Cruise Report of the Japanese Whale Research Program under Special Permit in the western North Pacific -Phase II (JARPN II) in 2003 (part I) - Offshore component –

TAMURA, T. [1)], FUJISE, Y. [1)], BANDO, T. [1)], YASUNAGA, G. [1)], KONISHI, K. [1)], KIWADA, H. [1)], ISODA, T. [1)], ITOH, S. [2)], MACHIDA, S. [1)], TSUNEKAWA, M. [1)], KONAGAI, T. [1)], TAKAMATSU, T. [1)], OHSHIMA, T. [1)], HONJO, K. [1)], MATSUOKA, T. [3)], ZHARIKOV, K.A. [4)], AN, YONG ROCK [5)], TOHYAMA D. [6)] AND KAWAHARA, S. [7)]

1) The Institute of Cetacean Research, 4-5, Toyomi-cho, Chuo-ku, Tokyo, 104-0055, Japan,
2) Hokkaido University, Faculty of Fisheries, 3-1-1, Minato-cho, Hakodate, 041-8611, Japan,
3) Obihiro University, Agriculture and Veterinary Medicine, 2-11, Inada-cho, Obihiro, 080-8555, Japan,
4) Marine Mammal Lab, VNIRO –Russian Federal Research Institute of Fisheries & Oceanography,17, V. Krasnoselskaya, Moscow, 107140, RUSSIA,
5) National Fisheries Research & Development, Cetacean Research Center, 408-1, Shirang-ri, Gijang-up, Gijang-gun, Busan, 619-902, Republic of Korea,
6) Kyodo Senpaku Co. Ltd., 4-5, Toyomi-cho, Chuo-ku, Tokyo, 104-0055, Japan,
7) National Research Institute of Far Seas Fisheries, 5-7-1, Shizuoka, 424-8633, Japan.

Contact e-mail: tamura@cetacean.jp

ABSTRACT

The full-scale survey of the second phase of the Japanese Whale Research Program under Special Permit in the North Pacific (JARPNII) started in 2002. The objectives of the full-scale research are (1) to study on feeding ecology and ecosystem studies, involving studies of prey consumption by cetaceans, prey preferences of cetaceans and ecosystem modeling, (2) to monitor environmental pollutants, and (3) to study on stock structure. Target species are common minke whale *Balaenoptera acutorostrata*, Bryde's whale *B. edeni*, sei whale *B. borealis* and sperm whale *Physeter macrocephalus*. The second cruise of the JARPNII survey was conducted from 17 May to 8 August 2003 in sub-areas 7, 8 and 9 of the western North Pacific. In the survey a total of seven research vessels was used: one trawl survey vessel equipped with scientific echo sounder (TSV), two dedicated sighting vessels (SVs), three sighting/sampling vessels (SSVs) and one research base vessel. A total of 11,903.0n.miles was surveyed for whale searching in a period of 84 days. During that period 125 common minke, 193 Bryde's, 236 sei and 935 sperm whales were sighted by the SSVs. A total of 100 common minke, 50 Bryde's, 50 sei and 10 sperm whales was sampled by the SSVs. The cooperative survey on ecosystem research with the participation of six vessels was conducted in a part of sub-area 8 and 9 from 10 to 22 June and in a part of sub-area 7 from 26 June to 7 July (excluding 30 June). All whales sampled were examined on board the research base vessel. Major prey species of common minke whales were Japanese anchovy (*Engraulis japonicus*) and Pacific saury (*Cololabis saira*). Small-sized Japanese anchovy, including larva, was found in the stomach of Bryde's whales. Major prey species of sei whales were copepods, krill, Pacific saury and Japanese anchovy. Dominant preys in the stomach of ten sperm whales were different kinds of squids, which inhabit in the mid- and deep-waters.

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

INTRODUCTION

The second phase of Japanese Whale Research Program under Special Permit in the North Pacific (JARPNII) planed in 2000 and 2001 as a two-year feasibility study (Government of Japan, 2000). The feasibility study was conducted in 2000 and 2001 and results were presented to the 2002 SC meeting (Government of Japan, 2002a). Based on the results of the feasibility study, Japan presented the research plan for the full-scale JARPN II (Government of Japan, 2002b) to the 2002 SC meeting.

The full-scale study aimed i) to study 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 to be covered by the *Nisshin Maru* research unit and the 'coastal' survey to be 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).

The research area was set in sub-areas 7, 8 and 9 and the target species and sample sizes were set as follows: 150 common minke whales (100 to be sampled by the offshore survey and 50 by the coastal survey); 50 Bryde's whales *B. edeni* (offshore survey); 50 sei whales *B. borealis* (offshore survey) and 10 sperm whales *Physeter macrocephalus* (offshore survey) (Government of Japan, 2002b).

In this paper, we present an outline of offshore component in the second full scale survey of the JARPNII survey which was conducted from 17 May to 8 August 2003.

RESEARCH OUTLINE

Research area

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

Sub-area 7: Five small blocks (7N, 7MI, 7MO, 7SI and 7SO) were determined for several type of oceanographic structure using satellite information on water temperature.

Sub-area 8, 9: Four small blocks (8N, 8S, 9N and 9S) were divided at 40ºN.

Whale survey was normally conducted in sub-areas 7, 8 and 9.

In the case of the cooperative survey on ecosystem research, a special block was predetermined in the sub-areas. In this season, two special blocks (SBs) were settled in offshore area (A) and coastal area (B) as shown in Fig. 1. We conducted the whale survey and the prey survey such as trawl sampling and echo sounder survey in the SBs concurrently.

Research vessels

Seven research vessels were used.

The research base vessel *Nisshin Maru* (NM: 7,575GT) commanded the research and was engaged in the biological examination of whale samples and 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) and *Shonan Maru* (SM: 712GT) were engaged as dedicated sighting vessels (SVs). The *Shunyo Maru* (SYO: 887GT) was engaged as a trawl survey and an echo sounder survey vessel. This vessel also conducted the trawl net and MOCNESS net sampling. Furthermore, this vessel conducted the oceanographic observations using CTD.

Research type

In this survey, three main components (the whale survey, dedicated sighting survey and the cooperative survey with prey survey) were consisted as follows:

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 an area where the number of common minke, Bryde's and sei whales was expected to be large.

Research period:

First period: Between 17 May and 9 June.

Second period: Between 23 and 25 June.

Third period: Between 29 and 30 June.

Forth period: Between 8 July and 8 August (Table 1).

Dedicating Sighting survey

Vessels: Two research vessels (SM and KS2)

Research area: Sub-areas 7, 8 and 9

Research period (SM):

First period: Between 30 April and 18 May for sub-area 8.

Research period (KS2):

First period: Between 14 May and 11 June for sub-area 7.

Second period: Between 16 June and 7 July for sub-areas 8 and 9.

Third period: Between 14 July and 5 September for sub-area 9 (Table 1).

Cooperative survey on the prey species and whale sampling
Vessels: Six research vessels (NM, YS1, YS2, K01, KS2 and SYO)

Research area: In the cooperative survey on ecosystem research, two special blocks (A and B) were settled.

Research periods:

First period (A) : Between 10 and 22 June for the A (offshore-block).

Second period (B): Between 26 June and 7 July for the B (excluding 30 June) (Table 1).

Cruise track line for the whale survey
Track line and allocation of vessels was 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). 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 (Fig. 2).

Furthermore, a 'special monitoring survey' (SMS) was conducted in an area where the abundance of common minke whales, Bryde's and sei whales was expected to be large. 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 (Figs 3 and 4).

Allocation of the prey survey vessel in the cooperative survey was determined in the following manner. The cruise track 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.The whale research fleet surveyed in the following manner: the research course consisted of one main track and two parallel tracks established six n.miles apart from both sides. Apart from these sampling activities, an independent track line for dedicated sighting survey, which is shown in Fig. 3, was determined in the research area.

Sighting surveys
Sighting procedure 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). 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 critical weather conditions 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 made mainly on sightings of common minke, Bryde's, sei and sperm whales or on schools that looked like those whales. Furthermore it was planned that closing was made on sightings of large whales, such as blue, humpback, right and fin whales. In these cases, closing was made 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
Sampling activities were conducted with the aim to take 100 common minke whales, 50 Bryde's whales 50 sei whales and 10 sperm whales. Most of these 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 to 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. As in a previous JARPN survey the sampling was conducted in cooperation with three sighting/sampling vessels in this survey (Fujise *et al.*, 1996, 2000).

Prey species survey

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 at Sendai Bay (30 June 2003) 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 routine and acoustic target identification stations. Target 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 60-100m (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. Target net samples were conducted to identify the species compositions of biological backscattering detected by the quantitative echo sounder. The depth layer was sampled at target net stations; 0-300m.

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 blue, fin, humpback, right, Bryde's, common minke, sei and sperm whales.
3. Photographic records of natural marks in blue, humpback and right whales.
4. Preliminary examination on attachment of data logger for 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 (SM and KS2), the following experiments and observations were conducted:

1. Sighting distance and angle experiment to examine the precision of sighting data.
2. Biopsy sampling on blue, fin, humpback, right, Bryde's, common minke, sei, grey and sperm whales.
3. Photographic records of natural marks in blue, humpback, grey and right whales.
4. Feeding behaviour patterns of large whales.
5. Oceanographic observations using EPCS (Electric particle counting and sizing system)(KS2).

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

1. Feasibility study to 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) during the 2003 JARPN II survey is shown in Figs 3 and 4. The total searching distance for SSVs and SV were 12,122.8 n.miles and 6,706.8 n.miles, respectively (Table 2).

In the cooperative survey on ecosystem research, the survey was conducted from June to July with two periods; first from 10 to 22 June, and second from 26 June to 7 July (except 30 June: 11 days). Under the cooperative survey, searching distance for SSVs was 3,024.6 n.miles consisting of 1,716.2 n.miles and 1,308.4 n.miles for first (SB-A) and second periods (SB-B) (Table 2).

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

Sighting and sampling vessels (SSVs)

During the research cruise, 122 schools (125 individuals) of common minke whales were sighted, consisting of 74 schools (75 individuals) of primary and 48 schools (50 individuals) of secondary sightings. For Bryde's whale, 148 schools (193 individuals) were sighted, consisting of 102 schools (129 individuals) of primary sightings and 46 schools (64 individuals) of secondary sightings. Sei whale, 145 schools (236 individuals) were sighted, consisting of 99 schools (163 individuals) of primary sightings and 46 schools (73 individuals) of secondary sightings. For sperm whale, 325 schools (935 individuals) were made, consisting of 212 schools (626 individuals) of primary sightings and 113 schools (309 individuals) of secondary sightings (Table 3).

Fig 5 shows the distribution of common minke whales sighted by the SSVs in the sub-areas 7, 8 and 9. Fig.6 shows the distribution of Bryde's and sei whales. Common minke whales were usually sighted in northern part of sub-areas 7, 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. 7 shows the distribution of sperm whale sightings in sub-area 7, 8 and 9. This species was widely distributed in sub-areas 7, 8 and 9.

Dedicated sighting vessel (SV)
SM

During the research cruise, 4 schools (4 individuals) of common minke whales were sighted of primary sightings. For sei whale, 2 schools (3 individuals) were sighted as primary sightings. For sperm whale, 36 schools (72 individuals) were sighted, consisting of 35 schools (71 individuals) of primary sightings and 1 school (1 individuals) of secondary sightings (Table 4-1).

KS2

During the research cruise, 79 schools (87 individuals) of common minke whales were sighted, consisting of 68 schools (76 individuals) of primary and 11 schools (11 individuals) of secondary sightings. For sei whale, 47 schools (79 individuals) were sighted, consisting of 35 schools (58 individuals) of primary sightings and 12 schools (21 individuals) of secondary sightings. For sperm whale, 185 schools (315 individuals) were sighted, consisting of 168 schools (296 individuals) of primary sightings and 17 schools (19 individuals) of secondary sightings (Table 4-2).

Sightings of other large cetacean species

Sighting and sampling vessels (SSVs)

Table 3 also shows the number of sightings for other cetacean species made by the SSVs. Large baleen whales such as blue (11 schs./13 inds.), fin (29 schs./36 inds.) and right whales (2 schs./3 inds.) were found in the sub-areas 7, 8 and 9 (Fig. 8).

Dedicated sighting vessel (SV)
SM

Large baleen whales such as fin (1 sch. /2 inds.), humpback whales (3 schs. /6 inds.) and right whale (1 sch. /1 ind.), were found in the sub-areas 7, 8 and 9 (Table 4-1).

KS2

Large baleen whales such as blue (39 schs. /51 inds.), fin (56 schs. /101 inds.) and humpback whales (18 schs. /31 inds.) were found in the sub-areas 7, 8 and 9 (Table 4-2).

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

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 were sampled, 83 during the whale survey component and 17 during the cooperative survey component. The whale samples consisted of 93 males and 7 females. A total of 50 Bryde's whales were sampled, 31 during the whale survey component and 19 during the cooperative survey component. The whale samples consisted of 19 males and 31 females. A total of 50 sei whales were sampled, 30 during the whale survey component and 20 during the cooperative survey component. These 50 whales consisted of 23 males and 27 females. A total of ten sperm whales were sampled, 6 during the whale survey component and 4 during the cooperative survey component. These ten animals consisted of one male and nine females.

Geographical distribution of common minke, Bryde's and sei whale samples is shown in Figs 9-11 and 13-15 based on the sighting positions. Distribution of sightings and sampling locations almost coincided. Figs. 12 and 16 show the distribution of sperm whale samples based on the sighting positions.

Causes of failure to collect the targeted whale were as follows. For common minke whales, a total of 12 individuals were not sampled, because quick mobility (5), long diving (5) and a sudden turn for the worse of sea condition (1). One common minke whale was missed by technical reason (struck but lost). For the Bryde's whales, three individuals were not sampled because of quick mobility (1) and long diving (2). In the case of sei whale, one individual was not sampled, because quick mobility (1).

Biological research for minke, Bryde's and sperm whales sampled

Table 6 summarizes the biological data and samples obtained from the common minke, Bryde's, sei and sperm whales sampled. A total of 59 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 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 7.21 m and 7.28 m for males and females, respectively. Mean body length of males and females tended to be higher in the sub-area 9 than those in sub-areas 7 and 8. For Bryde's whales, the statistics of body length are shown in Table 11. Mean body length of Bryde's whales is 11.64 m and 12.09 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 13.29 m and 14.09 m for males and females, respectively. For sperm whale, the information of body length and weight are also shown in Table 13. Relationship between body length and body weight of sei, Bryde's and common minke whales collected are shown in Fig. 18.

Prey species of common minke, Bryde's, sei and sperm whale

List of prey species found in the stomach contents of common minke, Bryde's, and sei whales is shown in Table 14. Common minke whale fed on five prey species consisting of one krill and four fish species. They fed mainly on Japanese anchovy and Pacific saury. Bryde's whale fed on three prey species consisting of one krill and two fish species. They fed mainly on krill and Japanese anchovy. Sei whale fed on seven prey species consisting of some copepods, one krill and three fish species. They fed mainly on copepods and Japanese anchovy. Sperm whale fed mainly on deep-sea squids.

Experiments, prey surveys and oceanographic surveys

Biopsy sampling trial for blue, humpback, right, fin, Bryde's and sei whales

Table 15 shows the result of biopsy skin sampling for blue, humpback, right, fin, Bryde's, sei and sperm whales. A total of 10 blue, 2 humpback, 1 right, 2 fin, 22 Bryde's, 2 sei and 27 sperm whales were targeted for biopsy sampling by the

SSVs. As a result, two blue, one humpback, one right, four Bryde's and one fin whale's biopsy skin samples were collected, respectively.

Natural marks (photo ID) for blue, humpback and right whales
Table 16 shows the result of recording using photograph for natural marks of blue, humpback, and right whales. A total of 8 blue, 4 humpback and 3 right whales were targeted by the SSVs. A total of 7, 4 and 3 trials were conducted for blue, humpback and right whales, respectively. In future, utility of the photographs will be examined.

Feeding behaviour for large baleen whales
The SV and SSVs had a plan to conduct recording 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 trackline. Target trawls were towed at 3 stations. Surface routine trawls were towed at 16 stations. Nighttime trawls were towed at 2 stations. MOCNESS was towed at 13 stations. The details of the prey species survey conducted by SYO are described in Appendix 1 of this document.

CTD and EPCS
The SV (KS2) conducted an experiment to measure the vertical thermal and salinity profiles using CTD. A total of 90 points was conducted. The EPCS recordings operated for 115 days during the research cruise. Details will be reported in future. CTD casts were made at 29 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. Two CTD casts were made down to 2,500m and 4,000m to collect water samples for the salinity compensation. Salinity compensation for CTD data and analysis of oceanographic conditions were made at the laboratory. The details of the oceanographic observations are reported in Appendix 1 of this paper.

By-products of whales
After biological measurements and sampling were completed, all the whales were processed according to the International Convention for the regulation of whaling, Article VIII. Total production including red meat and blubber from of the 100 sampled common minke, 50 Bryde's, 50 sei and 10 sperm whales were 286 tons, 415 tons, 651 tons and 34 tons, respectively.

DISCUSSIONS

1. Distribution and food habit of Bryde's whale
Bryde's whales were one of focused whales species of the research during JARPNII surveys since 2000. During the JARPNII surveys of 2000, 2001 and 2002, different distribution patterns of Bryde's whales have been observed. In the feasibility studies of 2000 and 2001, Bryde's whales were observed in the north-eastern part of sub-area 7 (block 7MO) in relatively high concentration. In that area, feeding behaviour of Bryde's whales was observed frequently. Operation of skipjack tuna fisheries was also observed in that area. Since Japanese anchovy were found in the stomach of Bryde's whales sampled, we postulated a relationship between Bryde's whale and skipjack tuna. This is because the prey of skipjack tuna is also Japanese anchovy. In contrast, few Bryde's whales were observed in this block in 2002. Also few operations of skipjack tuna fisheries were observed. A possible factor affecting Bryde's whale distribution is the rapid changes of water temperature. From late July to mid August 2002, relatively large typhoons passed on the research area. The surface water temperature decreased about two to five degrees than previous years. Future research should examine relationship between the whale distributions and oceanographic conditions such as water temperatures, water mass balance between warm and cold water masses. In 2003, relatively high density of Bryde's whales was observed in the southern part of sub-areas 8 and 9. There are seasonal changes of their prey species from krill to Japanese anchovy. In May and June, they fed mainly on krill. On the other hand, they fed mainly on Japanese anchovy after July.

2. Distribution and food habit of sei whale
In this full-scale JARPNII, sei whale is newly included as one of whale species focused for the research objective. Sample size of the sei whales in this program was also calculated from information on food habitat in the past studies, because no information is available for recent years. In this survey, the information on food habitat was obtained from 50 individuals collected in the entire research area. They fed on the various prey species such as copepod, amphipod,

krill and three species of fish. However, the survey in the last year did not covered fully the feeding season, especially lately feeding season (August and September).

3. Condition of concurrent survey

As same as previous JARPNII feasibility studies, this second full-scale research plan consisted of two survey groups. One is whales survey group (NM, YS1, YS2, and K01), and the other is prey survey group (SYO). In this season, the cooperative survey was conducted on two different survey blocks (SBs). The A in the first period was settled in the offshore area (around 157E, Fig. 1), and the B in the second period was in the 7SO and 7MO stratum. A total of 15 common minke and 15 sei whale samples were collected by the SSVs in this period. Information on the prey species distribution was also collected by SYO during this period (See Appendix 1). In the second period, a total of 2 common minke, 19 Bryde's, 5 sei and 4 sperm whale samples were collected by the SSVs. Information on the prey species distribution was also collected by SYO during this period.

4. Participation by foreign scientists

In 2003 JARPNII, A total of two foreign scientists participated. They actually learned our sighting and sampling survey on board. We cooperated and conducted 2003 JARPNII. It is expected that these international collaboration will continue in future.

ACKNOWLEDGMENTS

The authors are greatly indebted to Dr. Hiroshi Hatanaka and Dr. Seiji Ohsumi, The Institute of Cetacean Research (ICR), Dr. Hidehiro Kato, National Research Institute of Far Seas Fisheries (NRIFSF), and Mr. Joji Morishita, the Fisheries Agency of Japan for their guidance in the design and implementation of the research. We thank to all crew of the research vessels (NM, YS1, YS2, K01, KS2, SM and SYO) and the staff of the ICR, NRIFSF, and Kyodo-Senpaku Co. Ltd. We also thank to Mr. Koji Matsuoka for data preparation. The present research project (JARPNII) was funded under the subsidy of the Ministry of Agriculture, Forestry and Fisheries, Government of Japan.

REFERENCES

Fujise, Y., Kishiro, T., Zenitani, R., Matsuoka, K., Kawasaki, M. and Shimamoto, K. 1995. Cruise report of the Japanese whale research program under a special permit for North Pacific minke whales in 1994. Paper SC/47/NP3 presented to the IWC Scientific Committee, May 1995 (unpublished). 29pp.

Fujise, Y., Iwasaki, T., Zenitani, R., Araki, J., Matsuoka, K., Tamura, T., Aono, S., Yoshida, T., Hidaka, H., Nibe, T. and Tohyama, D. 1996. Cruise report of the Japanese whale research program under a special permit for North Pacific minke whales in 1995 with the results of a preliminary analysis of data collected. Paper SC/48/Np13 presented to the IWC Scientific Committee, June 1996 (unpublished). 39pp.

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

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

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

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

Fujise, Y., Tamura, T., Bando, T., Yasunaga, G., Konishi, K., Murase, H., Yoshida, T., Itoh, S. Ogawa, R., Oka, T., Sasaki, T., Fukutome, K., Isoda, T., Birukawa, N., Horii, N., Zharikov, K.A., Park, K.J., Tohyama, D. and Kawahara, S. 2003. Cruise report of the Japanese whale research program under special permit in the western North Pacific – Phase II (JARPNII) in 2002 (Part I). Paper SC/55/O7 presented to the IWC Scientific Committee, May 2003 (unpublished). 41pp.

Government of Japan. 2000. Research Plan for Cetacean Studies in the Western North Pacific under Special Permit (JARPN II) (Feasibility Study Plan for 2000 and 2001). Paper SC/52/01 presented to the IWC Scientific meeting, 68pp.

Government of Japan. 2002a. Report of the 2000 and 2001 feasibility study of the Japanese whale research program under special permit in the western North Pacific-phase II (JARPN II). Paper SC/54/O17 presented to the IWC Scientific Committee, May 2002 (unpublished). 202pp.

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

Ishikawa, H., Yuzu, S., Shimamoto, K., Bando, T., Ohshima, K., Kasai, H., Kinoshita, T., Mizushima, Y., Iwakami, H., Nibe, T., Hosoyama, T., Kuramochi, T., Numano, K. and Miyamoto, M. 1997. Cruise report of the Japanese Whale Research Program under a Special Permit in the North Pacific (JARPN) in 1997. Paper SC/49/NP9 presented to the IWC Scientific Committee, September 1997 (unpublished). 28pp.

Kato, H., Hiroyama, H., Fujise, Y. and Ono, K. 1989. Preliminary report of the 1987/88 Japanese feasibility study of the special permit proposal for Southern Hemisphere minke whales. Report of the International Whaling Commission, 39: 235-248.

Shimada, H. 1999. Report of western North Pacific Bryde's whale sighting survey in summer, 1998. Paper SC/51/RMP4 presented to the IWC Scientific Committee, May 1999 (unpublished). 11pp.

Shimada, H. 2000. Report of sighting survey on western North Pacific Bryde's whale conducted in August-September 1999. Paper SC/52/RMP9 presented to the IWC Scientific Committee, June 2000 (unpublished). 13pp+Appdx..

Tamura, T. and Ohsumi, S. 1999. *Estimation of total food consumption by cetaceans in the world's oceans. The Institute of Cetacean Research*: 16pp.

Zenitani, R., Fujise, Y., Matsuoka, K., Tamura, T., Bando, T., Ichihashi, H., Shimokawa, T., Krasnenko, A.S., Taguchi F., Kinoshita, T., Mori, M., Watanabe, M., Ichinomiya, D., Nakamura, M., Sakai, K., Matsuzaka, K., Kamei, H. and Tohyama, D. 1999. Cruise report of the Japanese Whale Research Program under a Special Permit in the North Pacific in 1998. Paper SC/51/RMP7 presented to the IWC Scientific Committee, May 1999 (unpublished). 20pp.

Table 1. Outline of 2003 JARPN II survey

Research	Research periods	Days	Sub-area	Research ships and remark
・*Whale sampling survey*	**May 17-Aug. 8, 2003**	**84**	**7,8,9**	
Whale survey (first period)	May 17-June 9, 2003	24	7, 8	NM, YS1, YS2 and K01
Cooperative survey (A: first period)	June 10-22, 2003	13	8+9	NM, YS1, YS2, K01 and SHU
Whale survey (second period)	June 23-25, 2003	3	8	NM, YS1and YS2
Cooperative survey (B: second period)	June 26-29, July 1-7, 2003	10.5	7	NM, YS1, YS2, K01 and SHU
Whale survey (third period)	June 29-30, July 8-Aug. 8, 2003	33.5	7, 8, 9	NM, YS1, YS2 and K01
・*Sighting survey*	**June 23-26, 2003**	**4**	**7**	**Special (K01)**
・*Sighting survey*	**April 30 - May 18, 2003**	**19**	**8**	**SM**
・*Sighting survey*	**May 14-Sept. 5, 2003**	**115**	**7,8,9**	**KS2**

Table 2. Searching distances made by the three sighting/sampling vessels (YS2, YS1 and K01) and sighting vessels (SM and KS2) in the 2003 JARPN II

Research	Sub-area	Period	Searching distance (n.miles)			
			NSC	ASP	NSS	Combined
SSVs	**Combined**	**May 17-Aug. 8, 2003**	**9,329.0**	**570.8**	**2,003.2**	**11,903.0**
Whale survey (first period)	7, 8	May 17-June 9, 2003	3,519.5	304.1	374.1	4,197.7
Cooperative survey (A: First period)	8+9	June 10-22, 2003	1,412.2	30.8	273.2	1,716.2
Whale survey (second period)	8	June 23-25, 2003	291.3	0.0	21.5	312.8
Cooperative survey (B: Second period)	7	June 26-29, July 1-7, 2003	1,016.6	187.9	103.9	1,308.4
Whale survey (third period)	7, 8, 9	June 29-30, July 8-Aug. 21, 2003	3,089.4	48.0	1,230.5	4,367.9
SV (K01)	7	June 23-26, 2003	0.0	219.8	0.0	219.8
SV (SM)	8	April 30 - May 18, 2003	0.0	1,044.5	0.0	1,044.5
SV (KS2)	7, 8, 9	May 14-Sept. 5, 2003	0.0	5,662.3	0.0	5,662.3

Table 3. List of cetacean species and number of sightings (no. schools/no. individuals) made by three sighting/sampling vessels in the 2003 JARPN II (Total area: May 17 – August 8).

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	61	62	38	39	9	9	1	1	4	4	0	0	9	10	74	75	48	50	122	125
Like minke whale	1	1	6	6	4	4	3	3	0	0	1	1	2	2	5	5	12	12	17	17
Blue whale	6	8	1	1	1	1	0	0	1	1	0	0	2	2	8	10	3	3	11	13
Fin whale	22	27	6	8	1	1	0	0	0	0	0	0	0	0	23	28	6	8	29	36
Sei whale	81	140	37	53	12	14	6	17	6	9	0	0	3	3	99	163	46	73	145	236
Bryde's whale	67	84	20	27	12	16	6	8	23	29	4	4	16	25	102	129	46	64	148	193
Humpback whale	21	25	6	8	2	2	0	0	1	2	0	0	0	0	24	29	6	8	30	37
Right whale	1	1	0	0	0	0	0	0	0	0	0	0	1	2	1	1	1	2	2	3
Sperm whale	168	524	88	255	30	71	11	18	14	31	3	7	11	29	212	626	113	309	325	935
Unidentified large cetacean	11	13	74	102	3	3	9	9	1	1	2	2	8	8	15	17	93	121	108	138
Unidentified cetacean	78	79	11	11	18	18	1	1	5	5	0	0	6	7	101	102	18	19	119	121

Table 4-1. List of cetacean species and number of sightings (no. schools/no. individuals) made by dedicated sighting vessel (SM) in the 2003 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	4	4	0	0	0	0	4	4	0	0	4	4
Fin whale	1	2	0	0	0	0	1	2	0	0	1	2
Sei whale	2	3	0	0	0	0	2	3	0	0	2	3
Humpback whale	1	1	2	5	0	0	1	1	2	5	3	6
Right whale	1	1	0	0	0	0	1	1	0	0	1	1
Sperm whale	28	57	0	0	1	1	28	57	1	1	29	58
Unidentified large cetacean	1	1	0	0	1	2	1	1	1	2	2	3
Unidentified cetacean	3	3	0	0	0	0	3	3	0	0	3	3

Table 4-2. List of cetacean species and number of sightings (no. schools/no. individuals) made by dedicated sighting vessel (KS2) in the 2003 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	68	76	8	8	3	3	68	76	11	11	79	87
Like minke whale	1	1	0	0	0	0	1	1	0	0	1	1
Blue whale	36	46	3	5	0	0	36	46	3	5	39	51
Fin whale	44	81	11	19	1	1	44	81	12	20	56	101
Sei whale	35	58	12	21	0	0	35	58	12	21	47	79
Bryde's whale	0	0	0	0	0	0	0	0	0	0	0	0
Humpback whale	14	24	3	6	1	1	14	24	4	7	18	31
Right whale	1	1	0	0	0	0	1	1	0	0	1	1
Sperm whale	168	296	15	17	2	2	168	296	17	19	185	315
Unidentified large cetacean	9	9	4	5	0	0	9	9	4	5	13	14
Unidentified cetacean	20	22	0	0	0	0	20	22	0	0	20	22

Table 5. Summary of whale sampling in the 2003 JARPN II survey

Research type	Research periods	Sub-area	Whale samples			
			Common minke	Bryde's	Sei	Sperm
Whale survey (first period)	May 17-June 9, 2003	7, 8	53	8	13	0
Cooperative survey (A: first period)	June 10-22, 2003	8+9	15	0	15	0
Whale survey (second period)	June 23-25, 2003	8	2	7	2	3
Cooperative survey (B: second period)	June 26-29, July 1-7, 2003	7	2	19	5	4
Whale survey (third period)	June 29-30, July 8-Aug. 8, 2003	7, 8, 9	28	16	15	3
Total	**May 17-Aug. 8, 2003**		**100**	**50**	**50**	**10**

Table 6. Summary of whale sampling in the 2003 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	93	7	100	23	27	50	19	31	50	1	9	10
External body proportion	93	7	100	23	27	50	19	31	50	1	9	10
Photographic record and external character	93	7	100	23	27	50	19	31	50	1	9	10
Diatom film record and sampling	93	7	100	23	27	50	19	31	50	1	9	10
Standard measurements of blubber thickness (eleven points)	93	7	100	23	27	50	19	31	50	1	9	10
Detailed measurements of blubber thickness (fourteen points)	93	7	100	23	27	50	19	31	50	1	9	10
Body weight	93	7	100	23	27	50	19	31	50	1	9	10
Body weight by parts	26	3	29	11	9	20	4	12	16	0	6	6
Blubber tissues for DNA study	93	7	100	23	27	50	19	31	50	1	9	10
Muscle, liver and heart tissues for isozyme analysis	93	7	100	23	27	50	19	31	50	1	9	10
Blubber, muscle, liver and kidney tissues for heavy metal analysis	93	7	100	23	27	50	19	31	50	1	9	10
Blubber, muscle, liver and kidney tissues for organochlorines analysis	93	7	100	23	27	50	19	31	50	1	9	10
Tissues for lipid analysis	26	3	29	11	9	20	4	12	16	0	6	6
Blubber, muscle and liver tissues for stable isotope analysis	93	7	100	23	27	50	19	31	50	1	9	10
Tissues for chemical analysis	93	7	100	23	27	50	19	31	50	1	9	10
Tissues for various analysis	93	7	100	23	27	50	19	31	50	1	9	10
Muscle, blubber and intestine content for energy flow analysis	26	3	29	11	9	20	4	12	16	0	6	6
Intestine contents for prey species identification	5	0	5	1	5	6	2	3	5	1	4	5
Tissues for virus test	34	4	38	23	17	40	3	11	14	1	3	4
Muscle samples for hemoprotein analysis	1	0	1	1	0	1	1	0	1	0	1	1
Mammary grand; lactation status, measurement and histological sample	-	7	7	-	27	27	-	31	31	-	9	9
Collection of maternal milk sample	-	0	0	-	4	4	-	3	3	-	1	1
Uterine horn; measurement and endometrium sample	-	7	7	-	27	27	-	31	31	-	9	9
Uterine mucus for sperm detection	-	0	0	-	27	27	-	31	31	-	9	9
Collection of ovary	-	7	7	-	27	27	-	31	31	-	9	9
Photographic record of foetus	-	4	4	-	10	10	-	17	17	-	0	0
Foetal sex (identified by visual observation)	-	4	4	-	10	10	-	16	16[*1]	-	0	0
Foetal length and weight	-	4	4	-	10	10	-	17	17	-	0	0
External measurements of foetus	-	4	4	-	10	10	-	17	17	-	0	0
Collection of foetus	-	4	4	-	10	10	-	17	17	-	0	0
Testis and epididymis; weight and histological sample	93	-	93	23	-	23	19	-	19	1	-	1
Smear samples from testis and epididymis tissues	0	-	0	23	-	23	19	-	19	1	-	1
Urine sample for sperm detection	0	-	0	17	-	17	8	-	8	0	-	0
Collection of serum sample	93	7	100	23	27	50	19	31	50	1	9	10
Collection of whole blood sample	89	7	96	23	27	50	19	31	50	1	9	10
Whole blood samples from umbilical cord	-	1	1	-	15	15	-	8	8	-	0	0
Stomach content, conventional record	93	7	100	23	27	50	19	31	50	1	9	10
Volume and weight of stomach content in each compartment	93	7	100	23	27	50	19	31	50	1	9	10
Stomach contents for feeding study	93	7	100	23	27	50	19	31	50	1	9	10
Record of external parasites	93	7	100	23	27	50	19	31	50	1	9	10
Collection of external parasites	3	1	4	3	3	6	2	9	11	1	6	7
Record of internal parasites	93	7	100	23	27	50	19	31	50	1	9	10
Collection of internal parasites	7	0	7	2	3	5	0	0	0	0	4	4
Earplug for age determination	93	7	100	23	27	50	19	31	50	0	0	0
Tympanic bulla for age determination	93	7	100	23	27	50	19	31	50	0	0	0
Maxillally teeth for age determination	-	-	-	-	-	-	-	-	-	1	9	10
Largest baleen plate for morphologic study and age determination	93	7	100	23	27	50	19	31	50	-	-	-
Largest baleen plate for stable isotopes	93	7	100	23	27	50	19	31	50	-	-	-
Baleen plate measurements (length and breadth)	93	7	100	23	27	50	19	31	50	-	-	-
Length of each baleen plate series	93	7	100	23	27	50	19	31	50	-	-	-
Vertebral epiphyses sample	93	7	100	23	27	50	19	31	50	1	9	10
Number of vertebrae	0	0	0	23	27	50	4	12	16	1	9	10
Number of ribs	93	7	100	23	27	50	19	31	50	1	9	10
Brain weight	26	3	29	11	9	20	4	12	16	0	6	6
Skull measurement (length and breadth)	93	7	100	23	26	49	19	29	48	1	9	10
Collection of skull	0	0	0	0	0	0	0	0	0	0	0	0
Collection of whole skeleton	0	0	0	1	0	1	0	0	0	0	0	0
Reproductive study	17	2	19	12	9	21	7	18	25	0	8	8
Collection of fat tissues	0	0	0	3	1	4	1	2	3	0	0	0

[*1]One fetus of sex unidentified

Table 7. Compositon of sex and sexual maturity of common minke whales collected by the 2003 JARPN II survey

Sub-area	Male			Female				Combined	Sex ratio	Maturity		Pregnancy
	Imm.	Mat.	Total	Imm	Rest.	Preg.	Total		(% males)	Male	Female	rate*)
7	8	14	22	1	0	1	2	24	91.7	63.6	50.0	100.0
	(33.3)	(58.3)	(91.7)	(4.2)	(0.0)	(4.2)	(8.3)	(100.0)				
8	4	31	35	1	0	2	3	38	92.1	88.6	66.7	100.0
	(10.5)	(81.6)	(92.1)	(2.6)	(0.0)	(5.3)	(7.9)	(100.0)				
9	1	35	36	0	1	1	2	38	94.7	97.2	100.0	50.0
	(2.6)	(92.1)	(94.7)	(0.0)	(2.6)	(2.6)	(5.3)	(100.0)				
Combined	13	80	93	2	1	4	7	100	93.0	86.0	71.4	80.0
	(13.0)	(80.0)	(93.0)	(2.0)	(1.0)	(4.0)	(7.0)	(100.0)				

*) Apparent pregnancy rate

Table 8. Compositon of sex and sexual maturity of Bryde's whales collected by the 2003 JARPN II survey

Sub-area	Male			Female						Combined	Sex ratio	Maturity		Pregnancy
	Imm.	Mat.	Total	Imm	Ovu	Rest.	Preg.	Lact.	Total		(% males)	Male	Female	rate*)
7	6	5	11	5	0	5	4	2	16	27	40.7	45.5	68.8	36.4
	(22.2)	(18.5)	(40.7)	(18.5)	(0.0)	(18.5)	(14.8)	(7.4)	(59.3)	(100.0)				
8	4	3	7	3	1	1	2	0	7	14	50.0	42.9	57.1	50.0
	(28.6)	(21.4)	(50.0)	(21.4)	(7.1)	(7.1)	(14.3)	(0.0)	(50.0)	(100.0)				
9	0	1	1	1	0	1	4	2	8	9	11.1	100.0	87.5	57.1
	(0.0)	(11.1)	(11.1)	(11.1)	(0.0)	(11.1)	(44.4)	(22.2)	(88.9)	(100.0)				
Combined	10	9	19	9	1	7	10	4	31	50	38.0	47.4	71.0	45.5
	(20.0)	(18.0)	(38.0)	(18.0)	(2.0)	(14.0)	(20.0)	(8.0)	(62.0)	(100.0)				

*) Apparent pregnancy rate

Table 9. Compositon of sex and sexual maturity of sei whales collected by the 2003 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	2	1	3	1	0	0	1	0	0	2	5	60.0	33.3	50.0	100.0
	(40.0)	(20.0)	(60.0)	(20.0)	(0.0)	(0.0)	(20.0)	(0.0)	(0.0)	(40.0)	(100.0)				
8	2	5	7	2	1	1	7	1	0	12	19	36.8	71.4	83.3	70.0
	(10.5)	(26.3)	(36.8)	(10.5)	(5.3)	(5.3)	(36.8)	(5.3)	(0.0)	(63.2)	(100.0)				
9	2	11	13	1	0	1	8	2	1	13	26	50.0	84.6	92.3	75.0
	(7.7)	(42.3)	(50.0)	(3.8)	(0.0)	(3.8)	(30.8)	(7.7)	(3.8)	(50.0)	(100.0)				
Combined	6	17	23	4	1	2	16	3	1	27	50	46.0	73.9	85.2	73.9
	(12.0)	(34.0)	(46.0)	(8.0)	(2.0)	(4.0)	(32.0)	(6.0)	(2.0)	(54.0)	(100.0)				

*) Apparent pregnancy rate

Table 10. Statistics of body length (m) of common minke whales collected by the 2003 JARPN II survey

Area	Male					Female				
	Mean	S.D.	Min	Max	n	Mean	S.D.	Min	Max	n
7	6.7	1.0	4.6	7.8	22	6.9	1.1	5.8	8.0	2
8	7.3	0.7	4.8	8.0	35	6.9	1.6	4.6	8.0	3
9	7.4	0.4	5.7	8.2	36	8.3	0.3	8.0	8.6	2
Combined	7.2	0.8	4.6	8.2	93	7.3	1.4	4.6	8.6	7

Table 11. Statistics of body length (m) of Bryde's whales collected by the 2003 JARPN II survey

Area	Male					Female				
	Mean	S.D.	Min	Max	n	Mean	S.D.	Min	Max	n
7	11.5	1.2	9.4	13.0	11	11.8	1.4	8.8	13.5	16
8	11.8	0.8	10.1	12.5	7	11.8	0.9	10.5	13.0	7
9	12.3	-	-	-	1	12.9	0.8	11.0	13.8	8
Combined	11.6	1.1	9.4	13.0	19	12.1	1.3	8.8	13.8	31

Table 12. Statistics of body length (m) of sei whales collected by the 2003 JARPN II survey

Area	Male					Female				
	Mean	S.D.	Min	Max	n	Mean	S.D.	Min	Max	n
7	12.9	0.2	12.6	13.1	3	13.5	0.1	13.4	13.7	2
8	13.0	1.0	10.6	13.8	7	14.1	0.8	12.5	15.5	12
9	13.6	0.9	11.6	14.8	13	14.2	1.2	10.5	15.5	13
Combined	13.3	0.9	10.6	14.8	23	14.1	1.0	10.5	15.5	27

Table 13. Biological data of sperm whales collected by the 2003 JARPN II survey

Sub	N		Body length (m)			Body weight (t)		
area	Male	Female	Mean	Min	Max	Mean	Min	Max
7	0	4	10.6	10.1	10.9	16.8	13.8	19.3
8	1	2	8.7	7.9	9.9	8.8	6.3	12.7
9	0	3	11.0	10.4	11.5	20.0	17.9	22.0

Table 14. Prey species found in stomach of common minke, Bryde's, sei and sperm whales sampled by the 2003 JARPN II surveys (1st.+2nd. stomachs)

Common minke whale

	Prey species	Range of weight (kg) in the stomach
Krill	Krill*	<0.1 - 1.1
Pisces	Japanese anchovy*	<0.1 - 159.9
	Pacific saury*	<0.1 - 106.4
	Japanese pomfret*	2.8 - 11.2
	Chum salmon*	12.0
	Salmonidae	13.4

*: dominant prey species

Bryde's whale

	Prey species	Range of weight (kg) in the stomach
Pisces	Krill	<0.1 - 268.8
	Larva of anchovy*	<0.1 - 10.9
	Japanese anchovy*	<0.1 - 196.9
	Chub mackerel*	89.0
	Jacks	

*: dominant prey species

Sei whale

	Prey species	Range of weight (kg) in the stomach
Copepods	Copepods*	<0.1 - 50.7
Krill	Krill*	<0.1 - 10.9
Pisces	Japanese anchovy*	<0.1 - 499.6
	Pacific saury*	6.2
	Chub mackerel	

*: dominant prey species

Table 15. Summary of biopsy skin sampling for some whale species in the 2003 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)
Blue whale	SSVs	5	10	18	6	2	3h15m	0.11	0.33
Humpback whale	SSVs	1	2	2	1	1	0h26m	0.50	1.00
Right whale	SSVs	1	1	2	1	1	0h16m	0.50	1.00
Fin whale	SSVs	2	2	5	1	1	1h03m	0.20	1.00
Sei whale	SSVs	2	2	0	-	-	1h15m	-	-
Bryde's whale	SSVs	16	22	35	7	4	8h14m	0.11	0.57
Sperm whale	SSVs	2	27	6	2	0	1h20m	0.00	0.00

Table 16. Summary of photo ID for blue, humpback, and right whales in the 2003 JARPN II survey

Whale species	Ship	Number of experiments (A)	Targeted individuals (B)	Number of trials (C)
Blue whale	SSVs	7	8	7
Humpback whale	SSVs	3	4	4
Right whale	SSVs	2	3	3

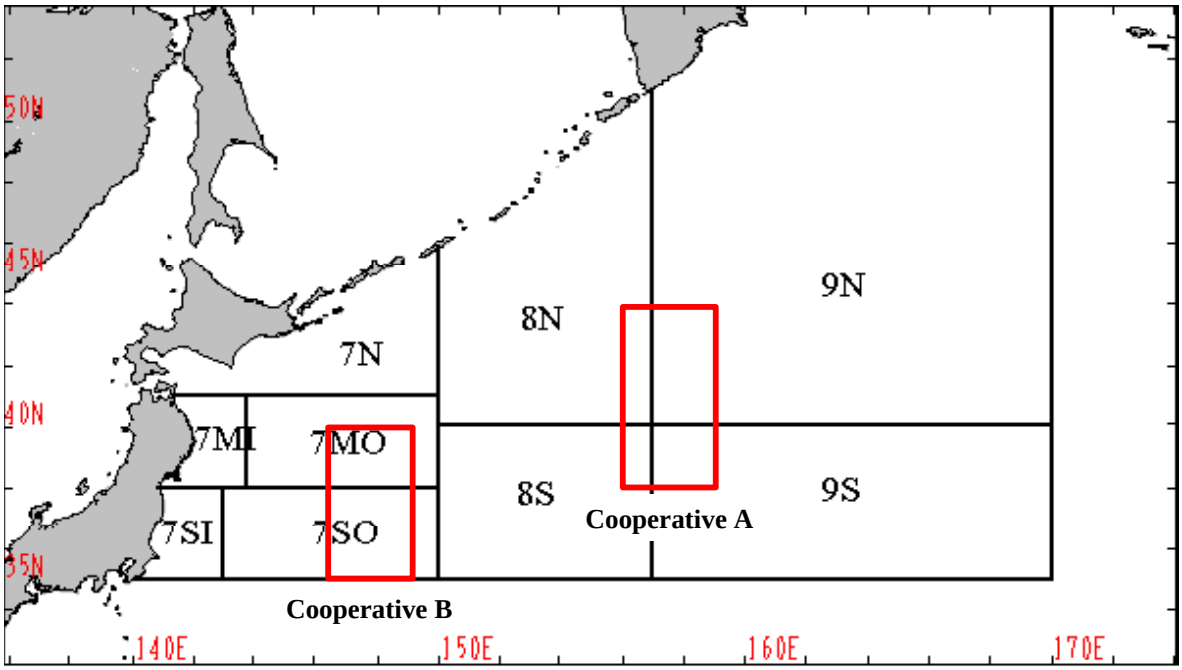


Fig 1. Map showing the research area and strata of the JARPN II full-scale program.

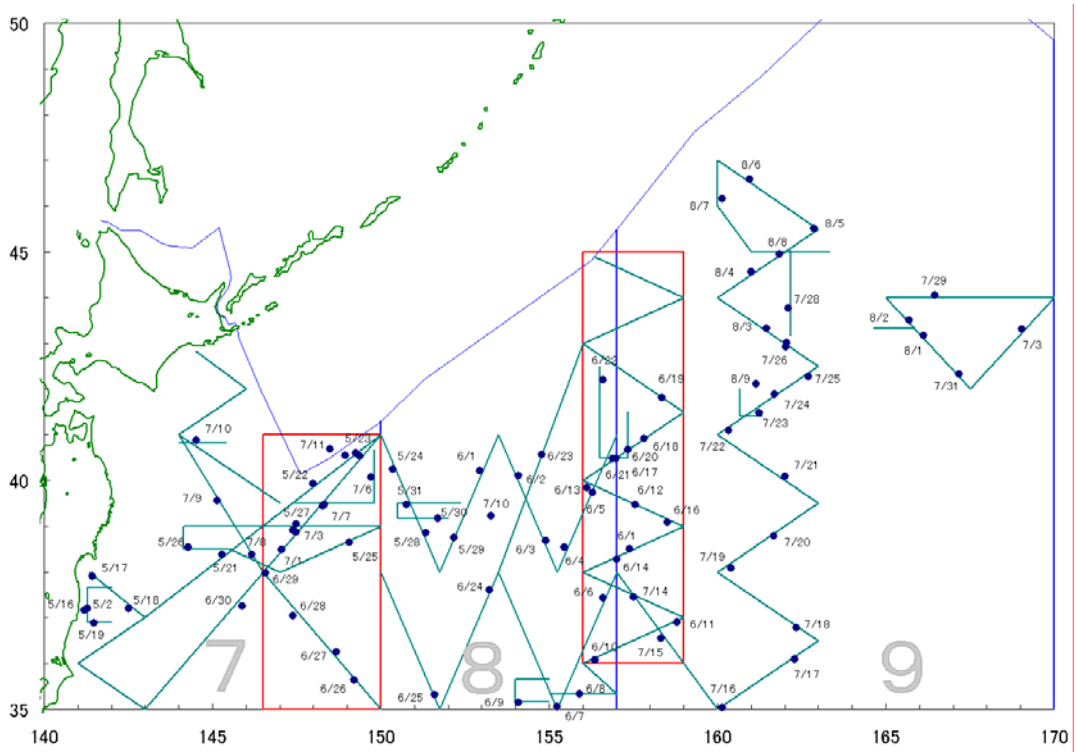


Fig. 2. Outline of the cruise track-line with mark indicating noon position of *Nisshin Maru* in the 2003 JARPNII cruise.

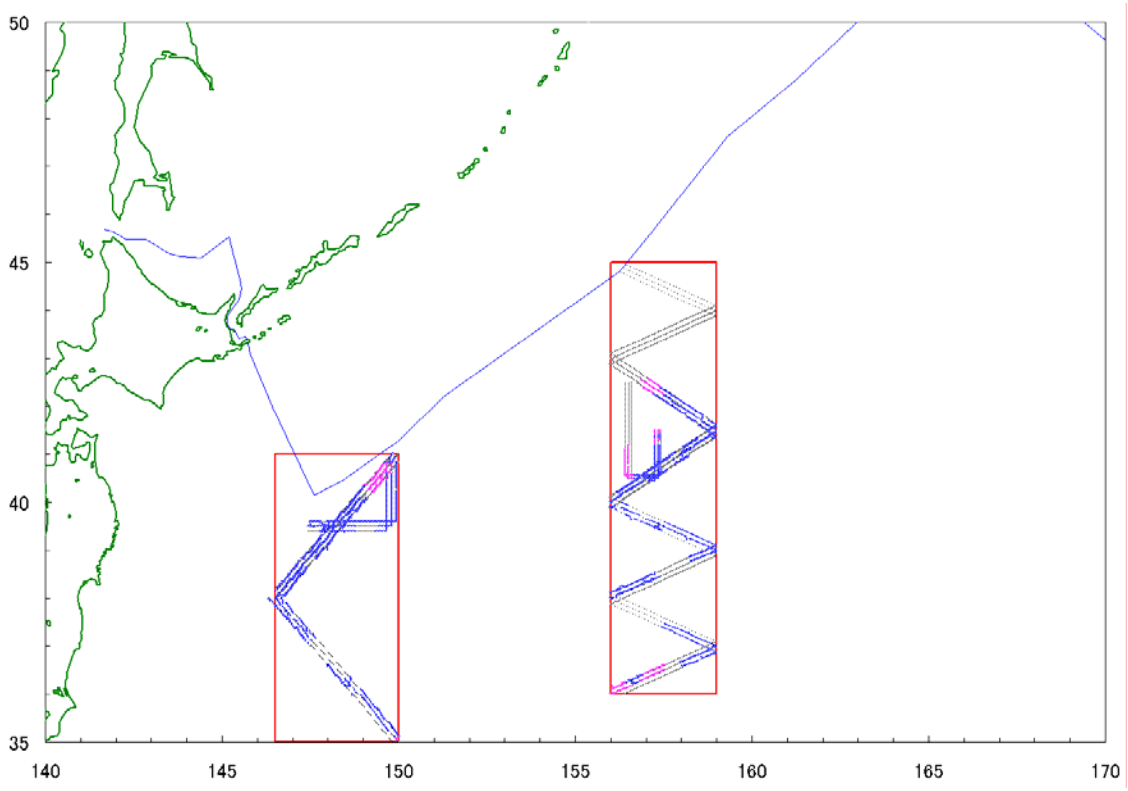


Fig. 3. Track-line covered by the three sighting/sampling vessels (SSVs) during the cooperative ecosystem survey of the 2003 JARPN II.

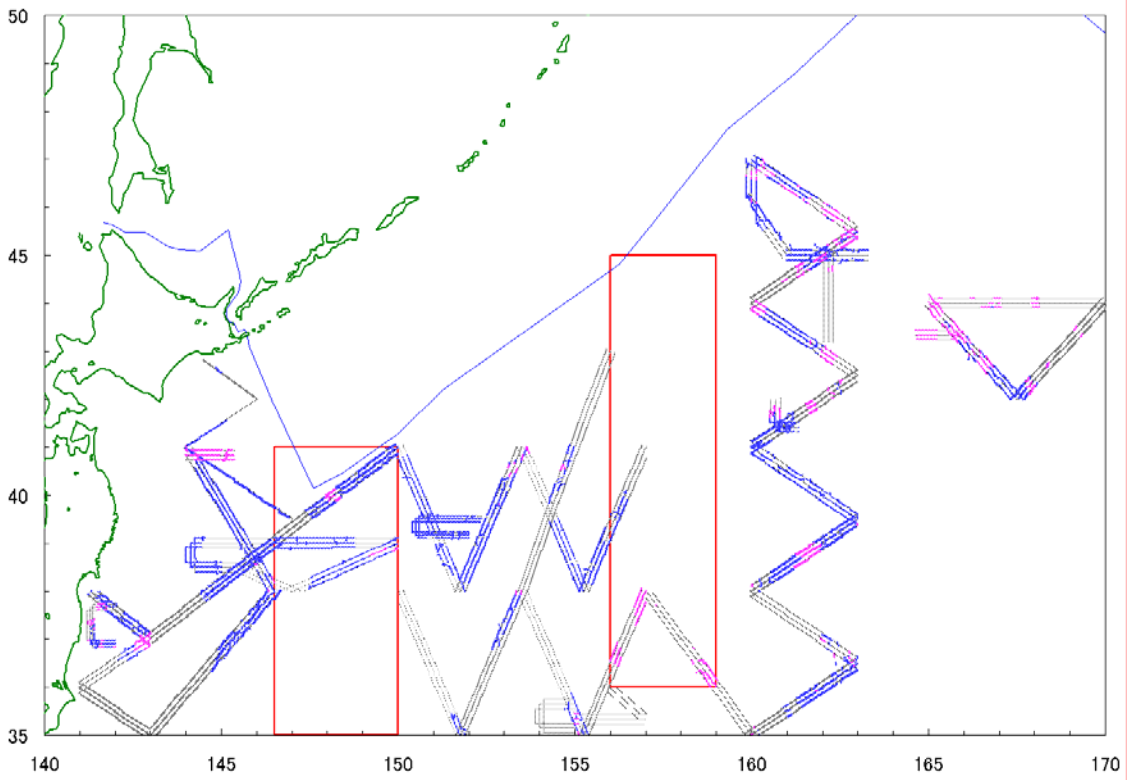
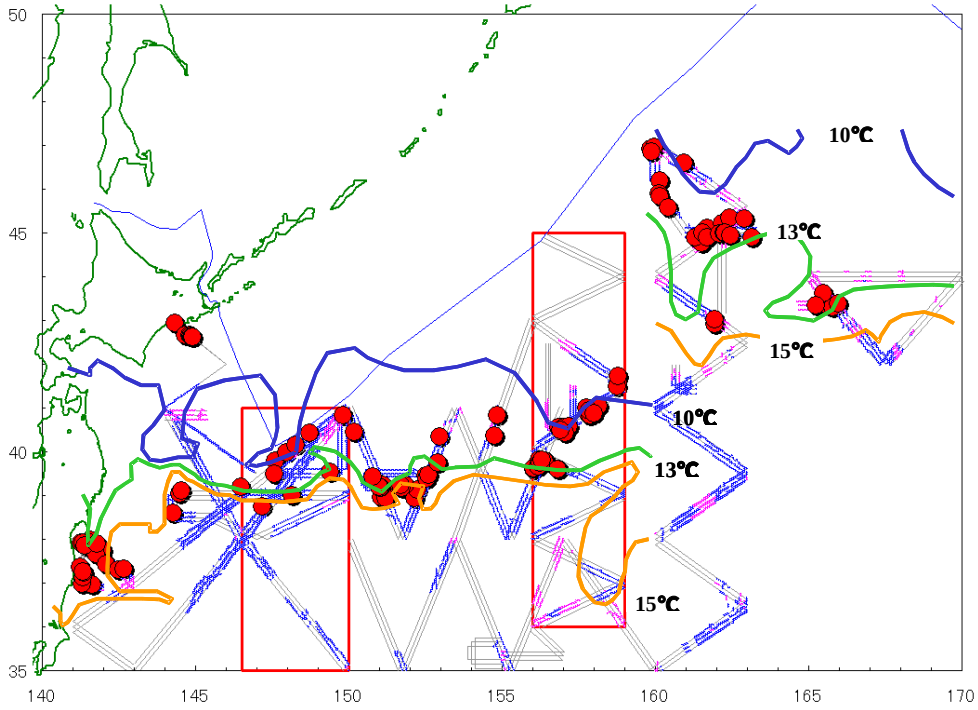
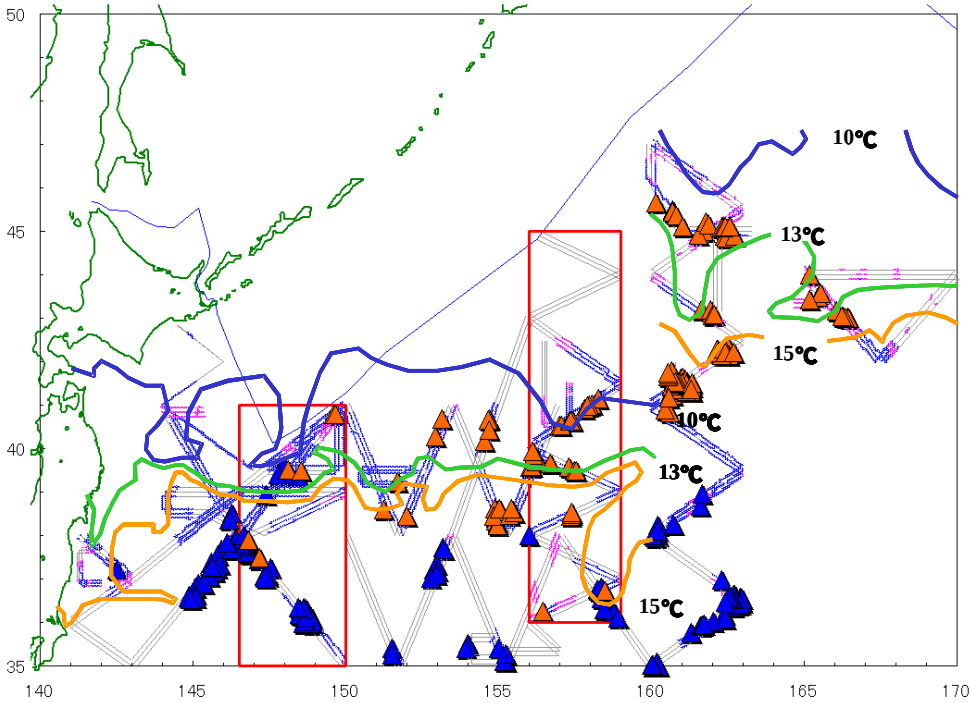


Fig. 4. Track - line covered by the three sighting/sampling vessels (SSVs) during the whale survey of the 2003 JARPN II.



Those temperature lines are made by using the information from the telex Nos. 20 (5 – 8 June, 2003) and 36 (31 July – 3 August, 2003) by the Fishing Information Service Centre in Japan.

Fig. 5. Position of the sightings of the common minke whales (●).



Those temperature lines are made by using the information from the telex Nos. 20 (5 – 8 June, 2003) and 36 (31 July – 3 August, 2003) by the Fishing Information Service Centre in Japan.

Fig. 6. Position of the sightings of the Bryde's whales (▲) and sei whales (▲).

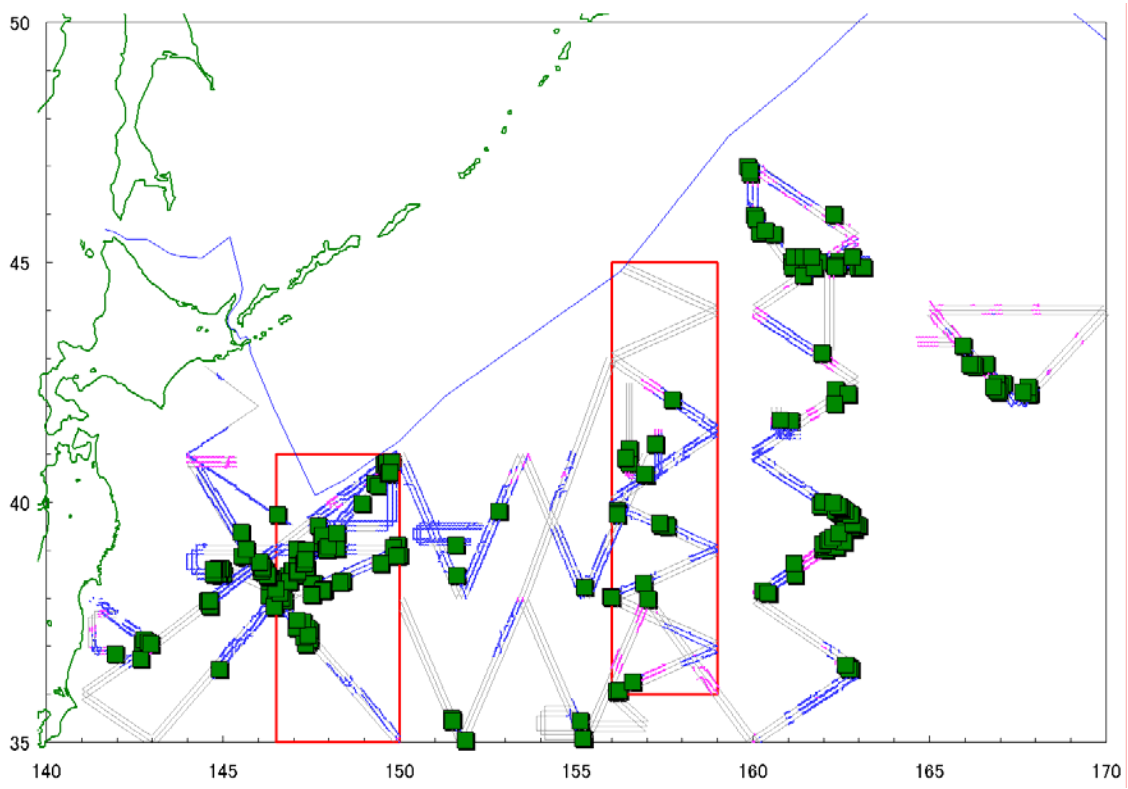


Fig. 7. Position of the sightings of the sperm whales (■).

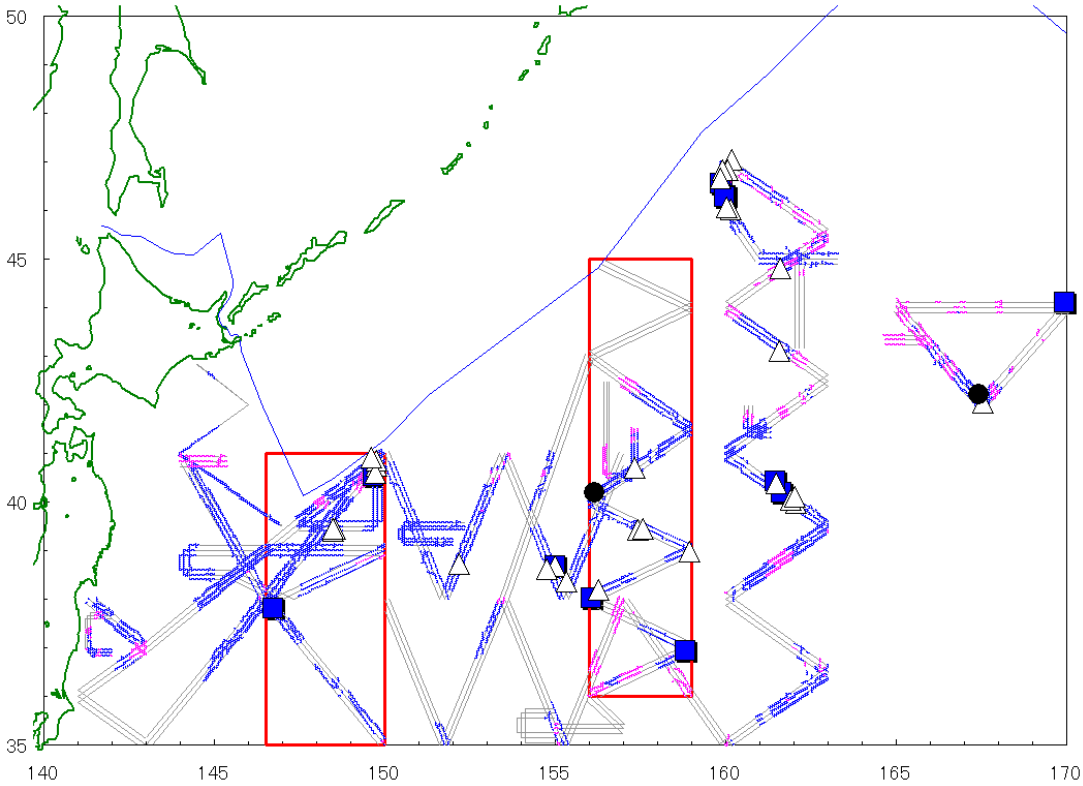


Fig. 8. Position of the sightings of the Blue whales (■), fin whales (△) and right whales (●).

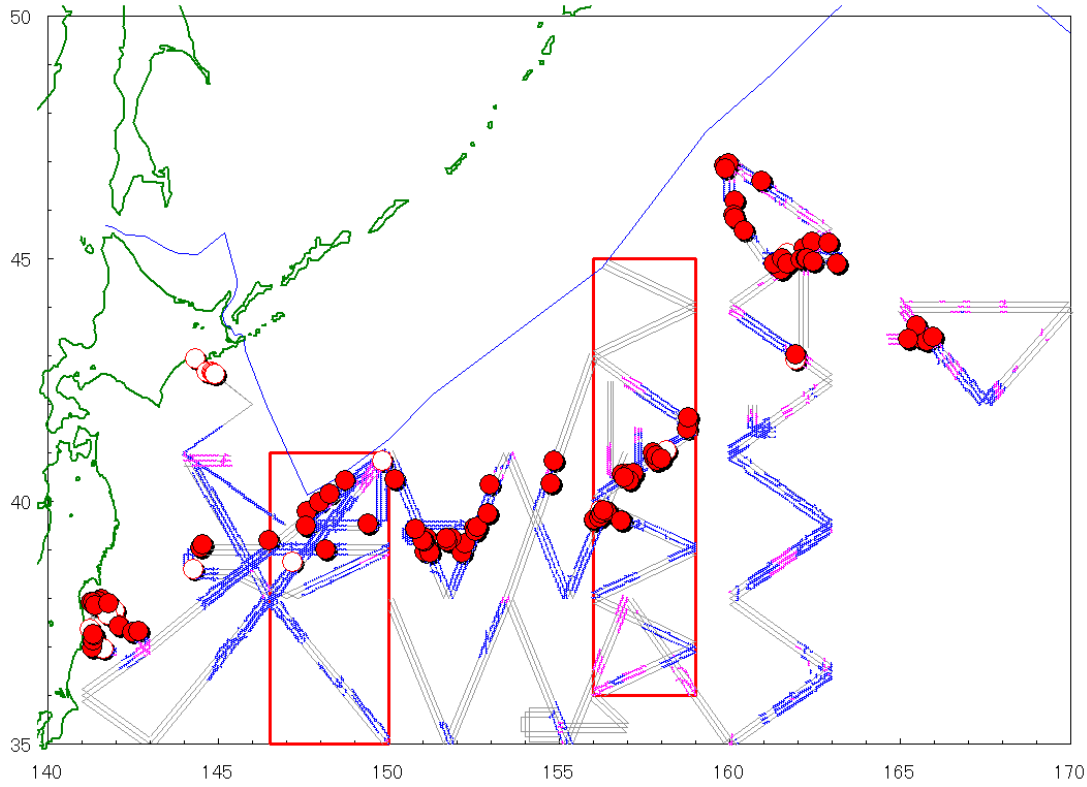


Fig. 9. Comparison of positions of the sightings and samplings of the common minke whales (●: sighted and sampled, ○: sighted only).

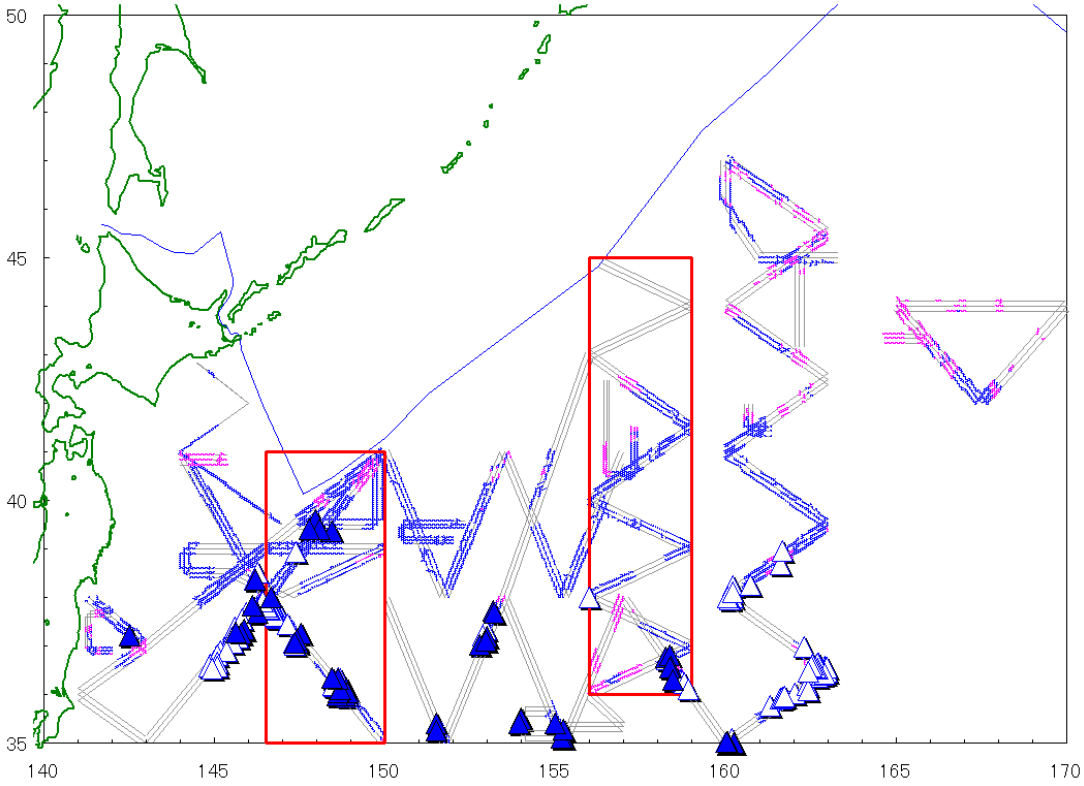


Fig. 10. Comparison of positions of the sightings and samplings of the Bryde's whales (▲: sighted and sampled, △: sighted only).

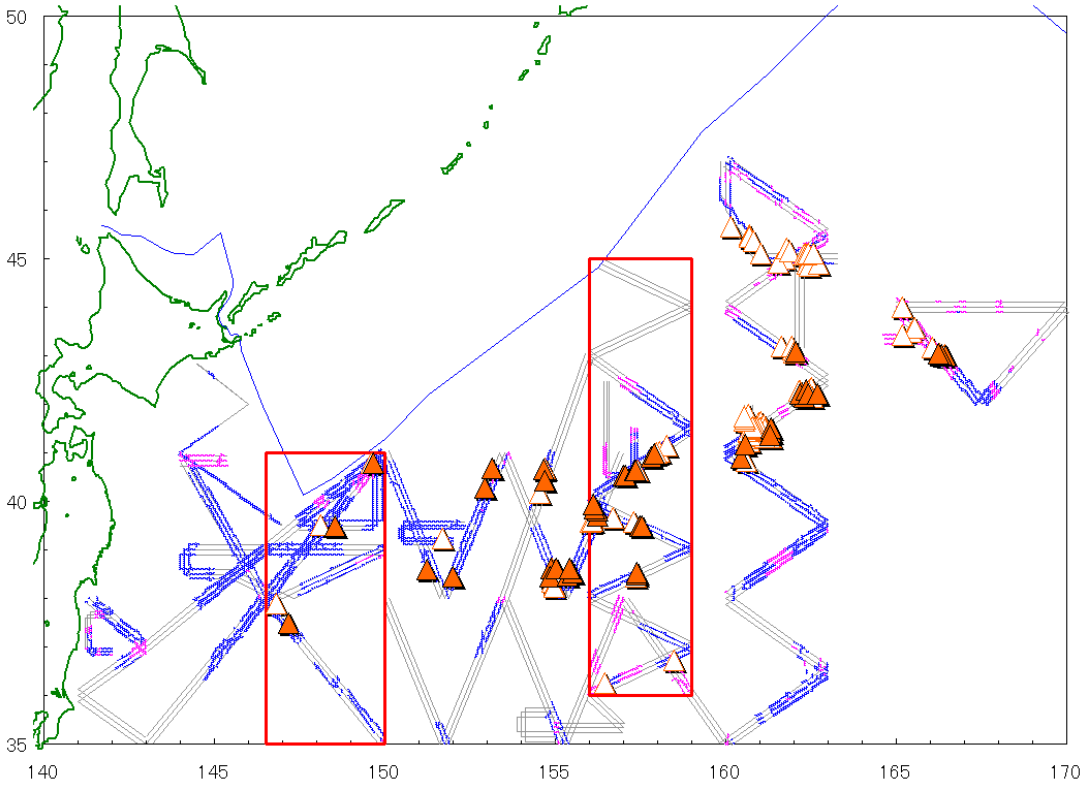


Fig. 11. Comparison of positions of the sightings and samplings of the sei whales

(▲: sighted and sampled, △: sighted only).

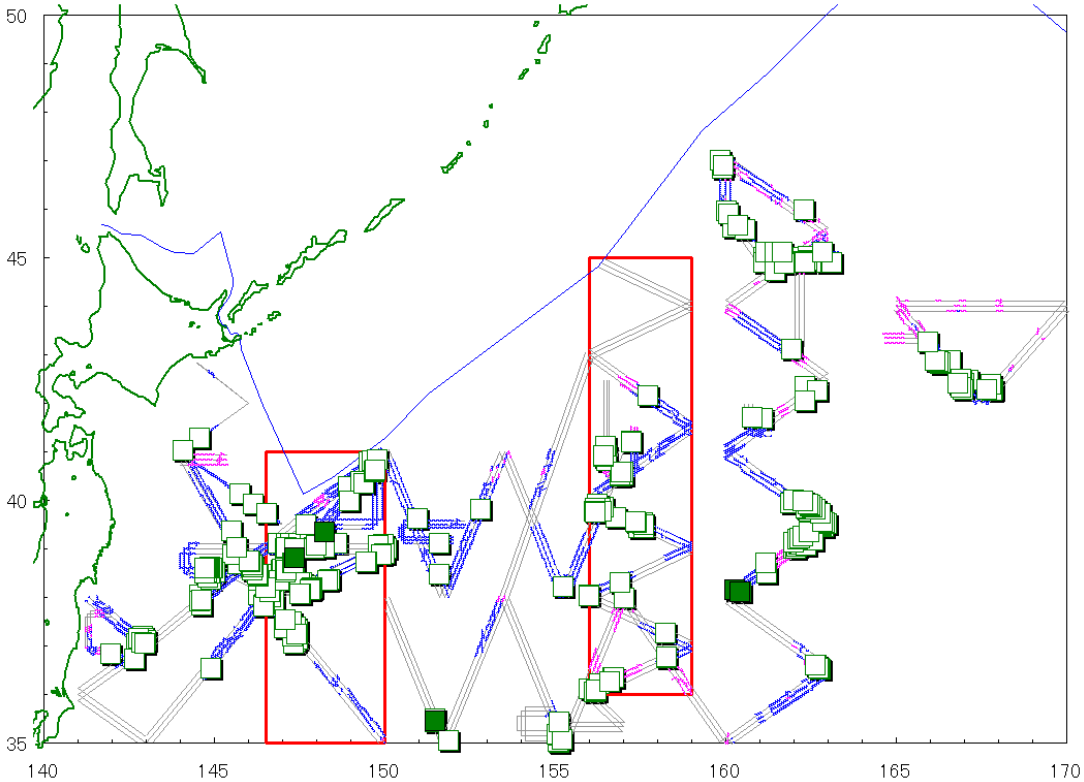


Fig. 12. Comparison of positions of the sightings and samplings of the sperm whales

(■: sighted and sampled, □: sighted only).

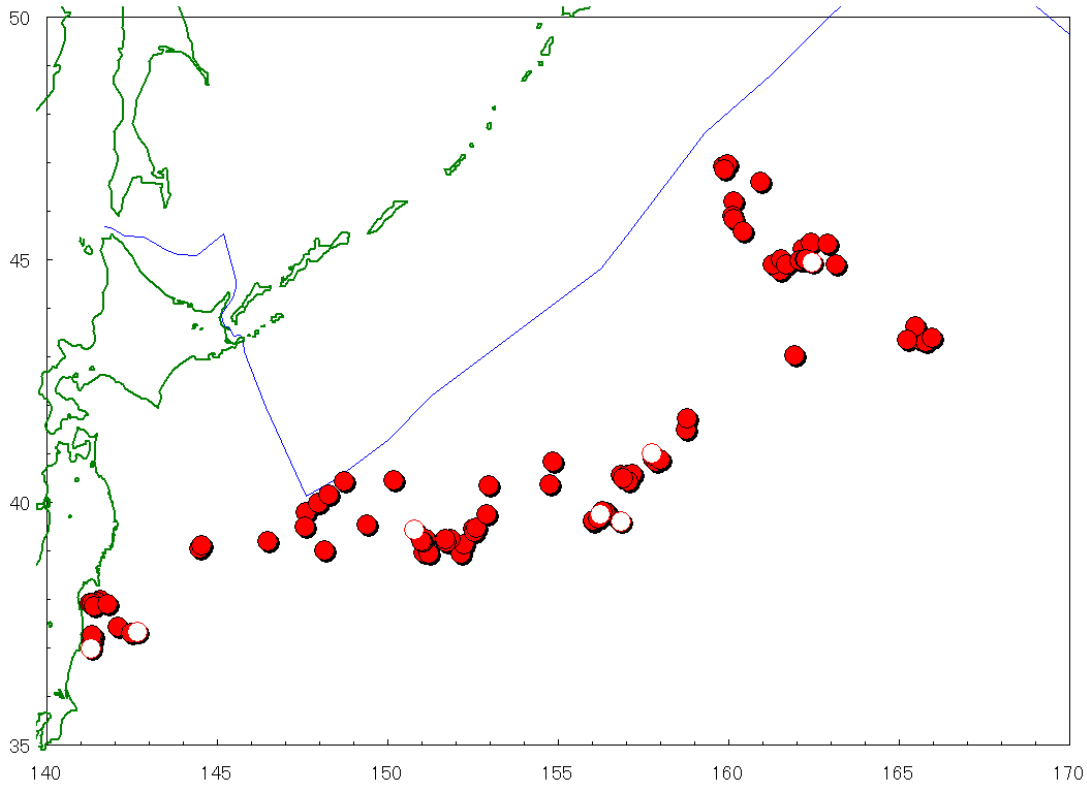


Fig. 13. Geographical position of common minke whales sampled in the 2003 JARPN II survey, based on the sighting position (●: Male; ○: Female).

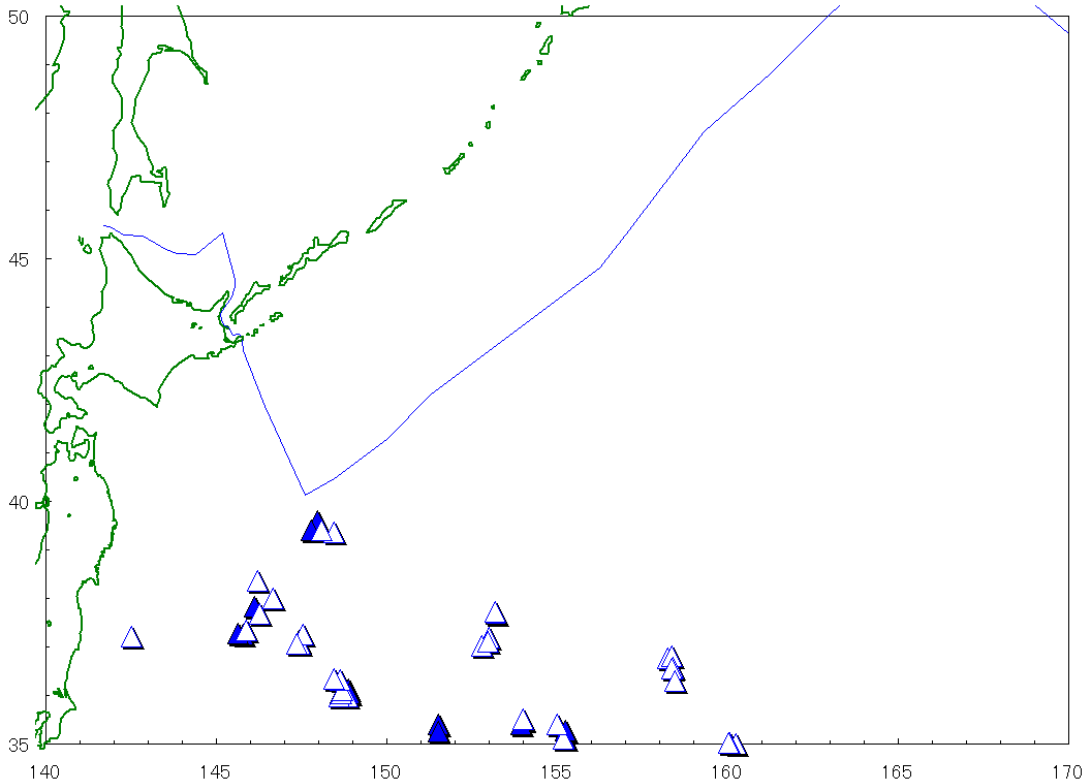


Fig. 14. Geographical position of Bryde's whales sampled in the 2003 JARPN II survey, based on the sighting position (▲: Male; △: Female).

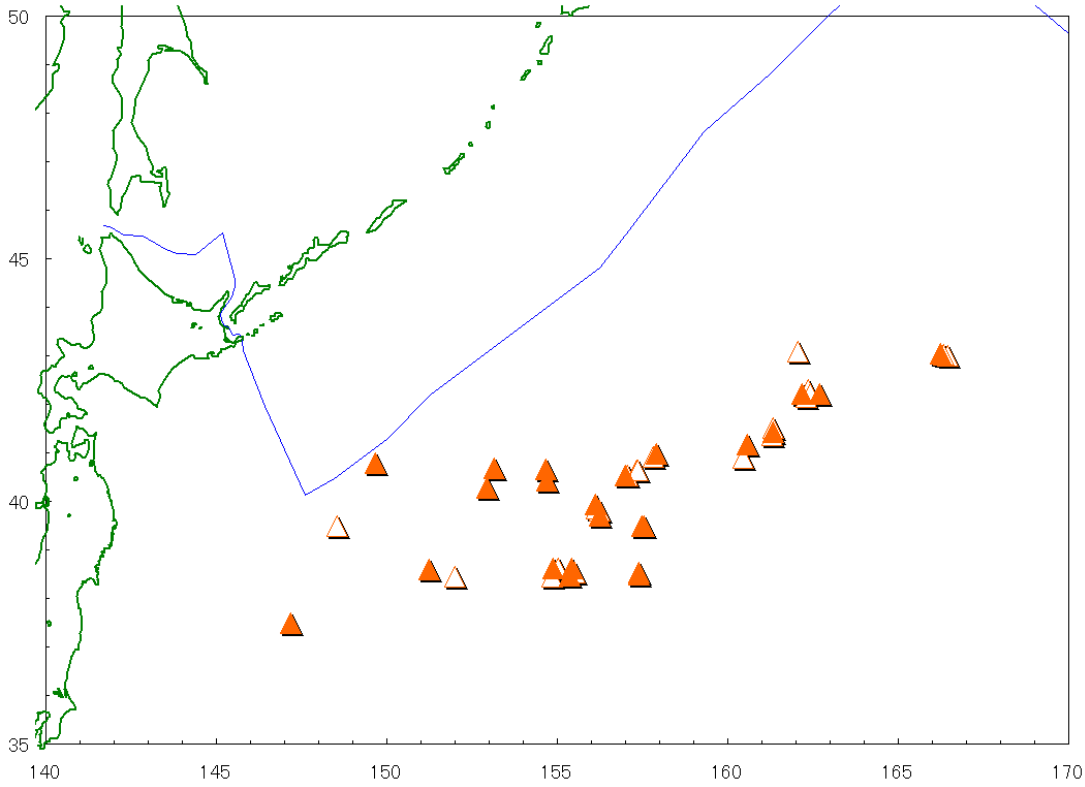


Fig. 15. Geographical position of sei whales sampled in the 2003 JARPN II survey, based on the sighting position (▲: Male; △: Female).

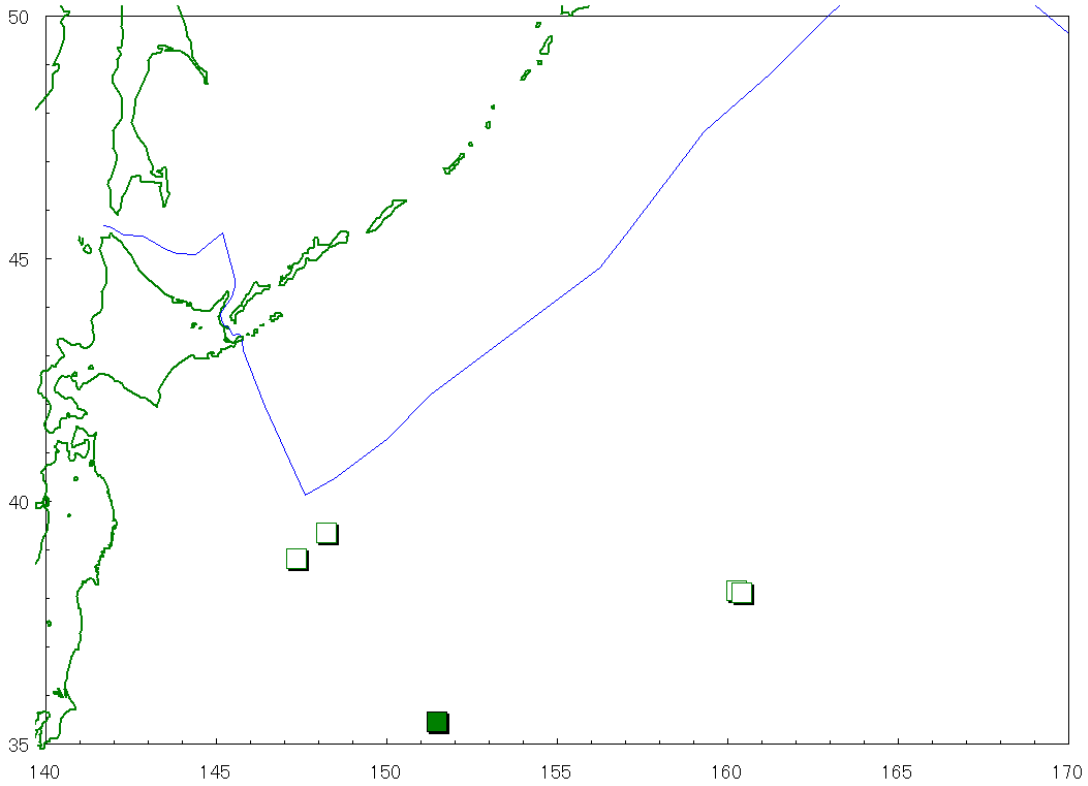


Fig. 16. Geographical position of sperm whales sampled in the 2003 JARPN II survey, based on the sighting position (■: Male; □: Female).

Appendx 1

Preliminary results of the prey survey of JARPN II (offshore component) in 2003

SHIGEYUKI KAWAHARA[1], HIROTO MURASE[2], HIKARU WATANABE[1] AND MORIO ICHIHARA[3]

[1] *National Research Institute of Far Seas Fisheries, 5-7-1, Shimizu-Orido, Shizuoka, 424-8633, Japan*
[2] *The Institute of Cetacean Research, 4-18 Toyomi-cho, Chuo-ku Tokyo, 104-0055, Japan*
[3] *Field Center for Northern Biosphere, Hokkaido University 3-1-1 Minato-cho Hakodata Hokkaido 041-8611 Japan*
kawahara@fra.affrc.go.jp

ABSTRACT

A prey survey was conducted concurrently with the whale survey off the coast of eastern Honsyu, Japan in June and July 2003 as a part of offshore component of JARPN II full scale study. The primary objective of cooperative study was estimation of prey selection by cetaceans. Two blocks with a zigzag track line were set. A trawler-type research vessel, Shunyo-maru equipped with the quantitative echosounder dedicated to the prey survey. The acoustic survey using a Simrad EK60 echosounder operating frequencies at 38, 70 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. MOCNESS was used to collect zooplanktons. Oceanographic observations were made with CTD down to 500m at 29 points. Trawlings were made at 21 stations. MOCNESS was towed at 19 stations. Five major cetacean preys, Japanese anchovy, Pacific saury, Japanese common squid, krill and copepods were distributed in the survey area reflecting the oceanographic structure. Most of the nighttime trawl catches consisted of fishes dominated by Lanternfishes.

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.

As the cooperative whale and prey surveys had never been conducted in the western North Pacific, a two-year feasibility study was conducted in 2000 and 2001 (Fujise et al. 2002). Preliminary analysis of prey selection of common minke and Bryde's (*Balaenoptera edeni*) whales using feasibility study data suggested that minke whale selected Japanese anchovy while they seemed to avoid krill while Bryde's whale showed seasonal prey selection change from krill to Japanese anchovy (Murase et al. 2002). 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 and sperm (*Physeter macrocephalus*) whales in the full scale study. The full scale study in 2003 was conducted in Sub-areas 7, 8 and 9, off the coast of eastern Honsyu, Japan in July and August. 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 mainly for the former three baleen whale species. In this document, the preliminary results of the prey survey in 2003 were presented.

When food use patterns were discussed, the term selection and preference have been used interchangeably raising some confusion (Litvaitis 2000). In this paper preference is defined as the likelihood that animal selects a resource given equal amount with others whereas selection is defined as the animal chooses a resource irrespective of amount of resources according to Jhonson (1980). Prey selection of cetaceans is inevitable to most ecosystem models and estimated with the cooperative whale and prey surveys.

MATERIALS AND METHOD

Survey area and research vessels

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, two blocks, Block A and Block B 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 (Fig.1). Waypoints were listed in Table 1. Prey distribution and abundance surveys using the quantitative echosounder, midwater trawl, Multiple Opening and Closing Nets Environmental Sampling System (MOCNESS) were conducted on Shunyo-maru (SYO, 887 GT). During the daytime, SYO steamed at about 10 knots along the tracklines to record acoustic data and to correct biological samples using the trawls and the MOCNESS.

Survey timing and survey hours

The cooperative survey was conducted from June to July, 2003 with two periods; first from June 15 to 25 in Block A and second from July 1 to 9 in Block B. Details of the itinerary of the survey were shown in Table 2. Time difference between the whale and prey surveys was less than about one week so that results of prey and cetacean 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. Generally, the survey started at 5:00 and end at 18:00 at local time.

Acoustic data acquisition

A quantitative echo sounder (Simrad EK60 with program version 1.4.3.64) with operating frequency at 38, 70 and 120 kHz was used on board SYO 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 June 30, 2003 using the copper sphere technique described in EK 60 online help manual.

Surface and midwater trawlings

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 of the mouth of the net were monitored with the scammer transducers attached to the head and the bottom rope of the trawl. Towing speed of the trawl net was 4-5 knot. Surface and midwater trawl was towed at predetermined and acoustic target identification stations. Surface trawls were conducted using the midwater trawls with the floats attached the bridle so that the trawl could be towed at the surface. Surface trawl was designed for collecting Pacific saury. Target trawls were conducted for 0.5 to 1 hour to identify the species and size compositions of biological backscattering detected by the quantitative echosounder.

Another type of trawl was conducted at predetermined (routine) stations in each block in daytime. Several nighttime predetermined trawls were also made. 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 echosounder. Three different depth layers were sampled at predetermined trawl stations; 0-30m (surface) and 0-100m (midwater). Surface predetermined trawls were conducted in northern part of Block A where Pacific saury seemed to be abundant. Nighttime trawls were conducted to examine day-night difference of prey species composition. Daytime trawls were towed before nighttime trawls were tow on the same day. Midwater predetermined trawl was towed for 20 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 at –30°C for further analysis in the laboratory.

Net sampling of zooplankton

In addition to the trawl net, MOCNESS (mouth opening size 1m2 and mesh size 0.33mm x 0.33mm) was used to collect macro and mesozooplanktons. At the predetermined station, following depth layers were towed; 0-20m, 20-40m, 40-60m, 60-80m, 80-100m, 100-150m, 150-200m and 200-250m. Target towing was also made to identify species and size compositions of biological backscattering detected by the quantitative echo sounder. Nighttime towing was conducted at several stations to examine day-night difference of prey species composition. Daytime towing was made before

nighttime trawls were towed on the same day. The samples were preserved in 10 % formalin for species identification at the laboratory.

Acoustic data analyses

Acoustic data were analyzed with the aid of SonarData Echoview (version 3.00.74.01) at the laboratory. In principle, backscattering on the echosounder was identified based mainly on the result of trawl and MOCNESS samplings. For fishes, data collected at 38 kHz were used with the threshold set at -60dB and the depth range from 10m to 250m. For Japanese anchovy that was the most common fish, school shape and backscattering intensity of backscattering were also used for species identification. The integration was made at an interval of one nautical mile by 50 m depth zone. For krills, data collected at 120 kHz were used with the threshold set at –80 dB. The analyzed depth range was from 12m to 250m (maximum depth at 120 kHz). Backscattering was identified as krills if ΔSv (the difference of Sv between 38 and 120) falls between 10 and 15 dB (Miyashita *et al.* 1997). Because most of krill species in the survey area have the body length similar to isada krill (*Euphausia pacifica*) taken in the coastal area off Tohoku, this ΔSv value was applied to. Species identification was based on both ΔSv and the samples form MOCNESS. For copepods, data collected at 120 kHz were used with the threshold set at –110 dB. Target strengths (TS) of copepods were calculated using the Distorted Wave Born Approximation based seformed cylinder model (Stanton and Chu, 2000). Based on the TS, ΔSv (the difference of Sv between 38 and 120) falls between 10 and 30dB were identified as copepods. Net sampling results as well as school shape were considered to distinguish between krill and copepods. The integration was made at an interval of one nautical mile by 50 m depth zone.

Oceanographic observations

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. Two CTD casts were made down to 2500m and 4000m to collect water samples for the salinity compensation. Salinity compensation for CTD data and analysis of oceanographic conditions were made after the cruise.

RESULTS AND DISCUSSION

A summary of the cooperative whale and prey surveys was shown on Table 3. Summary of trawl and MOCNESS sampling in the first and second survey periods were shown on Table 4 and 5, and 6 and 7, respectively. CTD stations were listed in Table 8. Positions of trawls, MOCNESS and CTD stations were shown on Figs. 2 and 3.

Results of echosounder survey

Currently, acoustic data are analyzed to estimate the cetacean prey abundance at the laboratory. Some preliminary results were presented here.

Calibration

The results of the calibration for 38, 70 and 120kHz were shown on Table 9. Those results were applied to the collected data.

Block A

Planned tracklines were almost surveyed using the echosounder. To identify acoustical backscattering, midwater trawls were towed at 2 stations. In addition, samples from predetermined trawl and MOCNESS stations were also used for species identification.

Krill distributed in the entire survey area. Three pelagic fish species, Japanese anchovy, Pacific, saury and chub mackerel were identified in the trawl. It is difficult to determine the fish species based on school morphology (shape, size, etc.) of backscattering. Species allocation of backscattering will be made using proportion of individual number by species in the trawl samples.

Result of MOCNESS sampling suggested that copepods species form species specific school. They formed layer shape school at specific depth. Acoustical abundance estimation will be conducted based on the contents of MOCNESS samples.

Block B

Planned tracklines were almost surveyed using the echosounder. To identify acoustical backscattering, midwater trawls and MOCNESS were towed at 1 and 5 stations, respectively. Japanese anchovy and krill were abundant prey species in Block B as in the past cruise. Japanese anchovy was distributed throughout Block B but the length frequencies were different from the northern part to the southern part.

Backscatterings that were assumed as krill were scarce and weak. Krill might be distributed at deeper water depth than we expected. This point will be considered further in the laboratory.

Trawls at predetermined stations

Block A
Midwater predetermined trawls were conducted at 13 stations (seven 0-100m water depth station and six 0-30m stations) in Block A. Small size Japanese anchovy and chub mackerel were caught in southern part of the survey area whereas large size Japanese anchovy and Pacific saury were caught in northern part.

Block B
Midwater routine trawls were conducted at 5 stations. Japanese anchovy was dominant species.

MOCNESS at predetermined stations

Block A
Predetermined MOCNESS tows were made at 3 stations. At each station, both day and night tows were made. Vertical distribution patterns zooplanktons will be examined using the collected samples.

Block B
Predetermined MOCNESS tows were made at 3 stations in only daytime. At each station, both day and night tows were made. Vertical distribution patterns zooplanktons will be examined using the collected samples.

Preliminary analysis suggested that length size of krill in the MOCNESS sample was smaller than we expected. Due to small mouth opening of MOCNESS, large size krill might avoid the net. Large size plankton net, such as IKMT (16 feet) should be also used in the future prey survey.

ACKNOWLEDGEMENT

A special thank is given to the crews and researchers for their dedication in collecting data. The authors would like to thank Dr. Hiroshi Hatanaka (The Institute of Cetacean Research, Japan). Dr. Kazushi Miyasita (Hokkaido University) provided useful comments on acoustic data analysis.

REFERENCES

Fujise, Y., Kawahara, S., Pastene, L. A. and Hatanaka, H. 2002. Report of 2000 and 2001 feasibility study of the Japanese whale research program under special permit in the western North Pacific – phase II. Paper SC/54/O17 submitted to the 54th IWC Scientific Committee Meeting, 202 pp (available from the IWC secretariat).

Government of Japan. 2000. Research plan for cetacean studies in the western North Pacific under Special Permit (JARPN II) (Feasibility Study Plan for 2000 and 2001). Paper SC/52/O1 submitted to the 52th IWC Scientific Committee Meeting,, 68 pp.

Government of Japan. 2002. Research plan for cetacean studies in the western North Pacific under Special Permit (JARPN II). Paper SC/54/O2 submitted to the 52th IWC Scientific Committee Meeting,,

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

Jhonson, D. H. 1980. The comparison of usage and availability measurements for evaluating resource preference. Ecology 61:65-71.

Litvaitis, J. A. 2000. Investigating food habits of terrestrial vertebrates. In: *Research techniques in animal ecology: controversies and consequences*, pp. 165-190. Boitani, L. and Fuller, T. K. (eds), Columbia University press, New York, pp.442.

Miyashita, K., Aoki, I., Seno, K., Taki, K. and Ogishima. 1997. Acoustic identification of isada krill, *Euphausia pacifica* Hansen, off the Sanriku coast, north-eastern Japan. Fish. Oceanogr. 6. 266-271.

Murase, H., Tamura, T., Kiwada, H., Fujise, Y., Watanabe, H., Ohizumi, H. and Kawahara, S. 2002. Preliminary estimation of prey preference of minke and Bryde's whales based on JARPN II. Appendix 5, pp 97-117. *In*: Fujise, Y., Kawahara, S., Pastene, L. A. and Hatanaka, H. 2002. Report of 2000 and 2001 feasibility study of the Japanese whale research program under special permit in the western North Pacific – phase II. Paper SC/54/O17 submitted to the 54th IWC Scientific Committee Meeting, 202 pp (available from the IWC secretariat)

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

Stanton, T., K. and Chu, D. 2000. Review and recommendations for the modelling of acoustic scattering by fluid-like elongated zooplankton: euphausiids and copepods. ICES J. Mar. Sci. 57:793-807

Table 1. List of waypoints.

Block A

WP	Lat	Long	Course	Distance (n.mile)
1	38-00N	156-00E	67	153
2	39-00N	159-00E	293	151
3	40-00N	156-00E	57	163
4	41-30N	159-00E	304	161
5	43-00N	156-00E	65	144
6	44-00N	159-00E	-	-
			Total	772

Block B

WP	Lat	Long	Course	Distance (n.mile)
1	40-00N	146-30E	117	130
2	39-00N	149-00E	243	130
3	38-00N	146-30E	127	150
4	36-30N	149-00E	234	150
5	35-00N	146-30E	-	-
			Total	560

Table 2. Itinerary of the survey

Date	Event
6/12	Departed Shimizu, Japan.
6/15	Started Block A survey.
6/25	Ended Block A survey.
6/27	Conducting CTD and water sampling casts (ST-17 and ST-18).
6/28	Arrived Shiogama, Japan
6/30	Departed Shiogama, Japan. Counducting echo sounder calibration.
7/1	Started Block B survey.
7/8	Conducting echo sounder noise measurement.
7/9	Ended Block B survey.
7/11	Arrived Shimizu, Japan.

Table 3. Summary of the survey.

Survey Block	Prey survey date	Whale survey date	No. of tracklines	No. of target trawl stations	No. of routine trawl stations (daytime)	No. of routine trawl stations (Nighttime)	NO. of target MOCNESS stations	NO. of routine MOCNESS stations (daytime)	NO. of routine MOCNESS stations (Nighttime)	No. of CTD stations	No. of sampled common minke whale	No. of sampled sei whale	No. of sampled Bryde's whale
A	6/15-25	6/10-22	5	2	11	2	0	3	3	16	15	15	-
B	7/1-9	6/26-29, 7/1-7	4	1	5	0	4	3	0	13	1	2	19

Table 4. Results of target and predetermined trawls in Block A.

Station	Predetermined/target	Day/night	Date	Lat.	Long.	Target depth (m)	Towing duration (min.)	Total sample wt. (kg)	Sampled weight by species (kg)												
									Engraulis japonicus	E. japonicus (juv)	Scomber japoniccus	Cololabis saira	Oncorhynchus gorbuscha	Oncorhynchus kisutch	Ceratoscopelus warmingii	Stenobrachius leucopsarus	Other Fish	Todarodes pacificus	Onychoteuthis borealijaponca	Other cephalopod	Gelatinous zooplankton	Other
1	P	D	2003/6/15	38-13N	156-39E	0-100	30	4.1	1.9	0.1	1.2	-	-	-	-	-	-	0.8	-	+	-	+
1	P	N	2003/6/15	38-13N	156-39E	0-100	30	32.5	6.8	-	0.2	-	-	-	9.2	-	3.1	0.8	1.7	0.3	-	10.6
3	T	D	2003/6/17	39-24N	157-44E	0-30	30	31.3	24.3	-	2.6	-	-	-	-	-	0.3	4.1	-	-	-	0.3
4	P	D	2003/6/17	39-31N	157-28E	0-30	30	188.5	150.8	-	1.8	-	-	-	-	-	-	35.9	-	-	-	-
5	P	D	2003/6/18	39-54N	156-17E	0-100	30	0.2	-	-	-	0.1	-	-	-	-	-	-	-	+	0.1	-
6	P	D	2003/6/18	40-08N	156-16E	0-30	30	+	-	-	-	-	-	-	-	-	-	-	-	+	+	-
7	P	D	2003/6/19	40-31N	157-02E	0-100	30	5.5	-	-	-	4.4	1.1	-	-	-	-	-	-	-	-	-
8	P	D	2003/6/19	40-55N	157-50E	0-30	30	158.2	-	-	-	158.2	-	-	-	-	-	-	-	-	-	-
9	P	D	2003/6/20	41-32N	158-55E	0-100	30	1.4	-	-	-	-	1.3	-	-	-	-	-	-	-	+	-
11	P	D	2003/6/21	42-08N	157-44E	0-30	30	464.3	-	-	-	434.0	-	2.3	-	-	-	-	-	-	-	-
12	T	D	2003/6/21	42-15N	157-28E	0-30	20	232.2	-	-	-	232.2	-	-	-	-	-	-	-	-	-	-
13	P	D	2003/6/22	42-50N	156-18E	0-30	30	+	-	-	-	-	-	-	-	-	-	-	-	-	+	-
14	P	D	2003/6/22	43-10N	156-30E	0-100	30	8.0	-	-	-	-	2.8	-	-	-	5.2	-	-	-	-	-
14	P	N	2003/6/22	43-10N	156-29E	0-100	30	29.9	-	-	-	-	-	-	-	8.0	20.0	-	0.5	1.3	-	-
15	P	D	2003/6/23	43-30N	157-26E	0-30	30	377.2	-	-	-	377.2	-	-	-	-	-	-	-	-	-	-

Table 5. Results of target and predetermined trawls in Block B.

Station	Predetermined/ target	Day/night	Date	Lat.	Long.	Target depth (m)	Towing duration (min.)	Total sample wt. (kg)	Sampled weight by species (kg)									
									Engraulis japonicus	E. japonicus (juv)	Scomber japoniccus	Trachurus japonicus	Cololabis saira	Other Fish	Todarodes pacificus	Other cephalopod	Gelatinous zooplankton	Other
21	P	D	2003/7/1	39-45N	147-06E	0-30	30	16.7	16.0	-	+	0.1	0.6	-	-	-	0.1	-
22	P	D	2003/7/2	39-36N	147-43E	0-100	30	90.9	83.5	-	-	-	-	2.1	0.2	-	4.8	-
24	P	D	2003/7/4	38-24N	147-30E	0-100	30	0.1	+	+	+	-	-	-	+	-	+	+
26	T	D	2003/7/4	38-01N	146-33E	0-30	30	0.2	+	+	+	+	-	-	+	+	0.1	-
28	P	D	2003/7/6	37-09N	147-53E	0-100	30	0.7	-	+	+	+	-	-	-	-	0.7	-
31	P	D	2003/7/8	36-00N	148-09E	0-100	30	4.1	+	2.4	+	+	-	+	-	-	1.7	+

Table 6. Results of MOCNESS in Block A.

Station	Predetermined/ target	Day/ night	Date	Lat	Long	Target depth (m)	Amount of filtered water (m^2)
2	P	D	2003/6/16	38-54N	158-41E	250→200	534.6
						200→150	383.6
						150→100	432.7
						100→80	207.7
						80→60	229.7
						60→40	167.0
						40→20	185.6
						20→0	200.6
2	p	N	2003/6/16	38-54N	158-41E	250→200	686.8
						200→150	311.8
						150→100	243.4
						100→80	150.5
						80→60	281.1
						60→40	281.8
						40→20	238.8
						20→0	250.5
10	P	D	2003/6/20	41-41N	158-40E	250→200	474.8
						200→150	358.1
						150→100	468.0
						100→80	238.4
						80→60	280.6
						60→40	220.3
						40→20	292.4
						20→0	291.8
10	p	N	2003/6/20	41-40N	158-40E	250→200	446.3
						200→150	471.3
						150→100	435.8
						100→80	205.4
						80→60	209.8
						60→40	225.6
						40→20	164.8
						20→0	239.5
16	P	D	2003/6/25	43-58N	158-53E	250→200	386.0
						200→150	442.2
						150→100	439.2
						100→80	176.2
						80→60	250.1
						60→40	229.3
						40→20	231.2
						20→0	288.7
16	p	N	2003/6/24	43-58N	158-53E	250→200	383.9
						200→150	524.9
						150→100	411.7
						100→80	219.9
						80→60	218.0
						60→40	165.0
						40→20	252.5
						20→0	301.1

Table 7. Results of MOCNESS in Block B

Station	Predetermined /target	Day/ night	Date	Lat	Long	Target depth (m)	Amount of filtered water (m^2)
20	P	D	2003/7/1	39-53N	146-43E	250→200	383.4
						200→150	492.6
						150→100	681.2
						100→80	167.1
						80→60	173.0
						60→40	176.0
						40→20	177.3
						20→0	267.4
23	T	D	2003/7/3	39-11N	148-32E	100→200	1104.8
						200→200	670.8
						200→150	829.5
						150→240	475.5
						240→230	575.8
						230→250	460.5
						250→220	482.6
						220→260	479.5
25	P	D	2003/7/4	38-15N	147-06E	250→200	627.4
						200→150	425.7
						150→100	671.5
						100→80	252.4
						80→60	256.0
						60→40	285.4
						40→20	281.1
						20→0	231.4
27	T	D	2003/7/6	37-35N	147-07E	160→140	329.0
						140→120	314.4
						120→100	311.0
						100→80	445.0
						80→60	266.5
						60→40	299.5
						40→20	208.5
						20→0	301.0
29	T	D	2003/7/3	36-55N	148-19E	230→250	801.9
						250→210	293.4
						210→230	868.8
						230→230	879.1
						230→260	672.4
						260→280	1075.8
						280→230	424.1
						230→260	511.4
30	T	D	2003/7/7	36-44N	148-41E	270→250	434.2
						240→200	324.0
						200→150	158.0
						150→100	276.4
						100→75	307.1
						75→50	123.3
						50→25	236.6
						25→0	296.2
32	P	D	2003/7/9	35-10N	146-49E	250→200	391.9
						200→150	467.5
						150→100	395.9
						100→80	266.4
						80→60	375.7
						60→40	272.0
						40→20	250.5
						20→0	467.8

Table 8. Results of CTD casts.

Station	Date	Lat.	Long.	Depth (m)	Note
ST-01	2003/6/15	38-13N	156-39E	500	
ST-02	2003/6/16	38-54N	158-41E	500	
ST-03	2003/6/17	39-25N	157-48E	500	
ST-04	2003/6/17	39-30N	157-28E	500	
ST-05	2003/6/18	39-54N	156-16E	500	
ST-06	2003/6/18	40-09N	156-11E	500	
ST-07	2003/6/19	40-31N	157-01E	500	
ST-08	2003/6/19	40-55N	157-51E	500	
ST-09	2003/6/20	41-32N	158-55E	500	
ST-10	2003/6/20	41-40N	158-40E	500	
ST-11	2003/6/21	42-08N	157-44E	500	
ST-13	2003/6/22	42-50N	156-18E	500	
ST-14	2003/6/22	43-10N	156-30E	500	
ST-15	2003/6/23	43-29N	157-27E	500	
ST-16	2003/6/24	43-58N	158-54E	500	
ST-17	2003/6/27	38-30N	146-00E	4000	Water sampling
ST-18	2003/6/27	38-30N	143-30E	2500	Water sampling

Block B

Station	Date	Lat.	Long.	Depth (m)	Note
ST-19	2003/6/30	38-14N	141-22E	36	Data for calibration
ST-20	2003/7/1	39-54N	146-44E	500	
ST-21	2003/7/2	39-45N	147-07E	500	
ST-22	2003/7/2	39-35N	147-43E	500	
ST-23	2003/7/3	39-08N	148-37E	500	
ST-24	2003/7/4	38-24N	147-31E	500	
ST-25	2003/7/4	38-14N	147-06E	500	
ST-26	2003/7/5	38-03N	146-36E	500	
ST-27	2003/7/6	37-33N	147-05E	500	
ST-28	2003/7/6	37-09N	147-53E	500	
ST-29	2003/7/7	36-57N	148-14E	500	
ST-30	2003/7/7	36-47N	148-42E	500	
ST-31	2003/7/8	36-00N	148-09E	500	
ST-32	2003/7/9	35-07N	146-48E	500	

Table 9. Results of the calibration of the echosounder.

	Frequency		
	38 kHz	70 kHz	120 kHz
Software	Calibration version 1.0.0.5	Calibration version 1.0.0.5	Calibration version 1.0.0.5
Date	6/30/2003	6/30/2003	6/30/2003
Latitude	38°14N	38°14N	38°14N
Logitude	141°22E	141°22E	141°22E
Referecne target			
TS	-33.60 dB	-39.20 dB	-40.40 dB
TS deviation	3.0 dB	3.0 dB	3.0 dB
Minimum distance	23.00 m	19.00 m	12.00 m
Maximum distance	25.00 m	24.00 m	17.00 m
Transducer			
Transducer type	ES38B	ES70-11	ES120-7
Transducer serial No.	30128	29897	29415
Frequency	38000 Hz	70000 Hz	120000 Hz
Gain	26.08 dB	21.82dB	25.49 dB
Athwartship angle sensitivity	21.90	13.00	21.00
Athwartship Beam angle	7.05 deg	11.51 deg	7.36 deg
Athwartship Offset angle	-0.04 deg	-0.08 deg	-0.18 deg
Alongship angle sensitivity	21.90	13.00	21.00
Alongship beam angle	7.10 deg	11.60 deg	7.42 deg
Alongship offset angle	-0.01 deg	0.09 deg	0.17 deg
Sa correction	-0.72 dB	0.00dB	-0.57dB
Beamtype	Split	Split	Split
Two way beam angle	-20.6 dB	-16.8 dB	-20.8 dB
Depth	0.00 m	0.00 m	0.00 m
Transceiver			
Transceiver type	GPT 38 kHz 0090720120f 1 ES38B	GPT 70 kHz 0090720171e5 1 ES70-11	GPT 120 kHz 009072017195 1 ES120-7
Pulse duration	1.024 ms	1.024 ms	1.024 ms
Power	2000 W	800 W	500 W
Sample interval	0.192 m	0.192 m	0.190 m
Receiver bandwidth	2.43 kHz	2.86 kHz	3.03 kHz
Sounder type	EK60 version 1.4.4.66	EK60 version 1.4.4.66	EK60 version 1.4.4.66
TS detection			
Minimum value	-60.0 dB	-60.0 dB	-60.0 dB
Maximum beam compensation	6.0 dB	6.0 dB	6.0 dB
Maximum phase deviation	8.0	8.0	8.0
Minimum echolength	80 %	80 %	80 %
Maximum echolength	180 %	180 %	180 %
Environment			
Water temperature	14.05°C	14.05°C	14.05°C
Salinity	33.29 PSU	33.29 PSU	33.29 PSU
Absorption coefficient	8.6 dB/km	22.1 dB/km	40.2 dB/km
Sound velocity	1502.5 m/s	1502.5 m/s	1502.5 m/s
Beam model results			
Transducer gain	25.91 dB	21.41 dB	25.88 dB
Athwartship Beam angle	7.12 deg	11.50 deg	7.39 deg
Athwartship Offset angle	-0.03 deg	-0.04 deg	-0.19 deg
Alongshipship Beam angle	7.07 deg	12.01 deg	7.46 deg
Alongshipship Offset angle	-0.06 deg	-0.06 deg	-0.16 deg
Sa correction	-0.66 dB	-0.38 dB	-0.78 dB

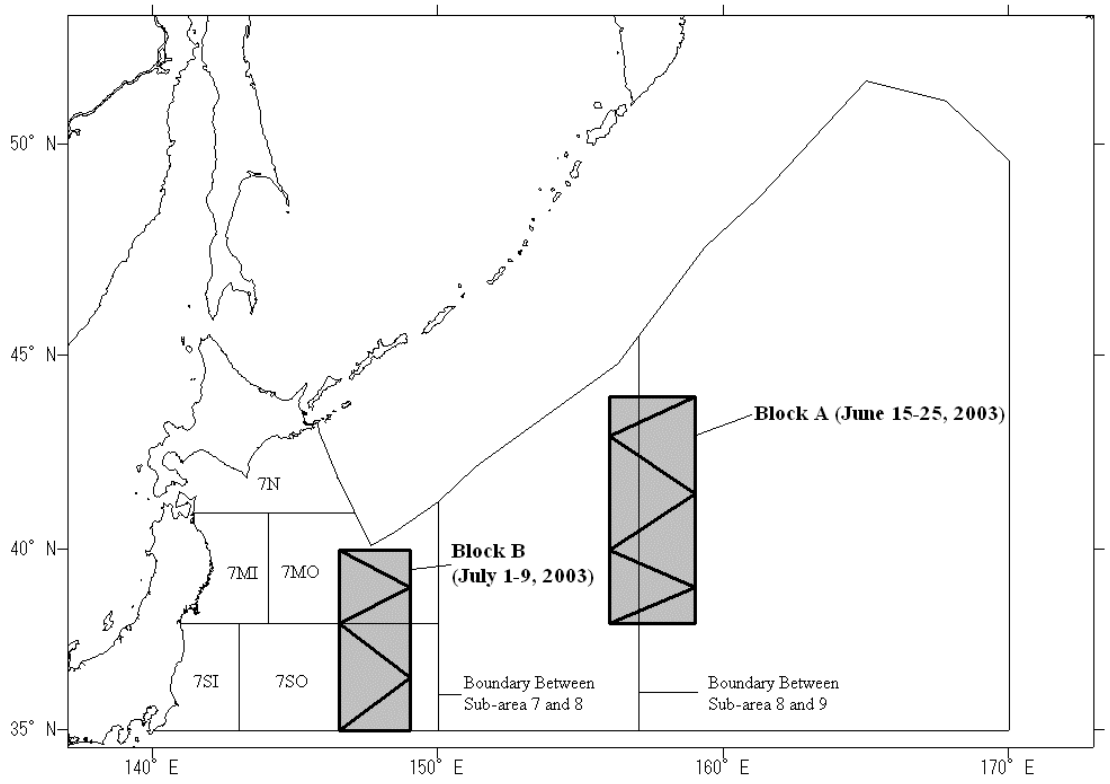
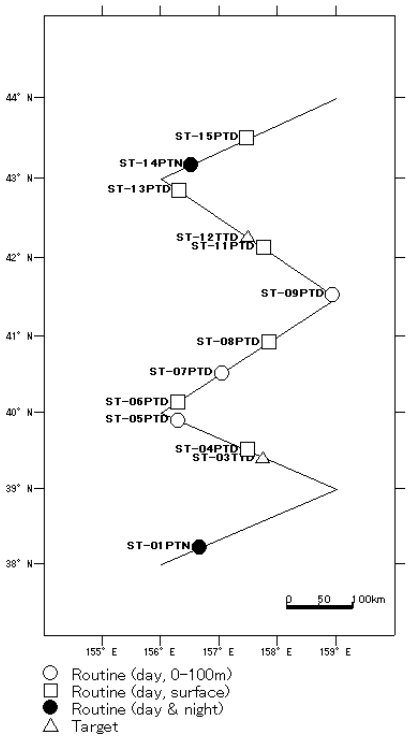
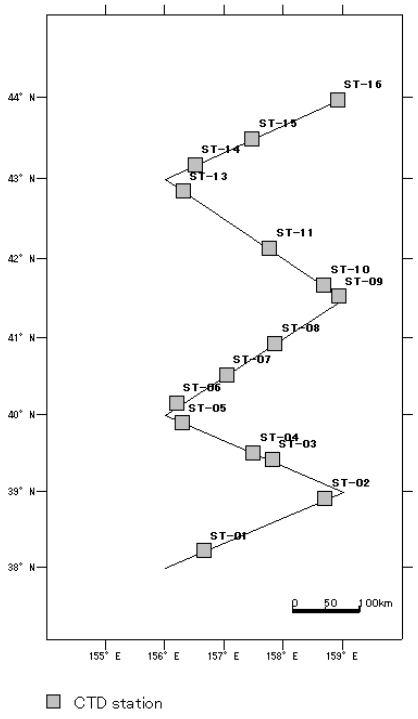


Fig. 1 Survey area and planned tracklines. Sub-area 7 was divided to 5 small areas.

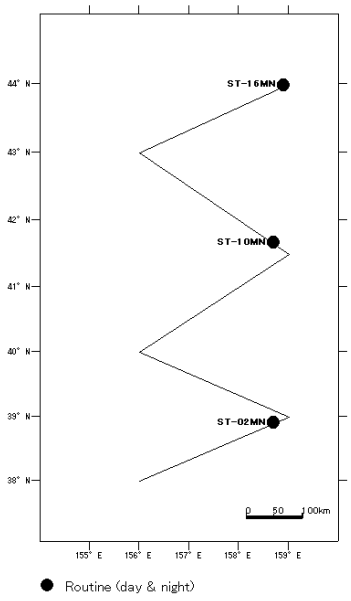
.



(a)

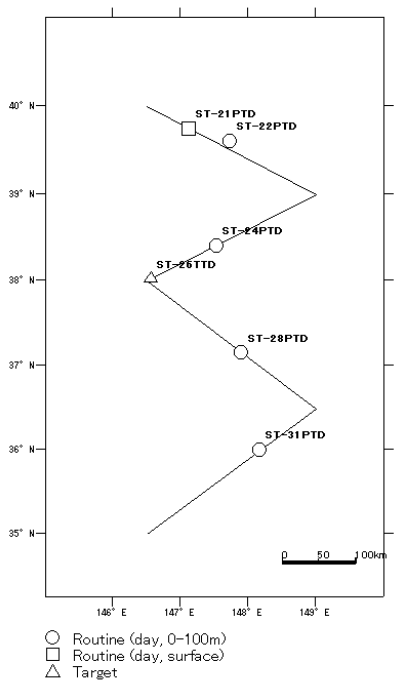


(c)

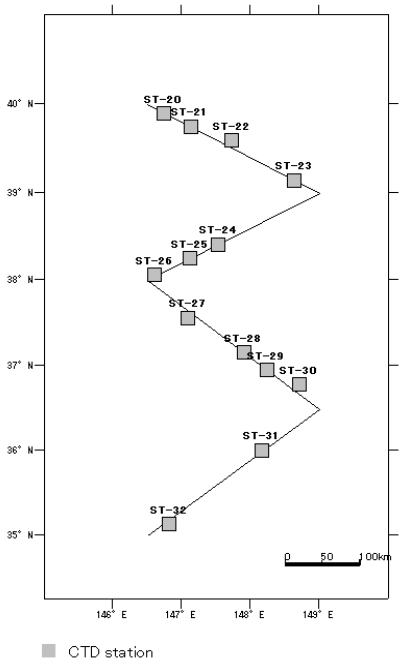


(b)

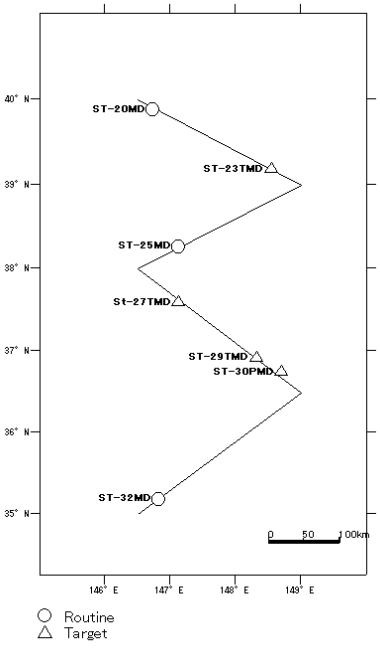
Fig. 2. Positions of trawl (a), MOCNESS (b), and CTD casts (c) in Block A.



(a)



(c)



(b)

Fig. 3. Positions of trawl (a), MOCNESS(b) and CTD casts (c) in Block B.

Appendx 2

Oceanographic conditions in the Kuroshio-Oyashio Inter-frontal zone in June to July 2003

DENZO INAGAKE, MAKOTO OKAZAKI, KAZUYUKI UEHARA AND SHIGEYUKI KAWAHARA

National Research Institute of Far Seas Fisheries, 5-7-1, Shimizu-Orido, Shizuoka, 424-8633, Japan

kawahara@fra.affrc.go.jp

INTRODUCTION

The Kuroshio is one of the strongest west-boundary current of subtropical gyre and flows northward with warm high-salinity water from the offshore area of the Philippine to the waters off Japan. The Oyashio flows southwestward along the Kuril Islands with cold low-salinity water. The Kuroshio and the Oyashio flows eastward from the Japan coast, and the area between the Kuroshio and Oyashio east off Japan was usually called the Kuroshio-Oyashio Inter-frontal zone. In this area, there are a lot of oceanic fronts and water masses. In the offshore area east of around 150° E, the Oyashio front branches to the Subarctic Front (temperature front defined by 4℃) and the Subarctic Boundary (salinity front defined by 34.0psu). Distributions of water masses and fronts in June to July 2003 will be described.

METHOD

Hydrographic observations with a conductivity-temperature-depth profiler (CTD; SBE 911plus) were carried out from 15th June to 9th July 2003 in the Kuroshio-Oyashio Inter-frontal Zone using *R/V Shunyo Maru* (Fig. 1). Salinity compensation for CTD data was done using water sampling data at two CTD stations. The accuracy of the salinity was expected 0.002 psu after the compensation.

The oceanographic conditions in June and July 2003 were analyzed by Tohoku National Fisheries Research Institute (TNFRI), which used quasi-real-time data from several cooperative organs and prefectures, that was 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/index-j.html). Oceanic fronts and water masses are usually detected by subsurface temperature map, because they are obscure in sea surface temperature distributions in warming seasons and the Oyashio water spreads into the subsurface layer. The Kuroshio Extension is defined by the 14℃ isotherm at the depth of 200m (Kawai , 1969). The Kuroshio warm-core rings and cold rings are defined by closed isothermal lines in a 200 m temperature map. The warm water spread from Kuroshio Extension is defied by temperature more than 10℃ at the depth of 100 m . The Tsugaru warm water is defined by an oceanic front in a 100 m temperature map. The first and the second Oyashio Intrusions are defined by temperature lass than 5℃ at the depth of 100 m (Murakami, 1994).

OCEANOGRAPHIC CONDITIONS IN THE RESEARCH AREA

Figure 2 shows the Temperature-Salinity diagrams using CTD station data. Water masses in the research area have characteristics of cold low-salinity water (the Oyashio water in the lower part of Fig. 2) and the mixed water of the Kuroshio water and Oyashio water.

Figure 3 shows the schematic hydrographic map in June and July 2003, presented by TNFRI. The northern limit of the Kuroshio Extension at the first crest was 36° 20'N in June and 36° 10'N (lower red area in Fig.3), which are almost mean position. The northern limit of the warm water spread from the Kuroshio Extension shifts northward from March to November. Its position in June 2003 was at 39° 10'N on 145° 30'E line and 40° 10'N on 152° E line. In July 2003, it was 39° 10'N on 146° E line and 40° 30'N on 158° 30'E line. The Kuroshio warm-core ring was detected by 200 m temperature map (Fig. 4) around 41° N, 146° 30'E and it moved westward to 40° 50'N, 145° 50'E. Tsugaru warm water spread eastward to 143° 50'E in June and 142° 50'E in July along 41° 30'N. The southern limit of the first Oyashio

Intrusion was located 39° N on 144° 40'E line in June and 38° 30'N on 142° 40'E line in July, which were more southern position from monthly mean location. The southern limit of the second Oyashio Intrusion in June was 39° 10'N, 146° 20'E where was in the south from the mean position. In July, it was obscure in Fig 3 but maybe existed around 39° 30'N, 146° 30'E, where was in a slightly south from the mean.

Figure 5 shows the 100 m depth temperature map observed by *R/V Shunyo Maru*. The Oyashio water colder than 5℃ was spreading at the northern part of the observation area. The warm water spreading from the Kuroshio area was observed in the southern part of this area. The Subarctic Boundary (defined by 34 psu) was observed around 40° N in the eastern part of this area.

Figure 6 shows the vertical temperature sections between 146° E -149° E and 156° E-159° E, which were zigzag lines. The warm water spread from the Kuroshio Extension was limited in the southern part of the 156° E -159° E section but observed in the almost whole area, north of the warm water (north of 40° N). In contrast, the warm water was observed at the upper layer in almost whole area in the 146° E -149° E section without the Oyashio water in the northern part of this section (north of 39° 30'N). There was a sharp temperature front around 39° 30'N between the warm water and the Oyashio water in this section. Similar pattern was also found in the salinity section, namely, a sharp salinity front was observed around 39° 30'N where was between southern high-salinity water higher than 34psu and northern low-salinity water less than 33.5psu (lower left panel in Fig. 6). That is to say, a warm and high-salinity water originating from subtropical water and cold law-salinity water originating from Subarctic water were also found in this section, and the Oyashio front (defined by 5℃ at 100m depth), the Subarctic Front (defined by temperature front of 4℃ isotherm), the Subarctic Boundary (defined by salinity front of 34psu) and the northern edge of the warm water spreading from the Kuroshio (defined by 10℃ at 100 m depth) were concentrated into almost same location (around 39° 30'N) in the 146° E -149° E section. In the 156° E -159° E section, the Subarctic Boundary (34psu isohaline) and the northern edge of the warm water (10℃ isotherm) were detected in the almost same location around 39° 30'N, but the Subarctic Front (4℃ isotherm) was between 42° 30'N -43° N separated from the Subarctic Boundary.

REFERENCES

Kawai, H. (1969): Statistical estimation of isotherms indicative of the Kuroshio axis, *Deep-Sea Res.*, **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).

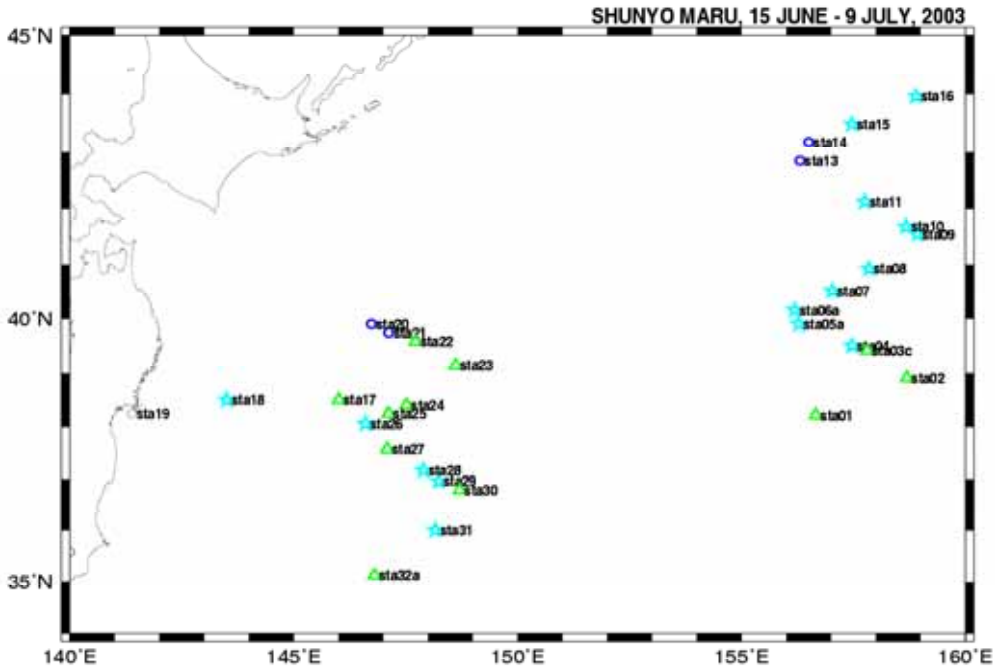


Fig. 1. Station map observed by *R/V Shunyo Maru* in 15 June – 9 July 2003. Green triangles, light blue stars and blue circles denote CTD stations in the warm area (100 m temperature was over 10℃ and 200 m temperature was less than 14℃), the cold area (100 m temperature was over 5℃ and less than 10℃) and the Oyashio area (100 m temperature was less than 5℃), respectively

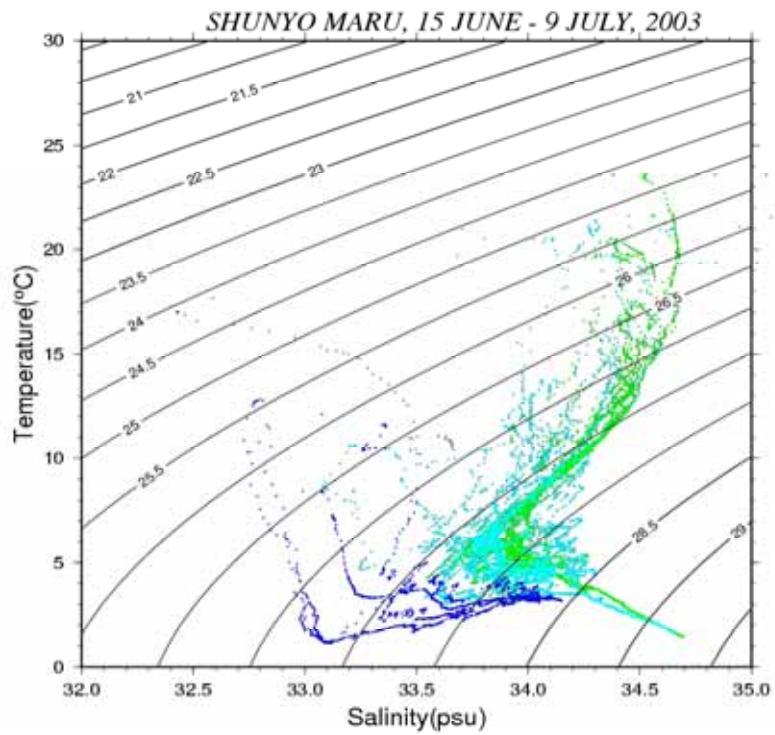


Fig. 2. Temperature-Salinity diagrams using CTD station data observe by *R/V Shunyo Maru* in 15 June – 9 July 2003. Each thin line in this figure denotes a density line of sigma-t. Green, light blue and blue points corresponded to the warm area, the cold area and the Oyashio area, respectively.

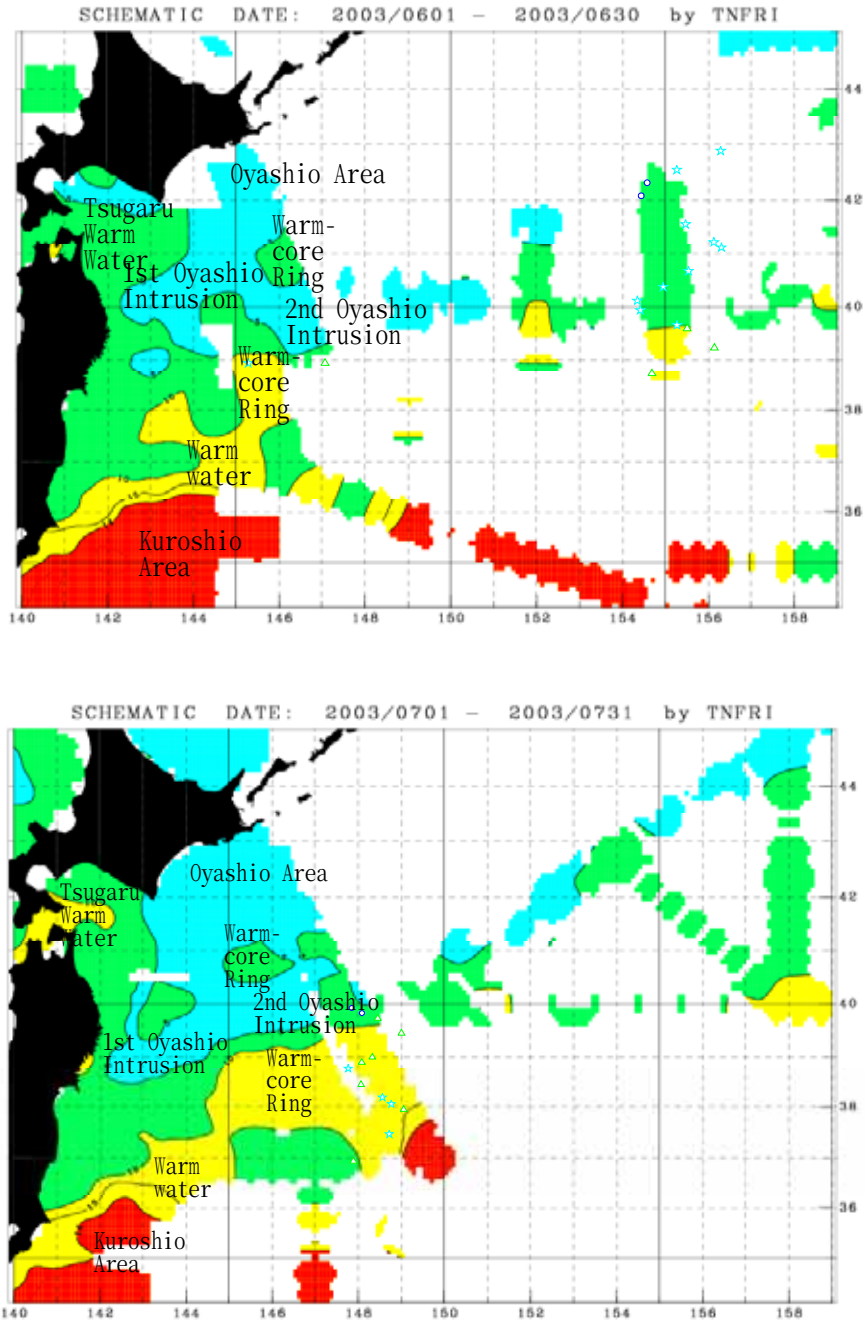


Fig. 3. Schematic hydrographic map in Tohoku area, northwestern Pacific, in June (upper panel) and July (lower panel) 2002. (Presented by Tohoku National Research Institute.) Blue area, green area, yellow area and red area denote the Oyashio (100 m temperature was less than 5℃), cold area (100 m temperature was over 5℃ and less than 10℃), warm water (100 m temperature was over 10℃ and 200 m temperature was less than 14℃) spreading from the Kuroshio Extension and the Kuroshio area (200 m temperature was over 14℃), respectively. 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

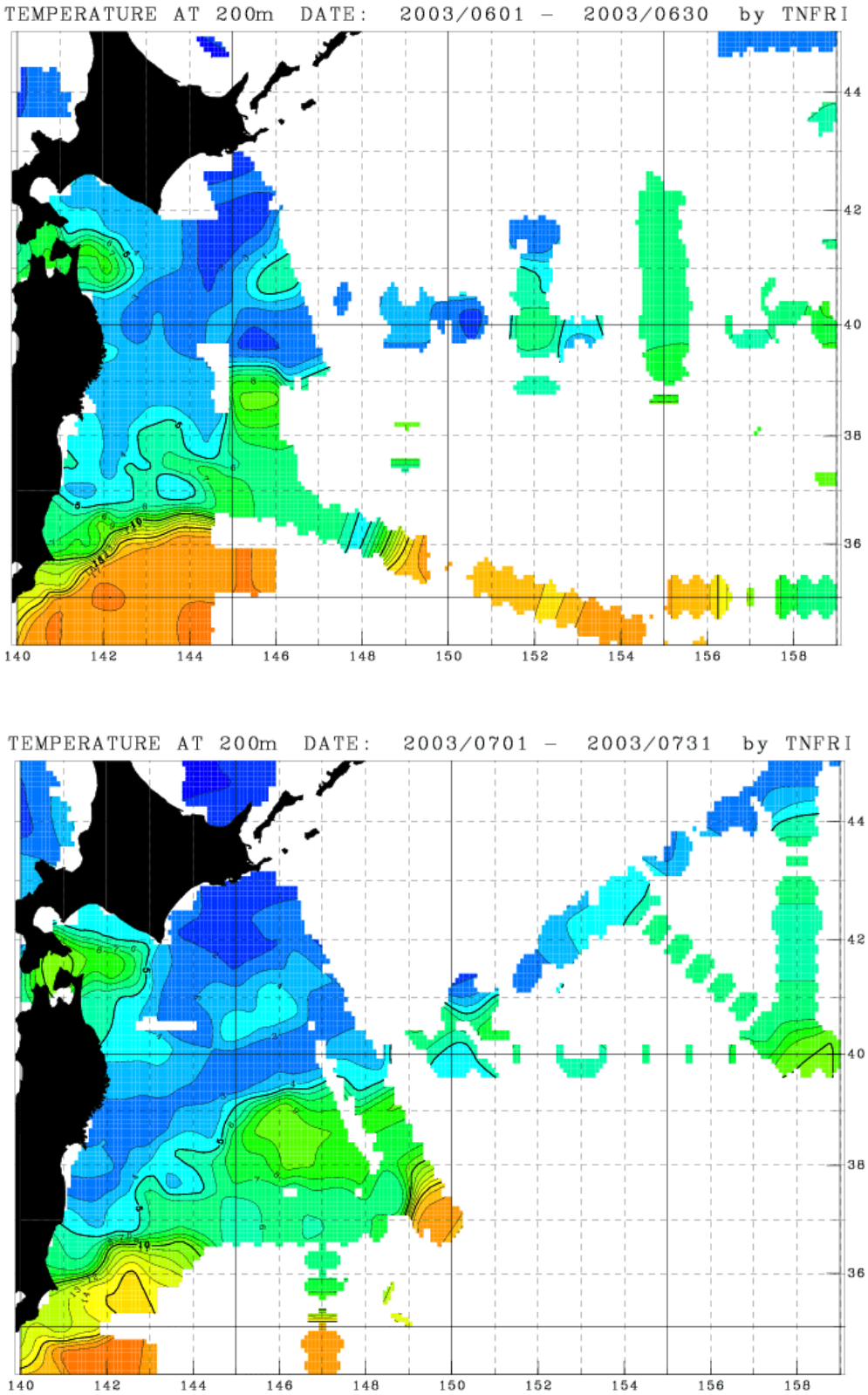


Fig. 4. Temperature map at the depth of 200m in June (upper panel) and July (lower panel) 2003, presented by Tohoku National Research Institute.

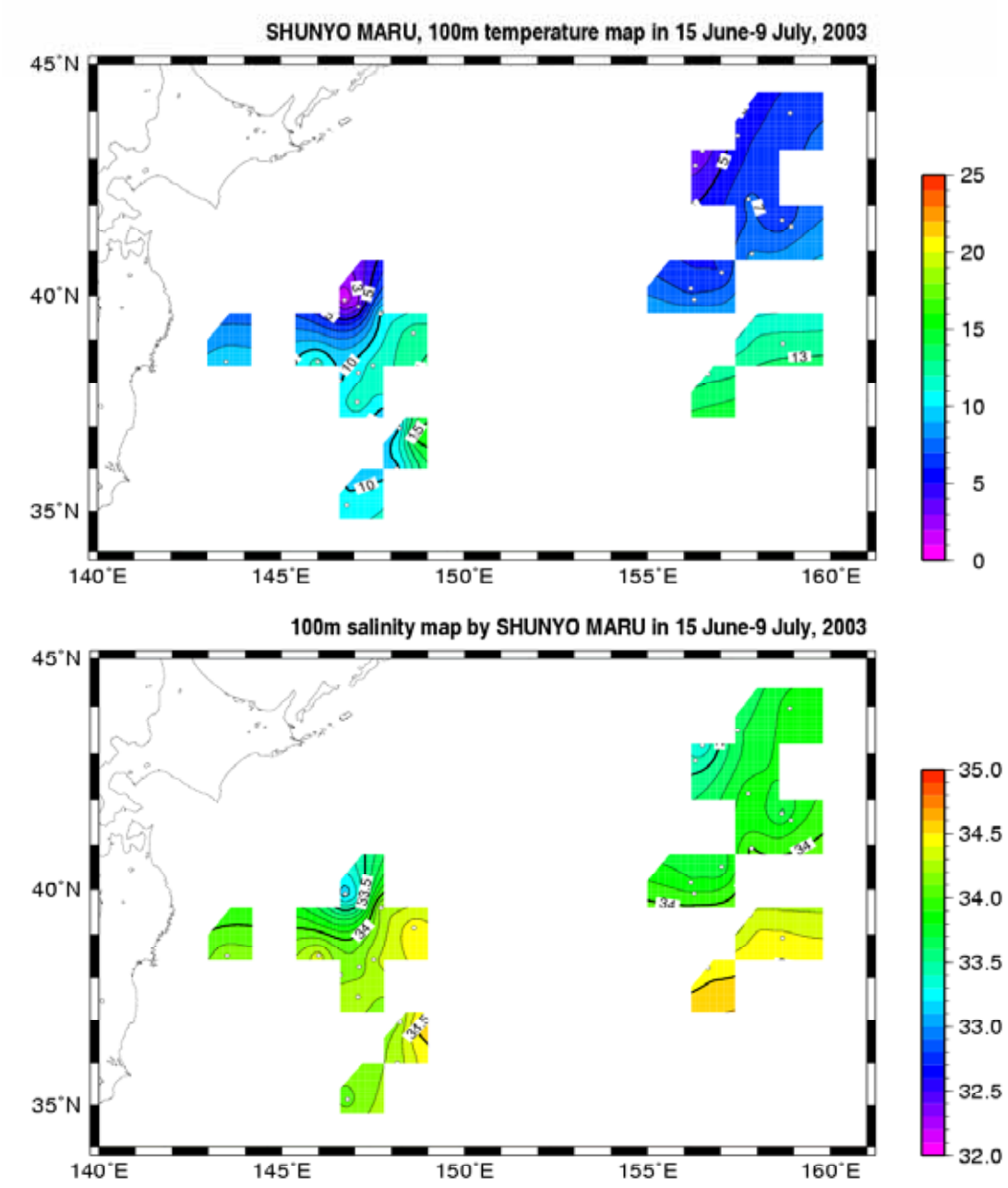


Fig.5. 100m temperature (upper left panel) and salinity (lower panel) maps observed by *R/V Shunyo Maru* in 15 June – 9 July 2003.

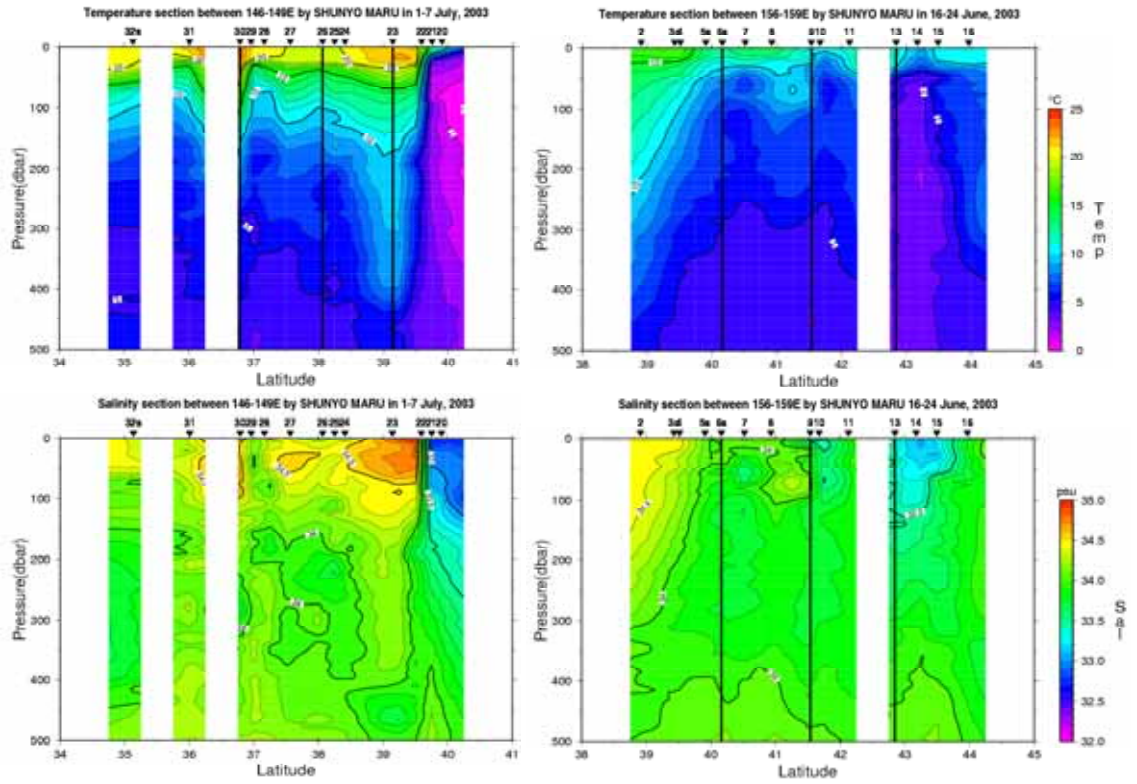


Fig. 6. Temperature (upper panels) and salinity (lower panels) between 146° E-149° E (left panels) and between 156° E-159° E (right panels) observed by *R/V Shunyo Maru* in 16-24 June and 1-7 July 2003.