natural marks (photo ID) for blue and humpback whales
Table 10 shows the result of the photo-ID experiments on blue and humpback whales. A total of 10 blue and 3 humpback whales were targeted and 8 blue and 2 humpback whales photographed by the SV and SSVs.

Feeding behaviour for large baleen whales
The SV and SSVs had a plan to conduct recording of the feeding behaviour of large baleen whales using a video recorder. A total of 24 schools of Bryde's and 2 schools of sei whale's feeding behaviour were observed. However, because of far from distance from the schools, it was difficult to take video recording for these schools.

Cooperative survey on the prey species and whale sampling
Echo sounder survey was conducted on TSV (KK1) and they operated to cover the planned track lines using a Simrad EK500 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 NORPAC were used to collect zooplanktons. Midwater trawl, IKMT and NORPAC were

towed at 66, 12 and 62 stations, respectively. The details of these survey conducted by TSV are described in Appendix A.

Oceanographic observation

CTD (Model SBE 19) casts were made at 16 stations by SV with down to 500m at each station to collect the temperature and salinity profiles in the study area. Oceanographic observations were conducted using CTD and XCTD (1,000m) at 57 and 16 stations respectively by TSV. EPCS (Electric particle counting and sizing system) data were collected at 913 hours by SV.

Attachment of satellite telemetry

One satellite telemetry tag was attached for sei whale in the Western North Pacific dated 4th August by YS2. However, position data was not received successfully.

By-products of whales

After biological measurements and sampling were completed, all the whales were processed according to Article VIII of The International Convention for the Regulation of Whaling. Total production including red meat and blubber from 100 sampled common minke, 100 sei, 50 Bryde's and 3 sperm whales was 258 tons, 1,220 tons, 413 tons and 9 tons, respectively.

DISCUSSIONS

This sixth JARPN II was completed satisfactorily. New samples and data ware collected to allow advances in the main objectives of JARPN II, some of samples and data were collected from areas and months not covered in previous surveys.

The distributions and food habits of whales targeted

Common minke whale

Common minke whales were widely distributed in the sub-area 7, 8 and 9. They were not found in the southern parts of sub-area 7, 8 and 9, where surveyed after late June. It was confirmed that they migrated into higher latitude waters during the summer season. Regarding to seasonal movement, Hatanaka and Miyashita (1997) conducted the examination of movement of common minke whales in the western North Pacific. They summarized the pattern of seasonal movement of the O stock as follows: i) immature males migrate into the coastal area of sub-area 7 south in April and then disperse to sub-area 7 north and the southern Okhotsk Sea from June, ii) immature females follow a similar pattern of immature males, iii) mature males found throughout coastal and offshore waters during May to September, iv) mature females are found in the Okhotsk Sea in May, after which they move further north to the middle and northern Okhotsk Sea. In this research, the proportion of mature females was only 6.0% (6 individuals). This fact is indirect confirmations of the hypothesis that in summer season almost all females are feeding in the Okhotsk Sea.

In recent years, during early seasons (May - June) in the sub-areas 8 and 9, Japanese anchovy was the dominant prey species (Tamura and Fujise, 2002a). However, they fed mainly on Pacific saury, krill and Chub mackerel this year. It seems likely that the Japanese anchovy will be replaced by other prey in this year in sub-areas 8 and 9. On the other hand, coastal area in sub-area 7 during June, Japanese anchovy was the dominant prey species in this research. This is consistent with the results of previous years. We confirmed that Japanese anchovy was the most important prey species for common minke whales in the coastal area in sub-area 7.

Sei whale

Sei whales were sighted mainly in the sub-areas 8 and 9. It was confirmed that they were distributed into middle and higher latitude waters in the research area during the summer season. Our research seems to investigate habitat of the southern limit of their distribution. Sighting north of 45 ^{o}N was few, because we could not conduct the research activity due to bad weather such as high density fog. In recent years, during all seasons (May - September), Copepods and Japanese anchovy were the dominant prey species. And, during late season (July – August), Japanese anchovy was the dominant prey species (Tamura *et al.*, 2006). However, they fed mainly on mackerels in the sub-areas 8 and 9 during early season (May - June) this year. This is first information through the JARPNII. During late season (July - August), Japanese anchovy was the dominant prey species which is consistent with the results of previous years.

Bryde's whale

Bryde's whales were sighted mainly in the southern part of sub-areas 7, 8 and 9. It was confirmed that they were distributed in lower latitude waters in the research area during the summer season. Regarding seasonal movement, some researchers conducted the examination of movement of Bryde's whales in the western North Pacific that Bryde's whales were distributed south of 40 ^{o}N within higher surface water temperatures (over 20 ^{o}C) and migrated in the areas of the higher surface water temperature of 18 ^{o}C or more degrees. Water temperature of 20 ^{o}C was their distribution boundary in the offshore (Nemoto, 1959). In this research, it was confirmed that their distribution area was south of 40 ^{o}N, and our research seems to investigate habitat of the northern limit of their distribution. In previous years, during early seasons (May - June), krill was the dominant prey species. And, during late season (July – August), Japanese anchovy was the dominant prey species (Tamura and Fujise, 2002b). In this research they fed mainly on Japanese anchovy in the research area in July and August which is consistent with the results of previous years.

The importance of the research for ecosystem modelling

In this research, there was difference of prey species among three baleen whale species. Especially, the proportion of Japanese anchovy as the prey for baleen whales was lower than that in previous years. It is well known that the most abundant species were replaced successively starting with the Japanese sardine, Pacific saury and Japanese anchovy, chub mackerel and Japanese sardine again in periods of 10 to 20 years in Japanese waters (Yatsu *et al*. 2001). In recent years, Japanese anchovy was dominant. Japanese anchovy will be replaced by other fishes in the future. There is a need to monitor the resource of prey species and the food habit of whales. Our results will be used to build ecosystem models.

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Table 1. Outline of 2007 JARPN II survey.

・Dedicated whale sighting surveys (SV)

Research	Sub-area	Research periods	Research Days	Research ships and remarks
Departure from Shiogama		May 11	1	KS2
transit		May 12-14	3	KS2
Sighting survey	7, 8, 9	May 15- July 30	77	KS2
transit		July 31	1	KS2
Arrived Shiogama		August 1	1	KS2
Total	**7, 8, 9**	**May 11- August 1**	**83**	

・Whale survey (SSV)

Research		Sub-area	Research periods	Research Days	Research ships and remarks
Whale survey (first period)		**7, 8, 9**	**May 11-July 4**	**55**	**YS1, YS2, K01, NM**
Departure from Shimonoseki			May 11	1	YS1, YS2, K01
Departure from Innoshima			May 12		NM
transit			May 12	1	YS1, YS2, K01
pre-survey		7, 8	May 13-17	5	YS1, YS2, K01
		8	May 18- 25	8	YS1, YS2, K01, NM
		9	May 26- June 10	16	YS1, YS2, K01, NM
		8	June 11-15	5	YS1, YS2, K01, NM
		7	June 16- July 3	18	YS1, YS2, K01, NM
transit			July 4	1	YS1, YS2, K01, NM
Whale survey (second period)		**7, 8, 9**	**July 5-August 18**	**45**	**YS1, YS2, K01, NM, KK1**
pre-survey		8, 9	July 5-8	4	YS1, YS2, K01
	Block 1	8, 9 *	July 9- 22	14	YS1, YS2, K01, NM, KK1
		9	July 23-August 2	11	YS1, YS2, K01, NM
	Block 2	9*	August 3-5	3	YS1, YS2, K01, NM, KK1
pre-survey		7,8	August 6-10	5	YS1, YS2, K01
	Block 3	7,8*	August 11-13	3	YS1, YS2, K01, NM, KK1
transit			August 14-16	3	YS1, YS2, K01, NM
Arrived Shimonoseki			August 17	1	YS1, YS2, K01
Arrived Ishinomaki			August 18	1	NM
Total		**7, 8, 9**	**May 11-August 18**	**100**	

*: Cooperative survey on the prey species and whale sampling.

YS1= *Yushin Maru,* YS2= *Yushin Maru No.2,* K01= *Kyo Maru No.1,* NM= *Nisshin Maru,* KK1=*Kaiko-Maru.*

・Dedicated whale sighting & whale prey species surveys (TSV)

Research	Sub-area	Research periods	Research Days	Research ships and remarks
Departure from Shiogama		July 4	1	KK1 (*Kaiko-Maru*)
transit		July 5-6	2	KK1
Sighting & whale prey species survey*	7, 8, 9	July 7-September 4	60	KK1
transit		September 5	1	KK1
Arrived Kushiro		September 6	1	KK1
Total	**7, 8, 9**	**July 4- September 6**	**65**	

*: including cooperative survey on the prey species and whale sampling. (See Appendix B).

Table 2. Searching distances made by the dedicated sighting vessel (SV), three sighting/sampling vessels (SSVs) and the dedicated whale sighting and whale species surveys (TSV) in the 2007 JARPN II.

SV

Research	Sub-area	Research periods	Searching distance (n.miles) ASP	NSP	Combined
Dedicated sighting survey	7, 8, 9	May 11- August 1	4,005.5	37.0	4,042.5
Total	**7, 8, 9**		**4,005.5**	**37.0**	**4,042.5**

SSV

Research		Sub-area	Research periods	Searching distance (n.miles) NSC	ASP	NSS	Combined
Whale survey (First period)		**7, 8, 9**	**May 11-July 4**	**4,923.0**	**880.2**	**1,231.5**	**7,034.7**
pre-survey		7	May 13-17	0.0	727.3	0.0	727.3
		8	May 18- 25	22.8	0.0	583.6	606.4
		9	May 26- June 10	1,608.3	152.9	388.9	2,150.1
		8	June 11-15	1,194.3	0.0	8.7	1,203.0
		7	June 16- July 3	2,097.6	0.0	250.3	2,347.9
Whale survey (second period)		**7, 8, 9**	**July 5-August 18**	**2,182.5**	**1,709.0**	**490.2**	**4,381.7**
pre-survey		8, 9	July 5-8	0.0	183.4	0.0	183.4
	Block 1	8, 9 *	July 9- 22	973.4	359.8	139.7	1,472.9
		9	July 23-August 2	756.7	0.0	294.2	1,050.9
	Block 2	9*	August 3-5	396.1	18.6	56.3	471.0
pre-survey		7,8	August 6-10	0.0	791.6	0.0	791.6
	Block 3	7,8*	August 11-13	56.3	355.6	0.0	411.9
Total		**7, 8, 9**	**May 11-August 18**	**7,105.5**	**3,499.9**	**1,721.7**	**11,416.4**

*: Cooperative survey on the prey species and whale sampling.

TSV

Research	Sub-area	Research periods	Searching distance (n.miles) ASP	NSP	Combined
・Dedicated whale sighting & whale prey species surveys	7, 8, 9	July 4- September 6	0.0	1,741.6	1,741.6
Total	**7, 8, 9**		**0.0**	**1,741.6**	**1,741.6**

Table 3a. List of cetacean species and number of sightings (no. schools/no. individuals) were made by the SV in the 2007 JARPN II.

Cetacean species	ASP				OE		Total					
	Primary		Secondary		Secondary		Primary		Secondary		Total	
	Sch.	Ind.	Sch.	Ind.	Sch.	Ind.	Sch.	Ind.	Sch.	Ind.	Sch.	Ind.
Common minke whale	8	8	1	1	0	0	8	8	1	1	9	9
Like minke whale	0	0	0	0	0	0	0	0	0	0	0	0
Blue whale	1	4	1	1	0	0	1	4	1	1	2	5
Fin whale	18	22	2	2	0	0	18	22	2	2	20	24
Sei whale	34	51	0	0	1	1	34	51	1	1	35	52
Bryde's whale	148	229	4	6	0	0	148	229	4	6	152	235
Humpback whale	8	12	0	0	0	0	8	12	0	0	8	12
Sperm whale	90	248	11	16	0	0	90	248	11	16	101	264
Unidentified large cetacean	12	12	26	37	1	1	12	12	27	38	39	50
Unidentified cetacean	13	13	2	2	0	0	13	13	2	2	15	15

Table 3b. List of cetacean species and number of sightings (no. schools/no. individuals) were made by the SSVs and the NM in the 2007 JARPN II.

Cetacean species	NSC				NSS				ASP				OE	
	Primary		Secondary		Primary		Secondary		Primary		Secondary		Secondary	
	Sch.	Ind.	Sch.	Ind.	Sch.	Ind.	Sch.	Ind.	Sch.	Ind.	Sch.	Ind.	Sch.	Ind.
Common minke whale	57	58	63	64	5	5	11	11	1	1	0	0	9	9
Like minke whale	4	4	10	10	1	1	0	0	0	0	0	0	1	1
Blue whale	8	10	1	1	4	5	0	0	1	1	0	0	0	0
Fin whale	21	27	0	0	3	3	2	2	7	10	0	0	0	0
Sei whale	155	293	62	103	15	22	21	31	34	83	1	1	10	15
Bryde's whale	34	44	21	31	6	9	9	10	175	261	10	14	5	7
Humpback whale	20	36	4	5	3	4	2	3	16	35	1	2	0	0
North Pacific right whale	0	0	0	0	1	1	0	0	0	0	0	0	0	0
Sperm whale	117	323	45	129	10	23	5	13	46	111	7	20	1	1
Unidentified large cetacean	13	14	76	114	4	4	20	23	3	3	16	21	5	5
Unidentified cetacean	37	39	15	15	5	5	3	3	2	2	0	0	1	1

Cetacean species	Total					
	Primary		Secondary		Total	
	Sch.	Ind.	Sch.	Ind.	Sch.	Ind.
Common minke whale	63	64	83	84	146	148
Like minke whale	5	5	11	11	16	16
Blue whale	13	16	1	1	14	17
Fin whale	31	40	2	2	33	42
Sei whale	204	398	94	150	298	548
Bryde's whale	215	314	45	62	260	376
Humpback whale	39	75	7	10	46	85
North Pacific right whale	1	1	0	0	1	1
Sperm whale	173	457	58	163	231	620
Unidentified large cetacean	20	21	117	163	137	184
Unidentified cetacean	44	46	19	19	63	65

Table 3c. List of cetacean species and number of sightings (no. schools/no. individuals) were made by the TSV in the 2007 JARPN II.

Cetacean species	NSP				OE		Total					
	Primary		Secondary		Secondary		Primary		Secondary		Total	
	Sch.	Ind.	Sch.	Ind.	Sch.	Ind.	Sch.	Ind.	Sch.	Ind.	Sch.	Ind.
Like minke whale	3	3	2	2	0	0	3	3	2	2	5	5
Blue whale	2	3	0	0	0	0	2	3	0	0	2	3
Fin whale	5	5	0	0	0	0	5	5	0	0	5	5
Sei whale	55	105	1	2	0	0	55	105	1	2	56	107
Bryde's whale	42	69	5	7	0	0	42	69	5	7	47	76
Sperm whale	59	86	1	1	0	0	59	86	1	1	60	87
Unidentified large cetacean	67	86	17	23	0	0	67	86	17	23	84	109

Table 3d. List of cetacean species and number of sightings (no. schools/no. individuals) were made by all vessels in the 2007 JARPN II.

Cetacean species	Total					
	Primary		Secondary		Total	
	Sch.	Ind.	Sch.	Ind.	Sch.	Ind.
Common minke whale	71	72	84	85	155	157
Like minke whale	8	8	13	13	21	21
Blue whale	16	23	2	2	18	25
Fin whale	54	67	4	4	58	71
Sei whale	293	554	96	153	389	707
Bryde's whale	405	612	54	75	459	687
Humpback whale	47	87	7	10	54	97
North Pacific right whale	1	1	0	0	1	1
Sperm whale	322	791	70	180	392	971
Unidentified large cetacean	99	119	161	224	260	343
Unidentified cetacean	57	59	21	21	78	80

Table 4. Summary of whale sampling in the 2007 JARPN II survey.

	Sub-area	Period	Whale samples			
			Common minke	Sei	Beyde's	Sperm
Whale survey (First period)	**7, 8, 9**	**May 11-July 4**	**100**	**69**	**5**	**2**
	8	May 18- 25	1	17	0	0
	9	May 26- June 10	6	44	0	2
	8	June 11-15	14	2	0	0
	7	June 16- July 4	79	6	5	0
Whale survey (second period)	**7, 8, 9**	**July 5-August 18**	**0**	**31**	**45**	**1**
Block 1	8, 9 *	July 9- 22	0	18	28	1
	9	July 23-August 2	0	8	0	0
Block 2	9*	August 3-5	0	5	2	0
Block 3	7,8*	August 11-13	0	0	15	0
Total	**7, 8, 9**	**May 11-August 18**	**100**	**100**	**50**	**3**

*: Cooperative survey on the prey species and whale sampling.

Table 5. Summary of biological data and samples collected during the 2007 JARPN II survey.

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	86	14	100	54	46	100	23	27	50	0	3	3
External body proportion	86	14	100	54	46	100	23	27	50	0	3	3
Photographic record and external character	86	14	100	54	46	100	23	27	50	0	3	3
Diatom film record	86	14	100	54	46	100	23	27	50	0	3	3
Standard measurements of blubber thickness (five points)	86	14	100	54	46	100	23	27	50	0	3	3
Detailed measurements of blubber thickness (eleven points)	14	1	15	13	13	26	6	7	13	0	3	3
Body weight	86	14	100	54	46	100	23	27	50	0	3	3
Body weight by parts	14	1	15	13	13	26	6	7	13	0	3	3
Blubber tissues for DNA study	86	14	100	54	46	100	23	27	50	0	3	3
Blubber, muscle, liver and kidney tissues for heavy metal analysis	86	14	100	54	46	100	23	27	50	0	3	3
Blubber, muscle, liver and kidney tissues for organochlorines analysis	86	14	100	54	46	100	23	27	50	0	3	3
Blubber, muscle tissues for ingredient analysis	3	2	5	2	2	4	1	3	4	0	3	3
Lung tissue for atmospheric analysis	8	0	8	10	0	10	8	0	8	0	2	2
Tissues for lipid analysis	14	1	15	14	13	27	6	7	13	0	3	3
Tissues for various analysis	86	14	100	54	46	100	23	27	50	0	3	3
Tissues for virus test	86	6	92	54	25	79	23	15	38	0	0	0
Mammary gland; lactation status, measurement and histological sample	-	14	14	-	46	46	-	27	27	-	3	3
Collection of spermaceti sample	-	-	-	-	-	-	-	-	-	0	3	3
Collection of maternal milk sample	-	0	0	-	0	0	-	1	1	-	1	1
Uterine horn; measurement and endometrium sample	-	14	14	-	46	46	-	27	27	-	3	3
Collection of ovary	-	14	14	-	46	46	-	27	27	-	3	3
Photographic record of foetus	2	5	7[*1]	15	10	25	4	10	15[*2]	0	0	0
Foetal sex (identified by visual observation)	2	5	7[*1]	15	10	25	4	10	15[*2]	0	0	0
Foetal length and weight	2	5	7[*1]	15	10	25	4	10	15[*2]	0	0	0
External measurements of foetus	2	5	7[*1]	15	10	25	4	10	14	0	0	0
Foetal blubber tissues for DNA study	2	5	7[*1]	15	10	25	4	10	15[*2]	0	0	0
Foetal tissues for various analysis	2	5	7[*1]	14	9	23	3	10	13	0	0	0
Foetal lens for age determination	2	5	7[*1]	14	9	23	3	10	13	0	0	0
Testis and epididymis; weight and histological sample	86	-	86	54	-	54	23	-	23	0	-	0
Collection of plasma sample	86	14	100	54	46	100	23	27	50	0	3	3
Collection of whole blood sample	86	14	100	54	46	100	23	27	50	0	3	3
Whole blood samples from umbilical cord	-	3	3	-	15	15	-	11	11	-	0	0
Plasma samples from umbilical cord	-	5	5	-	22	22	-	13	13	-	0	0
Stomach content, conventional record	86	14	100	54	46	100	23	27	50	0	3	3
Volume and weight of stomach content in each compartment	86	14	100	54	46	100	23	27	50	0	3	3
Stomach contents for feeding study	86	14	100	54	46	100	23	27	50	0	3	3
Record of external parasites	86	14	100	54	46	100	23	27	50	0	3	3
Collection of external parasites	5	1	6	5	7	12	3	3	6	0	1	1
Record of internal parasites	86	14	100	54	46	100	23	27	50	0	3	3
Collection of internal parasites	0	0	0	3	6	9	2	5	7	0	3	3
Earplug for age determination	86	14	100	54	46	100	23	27	50	-	-	-
Tympanic bulla for age determination	86	14	100	54	46	100	23	27	50	-	-	-
Maxillally teeth for age determination	-	-	-	-	-	-	-	-	-	0	3	3
Lens for age determination	86	14	100	54	46	100	23	27	50	-	-	-
Largest baleen plate for morphologic study and age determination	86	14	100	54	46	100	23	27	50	-	-	-
Baleen plate measurements (length and breadth)	84	14	98	54	46	100	23	27	50	-	-	-
Length of each baleen plate series	86	14	100	54	46	100	23	27	50	-	-	-
Vertebral epiphyses sample	86	14	100	54	46	100	23	27	50	0	3	3
Number of vertebrae	0	0	0	13	13	26	6	7	13	0	3	3
Number of ribs	86	14	100	54	46	100	23	27	50	0	3	3
Brain weight	14	1	15	12	13	25	6	7	13	0	2	2
Skull measurement (length and breadth)	83	13	96	52	42	94	21	26	47	0	3	3

[*1]:including twins

*2including a fetus of sex unidentified

Table 6a. Composition of sex and sexual maturity of common minke whales collected by the 2007 JARPN II survey.

Sub-area	Male				Female				Combined	Sex ratio	Maturity		Pregnancy
	Imm.	Mat.	Unknown	Total	Imm	Rest.	Preg.	Total		(% males)	Male	Female	rate*)
7	13	48	5	66	7	0	6	13	79	83.5	72.7	46.2	100.0
	(16.5)	(60.8)	(6.3)	(83.5)	(8.9)	(0.0)	(7.6)	(16.5)	(100.0)				
8	2	10	3	15	0	0	0	0	15	100.0	66.7	0.0	0.0
	(13.3)	(66.7)	(20.0)	(100.0)	(0.0)	(0.0)	(0.0)	(0.0)	(100.0)				
9	1	4	0	5	1	0	0	1	6	83.3	80.0	0.0	0.0
	(16.7)	(66.7)	(0.0)	(83.3)	(16.7)	(0.0)	(0.0)	(16.7)	(100.0)				
Combined	16	62	8	86	8	0	6	14	100	86.0	72.1	42.9	100.0
	(16.0)	(62.0)	(8.0)	(86.0)	(8.0)	(0.0)	(6.0)	(14.0)	(100.0)				

*) Apparent pregnancy rate

Table 6b. Composition of sex and sexual maturity of sei whales collected by the 2007 JARPN II survey.

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	5	5	1	0	0	0	0	0	1	6	83.3	100.0	0.0	-
	(0.0)	(83.3)	(83.3)	(16.7)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(16.7)	(100.0)				
8	3	6	9	3	0	1	10	1	0	15	24	37.5	66.7	80.0	83.3
	(12.5)	(25.0)	(37.5)	(12.5)	(0.0)	(4.2)	(41.7)	(4.2)	(0.0)	(62.5)	(100.0)				
9	18	22	40	12	1	2	15	0	0	30	70	57.1	55.0	60.0	83.3
	(25.7)	(31.4)	(57.1)	(17.1)	(1.4)	(2.9)	(21.4)	(0.0)	(0.0)	(42.9)	(100.0)				
Combined	21	33	54	16	1	3	25	1	0	46	100	54.0	61.1	65.2	83.3
	(21.0)	(33.0)	(54.0)	(16.0)	(1.0)	(3.0)	(25.0)	(1.0)	(0.0)	(46.0)	(100.0)				

*) Apparent pregnancy rate

Table 6c. Composition of sex and sexual maturity of Bryde's whales collected by the 2007 JARPN II survey.

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	4	0	4	2	0	2	2	0	0	6	10	40.0	0.0	66.7	50.0
	(40.0)	(0.0)	(40.0)	(20.0)	(0.0)	(20.0)	(20.0)	(0.0)	(0.0)	(60.0)	(100.0)				
8	6	8	14	2	2	1	10	1	0	16	30	46.7	57.1	87.5	78.6
	(20.0)	(26.7)	(46.7)	(6.7)	(6.7)	(3.3)	(33.3)	(3.3)	(0.0)	(53.3)	(100.0)				
9	3	2	5	1	1	0	3	0	0	5	10	50.0	-	80.0	75.0
	(30.0)	(20.0)	(50.0)	(10.0)	(10.0)	(0.0)	(30.0)	(0.0)	(0.0)	(50.0)	(100.0)				
Combined	13	10	23	5	3	3	15	1	0	27	50	46.0	43.5	81.5	72.7
	(26.0)	(20.0)	(46.0)	(10.0)	(6.0)	(6.0)	(30.0)	(2.0)	(0.0)	(54.0)	(100.0)				

*) Apparent pregnancy rate

Table 7a. Statistics of body length (m) of common minke whale collected by the 2007 JARPN II survey.

Sub area	Male					Female				
	Mean	S.D.	Min.	Max.	n	Mean	S.D.	Min.	Max.	n
7	7.22	0.69	4.77	8.11	66	6.66	1.41	4.17	8.20	13
8	7.46	0.72	5.17	8.16	15	-	-	-	-	0
9	6.97	1.33	4.61	7.84	5	4.33	-	4.33	4.33	1
Combined	7.25	0.74	4.61	8.16	86	6.50	1.49	4.17	8.20	14

Table 7b. Statistics of body length (m) of sei whale collected by the 2007 JARPN II survey.

Sub area	Male					Female				
	Mean	S.D.	Min.	Max.	n	Mean	S.D.	Min.	Max.	n
7	13.69	0.54	13.09	14.37	5	11.83	-	11.83	11.83	1
8	13.25	0.57	12.66	14.41	9	13.97	1.12	11.46	15.19	15
9	13.05	0.96	11.18	14.85	40	13.84	1.11	10.71	15.51	30
Combined	13.14	0.88	11.18	14.85	54	13.84	1.13	10.71	15.51	46

Table 7c. Statistics of body length (m) of Bryde’s whale collected by the 2007 JARPN II survey.

Sub area	Male					Female				
	Mean	S.D.	Min.	Max.	n	Mean	S.D.	Min.	Max.	n
7	9.86	0.79	9.15	10.87	4	11.61	1.41	9.74	12.92	6
8	12.30	1.04	9.79	13.60	14	12.57	1.14	9.79	13.60	16
9	11.35	1.08	9.94	12.94	5	12.57	0.74	11.58	13.45	5
Combined	11.44	1.07	9.15	13.60	23	11.93	1.16	9.74	13.60	27

Table 7d. Statistics of body length (m) of sperm whale collected by the 2007 JARPN II survey.

Sub area	Male					Female				
	Mean	S.D.	Min.	Max.	n	Mean	S.D.	Min.	Max.	n
7	-	-	-	-	0	-	-	-	-	0
8	-	-	-	-	0	-	-	-	-	0
9	-	-	-	-	0	10.06	1.48	8.37	11.16	3
Combined	-	-	-	-	0	10.06	1.48	8.37	11.16	3

Table 8a. Prey species and stomach contents weight (1st. + 2nd. stomachs) found in stomach of common minke whales sampled by the 2007 JARPN II surveys.

Common minke whale (Broken 4; Empty 6)

Prey species		N (Dominant)	Range of weigth (kg) in the stomachs
Krill		9	7.7 - 105.6
Fish	Pacific saury	11	10.3 - 77.0
	Japanese anchovy	63	7.6 - 196.2
	Mackerels	2	20.8 - 61.0
	Walleye pollock	4	40.3 - 118.0
	Boreal clubhook squid	1	48.9
	Japanese sardine*		-

*: Minor prey species

Table 8b. Prey species and stomach contents weight (1st. + 2nd. stomachs) found in stomach of Sei whales sampled by the 2007 JARPN II surveys.

Sei whale (Broken 3; Empty 26)

Prey species		N (Dominant)	Range of weigth (kg) in the stomachs
Copepods	*Neocalanus spp.*	39	17.35 - 351.5
Krill		2	83.05 - 97.8
Fish	Pacific saury	3	13.20 - 51.7
	Japanese anchovy	11	24.35 - 321.7
	Mackerels	16	22.85 - 885.3
	Japanese sardine*		-

*: Minor prey species

Table 8c. Prey species and stomach contents weight (1st. + 2nd. stomachs) found in stomach of Bryde's whales sampled by the 2007 JARPN II surveys.

Bryde's whale (Broken 1; Empty 19)

Prey species		N (Dominant)	Range of weigth (kg) in the stomachs
Krill		1	348.0
Fish	Japanese anchovy	28	18.2 - 672.7
	Mackerels	1	134.0
	Japanese sardine*		-

*: Minor prey species

Table 9. Summary of biopsy skin sampling for blue, fin and humpback whales in the 2007 JARPN II survey.

Whale species	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	2	3	0	0	0	1:03	-	-
Fin whale	4	4	7	2	2	1:23	0.29	1.00
Humpback whale	2	3	11	1	1	2:01	0.09	1.00

Table 10. Summary of photo ID in the 2007 JARPN II survey.

Whale species	Number of experiments (A)	Targeted individuals (B)	Number of photos (C)
Blue whale	8	10	93
Humpback whale	2	3	10

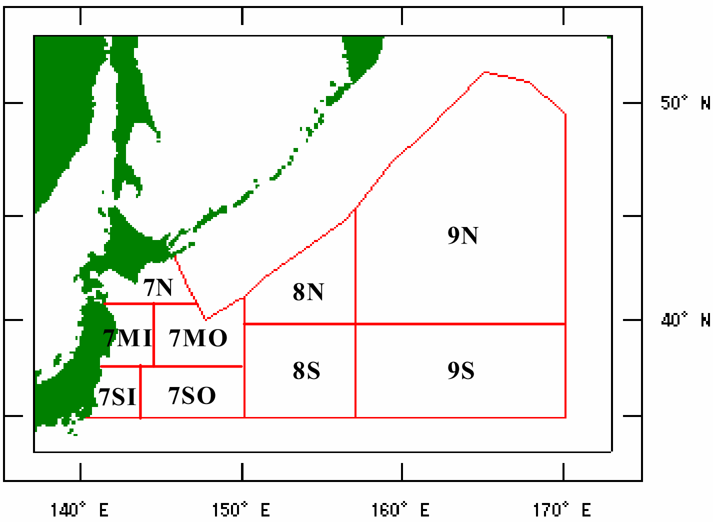

Fig 1. Map showing the research area and strata of the JARPN II full-scale survey.

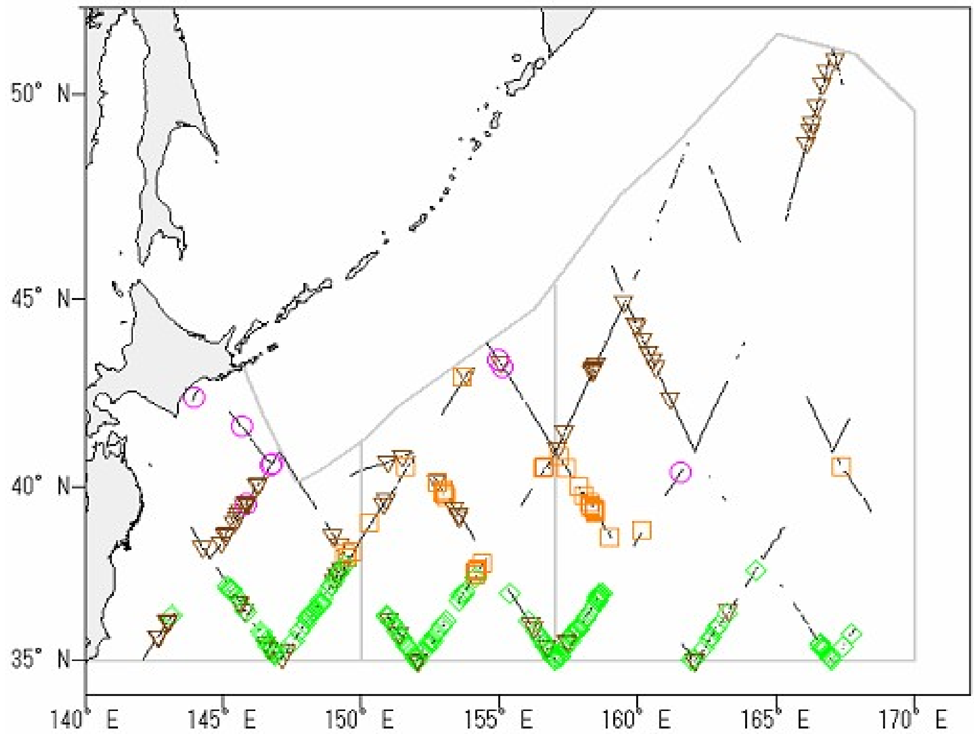

Fig. 2a. Track-line and primary search effort (thick line)covered by the dedicated sighting vessel (SV:KS2) and positions of the sightings of common minke (circle), Bryde's (diamond), sei (square) and sperm whales (triangle) during survey of the 2007 JARPN II.

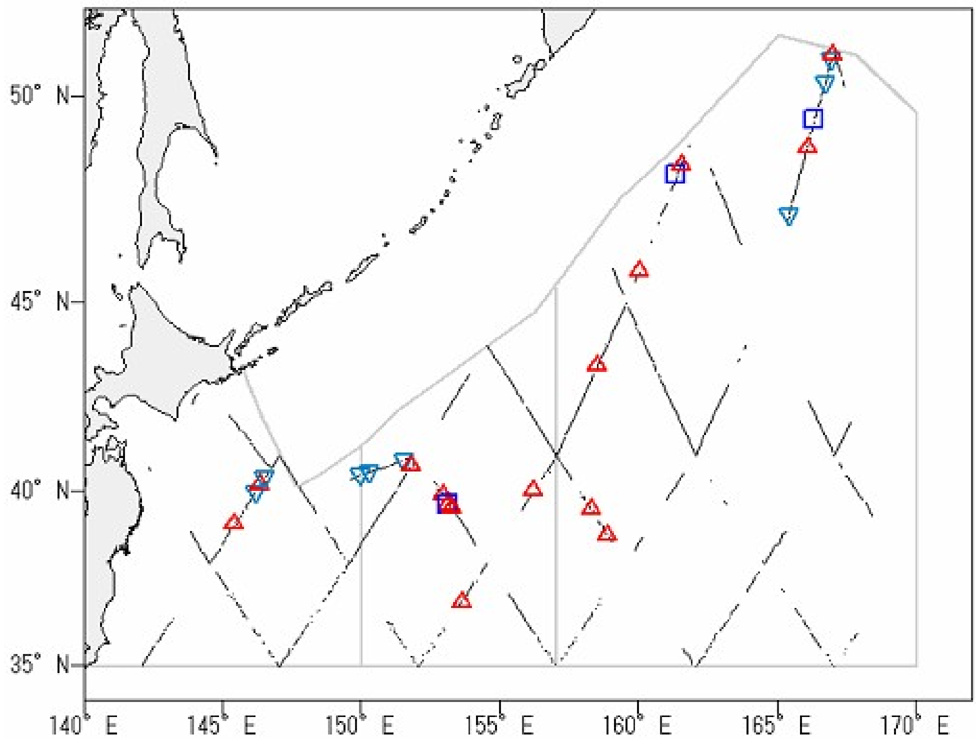

Fig. 2b. Track-line and primary search effort (thick line)covered by the dedicated sighting vessel (SV:KS2) and positions of the sightings of blue (square), fin (triangle) and humpback (inverted triangle) whales during survey of the 2007 JARPN II.

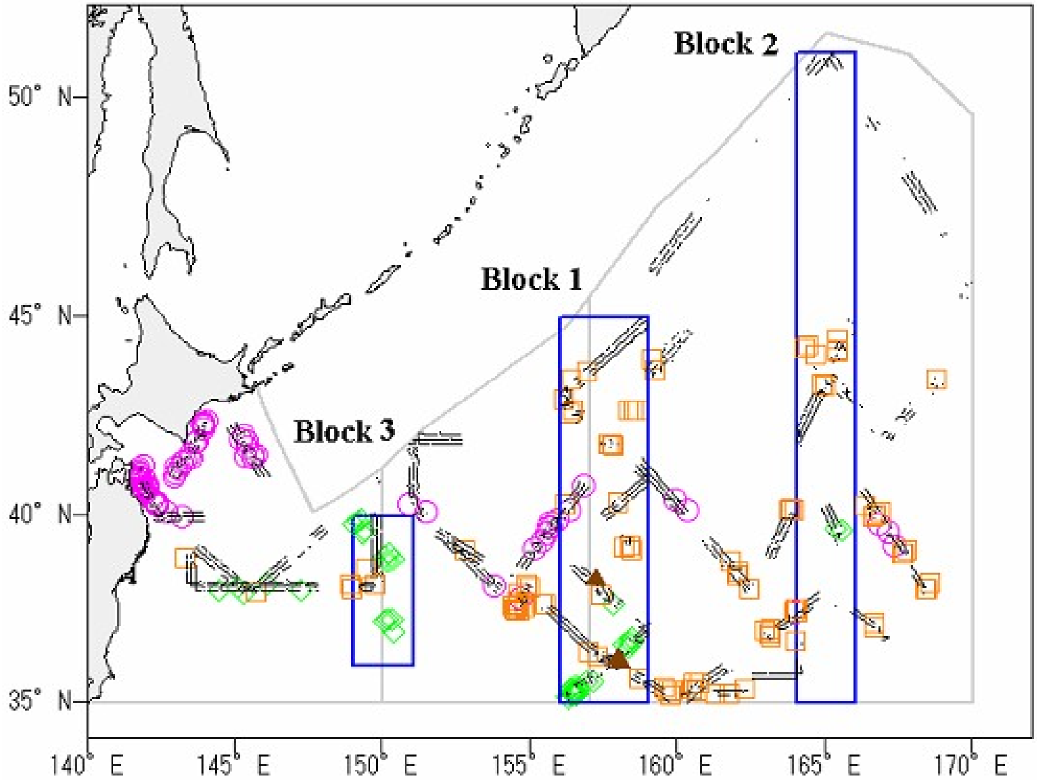

Fig. 3. Searching effort covered by the three sighting/sampling vessels (SSVs) during the 2007 JARPN II with the position of sampled common minke (circle), Bryde's (diamond), sei (square) and sperm (triangle) whales. Three blocks 1, 2 and 3 show the cooperative survey on the prey species and whale sampling area.

Appendix A

Cruise report of the cetacean prey speices survey of JARPNII (offshore component) in 2007

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ABSTRCAT

A whale prey species survey was conducted concurrently with a whale sampling survey as a part of the offshore component of JARPNII in 2007. The primary objective of the concurrent study was estimation of prey selection of whales. Three survey blocks with zigzag tracklines were set within the survey area of JARPNII. The survey was conducted from 4 July to 6 September. A trawler-type survey vessel, Kaiko-Maru (860 ton), equipped with the quantitative echo sounder dedicated to the prey survey. Kaiko-Maru also conducted cetacean sighing survey while she steamed on the tracklines. The acoustic survey using a Simrad EK500 echo sounder with operating frequencies at 38 and 120 kHz was carried out to quantify pray 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 NORPAC were used to collect zooplanktons. Midwater trawl, IKMT and NORPAC were towed at 66, 12 and 62 stations, respectively. Oceanographic observations were conducted using CTD and XCTD at 57 and 16 stations respectively. Total surveyed distance of cetacean sighting survey was 1741.6 n.miles. Primary sightings of sei and Bryde's whales were 42 groups/69 individuals and 55 groups/105 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 whales (*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, 2000) The overall goal of JARPN II is to contribute to the conservation and sustainable use of marine living resources including whales in the western North Pacific, especially within Japan's EEZ. The priority in this second phase is on feeding ecology, involving the studies on prey consumption by cetaceans, prey selection of cetaceans and ecosystem model. After the success in two feasibility studies, the study was expanded to full scale in 2002 (Government of Japan 2002). Sei whale (*Balaenoptera borealis*) was added as target cetacean species in addition to minke, Bryde's (*Balaenoptera edeni*) and sperm (*Physeter macrocephalus*) whales in the full scale study. The full scale study in 2007 was conducted in Sub-areas 7, 8 and 9, off the coast of eastern Honsyu, Japan from July to September. 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 JARPNII in 2007.

MATERIALS AND METHOD

The area of the cooperative whale and prey surveys was in Sub-areas 7, 8 and 9 off the coast of eastern Honsyu, Japan (Fig. 1). Within the survey area, three blocks, Block 1, 2 and 3 were set considering the oceanographic conditions such as positions of fronts and water masses as well as anticipated distribution pattern of the target whale species. In each block, a zigzag track line was set independently from whale survey. Waypoints were listed in Table 1. The research vessel, Kaiko-maru (KK1, 860 GT), departed Shiogama port on 4 July, 2007 and returned Kushiro port on 6 September, 2007. Details of itinerary were shown in Table 2. Prey distribution and abundance surveys using the quantitative echo sounder, midwater trawl, Isaacs Kidd Midwater Trawl (IKMT) and NORPAC were conducted KK1. In addition to the prey survey, KK1 conducted cetacean sighting survey. During the daytime, KK1 steamed at about 10 knots along the tracklines 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 EK500) 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 4.3m from the surface. Calibrations were carried out at off the coast of Shiogama on 27 June , 2007 using the copper sphere technique described in the EK500 manual (Simrad, 1997). Acoustic data were recorded while the KK1 steamed on the tracklines. 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 knot. 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 each block. The purpose of the predetermined trawls was to estimate the abundance and distribution patterns of cephalopods and neustnic organisms such as Pacific saury that are difficult to detect by the echo sounder. Two different depth layers were sampled at predetermined trawl stations; 0-30m (surface) and 0-100m (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, length of 100 individuals was 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 mesozooplanktons detected by the quantitative echo sounder. Mouth opening of the IKMT was about 3.7x3.1 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, 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 and mesh size of NORPAC are 45cm and 0.33mm, respectively. NORPAC was towed from 150m 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 (KS2), Seabird, USA) and expendable CTD (XCTD, Tsurumi Seiki Co., Japan). CTD and XCTD data were recorded from surface to 500m and from surface to 1000m, respectively. CTD was mainly used to record oceanographic data while XCTD was used when the time of deployment was limited.

Cetacean sighting survey was conducted by KK1 while she steamed on the tracklines. 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 2n.miles perpendicular to trackline.

To calculate theoretical target strength (TS), body-density and sound speed through body of two copepods, *Neocalanus cristatus* and *N. plumchrus*, were measured onboard KK1. Body-density and sound speed are crucial parameters in theoretical TS models. Copepods were sampled either IKMT or NORPAC. Body-mass density was measured using a density-bottle method. Body-mass density was determined by evaluating the buoyancy of each copepod sample via a series of 500ml plastic sample containers containing seawater-glycerol solution of different density. The speed of sound through the copepod body was estimated by a time-average approach. The principle of the time-average approach is based on the measurement of the time-of-flight of acoustic pulses through a uniform mixture of water and marine organisms. Ratio between speed of sound through seawater and copepod body was estimated using this method.

RESULTS AND DISCUSSION

Most of tracklines were surveyed by the quantitative echo sounder. Predetermined surface and midwater trawling was conducted at 32 and 28 stations, respectively. Target trawling was conducted at 6 stations. Positions of surface and midwater trawling were shown in Fig. 2. Summary of the results of trawling was shown in Table 3. Japanese anchovy and Pacific saury were dominant among sampled species. IKMT was towed at 12 stations (Table 4, Fig.3,). NORPAC was towed at 62 stations (Table 5, Fig. 4). CTD and XCTD casts were carried out 57 and 16 stations, respectively. Surveyed distances of cetacean sighting survey in Blocks 1, 2, and 3 were 450.0, 761.1 and 530.5 n.miles, respectively. About 50 % of planned surveyed distance was surveyed in each Block. Primary sightings of sei and Bryde's whales were 42 groups/69 individuals and 55 groups/105 individuals, respectively. Body-density and sound speed through body of copepods were measured at 3 and 4 stations, respectively. All recorded data will be used to estimate the prey selection of baleen whales (e.g. Murase *et al*., 2007).

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Table 1. Positions of waypoints in each blocks.

Waypoint	Latitude				Longitude				Course	Distance (n.mile)
Block 1										
601	35	-	00	N	156	-	00	E	59	114.6
602	36	-	00	N	158	-	00	E	302	113.6
603	37	-	00	N	156	-	00	E	58	112.5
604	38	-	00	N	158	-	00	E	303	111.5
605	39	-	00	N	156	-	00	E	57	110.4
606	40	-	00	N	158	-	00	E	303	109.2
607	41	-	00	N	156	-	00	E	56	108.1
608	42	-	00	N	158	-	00	E	304	106.9
609	43	-	00	N	156	-	00	E	56	105.8
610	44	-	00	N	158	-	00	E	313	88.0
611	45	-	00	N	156	-	30	E	-	-
									Total	1080.6
Block 2										
621	51	-	00	N	166	-	00	E	203	196.2
622	48	-	00	N	164	-	00	E	155	198.1
623	45	-	00	N	166	-	00	E	235	104.8
624	44	-	00	N	164	-	00	E	124	106.0
625	43	-	00	N	166	-	00	E	236	107.2
626	42	-	00	N	164	-	00	E	124	108.3
627	41	-	00	N	166	-	00	E	237	109.5
628	40	-	00	N	164	-	00	E	123	110.6
629	39	-	00	N	166	-	00	E	238	111.8
630	38	-	00	N	164	-	00	E	122	112.9
631	37	-	00	N	166	-	00	E	238	114.0
632	36	-	00	N	164	-	00	E	121	115.0
633	35	-	00	N	166	-	00	E	-	-
									Total	1494.4
Block 3										
641	35	-	0	N	151	-	0	E	301	115.0
642	36	-	0	N	149	-	0	E	58	114.0
643	37	-	0	N	151	-	0	E	302	112.9
644	38	-	0	N	149	-	0	E	58	111.8
645	39	-	0	N	151	-	0	E	303	110.6
646	40	-	0	N	149	-	0	E	57	109.5
647	41	-	0	N	151	-	0	E	-	-
									Total	673.8
									GrossTotal	3248.7

Table 2. Itinerary of the survey.

Date	Event
4 July	Departed Shiogama, Japan.
7 July	Started Block 1 survey.
26 July	Ended Block 1 survey.
28 July	Started Block 2 survey.
21 August	Ended Block 2 survey.
24 August	Started Block 3 survey.
4 September	Ended Block 3 survey.
6 September	Arrived Kushiro, Japan.

Table 3. Summary of the results of surface and midwater trawl.

St.	Latitude	Longitude	P/T *1	M/S *2	SST(°C)	Target depth(m)	Towing duration (min.)	Japanese anchovy	Juv. Japanese anchovy	Japanese Sardine	Chub mackerel	Pacific saury	Japanese pomfret	Salmonids	Other fish	Japanese common squid	Other squid	Total
Block 1																		
01	34 - 59.8 N	155 - 59.5 E	P	M	20.3	0-100	30						+		+			0.15
02	35 - 29.5 N	156 - 58.3 E	P	S	20.7	0-30	30	+										0.01
03	36 - 00.1 N	158 - 00.0 E	P	M	20.8	0-100	30	0.02							+		+	0.15
05	36 - 30.3 N	156 - 59.8 E	P	S	19.8	0-30	30	0.01										0.01
06	37 - 02.8 N	156 - 05.7 E	P	M	20.0	0-100	30						0.11		+			0.22
08	37 - 28.4 N	156 - 56.7 E	P	S	18.1	0-30	30	+			4.97							4.97
09	38 - 00.3 N	157 - 59.8 E	P	M	17.9	0-100	30								0.12		+	0.17
10	38 - 14.5 N	157 - 31.2 E	P	S	17.6	0-30	30				0.08							0.08
11	38 - 30.5 N	156 - 59.8 E	P	M	17.8	0-100	35				0.25				0.09			0.52
12	38 - 55.5 N	156 - 10.6 E	T	S	19.0	0-30	34	14.46										14.67
13	39 - 00.1 N	156 - 00.1 E	P	S	18.8	0-30	30											0.07
14	39 - 10.3 N	156 - 20.3 E	T	S	19.0	200	10	2.06							+		0.04	2.38
15	39 - 30.1 N	157 - 00.0 E	P	M	18.6	0-100	30						0.36		0.02			0.44
16	39 - 51.7 N	157 - 43.1 E	T	S	16.2	180-220	12	0.29			0.01				0.05		0.01	10.91
17	40 - 04.1 N	157 - 53.9 E	P	S	16.0	0-30	30	4.47		0.10	245.24				0.13			249.94
18	40 - 29.4 N	156 - 59.1 E	P	M	17.1	0-100	30	+			0.17				0.01	0.14		0.58
20	41 - 02.2 N	156 - 00.3 E	P	S	14.1	0-30	30	0.01							1.22	1.84	0.02	3.75
25	41 - 10.3 N	156 - 20.5 E	T	S	14.2	10	17	4.19			2.71	0.14				3.26		10.29
26	41 - 30.6 N	157 - 00.9 E	P	M	14.4	0-100	30	0.81					0.81		+		+	4.13
30	41 - 51.5 N	157 - 42.7 E	P	S	13.2	0-30	30	13.75		0.05						13.75	+	14.26
31	42 - 30.0 N	157 - 00.2 E	P	M	13.2	0-100	30					25.35	2.36	1.56	1.56			29.27
33	43 - 00.3 N	156 - 00.2 E	P	S	13.2	0-30	30		0.15			18.85			0.19		0.04	19.23
34	43 - 22.6 N	156 - 45.0 E	P	M	11.2	0-100	30								+		0.04	0.90
35	44 - 00.1 N	158 - 00.0 E	P	S	11.3	0-30	30					0.16	15.85	3.66	3.66			19.67
36	44 - 15.1 N	157 - 37.4 E	T	S	11.3	20	19					1191.45						1191.50
37	45 - 00.2 N	156 - 30.0 E	P	S	10.2	0-30	30						2.21	3.92	3.92		0.70	6.83
Block 2																		
38	51 - 00.0 N	166 - 00.1 E	P	S	9.7	0-30	30										0.86	0.94
40	50 - 00.2 N	165 - 19.4 E	P	S	9.5	0-30	30							6.20			0.38	6.58
41	48 - 00.0 N	164 - 00.0 E	P	M	9.3	0-100	30					219.95	1.16	6.22			0.29	227.62
42	46 - 51.5 N	164 - 46.5 E	P	S	10.0	0-30	30						17.23	1.21			+	18.81
43	46 - 00.0 N	165 - 20.7 E	P	M	9.7	0-100	30											2.36
44	44 - 59.5 N	165 - 59.5 E	P	S	10.4	0-30	30										+	0.05
45	44 - 30.0 N	164 - 59.7 E	P	M	10.7	0-100	30						1.84		+		+	1.84
46	43 - 59.9 N	164 - 00.1 E	P	S	11.9	0-30	30					147.40						147.40
47	43 - 29.8 N	165 - 00.6 E	P	M	11.8	0-100	30					0.20	0.93		0.03			1.16
48	43 - 02.9 N	165 - 54.3 E	P	S	11.5	0-30	30	+				20.90			+		+	21.33
49	42 - 29.8 N	164 - 59.5 E	P	M	13.1	0-100	30	0.07							0.004		0.046	0.26
50	42 - 00.1 N	164 - 00.1 E	P	S	13.6	0-30	30	4.66			0.01	1.11			+			5.78
51	41 - 28.6 N	165 - 02.9 E	P	M	14.7	0-100	30								+		+	0.15
52	41 - 03.0 N	165 - 54.0 E	P	S	16.9	0-30	30											0.02
53	40 - 29.8 N	164 - 59.4 E	P	M	15.7	0-100	30	0.02							+			0.02
54	39 - 59.7 N	164 - 00.5 E	P	S	19.0	0-30	30											0.00
55	39 - 32.3 N	164 - 55.7 E	P	M	17.0	0-100	30	0.02									0.25	0.35
56	39 - 00.9 N	166 - 01.9 E	P	S	20.0	0-30	30								+			0.04
57	38 - 30.4 N	165 - 00.6 E	P	M	20.2	0-100	30		+									0.25
58	38 - 00.0 N	164 - 00.1 E	P	S	20.8	0-30	30		+						+			0.01
60	37 - 28.5 N	165 - 03.0 E	P	M	22.7	0-100	30		0.01						0.01			0.05
61	36 - 59.8 N	165 - 59.9 E	P	S	22.4	0-30	30	49.75										49.76
62	36 - 30.1 N	165 - 00.0 E	P	M	22.6	0-100	30		+									0.58
63	35 - 57.8 N	164 - 00.1 E	P	S	24.4	0-30	30											0.00
64	35 - 30.0 N	165 - 00.1 E	P	M	23.8	0-100	30								0.01		0.01	0.17
65	35 - 00.0 N	166 - 00.2 E	P	S	24.0	0-30	30		0.01									0.01
Block 3																		
66	35 - 00.0 N	150 - 59.9 E	P	S	26.8	0-30	30								0.03			0.12
67	35 - 30.3 N	149 - 59.6 E	P	M	28.4	0-100	30								+		+	0.02
68	35 - 57.9 N	148 - 59.9 E	P	S	27.3	0-30	30		0.03						+		+	0.04
69	36 - 30.1 N	150 - 00.1 E	P	M	28.4	0-100	30								0.03		+	0.05
70	37 - 00.3 N	151 - 00.3 E	P	S	28.2	0-30	30		0.08						0.03		+	0.12
71	37 - 31.2 N	149 - 57.7 E	P	M	26.6	0-100	30								0.02		+	0.16
72	37 - 46.0 N	149 - 29.1 E	T	S	26.8	0-30	20	0.09							0.01			0.10
73	38 - 00.2 N	149 - 00.1 E	P	S	26.9	0-30	30	0.02							0.01			0.03
74	38 - 25.6 N	149 - 51.0 E	P	M	24.4	0-100	30				0.29							0.29
75	38 - 57.6 N	150 - 55.1 E	P	S	24.1	0-30	30								+		+	0.15
76	39 - 30.1 N	149 - 59.9 E	P	M	24.9	0-100	30	0.01							0.02		0.03	0.14
77	41 - 00.0 N	151 - 00.0 E	P	S	19.6	0-30	30	0.01							43.24			43.25
78	40 - 29.9 N	149 - 59.5 E	P	M	21.3	0-100	30	+							0.06			0.31
79	39 - 59.8 N	149 - 00.2 E	P	S	24.5	0-30	30		0.001						0.02		0.03	0.19

*1 P=predetermined trawl, T=target trawl

*2 M=midwater trawl, S=surface trawl

Table 4. Summary of the results of IKMT.

Station	Latitude	Longitude	SST(°C)	Target depth (m)	Targeted spp.
04	36 - 10.5 N	157 - 38.8 E	20.8	220-240	Krill
07	37 - 17.5 N	156 - 29.8 E	19.1	300	Krill
21	41 - 04.1 N	156 - 06.7 E	14.2	20-40	Copepods
22	41 - 02.6 N	156 - 06.1 E	14.1	50-100	Copepods
23	41 - 02.3 N	156 - 05.2 E	14.1	100	Copepods
24	41 - 05.8 N	156 - 04.9 E	14.2	100	Krill
28	41 - 50.4 N	157 - 38.8 E	13.2	30	Copepods
29	41 - 49.6 N	157 - 38.4 E	13.2	50	Copepods
39	50 - 29.4 N	165 - 39.8 E	9.5	70-100	Krill
44-1	44 - 56.5 N	165 - 54.8 E	10.5	20	Copepods
44-2	44 - 57.4 N	165 - 52.6 E	10.6	45	Copepods
59	37 - 51.2 N	164 - 18.1 E	21.9	45-50	Krill

Table 5. Summary of the results of NORPAC.

Block 1

Station	Latitude	Longitude	P/T	SST(°C)	Target depth (m)	Filtered volume (m^3)
01	35 - 02.3 N	156 - 06.0 E	P	20.4	150	57.5
02	35 - 32.4 N	157 - 02.9 E	P	21.0	150	39.2
03	36 - 04.4 N	157 - 56.2 E	P	20.6	150	58.5
04	36 - 09.3 N	157 - 42.5 E	T	20.8	150	22.7
05	36 - 32.0 N	156 - 55.6 E	P	19.4	150	29.4
06	37 - 05.5 N	156 - 11.1 E	P	19.7	150	27.2
07	37 - 15.1 N	156 - 32.4 E	T	19.2	150	27.3
08	37 - 31.4 N	157 - 00.1 E	P	18.0	150	29.5
09	38 - 01.7 N	157 - 53.2 E	P	17.8	150	24.0
10	38 - 16.7 N	157 - 27.6 E	P	17.7	150	25.6
11	38 - 33.1 N	156 - 54.0 E	P	17.7	150	31.9
13	39 - 01.4 N	156 - 05.0 E	P	18.8	150	29.4
15	39 - 33.1 N	157 - 05.6 E	P	18.6	150	26.9
17	40 - 00.7 N	157 - 52.0 E	P	16.2	150	26.8
18	40 - 35.5 N	156 - 55.2 E	P	15.2	150	25.7
19	40 - 43.3 N	156 - 36.9 E	T	15.0	60-20	102.9
20	41 - 03.3 N	156 - 04.2 E	P	14.1	150	43.2
26	41 - 34.0 N	157 - 05.3 E	P	13.8	150	30.5
27	41 - 43.0 N	157 - 32.8 E	T	13.6	150	29.8
30	41 - 55.0 N	157 - 44.7 E	P	14.2	170	22.6
31	42 - 33.6 N	156 - 54.6 E	P	13.3	150	22.4
32-1	42 - 42.1 N	156 - 32.2 E	T	13.4	150	28.1
32-2	42 - 42.1 N	156 - 32.2 E	T	13.4	70	30.4
32-3	42 - 42.1 N	156 - 32.2 E	T	13.4	40	8.5
33	43 - 02.9 N	156 - 04.4 E	P	13.3	150	27.7
34	43 - 27.3 N	156 - 48.6 E	P	11.0	150	25.9
35	44 - 04.1 N	157 - 57.7 E	P	11.3	150	58.5
37	45 - 03.6 N	156 - 35.1 E	P	10.1	150	32.8

Block 2

Station	Latitude	Longitude	P/T	SST(°C)	Target depth (m)	Filtered volume (m^3)
38	50 - 56.1 N	165 - 58.3 E	P	9.6	150	25.9
39	50 - 30.8 N	165 - 37.9 E	T	9.5	150	41.5
40	49 - 57.0 N	165 - 19.3 E	P	9.5	150	42.9
41	47 - 56.2 N	164 - 05.6 E	P	9.4	150	35.1
42	46 - 48.0 N	164 - 48.7 E	P	9.6	150	26.3
43	45 - 55.0 N	165 - 23.3 E	P	9.9	150	35.6
44	44 - 56.6 N	165 - 54.8 E	P	10.5	150	30.3
45	44 - 27.4 N	164 - 53.1 E	P	10.9	150	29.7
46	43 - 59.3 N	164 - 06.1 E	P	11.8	150	27.7
47	43 - 27.4 N	165 - 05.0 E	P	12.0	150	24.1
48	43 - 02.3 N	165 - 58.0 E	P	11.6	150	25.6
49	42 - 25.1 N	164 - 57.2 E	P	13.0	150	27.1
50	41 - 58.9 N	164 - 03.9 E	P	13.5	150	21.3
51	41 - 28.4 N	165 - 11.2 E	P	15.6	150	22.9
52	41 - 01.6 N	165 - 59.0 E	P	17.0	150	22.8
53	40 - 25.3 N	164 - 54.1 E	P	15.6	170	49.7
54	39 - 56.6 N	164 - 05.5 E	P	19.0	150	22.3
55	39 - 32.0 N	165 - 02.4 E	P	17.9	150	24.0
56	39 - 00.8 N	166 - 06.8 E	P	19.9	150	46.2
57	38 - 26.7 N	164 - 57.1 E	P	20.6	150	42.0
58	37 - 58.5 N	164 - 05.0 E	P	21.0	150	30.3
60	37 - 25.4 N	165 - 09.2 E	P	22.7	150	25.6
61	36 - 57.1 N	165 - 56.8 E	P	22.6	150	32.7
62	36 - 26.1 N	164 - 57.8 E	P	22.6	150	28.3
63	35 - 55.9 N	164 - 03.7 E	P	24.1	150	25.7
64	35 - 28.4 N	165 - 05.6 E	P	24.2	150	25.2
65	35 - 04.1 N	165 - 59.5 E	P	24.2	150	30.5

Block 3

Station	Latitude	Longitude	P/T	SST(°C)	Target depth (m)	Filtered volume (m^3)
66	35 - 01.0 N	150 - 55.2 E	P	27.2	150	37.3
67	35 - 30.9 N	149 - 54.9 E	P	28.4	150	39.7
68	36 - 04.8 N	149 - 02.6 E	P	27.5	160	21.2
69	36 - 37.0 N	150 - 09.3 E	P	28.4	150	32.2
70	37 - 04.5 N	151 - 03.0 E	P	27.9	150	27.6
71	37 - 34.1 N	149 - 52.2 E	P	26.5	150	26.2
72	37 - 46.6 N	149 - 24.6 E	P	26.7	150	32.7
73	38 - 03.3 N	149 - 04.2 E	P	26.7	150	40.8
74	38 - 29.0 N	149 - 54.9 E	P	24.2	150	30.1
75	38 - 59.1 N	150 - 58.8 E	P	24.1	150	23.7
76	39 - 31.3 N	149 - 52.7 E	P	24.1	150	54.5
77	40 - 57.5 N	150 - 54.7 E	P	19.1	150	45.3
78	40 - 28.2 N	149 - 53.0 E	P	22.2	150	24.3
79	39 - 59.2 N	149 - 06.5 E	P	24.5	150	53.1

*P/T: P=predetermined trawl, T=target trawl

Table 6. Lists of oceanographic observation stations.

Block 1

Station	CTD / XCTD	Latitude	Longitude	Water tempráture (°C)		
				0m	100m	200m
01	CTD	35 - 02.8 N	156 - 06.5 N	20.0	11.5	9.0
02	CTD	35 - 32.8 N	156 - 03.2 N	20.5	14.0	11.7
03	CTD	36 - 04.9 N	157 - 56.6 N	20.2	15.5	13.4
04	CTD	36 - 09.1 N	157 - 42.2 N	20.6	14.7	12.6
05	CTD	36 - 37.1 N	156 - 55.8 N	19.1	12.7	10.5
06	CTD	37 - 05.3 N	156 - 11.2 N	19.4	14.2	11.2
07	CTD	37 - 15.2 N	156 - 32.2 N	19.0	12.3	10.1
08	CTD	37 - 31.2 N	157 - 00.3 N	17.5	11.4	9.2
09	CTD	38 - 01.6 N	157 - 53.3 N	17.4	11.8	9.5
10	CTD	38 - 17.4 N	157 - 28.5 N	17.2	11.9	9.4
11	CTD	38 - 33.3 N	156 - 54.4 N	17.4	11.7	9.8
12	XCTD	38 - 55.6 N	156 - 12.7 N	18.4	13.6	9.4
13	CTD	39 - 01.3 N	156 - 05.1 N	18.7	13.0	9.1
14	XCTD	39 - 07.9 N	156 - 18.2 N	18.5	12.6	8.7
15	CTD	39 - 33.3 N	157 - 05.7 N	18.3	12.4	9.0
17	CTD	40 - 00.6 N	157 - 52.3 N	16.0	9.4	6.1
18	XCTD	40 - 34.9 N	156 - 54.6 N	15.4	6.6	4.6
19	CTD	40 - 43.3 N	156 - 36.2 N	15.0	6.4	5.2
20	CTD	41 - 02.9 N	156 - 04.0 N	14.0	7.2	5.0
25	XCTD	41 - 10.7 N	156 - 21.9 N	14.0	6.8	5.1
26	CTD	41 - 34.2 N	157 - 05.6 N	13.6	7.2	5.8
27	XCTD	41 - 42.8 N	157 - 32.7 N	13.5	6.8	5.7
29	XCTD	41 - 48.9 N	157 - 38.2 N	13.1	6.3	5.8
30	CTD	41 - 54.9 N	157 - 44.9 N	14.0	6.2	5.9
31	CTD	42 - 33.4 N	156 - 54.7 N	13.6	6.2	6.0
32	XCTD	42 - 43.1 N	156 - 31.6 N	13.2	6.3	4.7
33	CTD	43 - 02.9 N	156 - 04.5 N	13.9	4.3	2.4
34	CTD	43 - 26.7 N	156 - 48.9 N	11.1	1.1	2.6
35	XCTD	44 - 04.3 N	157 - 57.7 N	11.7	3.0	2.6
36	XCTD	44 - 04.3 N	157 - 39.3 N	12.2	3.0	2.6
37	CTD	45 - 02.9 N	156 - 35.1 N	10.1	1.3	3.4

Block 2

Station	CTD / XCTD	Latitude	Longitude	Water temprature (°C)		
				0m	100m	200m
38	XCTD	50 - 56.2 N	165 - 58.5 N	9.6	3.1	4.1
39	CTD	50 - 31.3 N	165 - 37.8 N	9.6	-	-
40	CTD	49 - 56.5 N	165 - 19.4 N	9.9	3.1	4.1
41	CTD	47 - 56.1 N	164 - 05.0 N	9.4	2.6	3.0
42	XCTD	46 - 48.1 N	164 - 48.6 N	10.0	3.8	3.1
43	CTD	45 - 55.3 N	165 - 23.0 N	9.9	3.4	3.2
44	CTD	44 - 56.9 N	165 - 54.7 N	10.7	3.4	3.8
45	CTD	44 - 27.3 N	164 - 52.9 N	11.0	3.8	3.9
46	CTD	43 - 59.1 N	164 - 06.1 N	12.0	5.0	4.1
47	CTD	43 - 27.1 N	165 - 04.9 N	12.0	4.3	4.1
48	CTD	43 - 02.0 N	165 - 58.4 N	11.5	4.4	3.8
49	CTD	42 - 25.4 N	164 - 57.0 N	13.1	4.1	3.8
50	CTD	41 - 58.8 N	164 - 04.3 N	13.5	6.1	5.1
51	CTD	41 - 28.3 N	165 - 10.7 N	15.3	7.3	5.5
52	CTD	41 - 01.6 N	165 - 59.0 N	16.7	9.1	7.3
53	CTD	40 - 25.8 N	164 - 54.4 N	15.9	6.3	6.3
54	CTD	39 - 56.9 N	164 - 05.5 N	19.0	6.3	6.3
55	CTD	39 - 31.9 N	165 - 02.6 N	17.8	10.6	7.4
56	XCTD	39 - 00.9 N	166 - 06.5 N	20.0	11.3	8.9
57	CTD	38 - 26.5 N	164 - 57.0 N	20.6	11.3	9.5
58	CTD	37 - 58.2 N	164 - 04.9 N	21.0	11.5	9.3
60	XCTD	37 - 25.4 N	165 - 09.2 N	22.3	14.5	12.9
61	CTD	36 - 57.0 N	165 - 56.4 N	22.8	14.3	12.4
62	CTD	36 - 25.8 N	164 - 57.8 N	22.8	15.6	15.1
63	XCTD	35 - 55.9 N	164 - 03.6 N	24.0	14.4	12.5
64	CTD	35 - 28.1 N	165 - 05.6 N	24.1	15.1	12.9
65	CTD	35 - 03.9 N	165 - 59.2 N	24.2	15.3	14.0

Block 3

Station	CTD / XCTD	Latitude	Longitude	Water temprature (°C)		
				0m	100m	200m
66	CTD	35 - 01.1 N	150 - 55.2 N	27.1	18.5	14.9
67	CTD	35 - 31.2 N	149 - 54.5 N	28.4	20.2	18.4
68	CTD	36 - 04.1 N	149 - 02.3 N	28.0	14.6	10.6
69	CTD	36 - 36.2 N	150 - 08.3 N	28.3	19.5	17.6
70	CTD	37 - 03.6 N	151 - 00.5 N	28.0	17.4	13.2
71	CTD	37 - 33.9 N	149 - 52.2 N	26.6	12.9	8.9
72	CTD	37 - 46.5 N	149 - 24.6 N	26.9	14.6	10.5
73	CTD	38 - 02.9 N	149 - 04.2 N	27.0	15.8	11.3
74	CTD	38 - 28.9 N	149 - 55.1 N	24.1	10.9	7.7
75	CTD	38 - 59.1 N	150 - 59.1 N	24.1	12.8	8.9
76	XCTD	39 - 31.1 N	149 - 52.6 N	24.0	15.1	10.6
77	CTD	40 - 57.9 N	150 - 55.1 N	19.0	2.1	4.4
78	CTD	40 - 28.4 N	149 - 53.1 N	21.1	3.2	3.1
79	CTD	39 - 59.4 N	149 - 06.7 N	24.7	15.8	12.1
79	XCTD	39 - 59.6 N	149 - 07.1 N	24.7	15.6	12.0

Table 7 Summary of cetacean sightings.

Species	Block 1				Block 2				Block 3			
	Primary		Secondary		Primary		Secondary		Primary		Secondary	
	Sch.	Ind.	Sch.	Ind.	Sch.	Ind.	Sch.	Ind.	Sch.	Ind.	Sch.	Ind.
Bryde's whale	2	2	-	-	12	20	2	2	28	47	3	5
Sei whale	37	81	1	2	17	23	-	-	1	1	-	-
Fin whale	5	5	-	-	-	-	-	-	-	-	-	-
Blue whale	2	3	-	-	-	-	-	-	-	-	-	-
Sperm whale	36	60	-	-	22	25	1	1	1	1	-	-
Like minke	2	2	1	1	1	1	1	1			-	-
Unidentified large whale	35	52	7	12	24	26	2	2	8	8	8	9

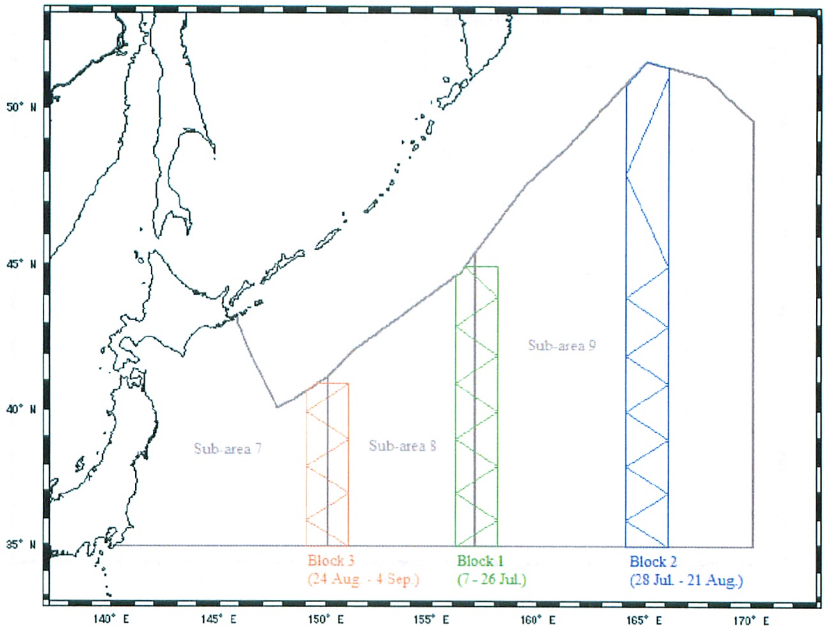

Fig. 1. Surveyed area and the planned tracklines. Gray thick line represented the entire JARPNII survey area and boundaries of Sub-areas.

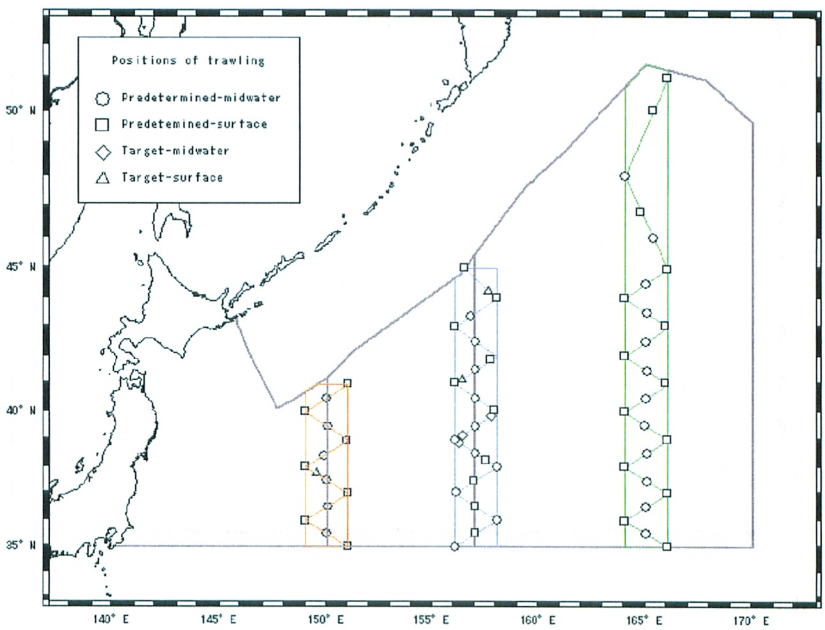

Fig. 2. Positions of trawling stations.

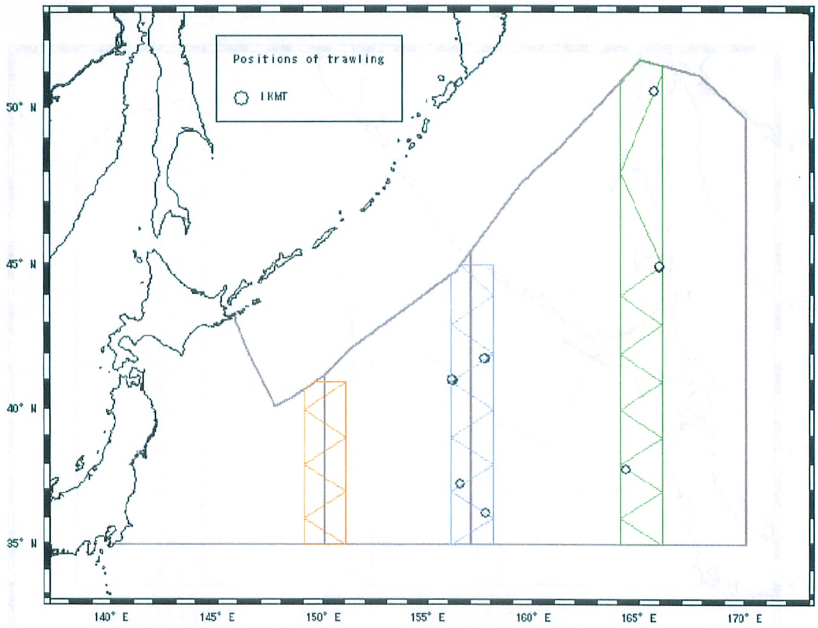

Fig. 3. Positions of IKMT trawling.

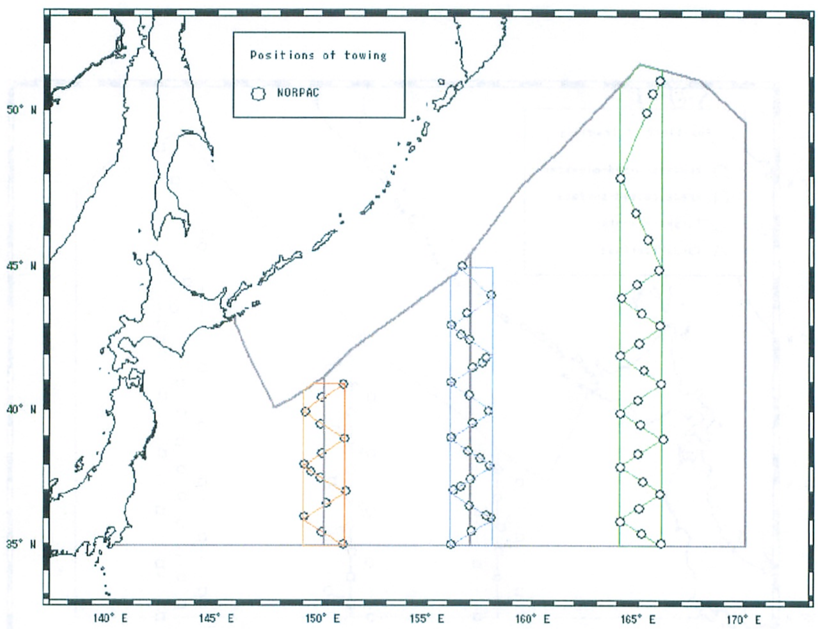

Fig. 4. Positions of NORPAC towing.

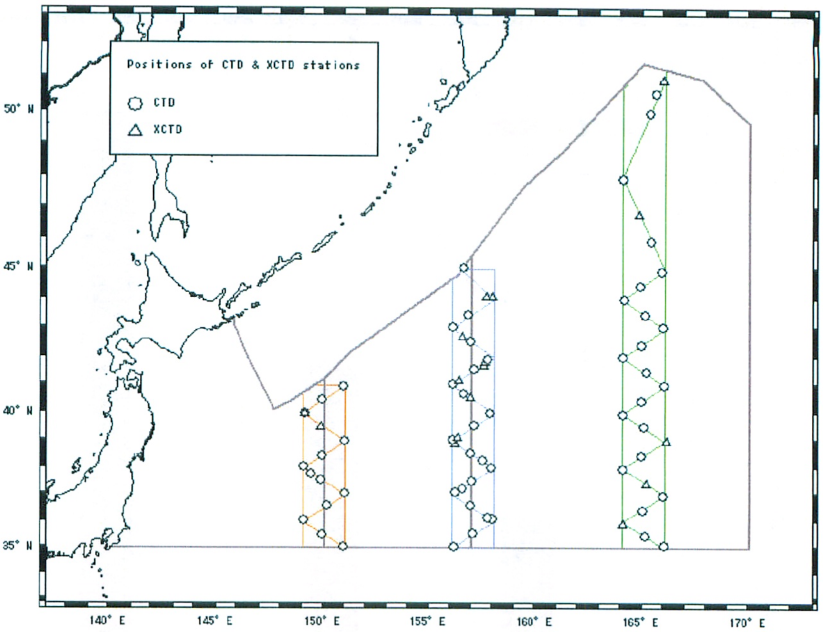

Fig. 5. Positions of CTD and XCTD stations.

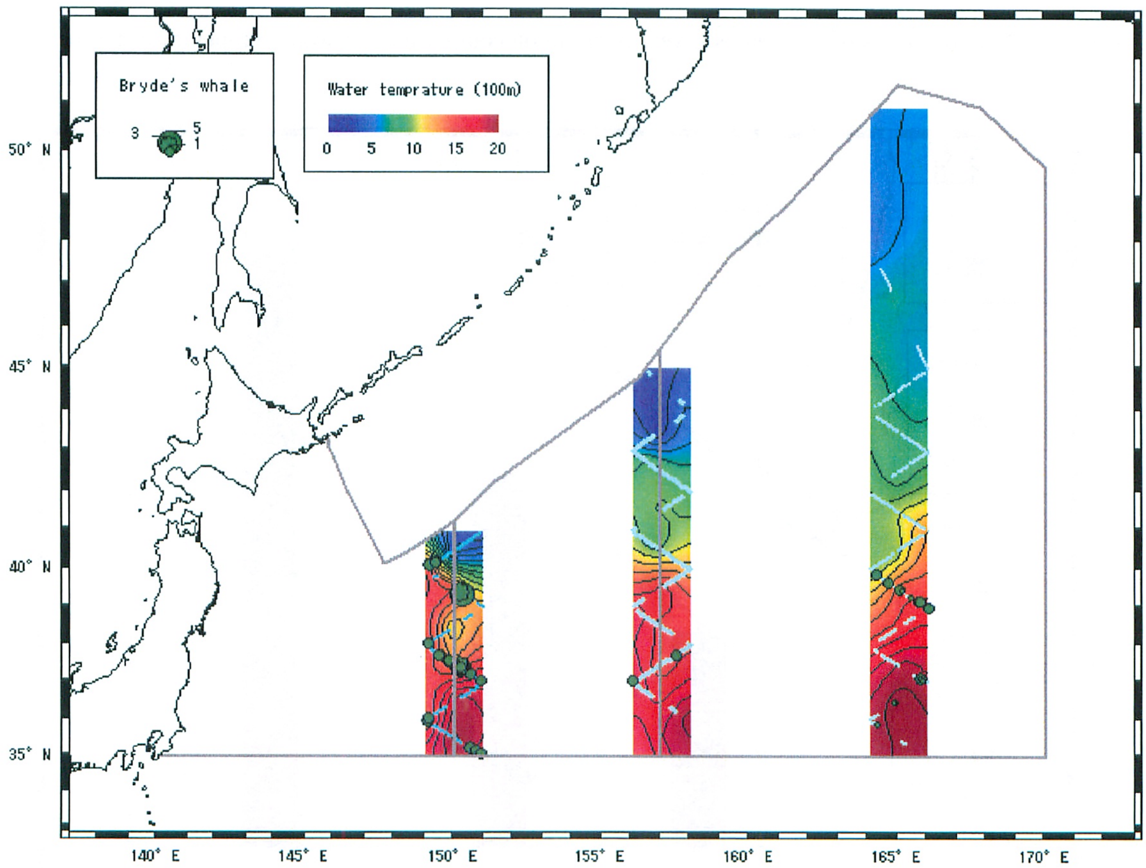

Fig.6. Primary sighing positions of Bryde's whales were overlaid on counter map of water temperature at 100m.

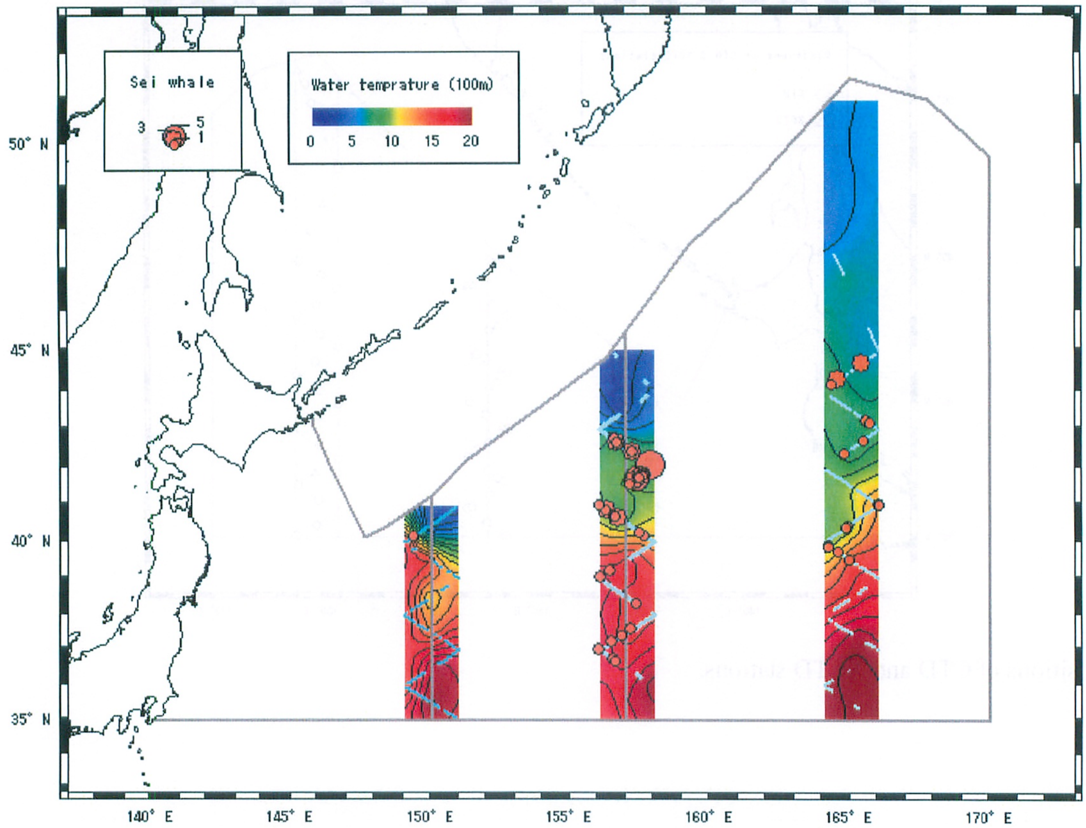

Fig. 7. Primary sighing positions of sei whales s were overlaid on counter map of water temperature at 100m.

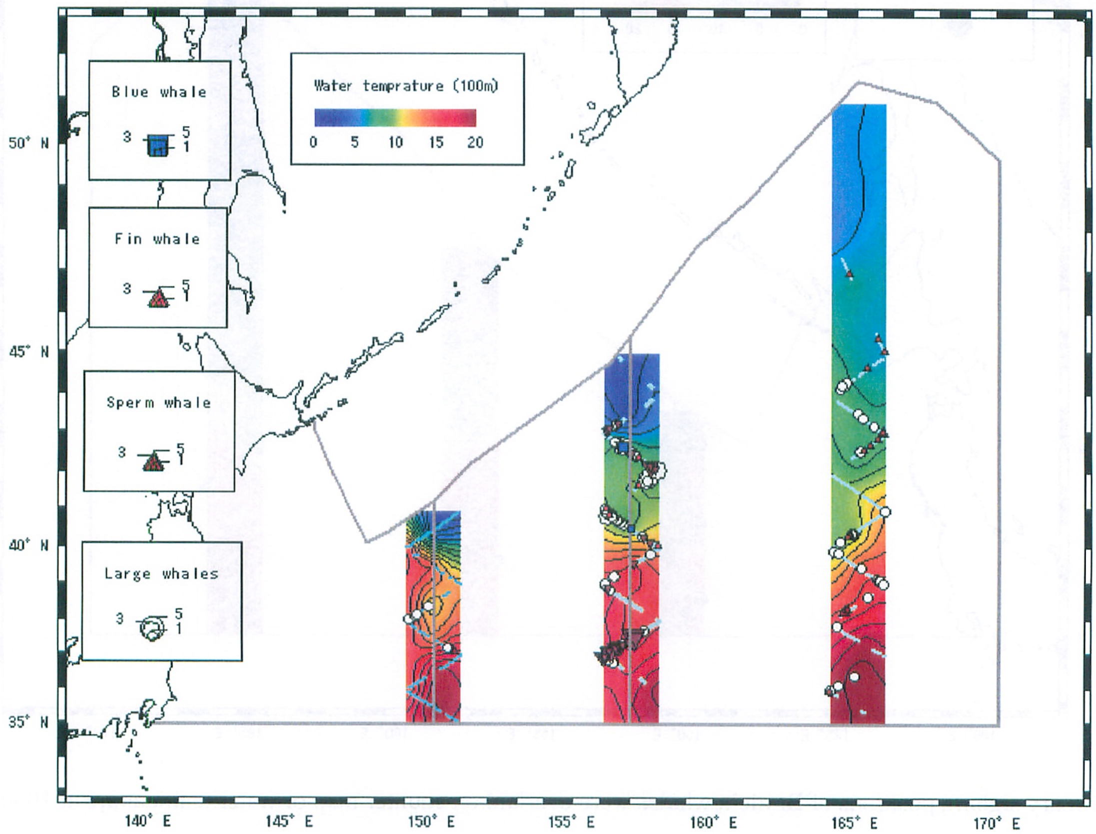

Fig.8. Primary sighing positions of blue, fin, sperm and unidentified large whales s were overlaid on counter map of water temperature at 100m.

Appendix B

Oceanographic conditions in the survey area of offshore compoent of JARPN II in the western North Pacific from July to September 2007

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ABSTRACT

A prey species survey was conducted in July-September 2007 using *Kaiko-Maru* as a part of offshore component of JARPN II. The survey covered from subarctic area to the adjacent area of the subtropical area around 150° E, 157° E and 165° E 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, as the water mass was characterized by the subarctic water, subtropical water and mixed water.

Introduction

A prey species survey was conducted in the offshore three blocks (around 150° E, 157° E and 165° E) of the western North Pacific in July-September 2007 using *Kaiko-Maru* in cooperation with the sampling survey by *Nisshin-Maru* (Fig. 1). 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; SBE 19) and expendable CTDs were carried out from July 7 to September 4 in the Kuroshio-Oyashio Inter-frontal Zone using *Kaiko-Maru*. Salinity correction for CTD data was not done using water sampling data.

Oceanic fronts and water masses are usually detected by subsurface temperature map, because they are obscure in sea surface temperature distributions from summer to fall seasons and the Oyashio water spreads into the subsurface layer (Table 1). 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 defied by temperature more than 10° C at the depth of 100 m. The first and the second Oyashio Intrusions are defined by temperature lass than 5° C at the depth of 100 m (Murakami, 1994). Subarctic front and the Subarctic Boundary is defined by 4° C temperature front and 34.0psu salinity front, respectively (Favorite *et al.* 1976). We use these indices to know the distribution of water mass in the survey area.

Oceanographic conditions in the survey area

The upper panel in Fig. 2 shows the Temperature-Salinity diagrams in the western block. There is typical Kuroshio water characterized by high salinity profile around 34.5 psu, especially in warm upper layer (over 10 ° C). Oyashio water characterized by cold profile less than 5 ° C 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 temperature and salinity maps at the depth of 100 m and 200 m. The cold water less than 5° C at 100 m depth was distributed in a northern part of the survey area. The Subarctic Front (defined by 4° C isotherm) was observed from 41° N, 150° E to 44° -30' N, 165° E in Fig. 3 (left upper panel). In 100 m and 200 m salinity maps (lower panels of Fig. 3), a salinity front around 34.0 psu is shown along 40° N line in the middle part of the survey area. The warmest temperature at the 200 m depth is observed at southwestern part of this area, and 14° C isotherm, which is an index of the Kuroshio Extension, is observed only this area.

Figure 4 shows the vertical sections of temperature, salinity and density anomaly along the cruise track of *Kaiko-Maru* between 156° E-158° E, which is a zigzag line. The Subarctic Water colder than 4° C is observed in the northern area, north of 43° N, and 4° C isotherm lies vertically from 50 m depth to 300 m depth around 43° N. It indicates that there is the subarctic front around 43° 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 high-salinity water greater than 34 psu, which is the index of the subarctic boundary, is shown at a surface layer in the southern area, south of 40° N. Around 40° N in this section, isotherms between 5° C and 10° C lie vertically and show an existence of a temperature front. At the southern part of this section, bowl shape isotherms and isohalines were observed around 36° N with subsurface mixed layer, which suggests that there is the Kuroshio warm-core ring. The Kuroshio Extension is not appeared in this section.

Figure 5 shows temperature, salinity and density anomaly sections between 164° E-166° E. The Subarctic Water is observed in the northern area, north of 41° 30'N where is 4° C isotherm (index of the subarctic front) running vertically from 200 m to 500 m depth. The high-salinity water greater than 34 psu (index of the subarctic boundary) is shown at a surface layer in the southern area, south of 39° 30'N. At the southern part of this section, bowl shape isotherms and isohalines were observed around 36° N with subsurface mixed layer similar with Fig. 4, which also suggests that there is the Kuroshio warm-core ring. Because isotherms around 35° N are running vertically and 14° C isotherm cross near the depth of 200 m, the Kuroshio Extension is nearby 35° N in this section.

Figure 6 shows temperature, salinity and density anomaly sections between 149° E-151° E. The Subarctic Water (colder than 4° C) and 4° C isotherm (index of the subarctic front) is observed around 40° 30'N. The salinity front around 34 psu (index of the subarctic boundary) is also shown around 40° 30'N nearby the subarctic front. At the southern part of this section, bowl shape isotherms and isohalines were observed around 36° 30'N with subsurface mixed layer, which also suggests that there is the Kuroshio warm-core ring as Fig. 4 and 5. As there is high-salinity water over 34.8 psu is observed around 35° 30'N, isotherms around 35° 45'N are running vertically and 14° C isotherm cross at the depth of 200 m around 35° 45'N, the Kuroshio Extension flows at 35° 45'N in this section.

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

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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. 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℃

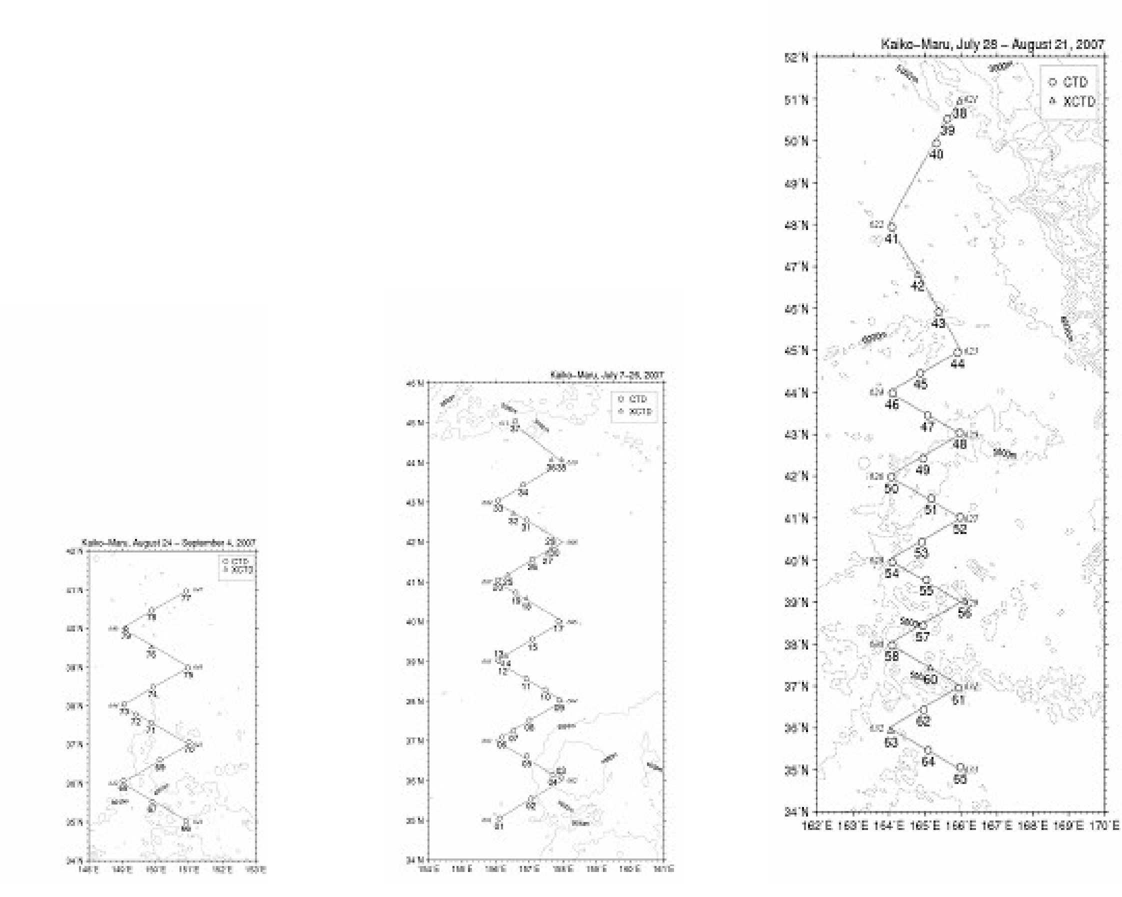

Fig. 1. Station map observed by *Kaiko-Maru* in July 7 to 26 (Leg 1: middle panel), July 28 to August 21 (Leg 2: right panel) and August 24 to September 4 (Leg 3: left panel), 2007.

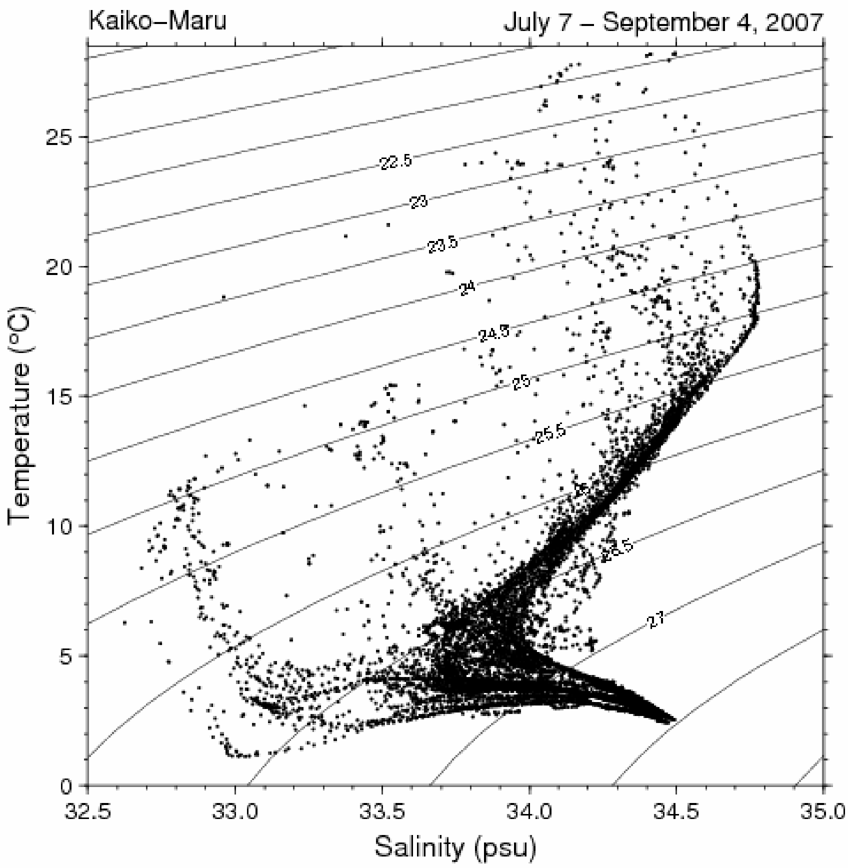

Fig. 2. Temperature-Salinity diagrams using CTD station data observed by *Kaiko-Maru* in July 7 to September 4, 2007. Each thin line in this figure denotes a density line of sigma-t.

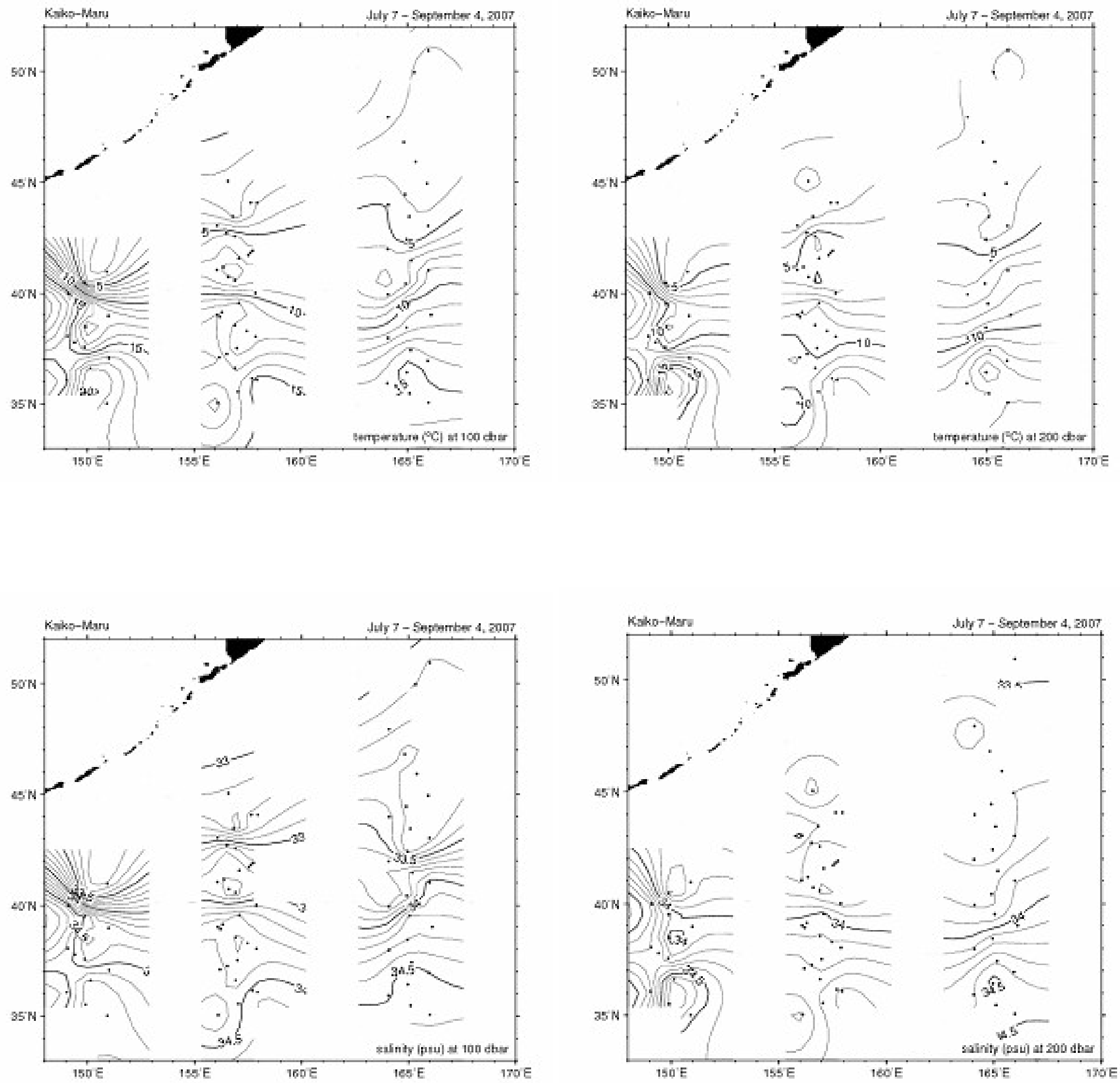

Fig. 3. Temperature (upper panels) and salinity (lower panels) maps at the depth of 100 m (left panels) and 200 m (right panels) observed by *Kaiko-Maru* in July 7 to September 4, 2007.

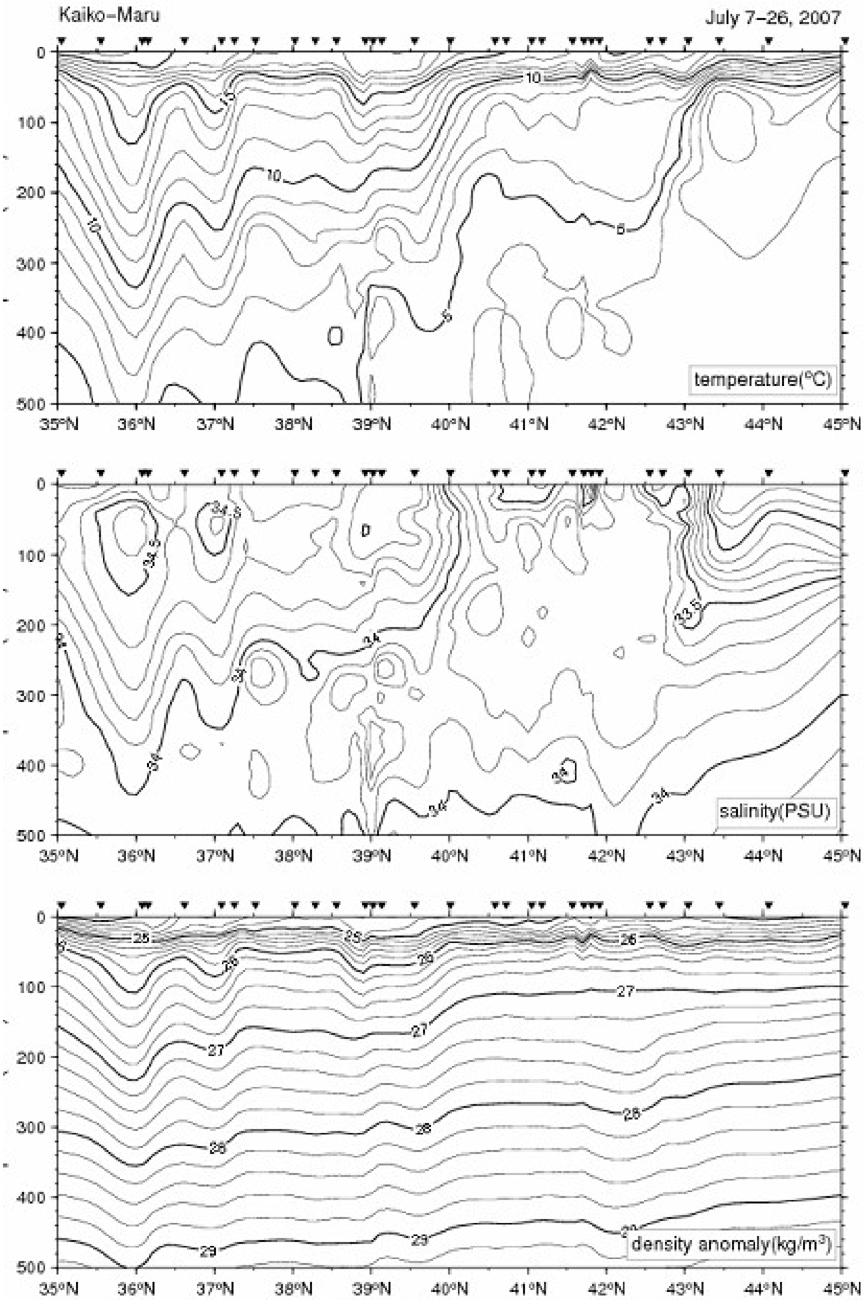

Fig. 4. Vertical sections of temperature (upper panel), salinity (middle panel) and density anomaly (lower panel) observed by *Kaiko-Maru* in July 7 to 26 along the cruise track of Leg 1 (middle part of *Kaiko-Maru* survey area).

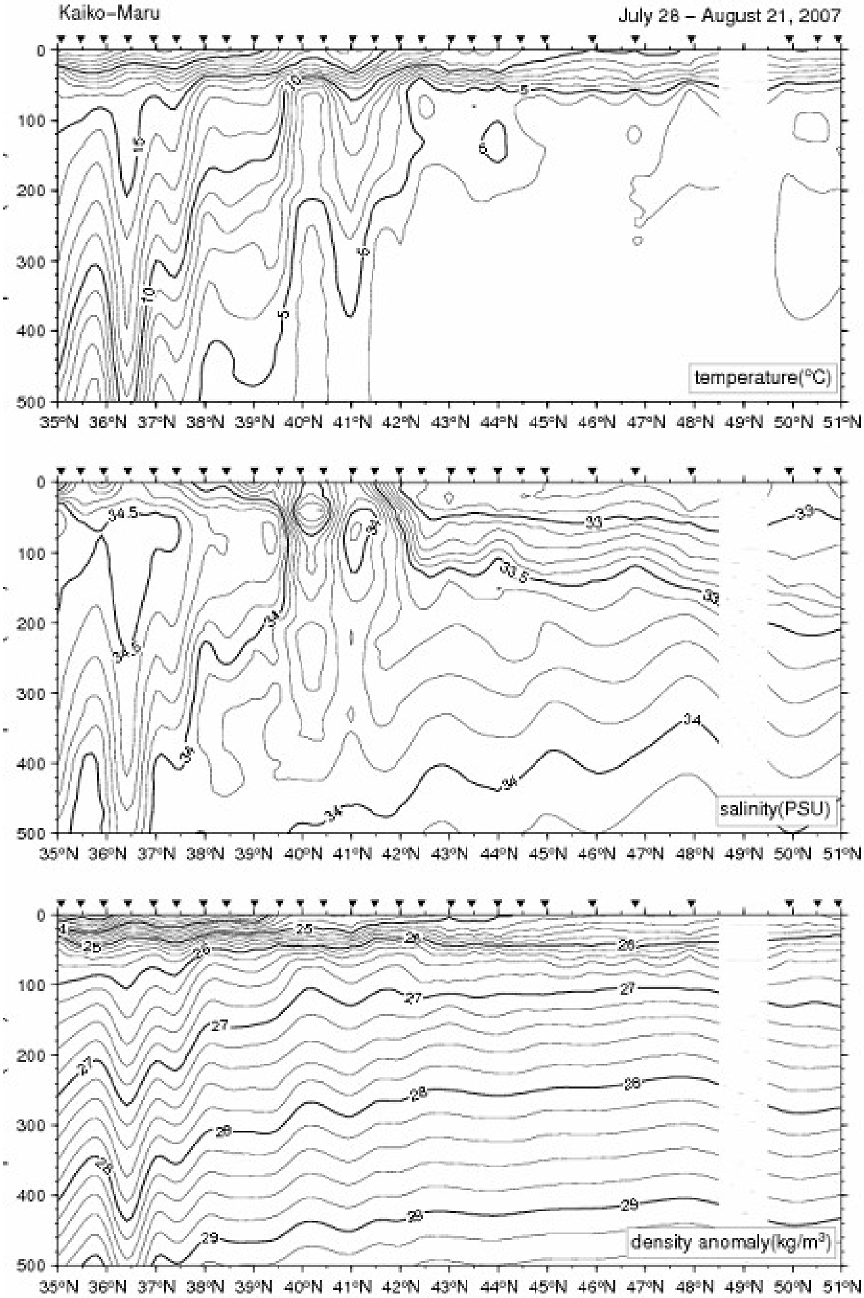

Fig. 5. Vertical sections of temperature (upper panel), salinity (middle panel) and density anomaly (lower panel) observed by *Kaiko-Maru* in July 28 to August 21 along the cruise track of Leg 2 (western part of *Kaiko-Maru* survey area).

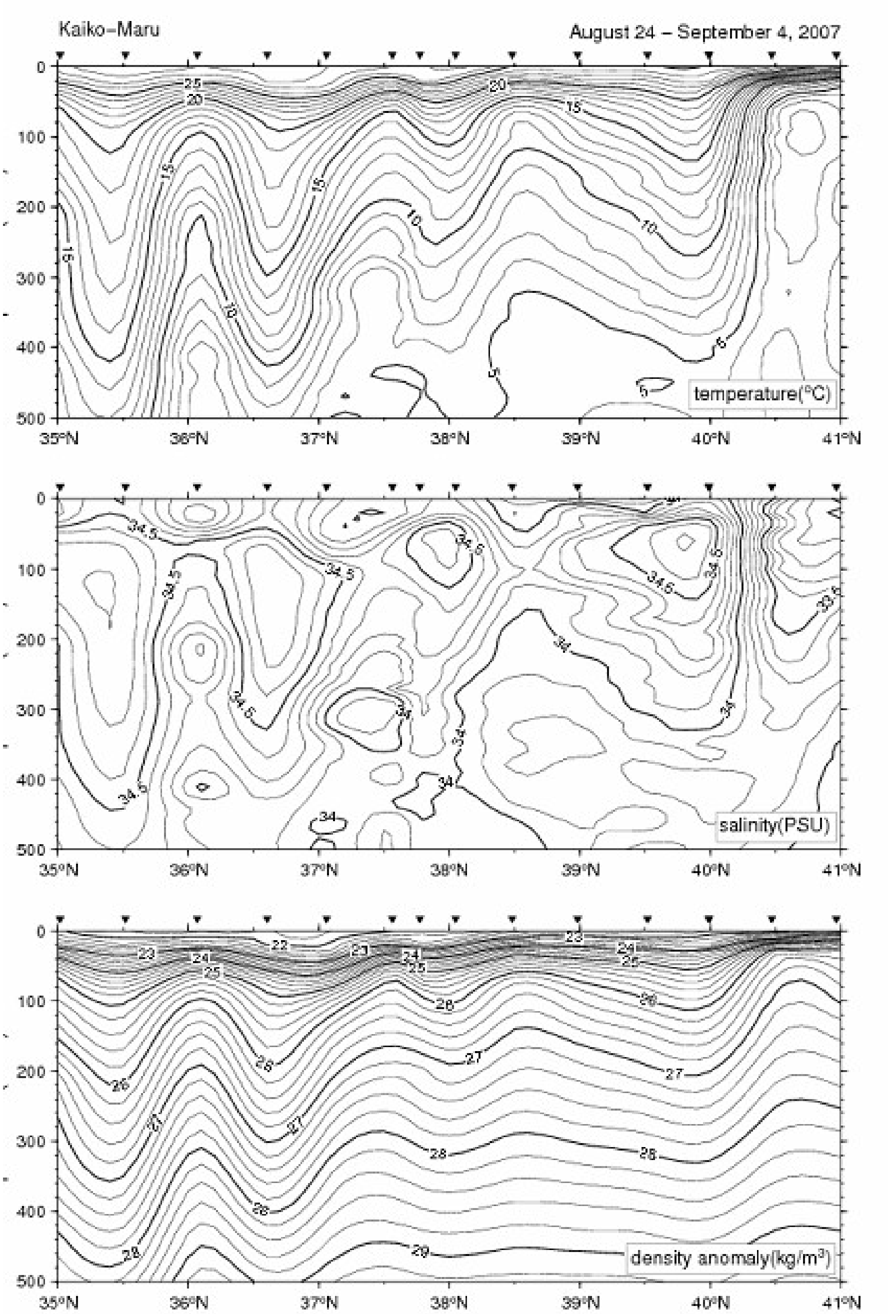

Fig. 6. Vertical sections of temperature (upper panel), salinity (middle panel) and density anomaly (lower panel) observed by *Kaiko-Maru* in July 28 to August 21 along the cruise track of Leg 2 (western part of *Kaiko-Maru* survey area).