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 –

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ABSTRACT

The fourth 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 16 May to 16 August 2005 in sub-areas 7, 8 and 9 of the western North Pacific. The objectives of the full-scale research 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 are common minke whale *Balaenoptera acutorostrata*, Bryde's whale *B. edeni*, sei whale *B. borealis* and sperm whale *Physeter macrocephalus*. A total of six research vessels were used: one trawl survey vessel equipped with scientific echo sounder (TSV), one dedicated sighting vessel (SV), three sighting/sampling vessels (SSVs) and one research base vessel. A total of 12.697.4 n.miles was surveyed in a period of 91 days. During that period 114 common minke, 110 Bryde's, 503 sei and 337 sperm whales were sighted by the SSVs. A total of 100 common minke, 100 sei, 50 Bryde's and 5 sperm whales was sampled by the SSVs. The cooperative prey and whale surveys were conducted with the participation of the six vessels in a part of sub-area 7 and 9 from 8 to 15 July, and from 25 July to 4 August. All whales sampled were examined on board the research base vessel. Previous surveys in this research area showed that common minke whales fed mainly on Pacific saury (*Cololabis saira*), minimal armhook squid (*Berryteuthis anonychus*) and Japanese anchovy (*Engraulis japonicus*). During early seasons (May - June), Japanese anchovy was the dominat as prey species. However, results of the present survey suggested that they fed mainly on krill. Japanese anchovy was replaced by other prey species in this year. As in previous surveys, Bryde's whales fed mainly on Krill and Japanese anchovy. Sei whales fed mainly on copepods, krill and Pacific saury. Dominant prey in the stomach of five sperm whales were various kinds of squids, which inhabit the mid- and deep-waters. The proportion of Japanese anchovy as a prey species for baleen whales was lower in this year than that in previous years. Based on this, it seems that the availability of Japanese anchovy may have been lower than other years due to changes in whale migration timing and/or decrease of the resource. It might be possible in the future that the Japanese anchovy will be replaced by other fishes as a major prey item.

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 meeting to review the survey results and data availability was held on February 2000. In that meeting, participants agreed that no sub-stock scenario existed within the O stock (Government of Japan, 1994) for common minke whale *Balaenoptera acutorostrata* 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. One of the major objectives of this research is 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 *Cololabis saira*, Japanese anchovy *Engraulis japonicus*. Japanese common 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 minke whale, Bryde's whale *Balaenoptera edeni* and sperm whale *Physeter macrocephalus* was conducted in the feasibility research program.

Based on the success of the feasibility study (Government of Japan, 2002) 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 whale, 50 Bryde's whale and 10 sperm whale as in the JARPN II feasibility study is continued in the full research program with the addition of 50 sei whales *Balaenoptera borealis* 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 common 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 whale and ii) the results of new calculations of required sample size for the sei whale 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 *Balaenoptera acutorostrata* (100 were to be sampled by the offshore survey and 60 - by the coastal survey); 100 sei whales *B. borealis* (offshore survey), 50 Bryde's whales *B. edeni* (offshore survey) and 10 sperm whales *Physeter macrocephalus* (offshore survey) (Government of Japan, 2004a, 2004b).

In this paper, we present an outline of the fourth full-scale survey of the JARPN II -offshore component-, which was conducted from 16 May to 16 August 2005.

MATERIALS AND METHODS

Research area

Sub-areas 7, 8 and 9, excluding the EEZ zones of foreign countries, 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 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 cooperative survey, two special blocks were predetermined in the survey areas. Two special blocks (SBs) were set in the offshore area as shown in Fig. 4. We conducted the whale and prey surveys in the SBs concurrently.

Research vessels
Six research vessels were used.

The research base vessel *Nisshin Maru* (NM: 7,659GT) 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 *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 K01)

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 (Table 1):

First period: Between 16 May and 7 July.

Second period: Between 15 and 24 July.

Third period: Between 5 and 16 August.

Dedicated Sighting survey (Table 1)
Vessels: One research vessel (KS2)

Research area: Sub-areas 7, 8 and 9

Research period:

Entire period: Between 15 May and 24 August.

Cooperative survey on the prey species and whale sampling (Table 1)
Vessels: Five research vessels (NM, YS1, YS2, K01 and SYO)

Research area: Two special blocks (A and B) were settled.

Reseach period:

First period (A): Between 8 and 15 July for the A (offshore-A block).

Second period (B): Between 25 July and 4 August for the B (offshore-B block).

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). 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 prey survey vessel in the cooperative survey was determined in the following manner. The zigzag-shaped track line was set independent of whale survey. If the SYO detected the existence of the prey species by response of echo sounder, the SYO conducted the trawl survey and/or MOCNESS survey for the target depth to identify these prey species, at the same time.

Apart from these sampling activities, an independent track line for dedicated sighting survey was determined in the research area. The track lines were determined randomly.

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). 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 mainly. 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 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 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

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.

Prey species survey

Detailed report on this activity is shown in Appendix I.

A quantitative echo sounder (Simrad EK60 with program version 1.4.3.64) was used on board SYO to acquire acoustic data with operating frequency at 38, 70 and 120 kHz. Those data were collected as the reference information for qualitative analysis. Calibrations were carried out in Sendai Bay in July 25 using the copper sphere technique described in EK 60 online help manual.

The mid-water 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. Surface and mid-water trawl was towed at acoustic identified stations. Trawls were conducted for 0.5 hour to identify the species compositions of biological backscattering detected by the quantitative echo sounder. Routine trawls were conducted at predetermined stations in each block in daytime and nighttime. The purpose of the routine trawls was to estimate the abundance and distribution patterns of cephalopods and neustonic organisms such as Pacific saury (*Cololabis saira*) that are difficult to detect by the echo sounder. Three different depth layers were sampled at routine trawl stations; 0-30m (surface) 30-60m and 60-90m (mid-water). Nighttime routine trawls were conducted twice to examine day-night difference of prey species composition. 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 and weight of 100 individuals were measured to examine their size composition. A part of samples were frozen at –30°C for further analysis in the laboratory.

MOCNESS was used to collect zooplankton such as copepods and krill. This net with a mouth opening of ca. 1 m^2 with a 0.33 x 0.33 mm mesh can take some samples in each depth layer and estimate the quantitative value. Eight different depth layer were sampled at routine trawl stations; 0-20m, 20-40m, 40-60m, 60-80m, 80-100m, 100-150m, 150-200m and 200-250m.

Experiments
The following experiments and observations were conducted on board the sighting/sampling vessels:

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 data logger to Minke, 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).
6. Oceanographic observations using EPCS (Electric particle counting and sizing system) (YS2).

On board the SV, 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).

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

1. Estimate abundance of prey species of common minke and other large whale species using an echo sounder system.
2. Oceanographic observations using CTD.

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 three sighting/sampling vessels (SSVs) is shown in Figs 2 and 3. The total searching distance for SSVs was 12,697.4 n.miles (Table 2).

In the cooperative surveys on ecosystem research, the surveys were conducted from 8 to 15 July and from 25 July to 4 August, respectively. Under the cooperative survey, searching distance for SSVs were 490.4 n.miles and 1,081.5 n.miles, respectively (Fig. 4, Table 2).

Track line covered by the dedicated sighting vessel (SV) is shown in Fig 5. The total searching distance was 5,078.7 n.miles (Table 2).

Sightings of common minke, Bryde's, sei and sperm whales
Sighting and sampling vessels (SSVs)

A total of 113 schools (114 individuals) of common minke whales were sighted, consisting of 73 schools (73 individuals) of primary and 40 schools (41 individuals) of secondary sightings. For sei whale, 311 schools (503 individuals) were sighted, consisting of 208 schools (339 individuals) of primary sightings and 103 schools (164 individuals) of secondary sightings. For Bryde's whale, 83 schools (110 individuals) were sighted, consisting of 57 schools (78 individuals) of primary sightings and 26 schools (32 individuals) of secondary sightings. For sperm whale, 186 schools (337 individuals) were observed, consisting of 151 schools (225 individuals) of primary sightings and 35 schools (112 individuals) of secondary sightings (Table 3).

Fig 6 shows the distribution of common minke whales sighted by the SSVs in the sub-areas 7, 8 and 9. Figs.7 and 8 show the distribution of Bryde's and sei whales. Common minke whales were sighted in northern part of sub area 7, entire part of sub-areas 8 and 9. But, Bryde's whales were sighted mainly in southern part of sub-areas 7, 8 and 9. Sei whales were sighted mainly in offshore of sub-areas 8 and 9. In the sub-areas 8 and 9, some segregation was observed between sei and Bryde's whales. Fig. 9 shows the distribution of sperm whale sightings in sub-areas 8 and 9. Sperm whales were widely distributed in sub-areas 7, 8 and 9.

Dedicated sighting vessel (SV)
During the research cruise, 20 schools (21 individuals) of common minke whales were sighted, consisting of 14 schools (15 individuals) of primary sightings and 6 schools (6 individuals) of secondary sightings. For sei whale, 181 schools (360 individuals) were sighted, consisting of 177 schools (339 individuals) of primary sightings and 4 schools (21 individuals) of secondary sightings. For Bryde's whale, 12 schools (15 individuals) were sighted, consisting of 12 schools (15 individuals) of primary sightings. For sperm whale, 79 schools (210 individuals) were sighted, consisting of 68 schools (198 individuals) of primary sightings and 11 schools (12 individuals) of secondary sightings (Fig. 14, Table 4).

Sightings of other large cetacean species
Sighting and sampling vessels (SSVs)

Table 3 also shows the number of sightings for other large whale species made by the SSVs, including large baleen whales such as blue (24 schs./28 inds.), fin (90 schs./136 inds.), humpback whales (32 schs./47 inds.) and right whale (1 sch./2 inds.) (Figs. 10, 11, 12 and 13).

Dedicated sighting vessel (SV)
Large baleen whales such as blue (15 schs. /18 inds.), fin (32 schs. /60 inds.) and humpback whales (19 schs. /43 inds.) were found in the sub-areas 7, 8 and 9 (Figs. 15 and 16, Table 4).

Sampling of common minke, Bryde's, sei and sperm whales
This survey covered spatial and temporal gaps for studies on feeding ecology and stock structure. Table 5 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, 85 during the whale survey component and 15 during the cooperative survey component. A total of 100 sei whales (Male: 51 individuals, Female: 49 individuals) were sampled, 78 during the whale survey component and 22 during the cooperative survey component. A total of 50 Bryde's whales (Male: 21 individuals, Female: 29 individuals) were sampled, 14 during the whale survey component and 36 during the cooperative survey component. A total of three male and two female sperm whales were sampled during the whale survey component.

Geographical distribution of common minke, Bryde's and sei whale samples are also shown in Figs 6 - 8 based on the sighting positions. Fig. 7 shows the distribution of sperm whale samples based on the sighting positions. One minke whale was struck but lost due to technical failure.

Biological research for common minke, Bryde's and sei whales
Table 6 summarizes the biological data and samples collected from whale sampled such as the common minke, Bryde's, sei and sperm whales sampled. A total of 55 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, Bryde's, and sei whales is shown in Tables 7, 8 and 9. 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 common minke whales are shown in Table 10. Mean body length of common minke whales is 7.23 m and 6.79 m for males and females, respectively. For Bryde's whales, the statistics of body length are shown in Table 11. Mean body length of Bryde's whales is 11.44 m and 11.93 m for males and females, respectively. For sei whales, the statistics of body length are shown in Table 12. Mean body length of sei whales is 13.53 m and 14.06 m for males and females, respectively. For sperm whale, the statistics of body length are shown in Table 13. Mean body length of sperm whales is 10.12 m and 9.09 m for males and females, respectively.

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 krill, Japanese anchovy, and minimal armhook squid. 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 13). Bryde's whales were distributed in the southern part of research area during research periods. They fed mainly on krill and Japanese anchovy (Table 13). Sei whales were distributed widely in the research area. From May to August, they fed mainly on copepods 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 13). Sperm whales were distributed widely in the research area. They fed mainly on deep sea squids in offshore area (sub area 7, 8 and 9).

In this research, there were differences of prey species among three baleen whale species. Especially, in May and June, common minke whale usually fed mainly on Japanese anchovy. However, they fed mainly on zooplanktons such as krill and copepods in this year. Sei whales did not feed on Japanese anchovy during this research season. Bryde's whale fed on krill and Japanese anchovy, the proportion of Japanese anchovy was lower than that in other research years (Figs. 17-a, b, c).

The length composition of Japanese anchovy and Pacific saury in the stomach of each whale
Japanese anchovy

Even though, three whale species fed on Japanese anchovy, the sizes of the fish were different. The body length of Japanese anchovy in the stomachs of common minke whale, Bryde's whale, sei whale, were from 68 to 137 mm, from 29 to 146 mm, and from 37 to 50 mm, respectively (Fig. 18).

Pacific saury

Common minke whale and sei whale fed on Pacific saury, and the sizes of the fish were different. The body length of Pacific saury in the stomachs of common minke whale and sei whale, were from 219 to 336 mm, and from 100 to 345 mm, respectively (Fig. 19).

Condition of concurrent survey

In this season, the cooperative surveys were conducted in two survey blocks. The survey areas were set in the offshore areas (Fig. 1). During the survey period, a total of 22 sei whale samples, 36 Bryde's whales and 15 common minke whales were collected by the SSVs. Information on the prey species distribution was also collected by SYO during these periods (See Appendix 1).

Experiments, prey surveys and oceanographic surveys

Biopsy sampling trial

Table 14 shows the results of biopsy skin sampling for right whales. A total of 2 right whales were targeted for biopsy sampling by the SVs and SSVs. As a result, two right whale's biopsy skin samples were collected.

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

Table 15 shows the result of the photo-ID experiments on right whales. A total of two right whales were targeted by the SVs and SSVs. These trials were conducted for right whales.

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. However, we did not have a chance to record the feeding behaviour of large baleen whales in this year.

Prey species survey

Echo sounder survey was conducted on SYO and they operated to cover the planned track lines. Surface routine trawls were towed at 28 stations. MOCNESS was towed at 10 stations. The details of the prey species survey conducted by SYO are described in Appendix 1.

CTD

CTD casts were made at 59 stations by KS2. CTD (Model SBE 19) casts were conducted down to 500m at each station to collect the temperature and salinity profiles in the study area by KS2. CTD casts were made at some stations by SYO. In the SYO, CTD (Model SBE 9, Seabird Co.) casts were conducted down to 500m at each sampling station to measure the temperature and salinity profiles in the study area by SYO. The details of the oceanographic observations are reported in Appendix 2 of this document.

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 5 sperm whales was 265 tons, 1,259 tons, 367 tons and 14 tons, respectively.

Participation by foreign scientists
In 2005 JARPNII, two foreign scientists participated. They joined our sighting and sampling survey on board. It is expected that these international collaboration will continue in future.

DISCUSSIONS

This forth 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
Minke whale

Common minke whales were sighted in the northern part of sub area 7 and the entire part of sub-areas 8 and 9. They were not found in the centre and southern parts of sub area 7, because our research activity was conducted 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 an indirect confirmation of the hypothesis that in summer season almost all females are feeding in the Okhotsk Sea. In resent years, during early seasons (May - June), Japanese anchovy was the dominat prey species (Tamura and Fujise, 2002). However, they fed mainly on krill this year. It seems likely that the Japanese anchovy will be replaced by other prey in this year. During late season (July – August), Pacific saury was the dominat prey species (Tamura and Fujise, 2002). This is consistent with the results of previous years. We confirmed that Pacific saury was the most important prey species for common minke whales in the research area.

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. Omura and Nemoto (1959) reported that Bryde's whales were distributed south of 40 ^{o}N within higher surface water temperatures (over 20 ^{o}C). Nemoto (1959) stated that they 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. 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 dominat prey species. And, during late season (July – August), Japanese anchovy was the dominat prey species (Tamura and Fujise, 2002). However, the proportion of Japanese anchovy was lower than the previous years. It seems that the abundance of Japanese anchovy was lower than other years due to change of their migration timing and/or decrease of their resources.

Sei whale

Sei whales were sighted mainly in the southern part of 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 were few, because we could not conduct the research activity due to bad weather such as high density fog. In resent years, during all seasons (May - September), Copepods and Japanese anchovy were the dominat prey species. And, during late season (July – August), Japanese anchovy was the dominat prey species (Tamura and Fujise, 2002). However, the proportion of Japanese anchovy was

lower than the previous years. It seems that the abundance of Japanese anchovy was lower than other years due to change of their migration timing and/or decrease of their resources.

The length composition of Japanese anchovy and Pacific saury in the stomach of each whale
Japanese anchovy

The common minke whales fed mainly on mature Japanese anchovy, on the other hand, Bryde's whales and sei whales fed mainly on pre-mature Japanese anchovy. This size difference probably reflects the distribution of Japanese anchovy in the area (Murase et al, 2002). It seems that there is size selectivity of prey among whales. This data may be useful for development of ecosystem models for the western North Pacific.

Pacific saury

Prey size differences probably reflects the distribution of Pacific saury in the area. It seems that there is size selectivity of prey between common minke whales and sei whales. Our results will useful in assessing their feeding impact on Pacific saury resources and the level of inter-specific competition among other baleen whales. The data will also be useful for developing ecosystem models for the western North Pacific. This size differences probably reflects the distribution of Pacific saury in the area. It seems that there is size selectivity of prey between common minke whales and sei whales.

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 dominat. 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 used to build ecosystem models.

Response to the discussion in the IWC/SC meeting

The revised JARPN II research plan was presented in the 56th IWC/SC annual meeting (Government of Japan, 2004a). Although, discussions were made at those meetings, there remained divided views in the Committee members (IWC, 2005, 2006). Thus, the 2005 surveys were conducted following the original plan and almost same methodology in the 2004 revised JARPN II research plan.

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Table 1. Outline of 2005 JARPN II survey

・Whale sampling survey

Research	Sub-area	Research periods	Days	Research ships and remark
Sighting survey	**9**	May 16-17	(2)	**YS2**
Whale survey (First period)	**7, 8, 9**	**May 18-July 7**	**51**	**NM, YS1, YS2 and K01**
	8	May 18-24	6.5	
	9	24-May	0.5	
	8	May 25-26	2	
	9	May 27-June 19	24	
	8	June 20-24	5	
	7	June 25-July 7	13	
Cooperative survey (SB-A)	**7**	**July 8-15**	**7.5**	**NM, YS1, YS2, K01 and SHU**
Whale survey (Second period)	**7, 8, 9**	**July 15-24**	**9.5**	**NM, YS1, YS2 and K01**
	7	July 15-16	1.5	
	8, 9	July 17-24	8	
Cooperative survey (SB-B)	**8, 9**	**July 25-August 4**	**11**	**NM, YS1, YS2, K01 and SHU**
Whale survey (Third period)	**9**	**August 5-16**	**12**	**NM, YS1, YS2 and K01**
Total	**7, 8, 9**	**May 16-August 16**	**91**	**NM, YS1, YS2, K01 and SHU**

・Sighting survey by Kyoshin Maru No.2

Research	Sub-area	Research periods	Days	Remarks
Dedicated sighting survey	**7, 8, 9**	**May 15-August 24**	**113**	

Research base ship: *Nisshin Maru (NM)*
Sighting and Sampling vessels (SSVs) : *Yushin Maru (YS1), Yushin Maru No.2 (YS2) and Kyo Maru No.1 (K01)*
Sighting vessel (SV) : *Kyoshin Maru No.2 (KS2)*
Prey species survey vessel : *Shunyo Maru (SHU)*

Table 2. Searching distances made by the three sighting/sampling vessels (YS2, YS1 and K01) and sighting vessels (KS2) in the 2005 JARPN II

SSVs

	Sub-area	Period	Searching distance (n.miles)			
			NSC	ASP	NSS	Combined
Whale survey (First period)	**7, 8, 9**	**May 16-July 7**	**5,734.2**	**173.3**	**1,894.1**	**7,801.6**
	9	16-May	0.0	110.6	0.0	110.6
	8	May 18-24	1,149.5	0.0	569.0	1,718.5
	9	24-May	34.6	0.0	0.0	34.6
	8	May 25-26	82.9	0.0	0.0	82.9
	9	May 27-June 19	2,677.0	59.1	599.7	3,335.8
	8	June 20-24	196.0	0.0	351.4	547.4
	7	June 25-July 7	1,594.2	3.6	374.0	1,971.8
Cooperative survey (SB-A)	**7**	**July 8-15**	**318.6**	**0.0**	**171.8**	**490.4**
Whale survey (Second period)	**7, 8, 9**	**July 15-24**	**829.5**	**0.0**	**624.6**	**1,454.1**
	7	July 15-16	221.0	0.0	61.1	282.1
	8, 9	July 17-24	608.5	0.0	563.5	1,172.0
Cooperative survey (SB-B)	**9**	**July 25-August 4**	**714.9**	**0.0**	**366.6**	**1,081.5**
Whale survey (Third period)	**9**	**August 5-16**	**845.5**	**170.8**	**853.5**	**1,869.8**
Total	**7, 8, 9**	**May 18-August 16**	**8,442.7**	**344.1**	**3,910.6**	**12,697.4**

SV (KS2)

	Sub-area	Period	Searching distance (n.miles)
			ASP
Dedicated sighting survey	7,8,9	**May 15-Aug. 24**	**4,974.9**
Transit			**103.8**
	Combined	**May 15-Aug. 24**	**5,078.7**

Table 3. List of cetacean species and number of sightings (no. schools/no. individuals) were made by three sighting/sampling vessels and research base in the 2005 JARPN II (Total area: May 15 - August 16).

Cetacean species	NSC				NSS				ASP				OE		Total					
	Primary		Secondary		Primary		Secondary		Primary		Secondary		Secondary		Primary		Secondary		Total	
	Sch.	Ind.	Sch.	Ind.	Sch.	Ind.	Sch.	Ind.	Sch.	Ind.	Sch.	Ind.	Sch.	Ind.	Sch.	Ind.	Sch.	Ind.	Sch.	Ind.
Common minke whale	55	55	24	25	16	16	11	11	2	2	0	0	5	5	73	73	40	41	113	114
Like minke whale	1	1	1	1	3	3	3	3	1	1	0	0	2	2	5	5	6	6	11	11
Sei whale	139	227	63	101	69	112	29	48	0	0	0	0	11	15	208	339	103	164	311	503
Bryde's whale	45	62	16	20	12	16	8	10	0	0	0	0	2	2	57	78	26	32	83	110
Sperm whale	118	175	24	50	25	42	10	32	8	8	0	0	1	30	151	225	35	112	186	337
Fin whale	47	70	20	27	11	14	10	21	0	0	0	0	2	4	58	84	32	52	90	136
Blue whale	15	18	6	7	1	1	2	2	0	0	0	0	0	0	16	19	8	9	24	28
Humpback whale	15	22	2	3	5	7	3	4	5	6	0	0	2	5	25	35	7	12	32	47
Right whale	0	0	0	0	1	2	0	0	0	0	0	0	0	0	1	2	0	0	1	2

Table 4. List of cetacean species and number of sightings (no. schools/no. individuals) was made by dedicated sighting vessel (KS2) in the 2005 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	14	15	0	0	6	6	14	15	6	6	20	21
Like Common minke whale	2	2	0	0	0	0	2	2	0	0	2	2
Blue whale	13	16	1	1	1	1	13	16	2	2	15	18
Fin whale	31	58	0	0	1	2	31	58	1	2	32	60
Sei whale	177	339	3	19	1	2	177	339	4	21	181	360
Bryde's whale	12	15	0	0	0	0	12	15	0	0	12	15
Humpback whale	15	34	3	8	1	1	15	34	4	9	19	43
Sperm whale	68	198	6	7	5	5	68	198	11	12	79	210
Unidentified large cetacean	10	11	21	31	1	1	10	11	22	32	32	43
Unidentified cetacean	29	29	0	0	0	0	29	29	0	0	29	29

Table 5. Summary of whale sampling in the 2005 JARPN II survey

Research type	Sub-area	Sub-area	Research periods	Whale samples			
				Common minke	Sei	Bryde's	Sperm
Whale survey (First period)	**7, 8, 9**	**7, 8, 9**	**May 18-July 7**	**55**	**61**	**14**	**5**
	8	8	May 18-24	7	6	0	0
	9	9	24-May	0	0	0	0
	8	8	May 25-26	3	6	0	0
	7	9	May 27-June 19	13	46	3	2
		8	June 20-24	0	3	8	2
		7	June 25-July 7	32	0	3	1
Cooperative survey (SB-A)	**7**	**7**	**July 8-15**	**0**	**0**	**36**	**0**
Whale survey (Second period)	**7, 8, 9**	**7, 8, 9**	**July 16-24**	**4**	**16**	**0**	**0**
	7	7	16-Jul	0	0	0	0
	8, 9	8, 9	July 17-24	4	16	0	0
Cooperative survey (SB-B)	**8, 9**	**8, 9**	**July 25-August 4**	**15**	**22**	**0**	**0**
Whale survey (Third period)	**9**	**9**	**August 5-16**	**26**	**1**	**0**	**0**
Total	**7, 8, 9**	**7, 8, 9**	**May 18-August 16**	**100**	**100**	**50**	**5**

Table 6. Summary of whale sampling in the 2005 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	51	49	100	21	29	50	3	2	5
External body proportion	86	14	100	51	49	100	21	29	50	3	2	5
Photographic record and external character	86	14	100	51	49	100	21	29	50	3	2	5
Diatom film record and sampling	86	14	100	51	49	100	21	29	50	3	2	5
Standard measurements of blubber thickness (five points)	86	14	100	51	49	100	21	29	50	3	2	5
Detailed measurements of blubber thickness (eleven points)	20	6	26	4	9	13	12	15	27	1	2	3
Body weight	86	14	100	51	49	100	21	29	50	3	2	5
Body weight by parts	20	6	26	4	9	13	12	15	27	1	2	3
Blubber tissues for DNA study	86	14	100	51	49	100	21	29	50	3	2	5
Blubber, muscle, liver and kidney tissues for heavy metal analysis	86	14	100	51	49	100	21	29	50	3	2	5
Blubber, muscle, liver and kidney tissues for organochlorines analy	86	14	100	51	49	100	21	29	50	3	2	5
Tissues for lipid analysis	20	6	26	4	9	13	12	15	27	1	2	3
Tissues for various analysis	86	14	100	51	49	100	21	29	50	3	2	5
Intestine contents for prey species identification	5	0	5	2	3	5	0	4	4	3	2	5
Tissues for virus test	86	5	91	51	32	83	21	8	29	3	0	3
Mammary grand; lactation status, measurement and histological sa	-	14	14	-	49	49	-	29	29	-	2	2
Collection of maternal milk sample	-	0	0	-	1	1	-	3	3	-	0	0
Uterine horn; measurement and endometrium sample	-	14	14	-	49	49	-	29	29	-	2	2
Collection of ovary	-	14	14	-	49	49	-	29	29	-	2	2
Photographic record of foetus	3	1	4	4	3	7	15	16	31	0	1	1
Foetal sex (identified by visual observation)	3	1	4	4	3	7	15	16	31	0	1	1
Foetal length and weight	3	1	4	4	3	7	15	16	31	0	1	1
External measurements of foetus	3	1	4	4	3	7	15	16	31	0	1	1
Foetal tissues for various analysis	3	1	4	4	3	7	15	16	31	0	1	1
Testis and epididymis; weight and histological sample	86	-	86	51	-	51	21	-	21	3	-	3
Collection of serum sample	86	14	100	51	49	100	21	29	50	3	2	5
Collection of whole blood sample	86	14	100	51	49	100	21	29	50	3	2	5
Whole blood samples from umbilical cord	-	1	1	-	23	23	-	1	1	-	0	0
Stomach content, conventional record	86	14	100	51	49	100	21	29	50	3	2	5
Volume and weight of stomach content in each compartment	86	14	100	51	49	100	21	29	50	3	2	5
Stomach contents for feeding study	86	14	100	51	49	100	21	29	50	3	2	5
Record of external parasites	86	14	100	51	49	100	21	29	50	3	2	5
Collection of external parasites	0	0	0	4	0	4	0	6	6	3	1	4
Record of internal parasites	86	14	100	51	49	100	21	29	50	3	2	5
Collection of internal parasites	0	2	2	2	0	2	0	1	1	0	1	1
Earplug for age determination	86	14	100	51	49	100	21	29	50	-	-	-
Tympanic bulla for age determination	86	14	100	51	49	100	21	29	50	-	-	-
Maxillally teeth for age determination	-	-	-	-	-	-	-	-	-	3	2	5
Largest baleen plate for morphologic study and age determination	86	14	100	51	49	100	21	29	50	-	-	-
Baleen plate measurements (length and breadth)	86	14	100	51	49	100	21	29	50	-	-	-
Length of each baleen plate series	86	14	100	51	49	100	21	29	50	-	-	-
Vertebral epiphyses sample	86	14	100	51	49	100	21	29	50	3	2	5
Number of vertebrae	0	0	0	4	9	13	12	15	27	1	2	3
Number of ribs	86	14	100	51	49	100	21	29	50	3	2	5
Brain weight	20	6	26	3	9	12	12	15	27	1	2	3
Skull measurement (length and breadth)	86	14	100	47	46	93	19	27	46	3	2	5

Table 7. Compositon of sex and sexual maturity of common minke whales collected by the 2005 JARPN II survey

Sub-area	Male				Female					Combined	Sex ratio	Maturity		Pregnancy
	Imm.	Mat.	Unknown	Total	Imm	Ovu.	Rest.	Preg.	Total		(% males)	Male	Female	rate*)
7	4	19	5	28	3	0	0	1	4	32	87.5	67.9	25.0	100.0
	(12.5)	(59.4)	(15.6)	(87.5)	(9.4)	(0.0)	(0.0)	(3.1)	(12.5)	(100.0)				
8	3	4	0	7	5	2	0	0	7	14	50.0	57.1	28.6	0.0
	(21.4)	(28.6)	(0.0)	(50.0)	(35.7)	(14.3)	(0.0)	(0.0)	(50.0)	(100.0)				
9	9	32	10	51	0	0	0	3	3	54	94.4	62.7	100.0	100.0
	(16.7)	(59.3)	(18.5)	(94.4)	(0.0)	(0.0)	(0.0)	(5.6)	(5.6)	(100.0)				
Combined	16	55	15	86	8	2	0	4	14	100	86.0	64.0	42.9	66.7
	(16.0)	(55.0)	(15.0)	(86.0)	(8.0)	(2.0)	(0.0)	(4.0)	(14.0)	(100.0)				

*) Apparent pregnancy rate

Table 8. Compositon of sex and sexual maturity of Bryde's whales collected by the 2005 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	8	10	18	10	1	2	4	4	0	21	39	46.2	55.6	52.4	72.7
	(20.5)	(25.6)	(46.2)	(25.6)	(2.6)	(5.1)	(10.3)	(10.3)	(0.0)	(53.8)	(100.0)				
8	2	1	3	2	0	0	3	0	0	5	8	37.5	33.3	60.0	100.0
	(25.0)	(12.5)	(37.5)	(25.0)	(0.0)	(0.0)	(37.5)	(0.0)	(0.0)	(62.5)	(100.0)				
9	0	0	0	1	0	2	0	0	0	3	3	0.0	-	66.7	0.0
	(0.0)	(0.0)	(0.0)	(33.3)	(0.0)	(66.7)	(0.0)	(0.0)	(0.0)	(100.0)	(100.0)				
Combined	10	11	21	13	1	4	7	4	0	29	50	42.0	52.4	55.2	68.8
	(20.0)	(22.0)	(42.0)	(26.0)	(2.0)	(8.0)	(14.0)	(8.0)	(0.0)	(58.0)	(100.0)				

*) Apparent pregnancy rate

Table 9. Compositon of sex and sexual maturity of sei whales collected by the 2005 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	0	0	0	0	0	0	0	0	0	0	0.0	0.0	0.0	0.0
8	3	10	13	3	1	1	13	0	0	18	31	41.9	76.9	83.3	86.7
	(9.7)	(32.3)	(41.9)	(9.7)	(3.2)	(3.2)	(41.9)	(0.0)	(0.0)	(58.1)	(100.0)				
9	4	34	38	11	1	1	16	1	1	31	69	55.1	89.5	64.5	90.0
	(5.8)	(49.3)	(55.1)	(15.9)	(1.4)	(1.4)	(23.2)	(1.4)	(1.4)	(44.9)	(100.0)				
Combined	7	44	51	14	2	2	29	1	1	49	100	51.0	86.3	71.4	88.6
	(7.0)	(44.0)	(51.0)	(14.0)	(2.0)	(2.0)	(29.0)	(1.0)	(1.0)	(49.0)	(100.0)				

*) Apparent pregnancy rate

Table 10. Statistics of body length (m) of common minke whales collected by the 2005 JARPN II survey

Sub area	Male					Female				
	Mean	S.D.	Min	Max	n	Mean	S.D.	Min	Max	n
7	7.32	0.63	5.11	8.08	28	6.25	1.81	4.59	8.79	4
8	6.72	1.19	4.72	7.68	7	6.44	1.33	5.03	8.69	7
9	7.25	0.82	4.49	8.12	51	8.33	0.19	8.17	8.54	3
Combined	7.23	0.80	4.49	8.12	86	6.79	1.51	4.59	8.79	14

Table 11. Statistics of body length (m) of Bryde's whales collected by the 2005 JARPN II survey

Sub area	Male					Female				
	Mean	S.D.	Min	Max	n	Mean	S.D.	Min	Max	n
7	11.52	1.05	9.86	13.02	18	11.97	1.13	10.09	14.18	21
8	10.90	1.25	9.78	12.25	3	12.18	0.74	11.11	13.02	5
9	-	-	-	-	0	11.18	2.00	8.92	12.70	3
Combined	11.44	1.07	9.78	13.02	21	11.93	1.16	8.92	14.18	29

Table 12. Statistics of body length (m) of sei whales collected by the 2005 JARPN II survey

Sub area	Male					Female				
	Mean	S.D.	Min	Max	n	Mean	S.D.	Min	Max	n
7	-	-	-	-	0	-	-	-	-	0
8	13.51	1.23	10.13	14.88	13	14.27	1.61	9.06	15.47	18
9	13.54	0.82	10.41	15.00	38	13.94	1.16	10.93	15.44	31
Combined	13.53	0.93	10.13	15.00	51	14.06	1.33	9.06	15.47	49

Table 13. Statistics of body length (m) of sperm whales collected by the 2005 JARPN II survey

Sub area	Male					Female				
	Mean	S.D.	Min	Max	n	Mean	S.D.	Min	Max	n
7	-	-	-	-	0	9.28	-	-	-	1
8	9.15	-	-	-	1	8.90	-	-	-	1
9	10.60	0.48	10.26	10.94	2	-	-	-	-	0
Combined	10.12	0.90	9.15	10.94	3	9.09	0.27	8.90	9.28	2

Table 14. Frequency of male common minke whales with anomalous testes tissues in the 2005 JARPN II survey

Area	Maturity	n	Normal	Anomalous			
				One side	Both side	Combined	(%)
7	Immature	4	4	0	0	0	(0.0)
	Mature	19	12	7	0	7	(36.8)
	Unknown	5	-	-	5	5	(100.0)
	Combined	28	16	7	5	12	(42.9)
8	Immature	3	3	0	0	0	(0.0)
	Mature	4	3	1	0	1	(25.0)
	Combined	7	6	1	0	1	(14.3)
9	Immature	9	9	0	0	0	(0.0)
	Mature	32	22	10	0	10	(31.3)
	Unknown	10	-	-	10	10	(100.0)
	Combined	51	31	10	10	20	(39.2)
Combined	Immature	16	16	0	0	0	(0.0)
	Mature	55	37	18	0	18	(32.7)
	Unknown	15	-	-	15	15	(100.0)
	Combined	86	53	18	15	33	(38.4)

Table 15. Prey species and stomach contents weight (1st. + 2nd. stomachs) found in stomach of common minke, Bryde's, sei and sperm whales sampled by the 2005 JARPN II surveys

Common minke whale (Broken 11; Empty 17)

	Prey species	N (Dominant)	Range of weight (kg) in the stomachs
Copepods	Neocalanus spp.	2	1.0, 1.9
Krill		17	1.2 - 65.7
Fish	Pacific saury	24	2.8 - 89.1
	Japanese anchovy	16	2.2 - 104.9
	Walleye pollock	6	2.5 - 115.2
	Unidentified fishes	3	<0.1 - 30.0
	Chub mackerel	1	10.7
	Salmonidae	1	6.7
	Japanese pomfret*		-
Squids	Minimal armhook squid	2	22.6, 27.2
	Japanese common squid*		-

*: Minor prey species

Bryde's whale (Empty 22)

	Prey species	N (Dominant)	Range of weight (kg) in the stomachs
Krill	Krill	13	<0.1 - 134.3
Fish	Japanese anchovy	15	<0.1 - 257.5
	Chub mackerel*		
	Japanese sardine*		

*: Minor prey species

Sei whale (Broken 2; Empty 23)

	Prey species	N (Dominant)	Range of weight (kg) in the stomachs
Copepods	Neocalanus spp.	34	<0.1 - 389.1
Krill		36	<0.1 - 346.8
Fish	Pacific saury	5	<0.1 - 186.3
	Japanese anchovy*		-
	Chub mackerel*		-
Squids	Japanese common squid*		-

*: Minor prey species

Table 16. Summary of biopsy skin sampling for right whales in the 2005 JARPN II survey

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)
Right whale	SSVs	1	2	5	3	2	0h30m	0.40	0.67

Table 17. Summary of photo ID for right whales in the 2005 JARPN II survey

Whale species	Ship	Number of experiments (A)	Targeted individuals (B)	Number of trials (C)
Right whale	SSVs	1	2	2

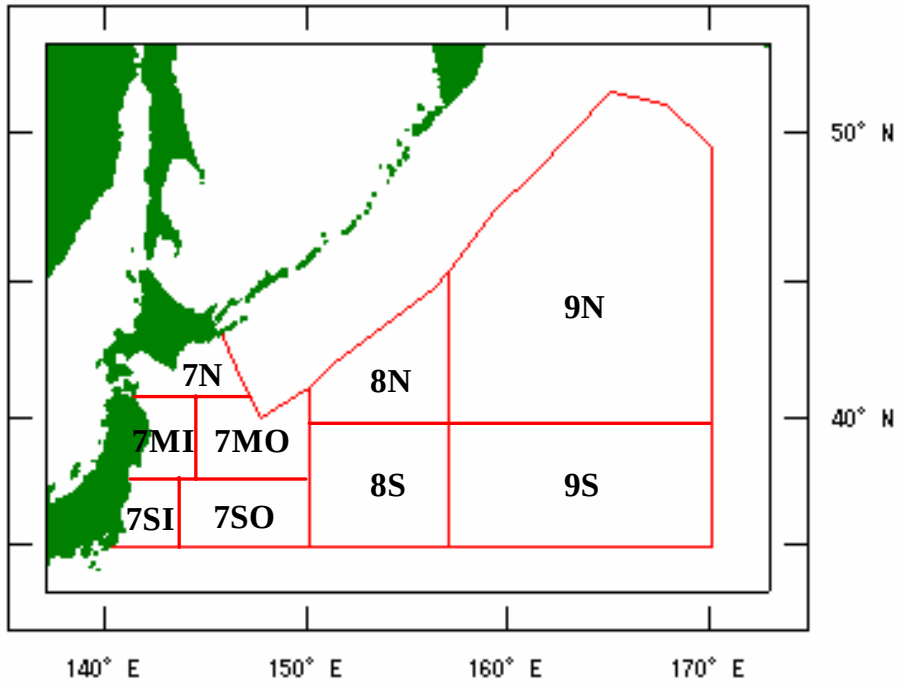


Fig 1. Map showing the research area and strata of the JARPN II full-scale program.

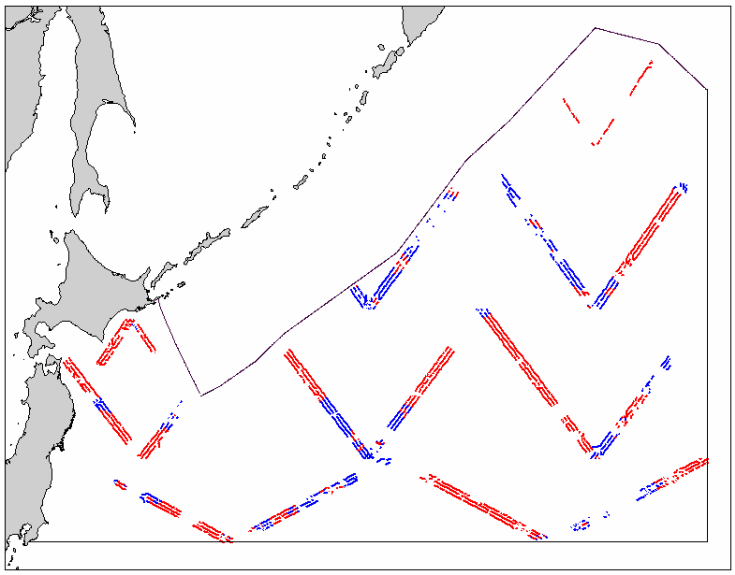


Fig. 2. Track-line covered by the three sighting/sampling vessels (SSVs) during the normal survey of the 2005 JARPN II (Red line: BC mode; Blue line: BS mode).

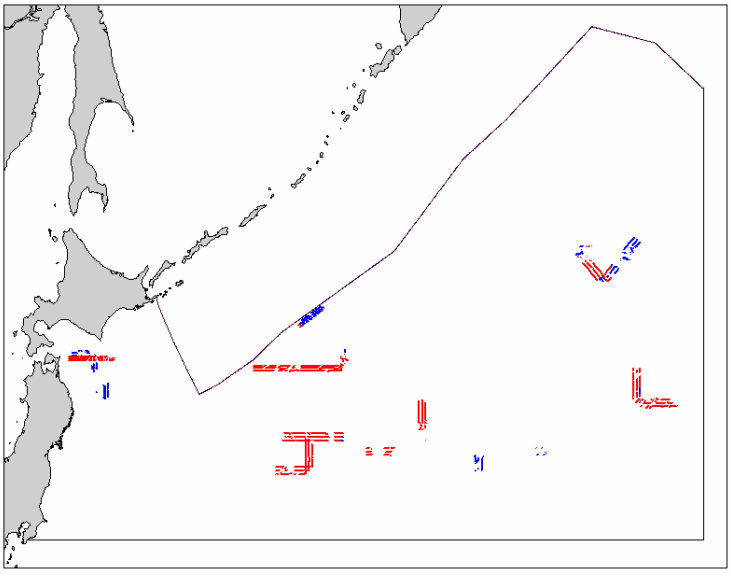


Fig. 3. Track-line covered by the three sighting/sampling vessels (SSVs) during the special survey of the 2005 JARPN II (Red line: BC mode; Blue line: BS mode).

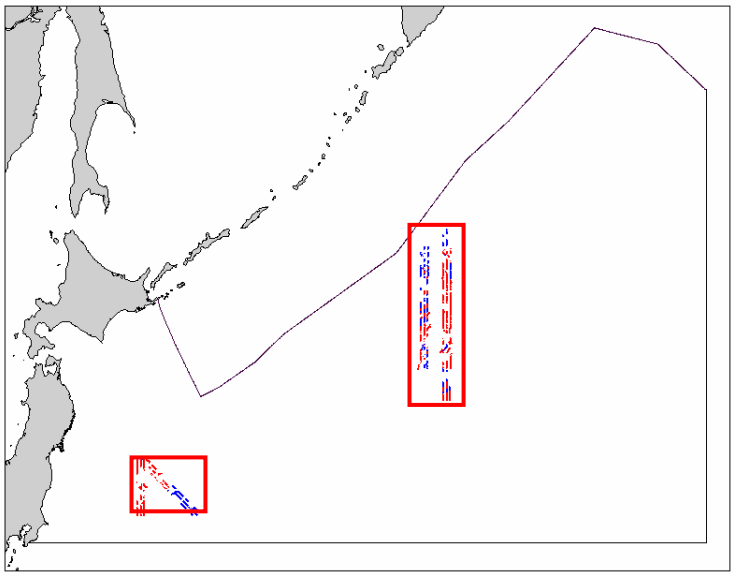


Fig. 4. Track-line covered by the three sighting/sampling vessels (SSVs) during the cooperative surveys of the 2005 JARPN II (Red line: BC mode; Blue line: BS mode).

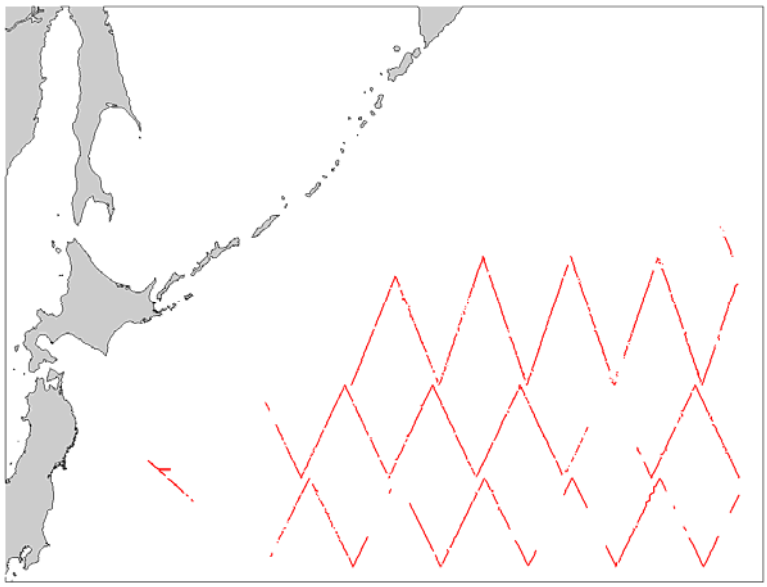


Fig. 5. Track-line covered by the three sighting vessel (SV:KS2) during the special survey of the 2005 JARPN II.

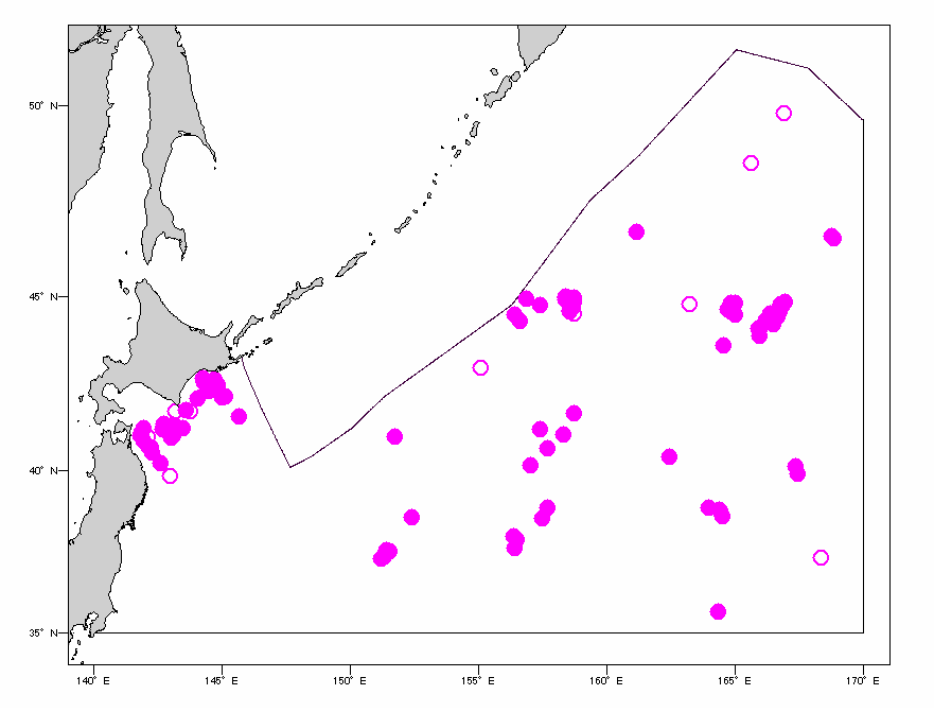


Fig. 6. Positions of the sightings and samplings of the common minke whales (●: sighted and sampled, ○: sighted only).

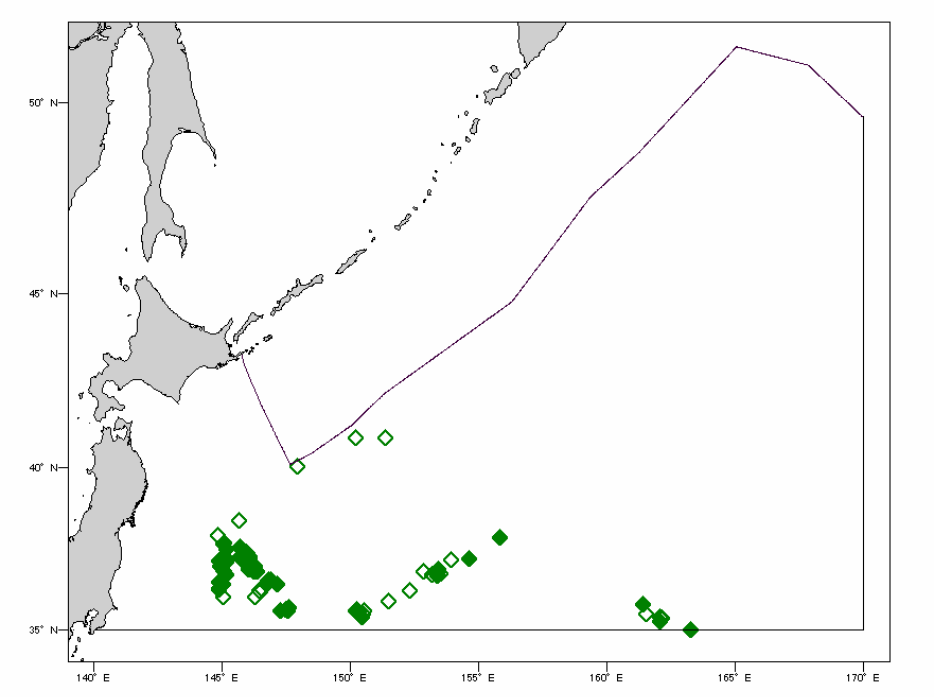


Fig. 7. Positions of the sightings and samplings of the Bryde's whales (◆: sighted and sampled, ◇: sighted only).

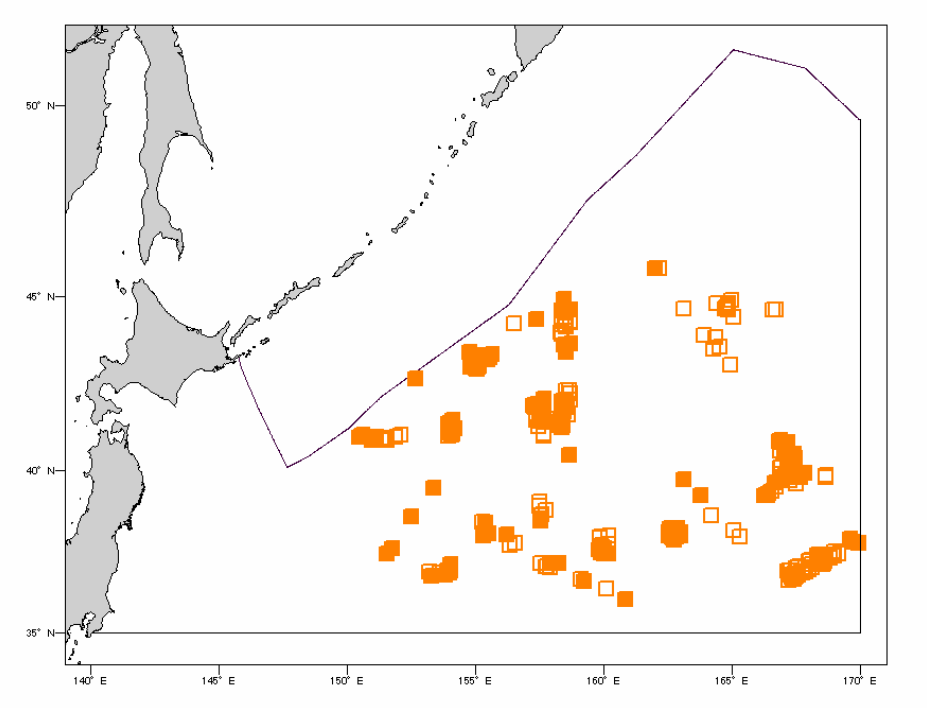


Fig. 8. Positions of the sightings and samplings of the sei whales (■: sighted and sampled, □: sighted only).

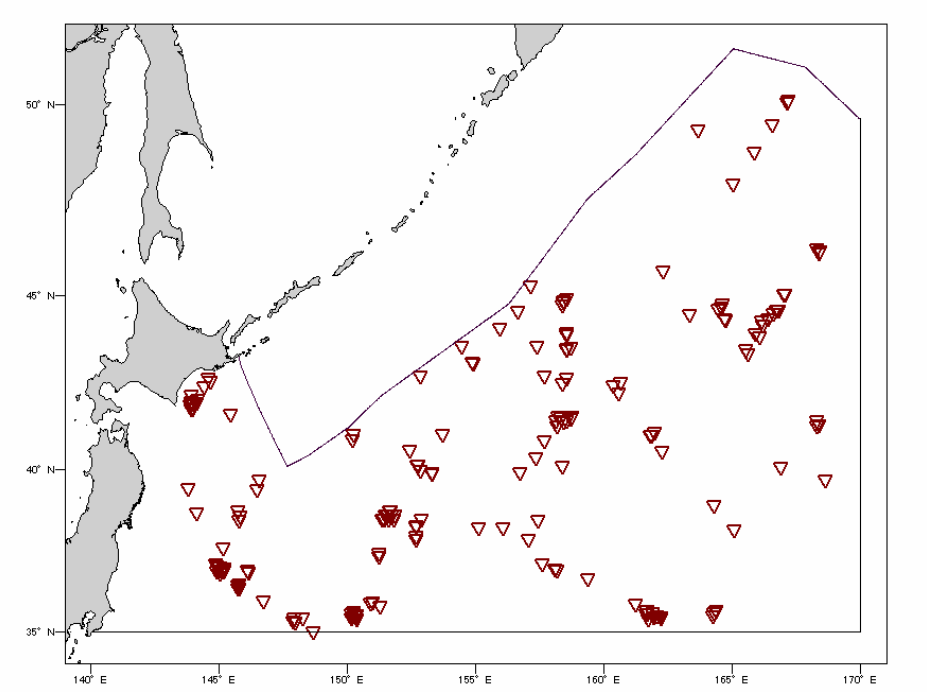


Fig. 9. Positions of the sightings and samplings of the sperm whales (▼: sighted and sampled, ▽: sighted only).

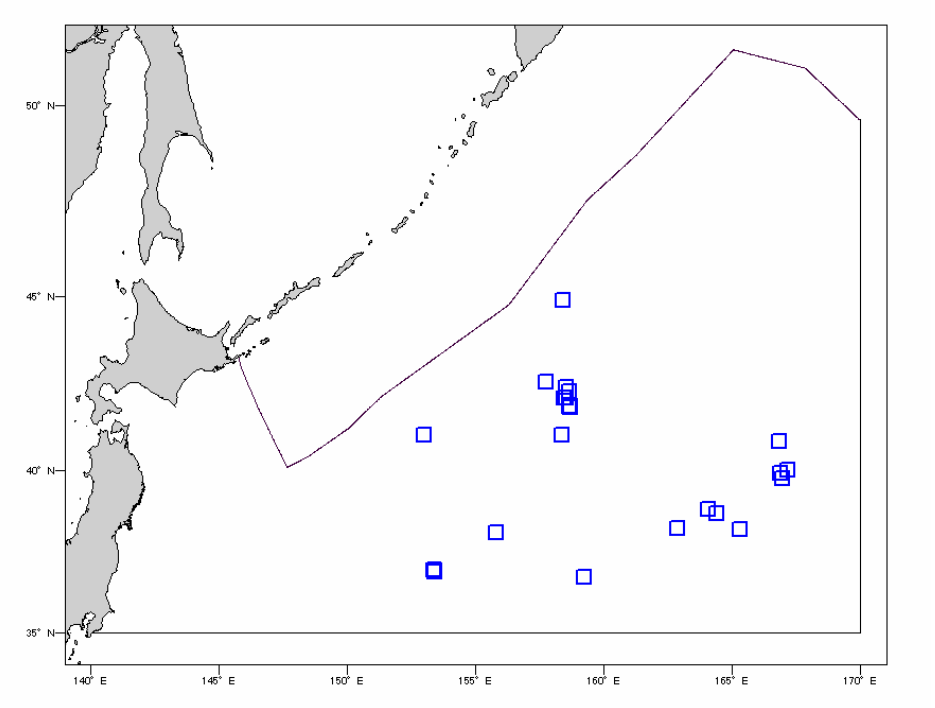


Fig. 10. Positions of the sightings of the Blue whales (□)

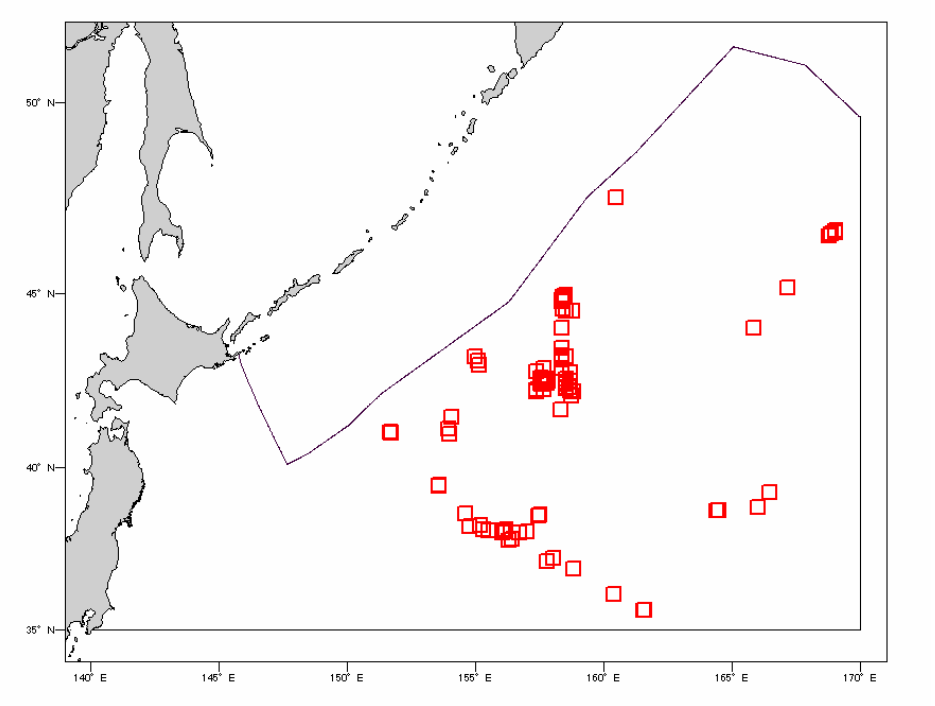


Fig. 11. Positions of the sightings of the fin whales (□)

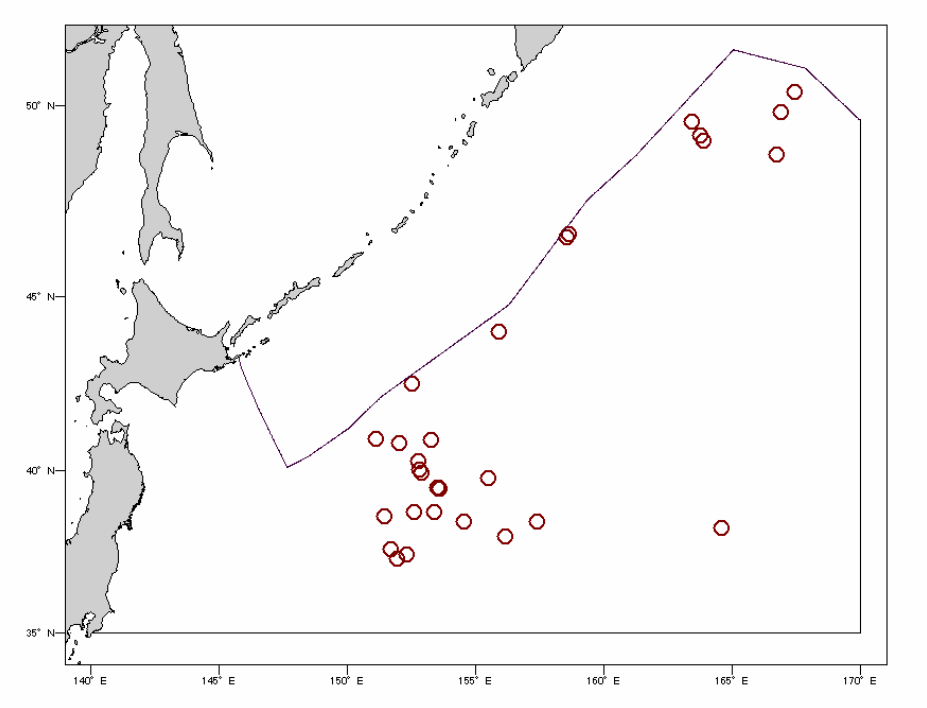


Fig. 12. Positions of the sightings of the humpback whales (◯).

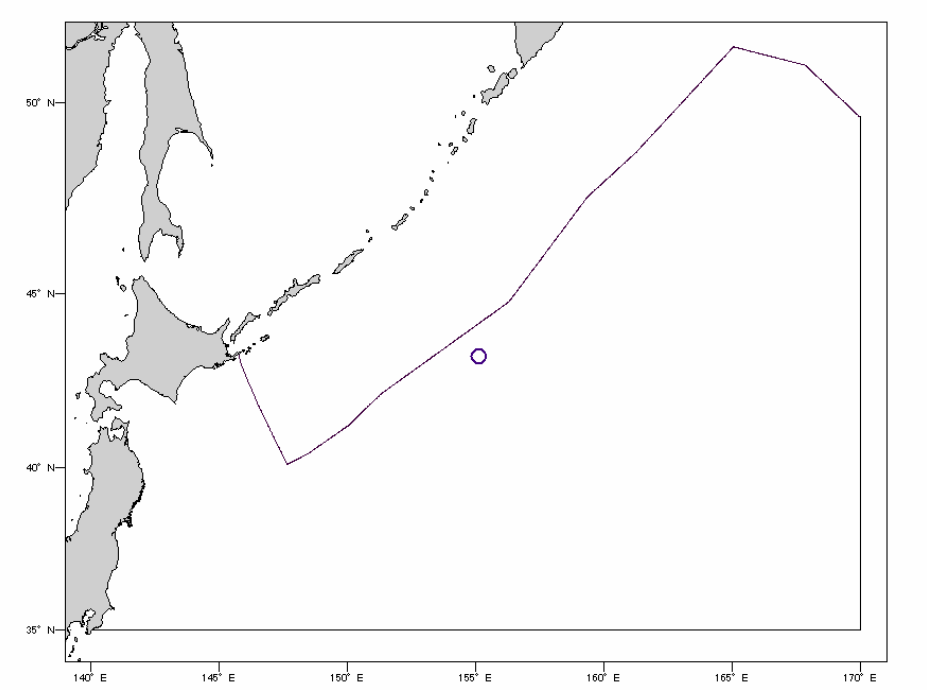


Fig. 13. Positions of the sightings of the right whales (◯).

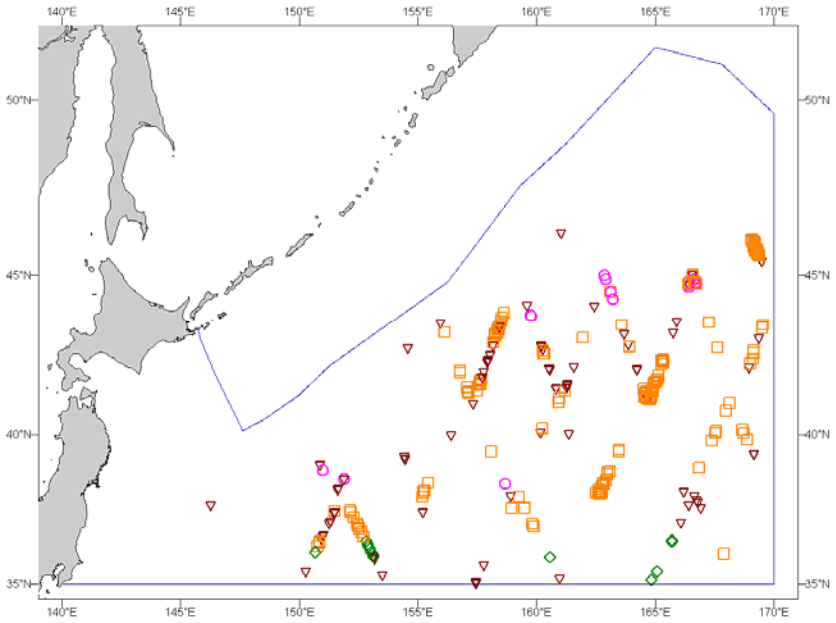


Fig. 14. Positions of the sightings of common minke, Bryde's, sei and sperm whales in dedicated sighting survey by KS2 (○: minke, ◇: Bryde's, □: sei, ▽: sperm)

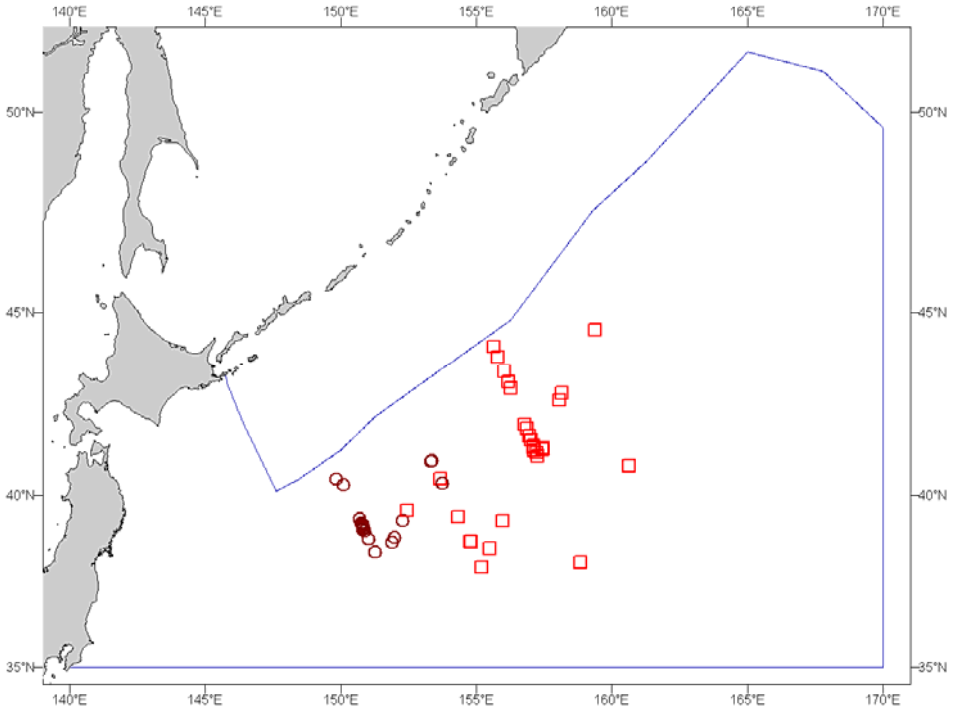


Fig. 15. Positions of the sightings of humpback and fin whales in dedicated sighting survey by KS2 (○: humpback, □: fin).

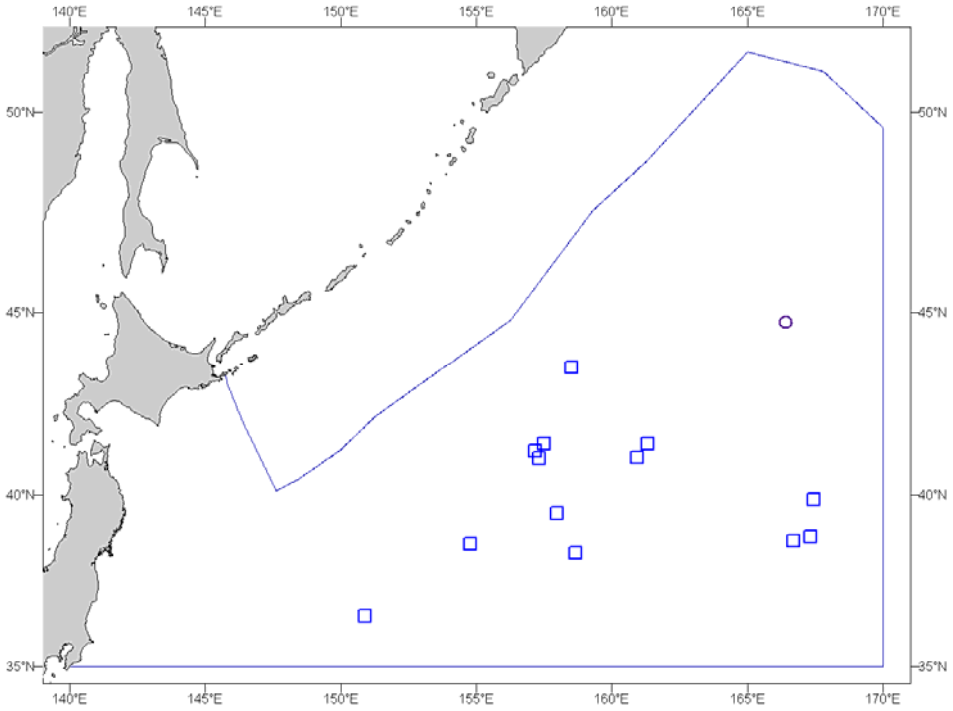
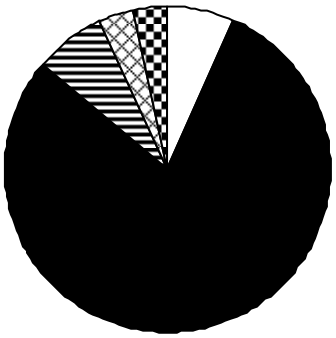


Fig. 16. Positions of the sightings of blue and right whales in dedicated sighting survey by KS2 (□: blue, ○: right).

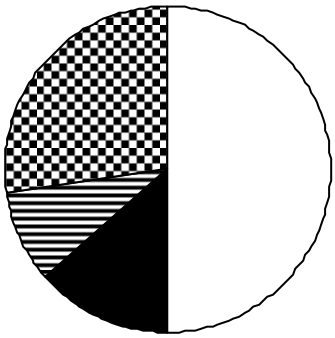
Minke whale

From May to June

1994 – 2004 (N=303)

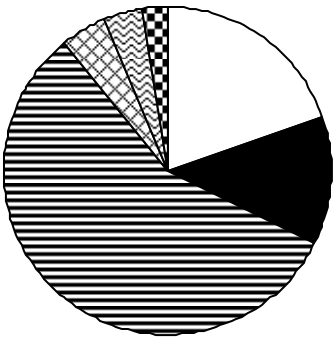


2005 (N=22)



From July to September

1994 – 2004 (N=511)



2005 (N=49)

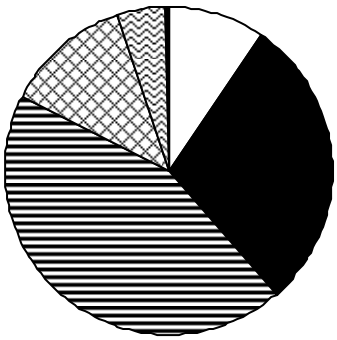


Fig.17-a. The comparison of prey species of common minke whale between previous seasons and this season

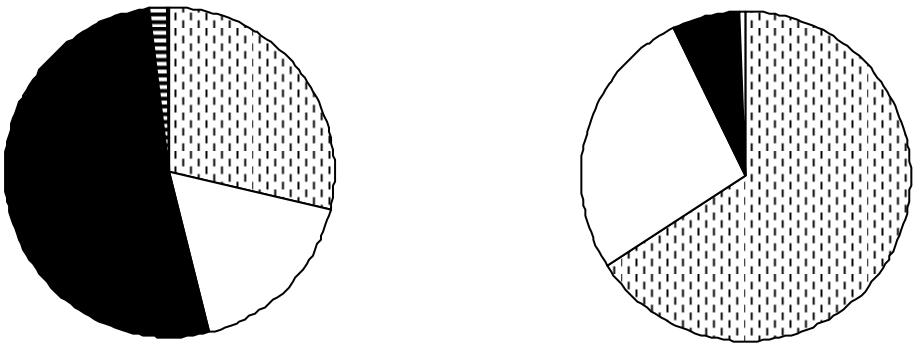
: Krill, : Japanese anchovy, : Pacific saury,

: Walleye pollock, : Common squid, : Others

Sei whale

From May to June

2000 – 2004 (N=30) **2005 (N=46)**



From July to September

2000 – 2004 (N=106) **2005 (N=29)**

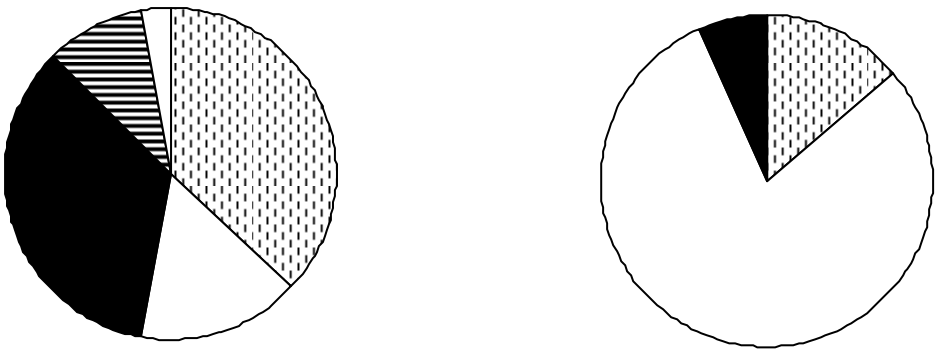


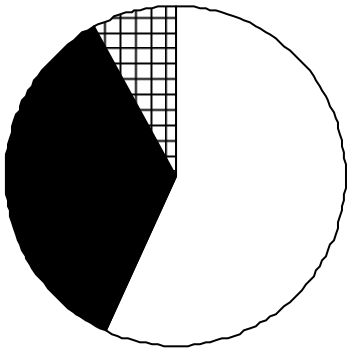
Fig.17-b. The comparison of prey species of sei whale between previous seasons and this season

: Copepods, : Krill, : Japanese anchovy, : Pacific saury, : Others

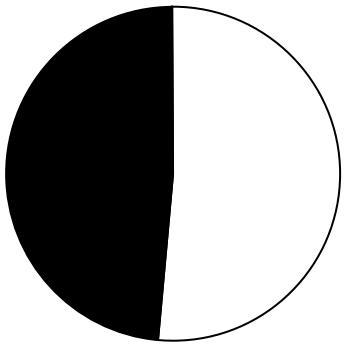
Bryde's whale

From May to June

2000 – 2004 (N=87)

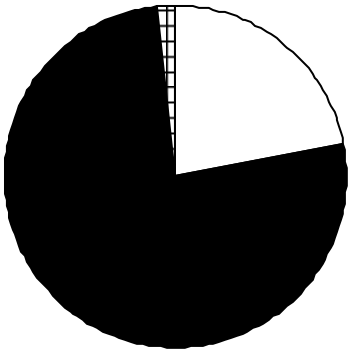


2005 (N=8)



From July to September

2000 – 2004 (N=95)



2005 (N=20)

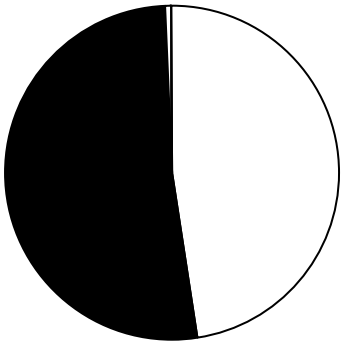
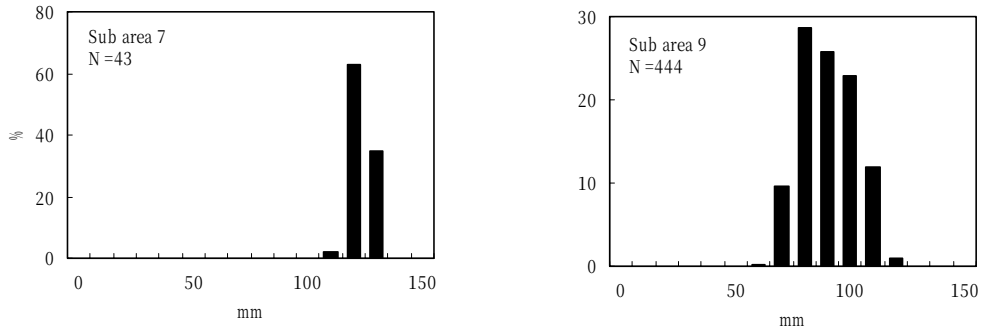


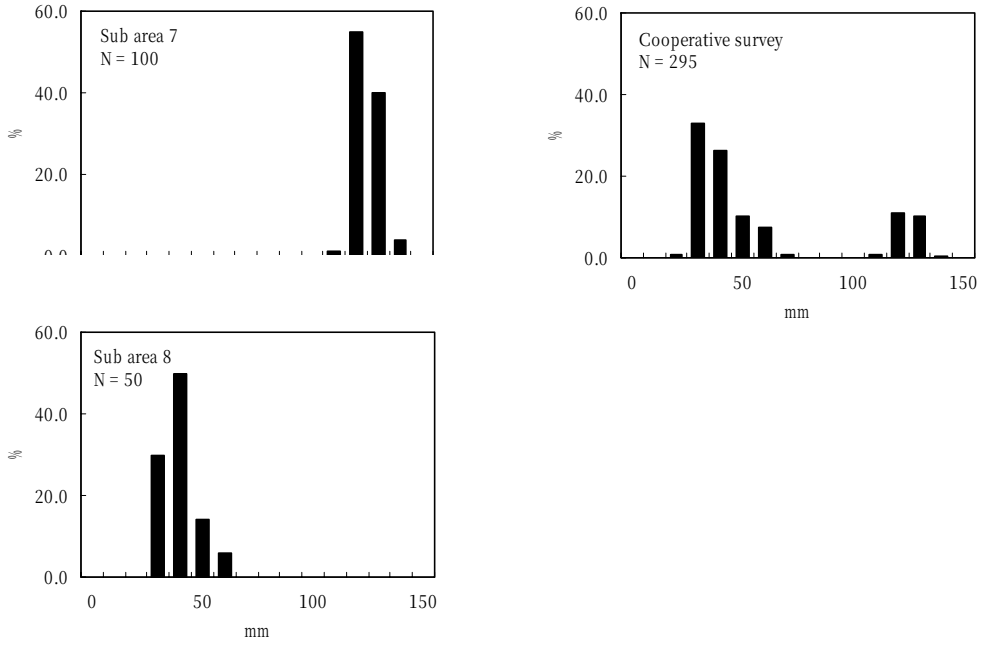
Fig.17-c. The comparison of prey species of Bryde's whale between previous seasons and this season

□: Krill, ■: Japanese anchovy, ⊞: Chub mackerel, ▩: Others

Common minke whale



Bryde's whale



Sei whale

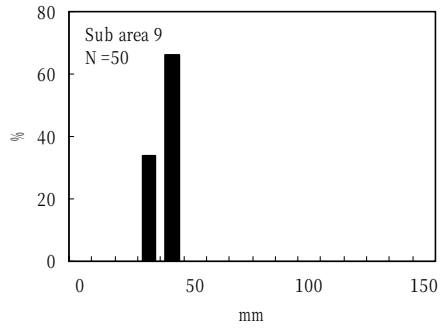


Fig.18. The size frequency distribution of Japanese anchovy fed on by whales in each area.

Minke whale **Sei whale**

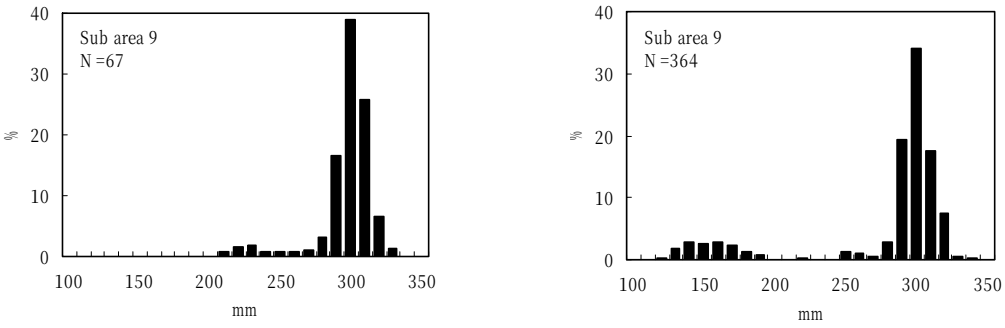


Fig.19. The size frequency distribution of Pacific saury fed on by whales in each area.

Appendix 1

Offshore prey species survey of JARPN II in 2005

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ABSTRACT

A prey species survey was conducted in offshore two blocks of the western North Pacific in cooperation with the sampling survey by the Nisshin Maru in July-August 2005. The primary objective of the prey species survey was to examine prey environment and prey preference of Bryde's, minke and sei whales. The distribution and abundance of the prey species were investigated with the quantitative echosounder (EK60), midwater trawl and MOCNESS of a trawler-type research vessel, Shunyo-maru, during the daytime. Acoustic data were acquired by steaming at about 10 knots along the track lines with operating frequency at 38, 70 and 120 kHz. Species and size compositions of acoustical backscatterings were identified by targeting midwater trawl and MOCNESS. Another type of trawlings was made at predetermined stations to estimate the distribution and abundance of cephalopods and neustonic organisms that are difficult to detect with the echosounder. In the western block where Bryde's whales were found, the abundance of prey was low and larvae of Japanese anchovy were sampled by MOCNESS. In the eastern block Japanese anchovy tends to occur in the southern part where sei whales were found. And Pacific saury occurs in the northern part where minke whales were found.

INTRODUCTION

After two-year feasibility surveys, the government of Japan submitted the full-scale Research Plan for Cetacean Studies in the Western North Pacific under Special Permit (JARPN II) to the 54th IWC/SC (Government of Japan 2002). 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 of this plan is to examine feeding habits of major cetacean species and ecosystem studies, including studies on prey consumption by cetaceans, prey preference (selection) of cetaceans, and ecosystem modelling. In JARPN II, the cooperative whale/prey surveys are

conducted to estimate the prey selection of cetaceans. In 2005, the prey species survey was conducted in cooperation with Nisshin Maru in two blocks in the offshore region of the western North Pacific. This document presents the preliminary results of this prey survey.

MATERIALS AND METHOD

Survey period and areas

The prey species survey was conducted in July-August 2005 in cooperation with Nisshin Maru; first from July 12 to 25 in the western block and second from July 27 to August 11 in the eastern block by a stern-trawler type research vessel, Shunyo-maru (887 GT) of Fisheries Research Agency (Fig. 1). Time difference between the whale and prey species surveys was controlled less than about one week so that results of two surveys were comparable. Research hour was from an hour after sunrise to an hour before sunset while the maximum research hours were set at 13 hours.

In each block a zigzag track line was set independently from the whale survey. The way points of planned track lines were shown in Table 1. The distribution and abundance of the prey species were investigated with the quantitative echosounder (Simrad EK60), midwater trawl, and Multiple Opening and Closing Nets Environmental Sampling System (MOCNESS). CTD casts were conducted down to 500 m at each sampling station to measure vertical temperature and salinity profiles in the study area.

Acoustic data acquisition and analyses

During the daytime, the ship steamed at around 10 knots along the track line. To record acoustic data a quantitative echo sounder (Simrad EK60 with program version 1.4.3.64) with operating frequency at 38, 70 and 120 kHz was used. The transducers were hull-mounted at the depth of 4.3 m from the surface. Calibrations were carried out in Sendai Bay in July 25 using the copper sphere technique described in EK 60 online help manual. Acoustic data are being analyzed now with the aid of Sonar Data Echoview (version 3.00.74.01) at the laboratory.

Trawl sampling

The midwater trawl net used 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 of the mouth of the net were monitored with the Scanmer transducers attached to the head and bottom ropes of the trawl. Towing speed of the trawl net was 4-5 knot. Two types of mid-water trawlings were made during daylight period. Targeting trawlings were to identify the species and size compositions of biological backscatterings detected by the echosounder. Another type of trawlings was made at predetermined stations to estimate the distribution and abundance of cephalopods and neustonic organisms that are difficult to detect with the echosounder. At predetermined stations the midwater trawl net was towed at surface or in a

stairs-like fashion at three depth layers (0-30m, 30-60m and 60-90m) shallower than 100 m. Towing duration was 30 minutes in total, 10 minutes for each layer. All samples were identified to the lowest taxonomic level possible and wet weight of each species was measured aboard the vessel. For the major species, body length of 100 individuals was measured to examine their size composition. Some frozen samples were taken for further analysis in the laboratory.

MOCNESS sampling

During the survey we used MOCNESS to examine species/size compositions and vertical distribution pattern of meso- and macro-zooplanktons. The mouth opening and mesh size of the net were 1 m^2 and 0.33 x 0.33 mm, respectively. MOCNESS was towed at about 2 knots in 8 target depths (0-20m, 20-40m, 40-60m, 60-80m, 80-100m, 100-150m, 150-200m, and 200-250m) during the daytime. The volume of water filtered by each net was measured with a flow meter mounted at the net mouth. Samples were preserved in 10 % formalin-buffered seawater for further analysis in the laboratory.

RESULTS AND DISCUSSION

During the survey, we conducted targeting and predetermined trawlings for 4 and 9 times in the western block and 3 and 12 times in the eastern block (Fig. 2). Results of trawlings in the eastern and western blocks are shown in Tables 2 and 3, respectively. We conducted MOCNESS for 7 Times in the western block and 4 times in the eastern block, respectively (Fig. 2). The oceanographic conditions are described in Appendix 2 in the report. While the acoustic data and MOCNESS samples are being analyzed now, the preliminary results are as follows.

In the western block where Japanese anchovy (juveniles and adults) and krill were found in the stomachs of sampled Bryde's whales, the abundance of prey species was low and mainly larvae of Japanese anchovy were sampled by MOCNESS. In the eastern block where minke and sei whales were found in the northern and southern parts, respectively, Japanese anchovy (5-10cm in scaled length) with sardine/mackerel and Pacific saury (30-35cm in knob length) are distributed in the southern and northern parts, respectively. Copepod and krill were distributed in the northern part and in the whole block, respectively. According to Nisshin Maru, minke and sei whales were distributed in the northern and southern parts, respectively.

ACKNOWLEDGEMENT

A special thank is given to Captain M. Onoda and the crews of Shunyo-maru for their dedication in collecting data.

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Table 1. Waypoints of planned track lines for the western (left) and eastern (right) blocks.

WP	Latitude		Longitude	
WP1	36	0	144	45
WP2	38	0	145	15
WP3	36	0	145	45
WP4	38	0	146	15
WP5	36	0	146	45
WP6	38	0	147	15
WP7	36	0	147	45

WP	Latitude		Longitude	
WP1	40	0.0	157	0.0
WP2	41	0.0	159	0.0
WP3	42	0.0	157	0.0
WP4	43	0.0	159	0.0
WP5	44	0.0	157	0.0
WP6	45	0.0	158	50.0
WP7	45	32.7	157	50.0

Table 2. Results of trawlings in the western block in 2005 offshore prey species survey.

Stn.	Date	Time	Depth (m)	Latitude	Longitude	Catch (kg)	Anchovy larvae	Anchovy adult	
2	2005.7.14	15:26-16:00	0-100	37.00.4N	144.55.9E	+	+	-	
6	2005.7.16	14:59-15:32	0-100	36.17.8N	145.41.3E	+	-	2 ind.	
8	2005.7.17	13:07-13:37	0-30	36.30.7N	145.54.1E	+	-	1 ind.	
11	2005.7.18	11:08-11:38	0-30	37.19.2N	146.00.4E	+	-	-	
12	2005.7.18	18:02-18:32	0-30	38.00.7N	146.15.7E	+	+	-	
13	2005.7.19	13:01-13:31	0-30	37.01.5N	146.31.6E	0.1	0.1	-	
15	2005.7.20	10:46-11:16	0-30	35.59.3N	146.44.0E	+	+	-	
16	2005.7.20	15:52-16:22	0-30	36.29.0N	146.52.5E	-	1 ind.	-	
17	2005.7.21	09:03-10:03	0-100	36.55.8N	146.59.6E	0.9	0.9	6 ind.	
19	2005.7.21	08:08-09:18	0-100	38.00.6N	147.12.0E	0.7	0.7	2 ind.	
20	2005.7.22	14:40-15:10	0-30	37.31.7N	147.22.2E	0.2	0.2	-	
21	2005.7.23	08:44-09:04	0-30	38.00.6N	147.12.0E	0.2	0.2	-	
22	2005.7.23	11:47-12:34	0-100	37.31.7N	147.22.2E	0.2	0.2	-	

Table 3. Results of trawlings in the eastern block in 2005 offshore prey species survey.
Results of MOCNESS during the offshore survey in 2004

Stn.	Date	Time	Depth (m)	Latitude	Longitude	Catch (kg)	Japanese Anchovy	Japanese Sardine	Pacific Mackerel	Pacific Saury	
1	2005.7.31	06:45-07:20	0-100	40.00.2N	156.58.3E	-	-	-	-	-	
3	2005.7.31	16:08-16:28	0-30	40.28.8N	157.55.2E	1.1	-	-	-	-	
4	2005.8.1	09:55-10:32	0-100	40.52.0N	158.40.7E	-	-	-	-	-	
5	2005.8.1	15:13-15:29	0-30	41.08.1N	158.45.3E	5.0	-	-	-	-	
6	2005.8.2	08:32-09:10	0-30	41.29.4N	158.00.3E	20.6	17.1	-	2.2	1.3	
8	2005.8.3	07:28-07:48	0-30	42.08.7N	157.21.2E	39.6	37.2	0.4	0.2	1.7	
9	2005.8.3	12:38-13:08	0-30	42.27.6N	157.53.6E	1.9	0.1	-	-	1.8	
10	2005.8.3	17:00-17:36	0-100	42.43.9N	158.23.1E	-	0.2	-	-	-	
11	2059.8.4	09:46-10:10	0-30	42.59.4N	158.58.2E	15.1	14.0	0.5	0.5	-	
12	2059.8.4	15:13-15:33	0-30	43.20.8N	158.21.2E	-	-	-	-	-	
13	2005.8.5	09:25-09:55	0-30	43.44.0N	157.28.0E	8.1	2.1	-	-	6.1	
15	2005.8.5	16:56-17:26	0-30	44.10.6N	157.22.6E	2.6	-	-	-	2.6	
17	2005.8.6	09:03-09:33	0-30	45.28.2N	158.07.3E	230.3	+	-	-	230.3	
19	2005.8.7	06:09-06:29	0-30	44.43.3N	158.21.4E	3.9	+	-	+	3.9	
20	2005.8.7	10:52-11:50	0-30	44.27.1N	157.50.1E	23.8	-	-	-	23.3	

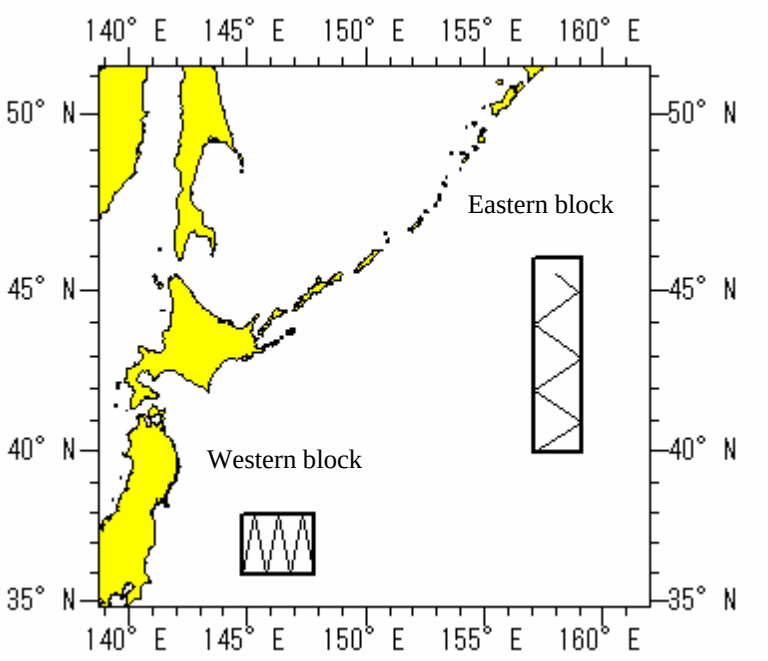

Fig. 1. The western and eastern blocks in 2005 offshore prey species survey.

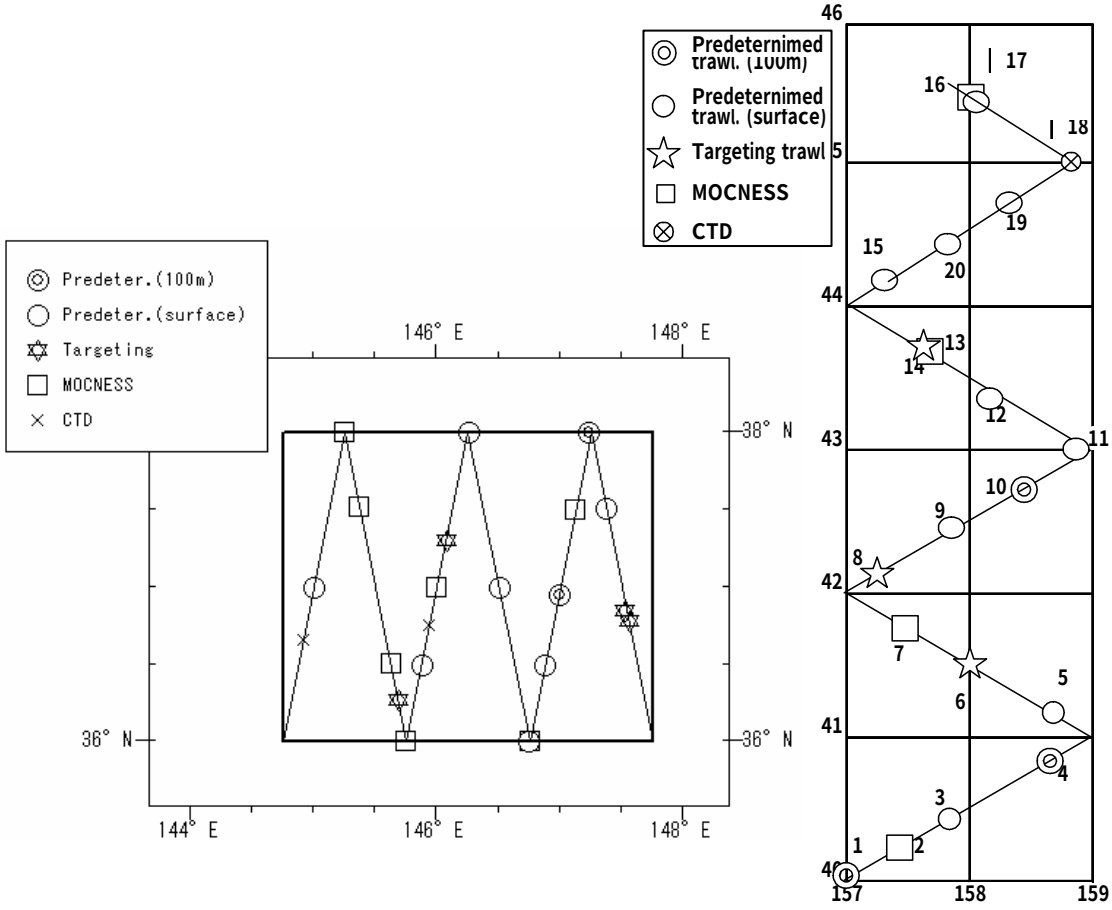

Fig. 2. Positions of trawlings, MOCNESS and CTD only stations in the western (left) and eastern (right) blocks in 2005 offshore prey species survey.

Appendix 2

Oceanographic conditions in the western North Pacific in July to August 2005

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ABSTRACT

A prey species survey was conducted in July-August 2005 using *R/V Shunyo Maru* as a part of offshore component of JARPN II. The survey covered two blocks; the western block where Bryde's whales were found and the eastern block where minke and sei whales were found. During the survey, oceanographic observation with CTD was made to make clear the environment of the prey. In the western block, the northern part was in the warm water with a warm-core ring and the southern part was characterized by the warm water and cold water. The eastern block is in and around the Transition Domain which is between the Subarctic Front and the Subarctic Boundary.

INTRODUCTION

A prey species survey was conducted in the offshore two blocks of the western North Pacific in July-August 2005 using *R/V Shunyo Maru* in cooperation with the sampling survey by *Nisshin Maru* (Fig. 1). While Bryde's whales were found in the western block, minke and sei whales were found in the northern and southern parts of the eastern block, respectively.

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. Both major current, the Kuroshio 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) and the Subarctic Boundary (salinity front defined by 34.0psu) with a week 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 two blocks will be described to make clear the environment of the prey of Bryde's, sei and minke whales.

METHODS

Hydrographic observations with a conductivity-temperature-depth profiler (CTD; SBE 911plus) were carried out from 13 to 23 July in the western block and from July to 8 August 2005 in the eastern block of the Kuroshio-Oyashio Inter-frontal Zone using *R/V Shunyo Maru*. Salinity compensation 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 isotherm at the depth of 200m (Kawai , 1969). The warm water spread from Kuroshio Extension is defied by temperature more than 10 at the depth of 100 m . The first and the second Oyashio Intrusions are defined by temperature lass than 5 at the depth of 100 m (Murakami, 1994). Subarctic front and the Subarctic Boundary is defined by 4 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 two blocks.

The oceanographic conditions in July 2005 were analyzed by Tohoku National Fisheries Research Institute (TNFRI), which used quasi-real-time data from several cooperative organs and prefectures, those were Fisheries Research Agency, Meteorological Agency, Hydrographic Department and Fisheries Experiment Stations, etc. TNFRI published temperature maps and schematic hydrographic maps using World Wide Web (http://www.myg.affrc.go.jp/kaiyo/temp/temp.html).

OCEANOGRAPHIC CONDITIONS IN THE WESTERN BLOCK

The upper panel in Fig. 2 shows the Temperature-Salinity diagrams in the western block. Light blue dots show the data in cold waters defined by 100 m temperature which is over 5 and less than 10 . Green dots show the data in warm water spread from the Kuroshio Extension defined by 100 m temperature over 10 and 200 m temperature less than 14 . There is no typical Kuroshio water characterized by high salinity profile around 34.5psu and Oyashio water characterized by cold profile less than 5 shown blue dots in lower panel in Fig. 2. It is appear that water masses in the western block have characteristics of the mixed water of the Oyashio and the Kuroshio.

Figure 3 shows temperature maps at the depth of 100 m and 200 m. The warm water spread from the Kuroshio appears in the northwestern part of the block and cold water less than 10 was distributed in the southeastern part of this block. Figure 5 shows warm water (yellow area in Fig. 5) was spreading from offshore area to the northern part of the block and cold water (green area in Fig. 5) was spreading from the Tohoku coast to southern part of the block. Figure 5 also shows the Kuroshio warm-core ring around 37° 50'N, 144° 50'E, and Fig. 3 shows a temperature front in the northwestern part of the survey area. So, St. 3 was in the warm-core ring.

Figure 4 shows the vertical sections of temperature along 36° N, 37° N and 38° N. The warm water, warmer than 20 , spread at the surface layer upper 20 m depth, and seasonal thermocline lies around the depth of 50 m. The warm water defined by warmer than 10 is observed above 100 m depth in the southern sections but this warm water is deepened in the northern area to the depth of 200 m. On the 38° N section, the thermocline rises eastward, it is caused by a temperature front of the Kuroshio warm-core ring shown in Fig. 5.

These figure shows that northern part of the western block was in the warm water spread from the Kuroshio and the southern part of this block was characterized by the warm water and cold water. The northwestern station of this block was in the Kuroshio warm-core ring.

OCEANOGRAPHIC CONDITIONS IN THE EASTERN BLOCK

Figure 2 shows the Temperature-Salinity diagrams using CTD station data. Water masses in the eastern block (lower panel in Fig. 2) have characteristics of cold low-salinity water (the subarctic water in the lower part of Fig. 2). Some of these stations show warm surface water above the subarctic water (left upper part of Fig. 2).

Figure 6 shows the 100 m depth temperature map observed by *R/V Shunyo Maru*. The cold water less than 5 was distributed in a northern half of the block. The Subarctic Front (defined by 4 isotherm) was observed around 43° N to 43-30° N in Fig. 6. In 100 m depth salinity map (Fig. 7), a salinity front around 34.0psu is shown in the southern part of this survey area, but is not shown in 200 m depth salinity map.

Figure 8 shows the vertical sections of temperature and salinity along the cruise track of *R/V Shunyo Maru* between 157° E-159° E, which is a zigzag line. The Subarctic Water colder than 4 is observed in the northern area, north of 43° N, and 4 isotherm lies vertically from 50 m depth to 500 m depth around St. 12. A surface low salinity water less than 33.5psu is also observed in the northern area, north of St. 12, The high salinity water, grater than 34psu, is shown at a surface layer in the southern area, south of St. 3. Around St. 3, isotherms between 5 and 10 lie vertically and show an existence of a temperature front. Because the salinity front around 34psu is limited in the surface layer, upper 100 m depth, it is not a typical Subarctic Boundary, but it is a part of the Subarctic Boundary.

Figure 5 shows the schematic hydrographic map in July 2005, presented by TNFRI. The cold water, colder than 5 lies around 42 ° N, 152 ° E and 43 ° 30'N, 158 ° 30'E. The eastern block is a northeastern part of Fig. 5 and the stations were denoted by light blue stars and blue circles, which denote stations in the cold area and the Oyashio area,

respectively. Northern part of our stations, north of 43° 30'N, is blue circles, and southern part of our stations shows light blue stars, that is coincide with the schematic hydrographic map shown in Fig. 5.

These figure shows that the eastern block is in and around the Transition Domain which is between the Subarctic Front and the Subarctic Boundary.

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

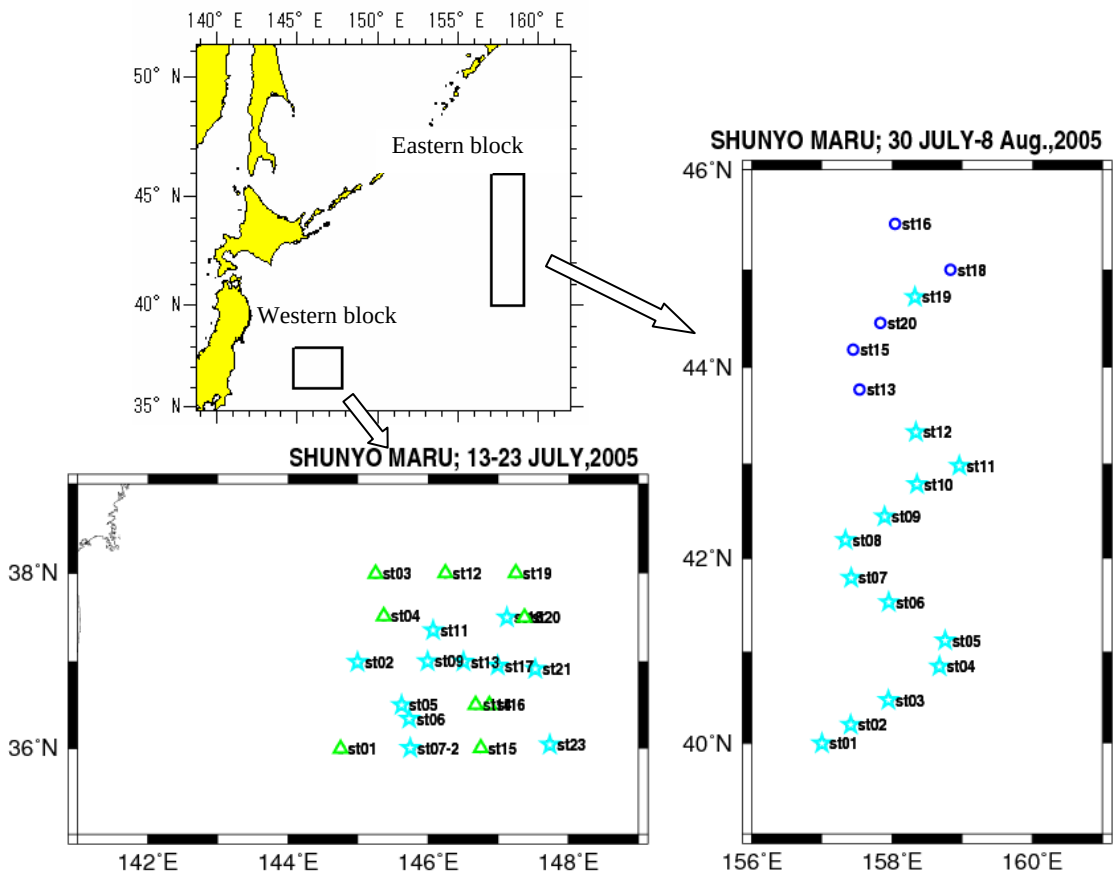

Fig. 1. Station map observed by *R/V Shunyo Maru* in 13－23 July in the western block (left panel) and 30 July – 8 August in the eastern block (right panel) 2005. Green triangles, light blue stars and blue circles denote CTD stations observed by *R/V Shunyo Maru* in the warm area, cold area and the Oyashio area, respectively. Green triangles, light blue stars and blue circles denote CTD stations in the warm area (100 m temperature was over 10 and 200 m temperature was less than 14), the cold area (100 m temperature was over 5 and less than 10) and the Oyashio area (100 m temperature was less than 5), respectively.

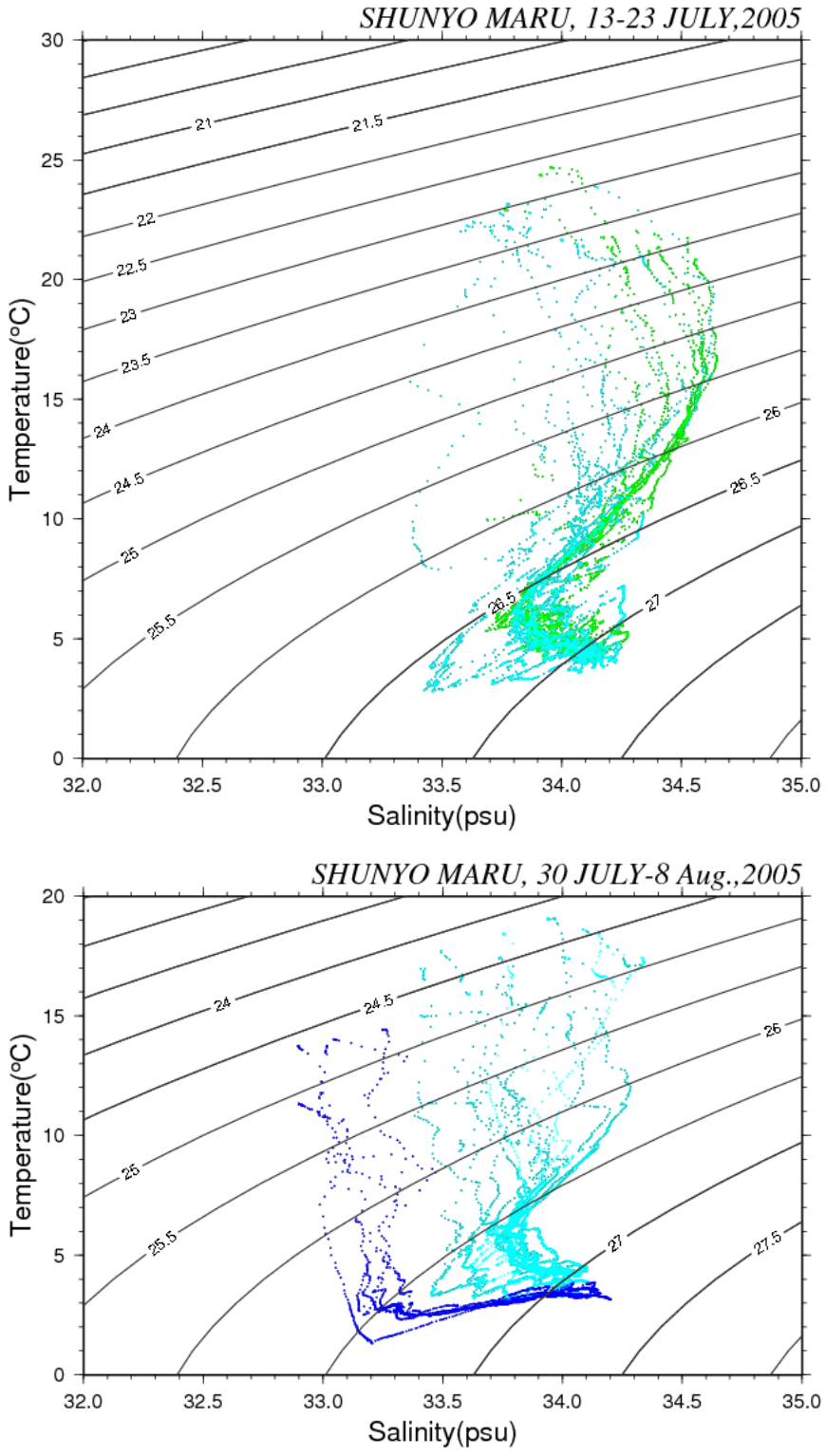

Fig. 2. Temperature-Salinity diagrams using CTD station data observed by *R/V Shunyo Maru* in 13－23 July in the western block (upper panel) and 30 July – 8 August in the eastern block (lower panel) 2005. Each thin line in this figure denotes a density line of sigma-t.

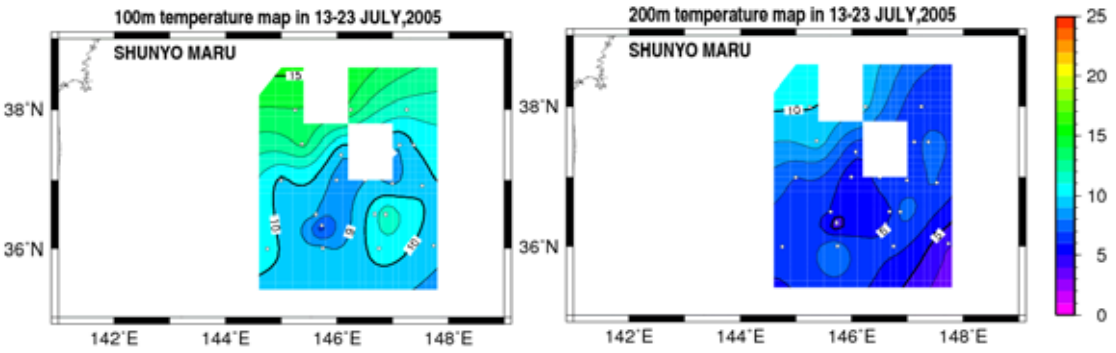

Fig. 3. 100 m (left panel) and 200 m (right panel) temperature maps observed by *R/V Shunyo Maru* in 13 – 23 July 2005 in the western block.

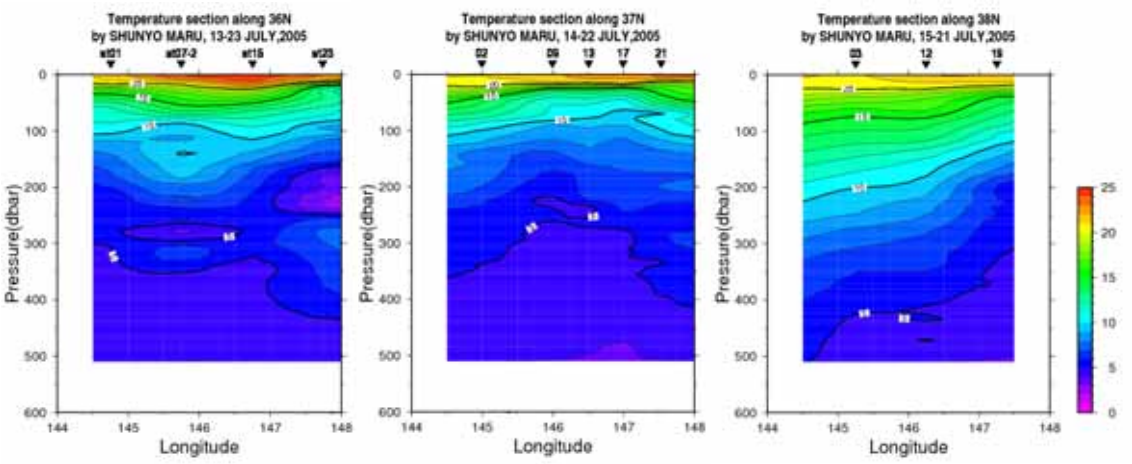

Fig. 4. Vertical sections of temperature along 36 ° N (left panel), 37 ° N (middle panel) and 38 ° N (right panel) observed by *R/V Shunyo Maru* in 13– 23 August 2005 in the western block.

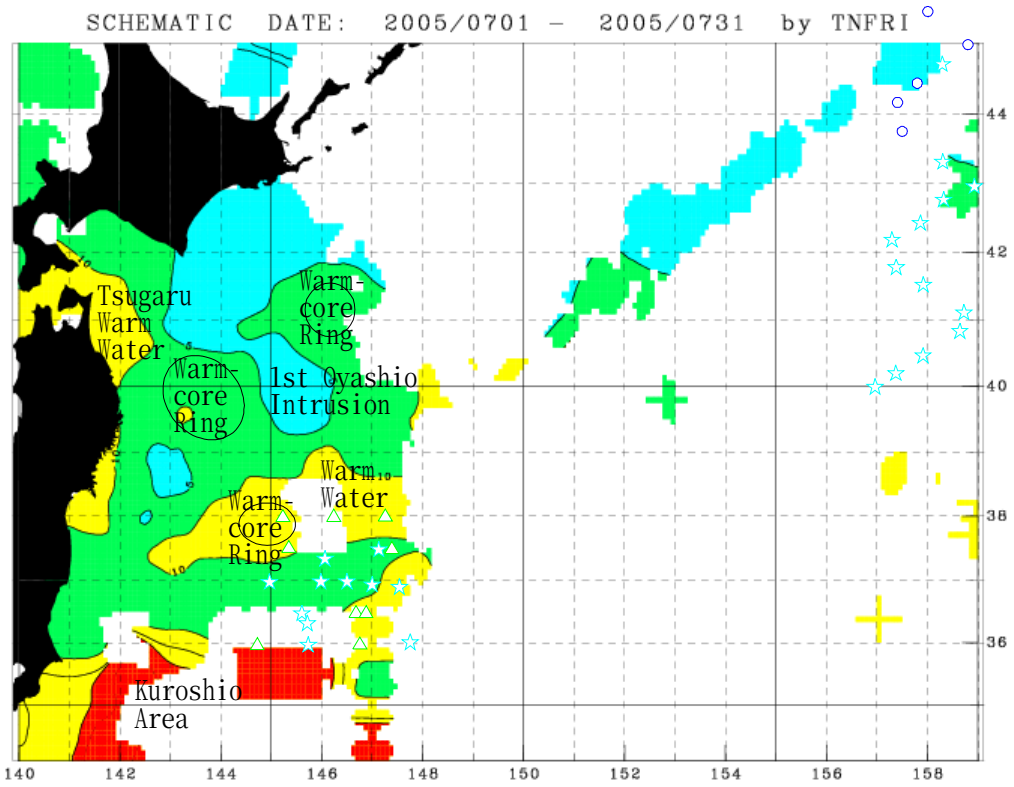

Fig. 5. Schematic hydrographic map in Tohoku area, northwestern Pacific, in July 2005 (presented by Tohoku National Fisheries Research Institute) with station map observed by *R/V Shunyo Maru*. Blue, green, yellow and red area show distributions of the Oyashio, the cold water, the warm water spread from the Kuroshio Extension and the Kuroshio Extension, respectively. Green area shows distribution of cold water between the Oyashio and warm water spread from the Kuroshio Extension. Green triangles, light blue stars and blue circles denote CTD stations observed by *R/V Shunyo Maru* in the warm area, cold area and the Oyashio area, respectively.

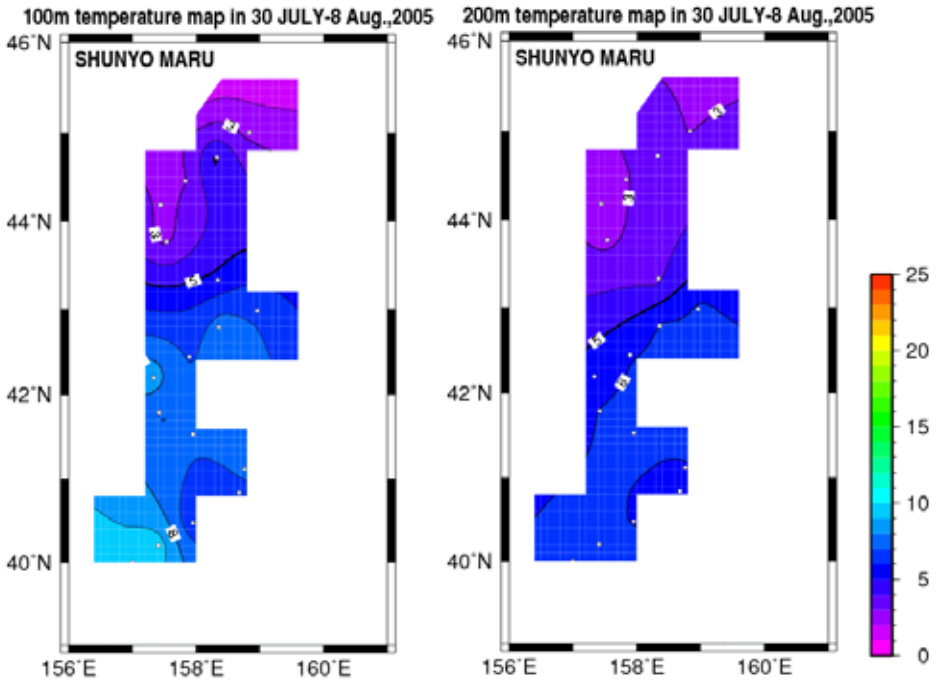

Fig.6. 100 m (left panel) and 200 m (right panel) temperature maps observed by *R/V Shunyo Maru* in 30 July – 8 August 2005 in the eastern block.

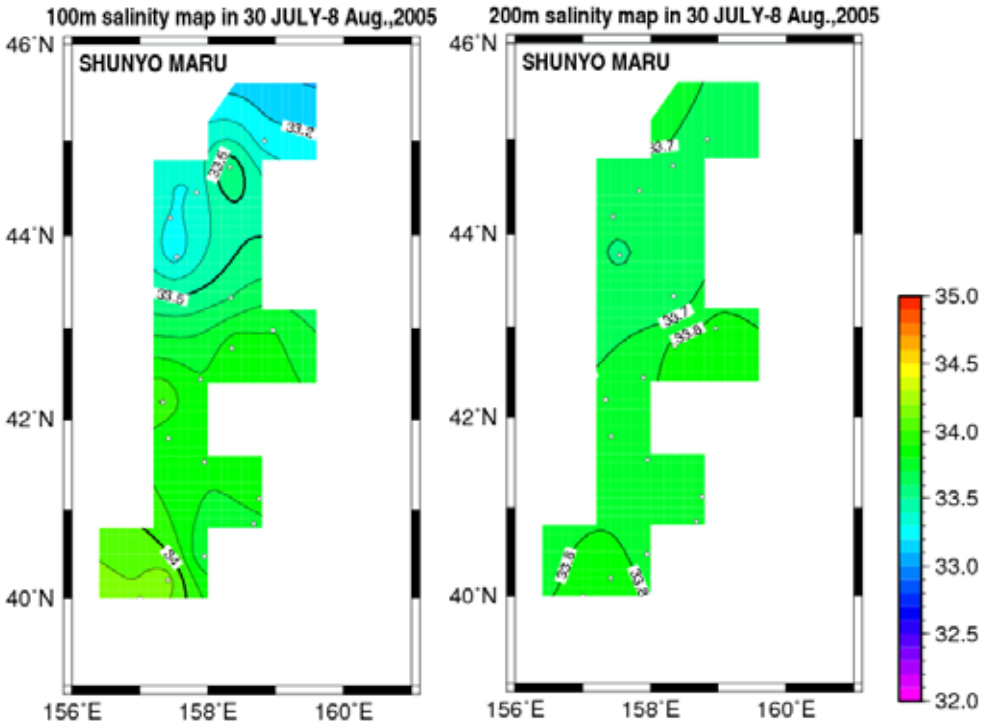

Fig.7. 100 m (left panel) and 200 m (right panel) salinity maps observed by *R/V Shunyo Maru* in 30 July – 8 August 2005 in the eastern block.

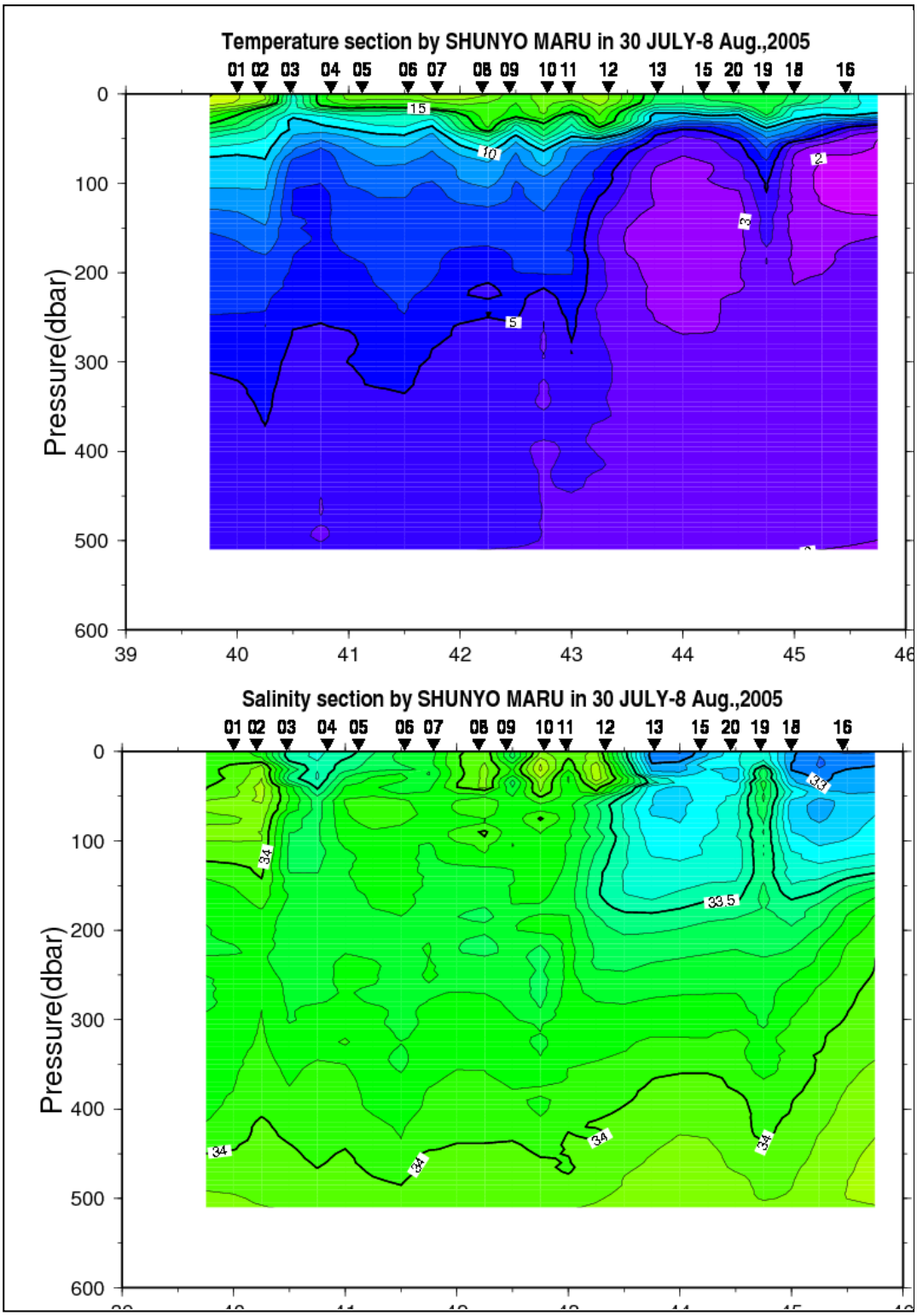

Fig. 8. Vertical sections of temperature (upper panel) and salinity (lower panel) along the cruise track between 157° E-159° E observed by *R/V Shunyo Maru* in 30 July – 8 August 2005 in the eastern block.