Cruise Report of the Japanese Whale Research Program under Special Permit in the western North Pacific-Phase II (JARPN II) in 2002 (part I) - Offshore component -

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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, after conducting two feasibility studies in 2000 and 2001. 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, particularly for minke whales. Target species are common minke whale *Balaenoptera acutorostrata*, Bryde's whale *B. edeni*, sei whale *B. borealis* and sperm whale *Physeter macrocephalus*. The first full-scale JARPNII survey was conducted from 5 July to 18 September 2002 in sub-areas 7, 8 and 9 of the western North Pacific. In the survey a total of six research vessels was used: one trawl survey vessel equipped with scientific echo sounder (TSV), one dedicated sighting vessel (SV), three sighting/sampling vessels (SSVs) and one research base vessel. A total of 11,497.3n.miles was surveyed for whale searching in a period of 76 days. During that period 141 common minke, 129 Bryde's, 212 sei and 556 sperm whales were sighted by the SSVs. A total of 100 common minke, 50 Bryde's, 39 sei and 5 sperm whales was sampled by the SSVs. The cooperative survey on ecosystem research with the participation of all five vessels was conducted in a part of sub-area 8 and 9 from 18 July to 1 August and in a part of sub-area 7 from 7 to 17 August. All whales sampled were examined on board the research base vessel. Regarding minke whales most of samples were males (85%) and females was relatively low (15%). In the case of Bryde's whales, males and females were observed equally (25 males and 25 females). On the other hand, in the case of sei whales, females were relatively higher in the samples (61.5%). In the case of sperm whale, two males and three females were sampled. Major prey species of minke whales were Japanese anchovy (*Engraulis japonicus*) and common squid (*Todarodes pacificus*) in sub-area 7; Pacific saury (*Cololabis saira*) in sub-areas 8 and 9. Small-sized Japanese anchovy, including larva, was found in the stomach of Bryde's whales. Copepods, krill, Pacific saury, Japanese anchovy and Japanese common squid were observed in stomachs of sei whales. Dominant preys in the stomach of five sperm whales were different kinds of squids which inhabit in the mid- and deep-waters. A full body of neon flying squid was found in the stomach of a sperm whale. The results of pray survey is shown independently in Appendix 1.

KEYWORDS: COMMON MINKE WHALE; BRYDE'S WHALE; SEI WHALE; SPERM WHALE; 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) started in 2000 and 2001 as a two-year feasibility study (Government of Japan, 2000). JARPNII was a continuation of JARPN, which was conducted between 1994 and 1999. One of major objectives in the JARPNII feasibility study was to study and to test the practicability of research methods on feeding ecology of whales and marine ecosystem. During the previous JARPN surveys, it was revealed that the minke whales *Balaenoptera acutorostrata* feed on various commercial fish species such as Pacific saury (*Cololabis saira*), Japanese anchovy (*Engraulis japonicus*), Japanese common squids (*Todarodes pacificus*) and walleye pollock (*Theragra chalcogramma*), and that minke whale consume a considerable amount of these prey species (Fujise *et al.*, 1995, 1996, 1997, 2000, 2001, 2002; Ishikawa *et al.*, 1997, Zenitani *et al.*, 1999). Tamura and Ohsumi (1999) estimated that a large amount of marine fish resources were consumed by cetaceans in the world's ocean, and they recommended further examination of prey consumption by cetacean. Second objective of the feasibility study was related to stock structure issues, and the third one to pollution studies. Sampling of minke whale, Bryde's whale *Balaenoptera edeni* and sperm whale *Physeter macrocephalus* was conducted in the feasibility study.

Based on the success of the feasibility study (Government of Japan, 2002) and increasingly strong support from international fisheries organizations, including FAO, for research to improve multispecies approaches to management,

JARPN II started from 2002 as a full-scale research program. 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. Sampling of 100 minke whales, 50 Bryde's whales and 10 sperm whales were planned as same as in the feasibility study, and 50 sei whales *Balaenoptera borealis* and 50 minke whales from coastal areas (to be taken by small-type whaling catcher boats), were added as target for the full scale JARPNII. Sei whale is newly selected as a target species as they feed on fisheries resources such as common squid and the estimated biomass of sei whales is larger than those of Bryde's and minke whales. The additional 50 minke whales will provide full coverage of the spring and autumn seasons in coastal waters where the competition between cetaceans and fisheries is likely to be substantial. Ten sperm whales will continue to be sampled because their biomass is too large to be ignored in the ecosystem models.

In this paper, we present an outline of the first full scale survey of the JARPNII survey, which was conducted from 4 June to 18 September 2002.

MATERIALS AND METHOD

Research area

Sub-areas 7, 8 and 9, excluding the EEZ zones of foreign countries, were research area (Fig. 1).

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 40°N.

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

In the case of the co-operative 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 (SB-A) and coastal area (SB-B) as shown in Fig. 1. We conducted the whale survey and the prey survey in the SBs concurrently.

Research vessels

Six 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), *Kyo Maru* No.1 (K01: 812.08GT) and *Toshi Maru* No. 25 (T25: 739.92GT) 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: 368GT) was engaged as a dedicated sighting vessel (SV). This vessel was also conducted the oceanographic observations using EPCS (Electric particle counting and sizing system) and CTD.

The *Shunyo Maru* (SYO: 887GT) was engaged as a trawl survey and an echo sounder survey vessel. This vessel was also conducted the trawl net IKMT net and NORPAC net sampling. Furthermore, this vessel was conducted the oceanographic observations using CTD.

Research type

In this survey, three main components (the whale survey, dedicated sighting survey and the co-operative survey) were consisted as follows:

Whale survey

Vessels: Four research vessels (NM, YS1, K01 and T25)

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

Research period:

First period: Between 5 and 17 July.

Second period: Between 2 and 6 August.

Third period: Between 18 August and 18 September (including 13 and 14 August) (Table 1).

Dedicating Sighting survey

Vessels: One research vessel (KS2)

Research area: Sub-areas 7, 8 and 9

Research period:

First period: Between 5 June and 30 July for 7SO, 8N, 8S, 9N and 9S blocks.

Second period: Between 11 and 18 August for 7MO block.

Third period: Between 24 August and 6 September for 8N block (Table 1).

Co-operative survey on the prey species and whale sampling
Vessels: Six research vessels (NM, YS1, K01, T25, KS2 and SYO)

Research area: In the co-operative survey on ecosystem research, two special blocks (SB-A and SB-B) was settled.

Research periods:

First period: Between 18 July and 1 August for the SB-A (offshore-block).

Second period: Between 7 and 17 August for the SB-B (excluding 13 and 14 August) (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; 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 minke whales and sea conditions.

Furthermore, a 'special monitoring survey' (SMS) was conducted in an area where the abundance of minke whales, Bryde's and sei whales were expected to be high. Track line in the SMS was designed separately from the original track line. Three SSVs were allocated to these tracks with the allocation being changed every day (Fig 2).

Allocation of the vessels in the co-operative survey was determined in the following manner. If the SYO detected the existing of the prey species by response of echo sounder, the SYO conducted the trawl survey for the target depth to identify these prey species.

The whale research fleet surveyed as the following manner: the research course consisted of one main track and two parallel tracks established six n.miles apart from both sides. In the SMS the distance between the main and parallel tracks was set at four n.miles, for better efficiency of sampling.

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; 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 speed 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. 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 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 minke, Bryde's, Sei and sperm whales
Sampling activities were conducted with the aim to take 100 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 (06:00-19:00), 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 did not targeted for sampling. As in a previous JARPN survey the sampling was made in co-operation 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. Calibrations were carried out at off the coast of Kushiro (August 1 2002) 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 midwater trawl was towed at routine and acoustic target identification stations. Target trawls were conducted for 0.5 to 1 hour to identify the species compositions of biological backscattering detected by the quantitative echosounder. 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 echosounder. Three different depth layer were sampled at routine trawl stations; 0-10m (surface) 0-100m and 0-200m (mid-water). Nighttime routine trawls were conducted once per each block 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.

Two types of plankton nets were used to collect zooplankton. The Isaacs-Kidd midwater trawl (IKMT) was used to collect macrozooplankton such as krills. NORPAC net was used to collect mesozooplankton such as copepods.

A quantitative echo sounder (Simrad EK500) was used on board SV to acquire acoustic data with operating frequency at 38, 120 and 200 kHz. Data were collected with the aid of Simrad BI500 post processing system. Those data were collected as the reference information for qualitative analysis. No calibration was conducted by SV. The details of the prey species survey conducted by SYO is reported in the Appendix 1 of this paper.

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, K01 and T25).
2. Biopsy sampling on blue, fin, humpback, right, Bryde's, 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, minke, right and sperm whales).

On board the SV (KS2) and/or prey survey vessel (SYO), 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, 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. Feasibility study to estimate abundance of prey species of minke and other large whale species using an echo sounder system.
6. Oceanographic observations using CTD.
7. Oceanographic observations using EPCS (Electric particle counting and sizing system)
8. Recording vocalization of large whales using a sonar buoy.

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 the 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 2002 JARPN II survey is shown in Figs 4-5. That by the dedicated sighting vessel (SV) is shown in Fig. 6. The total searching distance for SSVs and SV were 11,497.3 n.miles and 3,812.2 n.miles, respectively (Table 2).

In the co-operative survey on ecosystem research, the survey was conducted from July to August with two periods; first from 18 July to 1 August 2002, and second from 7 to 17 August 2002 (24 days). Under the co-operative survey, searching distance for SSVs was 3,929.7 n.miles consisting of 1,964.4 n.miles and 1,965.3 n.miles for first (SB-A) and second periods (SB-B) (Table 2).

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

Sighting and sampling vessels (SSVs)

During the research cruise, 133 schools (141 individuals) of minke whales were sighted, consisting of 68 schools (72 individuals) of primary and 65 schools (69 individuals) of secondary sightings. For Bryde's whale, 100 schools (129 individuals) were sighted, consisting of 52 schools (67 individuals) of primary sightings and 48 schools (62 individuals) of secondary sightings. Sei whale, 117 schools (207 individuals) were sighted, consisting of 90 schools (163 individuals) of primary sightings and 27 schools (44 individuals) of secondary sightings. For sperm whale, 259 schools (556 individuals) were made, consisting of 195 schools (390 individuals) of primary sightings and 64 schools (166 individuals) of secondary sightings (Table 3).

Fig 7 shows the distribution of common minke whales sighted by the SSVs in the sub-areas 7, 8 and 9. Fig. 8 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. 9 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)

During the research cruise, 6 schools (9 individuals) of common minke whales were sighted, consisting of 3 schools (6 individuals) of primary and 3 schools (3 individuals) of secondary sightings. For Bryde's whale, sightings for 54 schools (69 individuals) were sighted, consisting of 49 schools (64 individuals) of primary sightings and 5 schools (5 individuals) of secondary sightings. For sei whale, sightings for 47 schools (82 individuals) were sighted, consisting of 42 schools (73 individuals) of primary sightings and 5 schools (9 individuals) of secondary sightings. For sperm whale, sightings 66 schools (92 individuals) were sighted, consisting of 55 schools (74 individuals) of primary sightings and 11 schools (18 individuals) of secondary sightings (Table 4). Sightings of common minke, Bryde's, sei and sperm whales by SV were shown in Figs 10-13.

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 (28 sch./37 ind.), fin (34 sch./47 ind.) and right whales (1 sch./1 ind.) were found in the sub-areas 7, 8 and 9 (Fig. 14).

Dedicated sighting vessel (SV)

Table 4 also show the sightings for other cetacean species made by the SV. Large baleen whales such as blue (4 sch. /6 ind.), fin (7 sch. /8 ind.) and humpback whales (3 sch. /4 ind.) were found in the sub-areas 7, 8 and 9.

Sampling of 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, 80 during the whale survey component and 20 during the co-operative survey component. The whale samples consisted of 85 males and 15 females. A total of 50 Bryde's whales were sampled, 34 during the whale survey component and 16 during the co-operative survey component. The whale samples consisted of 25 males and 25 females. A total of 39 sei whales were sampled, 26 during the whale survey component and 13 during the co-operative survey component. The figure of 39 whales consisted of 15 males and 24 females. A total of five sperm whales were sampled in sub-area 7 (7MO) during the co-operative survey component. The figure of five animals consisted of two males and three females.

Geographical distribution of minke, Bryde's and sei whale samples is shown in Figs 15-17 based on the sighting positions. Distribution of sightings and sampling locations coincided, excepting for minke whale in the middle (41°N) of sub-area 9. Fig. 18 shows the distribution of sperm whale samples based on the sighting positions. The sampling of sperm whales covered only sub-area 7.

Causes of failure to collect the targeted whale was as follows. For common minke whales, a total of 26 individuals were not sampled because quick mobile (7), long diving (13), high speed swimming (1) and missing of the targeted animal before chasing (3). Rest of two minke whales was missed by technical reason (struck but lost). For the Bryde's whales, two individuals were not sampled because of quick mobile (1) and missing after sunset (1). In the case of sei whale, two individuals were not sampled, one is missing by long diving (1) and other is technical reason (struck and lost).

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

Table 6 summarizes the biological data and samples obtained from the minke, Bryde's, sei and sperm whales sampled. A total of 58 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, elucidation of stock structure and pollution studies.

Experiments, prey surveys and oceanographic surveys

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

Table 7 shows the result of biopsy skin sampling for blue, humpback, right, fin, minke, Bryde's and sei whales. A total of 21 blue, 2 humpback, 1 right, 2 fin, 1 minke, 4 Bryde's and 14 sei whales were targeted for biopsy sampling by the SSVs and SV. As a result, one blue, one minke, one Bryde's and eight sei whale's biopsy skin samples were collected, respectively. Using this equipment, skin samples were taken from the drifting carcasses of two sperm whales by the SV.

Natural marks for blue, humpback, right, and sei whales

Table 8 shows the result of recording using photograph for natural marks of blue, humpback, right and sei whales. A total of 19 blue, 2 humpback, 1 right and 3 sei whales were targeted by the SSVs and SV. A total of 16, 2 and 3 trials were conducted for blue, humpback and sei whales, respectively. In future, utility of the photographs will be examined.

Feeding behaviour for large baleen whales

The SV conducted recording the feeding behaviour of large baleen whales using a video recorder. A total of three schools of Bryde's whales was recorded for their feeding behaviours. Details will be reported in future.

Prey species survey

Echosounder survey was conducted on SYO and they operated to cover the planned trackline. Target trawls were towed at 11 stations. Midwater routine trawls were towed at 7 stations. Surface routine trawls were towed at 4 stations. Night time trawls were towed at 2 stations. IKMT was towed at 18 stations. NORPAC was towed at 13 stations. The details of the prey species survey conducted by SYO is described in Appendix 1 of this document. Echosounder onboard the SV were operated for 93 days.

CTD and EPCS

The SV conducted an experiment to measure the vertical thermal and salinity profiles using CTD. A total of 51 points was conducted. The EPCS recordings operated for 93 days during the research cruise. Details will be reported in future. CTD casts were made at 25 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 2500m 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.

Preliminary analyses of biological data and experiments

Body length of sampled whales

Body length frequencies of common minke, Bryde's and sei whale samples are shown in Fig. 19.

The statistics of body length of minke whales are shown in Table 9. Mean body length of minke whales is 7.34 m and 6.49 m for males and females, respectively. Mean body length of males and female tended to be high in the sub-area 8 and 9 than those in sub-area 7. Smaller individuals tend to be sampled in sub-area 7 rather than in sub-area 9 (Fig. 20). For Bryde's whales, the statistics of body length are shown in Table 10. Mean body length of Bryde's whales is 11.2 m

and 11.9 m for males and females, respectively. For sei whales, the statistics of body length are shown in Table 11. Mean body length of sei whales is 13.4 m and 14.4 m for males and females, respectively. For sperm whale, the information of body length and weight are also shown in Table 12.

Prey species of minke, Bryde's and sperm whale

List of prey species found in the stomach contents of minke, Bryde's, sei and sperm whales was shown in Table 13. Common minke whale fed on six prey species consisting of one krill, one squid and four fish species. They fed mainly on Pacific saury in sub-area 8 and 9. On the other hand, in sub-area 7, they fed on Japanese anchovy, Japanese common squid and Walleye pollock. Bryde's whale fed on seven prey species consisting of four fish species. They fed mainly on Japanese anchovy. Sei whale fed on seven prey species consisting of one copepod, one krill, three fish and one squid species. Sperm whale fed mainly on deep-sea squids.

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 minke, 50 Bryde's, 39 Sei and 5 sperm whales were 308 tons, 425 tons, 586 tons and 15 tons, respectively.

DISCUSSIONS

1. Distribution of Bryde's whale

Bryde's whales was 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 2002, relatively high density areas of Bryde's whales were observed in the southern part of sub-areas 8 and 9. Distribution of Bryde's whale in these sub-areas had been reported by the sighting survey (Shimada, 1999, 2000), but little effort was spend by the JARPNII. Therefore the research effort should be allocated in these areas in next surveys.

2. Distribution and food 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 39 individuals collected in sub-area 8 and 9. They fed on the various prey species such as copepod, krill, three species of fish and squid. However, the survey in the last year did not covered fully the feeding season, especially early feeding season. It is scheduled to conduct the examination on sample size of sei whale using data on feeding habitat from the first two years. The food habitat on this species will be reported in the next IWC/SC meeting.

3. Condition of concurrent survey

As same as previous JARPNII feasibility studies, this full-scale research plan consisted of two survey groups. One is whales survey group (NM, YS1, K01, and T25), and the other is prey survey group (SYO). In this season, the co-operative survey was conducted on two different survey blocks (SBs). The SB in the first period was settled in the offshore area (around 157E, Fig. 1), and the SB in the second period was in the 7MO stratum. In the first period, the concurrent surveys were successful. A total of 20 common minke, 14 Bryde's and 13 sei whale samples were collected by the SSVs in this period. Also information on the prey species distributions is also collected by TSV during this period (See Appendix 1). However, in the second period, little previous information was available on actual distribution and abundance of prey and whales, and only two Bryde's whales was sighted and sampled during the concurrent survey. No minke and sei whales was sighted and sampled. As mentioned above, the sub-block 7MO is an area in which Bryde's whales were sighted in 2000 and 2001. This may be caused from the decision for the target area with lack of information on the current distributions of these whales species from the SV. Therefore, the pre-survey by the SV or SSVs should be conducted prior to determine the monitoring zone in the future survey.

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Table 1. Outline of 2002JARPN II survey.

Whale sampling and co-operative surveys

Research	Research periods	Days	Sub-area	small block	Research ships and remark
Whale survey (first period)	July 5 - 17, 2002	13	9		NM, YS1, K01, T25
Cooperative survey (first period)	July 18 - Aug. 1, 2002	15	8+9		NM, YS1, K01, T25 and SHU
Whale survey (second period)	Aug. 2 - 6, 2002	5	9, 8		NM, YS1, K01, T25
Cooperative survey (second period)	Aug. 7 - 17, 2002	9	7		NM, YS1, K01, T25 and SHU
Whale survey (third period)	Aug. 13 - Sept. 18, 2002	34	7, 8, 9		NM, YS1, K01, T25
Total	July 5 - Sept. 18, 2002	76			NM, YS1, K01, T25, SHU

Sighting survey by Kyoshin Maru No.2 (KS2)

Research	Research periods	Days	Sub-area	small block	Remarks
Dedicated sighting survey	June 5 - Sept. 9, 2002		7, 8, 9		
	June 5 - 6	1.5	7	7SO	
	June 6 - 18	12.5	8	8S	
	June 18 - July 2	15	9	9S	
	July 3 - 24	20	9	9N	
	July 24 - 30	7	8	8N	
	Aug. 11 - 18	8	7	7MO	
	Aug. 19	1	7	7N	
	Aug. 24	1	8	8N	
	Aug. 25 - 28	4	8	8S	Special survey for Bryde's whale dist.
	Aug. 29-Sept. 4	7	8	8N	
	Sept. 5 - 6	1.5	8	8N	
	Sept. 6 - 8	2.5	7	7	
	June 5 - Sept. 9, 2002	97			

Research base ship: *Nisshin Maru (NM)*

Sighting and Sampling vessels (SSVs) : *Yushin Maru (YS1), Kyo Maru No.1 (K01) and Toshi Maru No.25 (T25)*

Sighting vessel (SV) : *Kyoshin Maru No.2 (KS2)*

Prey species survey vessel : *Shunyo Maru (SHU)*

Table 2. Searching distances made by the three sighting/sampling vessels (YS1, K01 and T25) and dedicated sighting vessel (KS2) in the 2002JARPN II survey.

SSVs

	Sub-area	Period	Searching distance (n.miles)			
			NSC	ASP	NSS	Combined
Pre-survey	9	July 1 - 4		317.2		317.2
Whale survey (first period)	9	July 5 - 17, 2002	405.4	56.7	730.1	1,192.2
Cooperative survey (first period)	8+9	July 18 - Aug. 1, 2002	1,539.6	104.8	320.0	1,964.4
	8+9 (North)	July 18 - 25	770.4	57.5	145.0	972.9
	8+9 (South)	July 27 - 29	33.2	28.1	38.9	100.2
	8+9 (Middle)	July 30 - Aug. 1	736.0	19.2	136.1	891.3
Whale survey (second period)	9, 8	Aug. 2 - 6, 2002	883.4	85.1		968.5
	8	Aug. 2 - 3	437.4	85.1		522.5
	9	Aug. 4	239.0			239.0
	8	Aug. 5 - 6	207.0			207.0
Cooperative survey (second period	7 (7MO)	Aug. 7 - 17, 2002	1,477.3		488.0	1,965.3
	7 (7MO)	Aug. 7 - 12	601.0		477.3	1,078.3
	7 (7MO)	Aug. 15 - 17	876.3		10.7	887.0
Whale survey (third period)	7, 8, 9	Aug. 13 - Sept. 18, 2002	3,721.3	50.1	1,318.3	5,089.7
	7 (7SO)	Aug. 13 - 14	472.4	6.5		478.9
	7 (7N)	Aug. 18 - 21	550.4		118.0	668.4
	7	Aug. 22 - 26	621.6		421.8	1,043.4
	8	Aug. 27 - Sept. 2	623.8	43.6	170.4	837.8
	9	Sept. 3 - 5	185.4		256.4	441.8
	8	Sept. 5 - 7	467.6		17.6	485.2
	7 (7N)	Sept. 7 - 18	800.1		334.1	1,134.2
	Combined	July 1 - Sept 18, 2002	8,027.0	613.9	2,856.4	11,497.3

SV(KS2)

	Sub-area	Period	Searching distance (n.miles)		
			ASP	NSP	Combined
Dedicated sighting survey	7SO	June 5 - 6		91.3	91.3
	8S	June 6 - 18	675.6	4.3	679.9
	9S	June 18 - July 2	837.7		837.7
	9N	July 3 - 25	1,028.3		1,028.3
	8N	July 24 - 30	239.9		239.9
		July 31 - Aug. 10			
	7MO	Aug. 11 - 18	244.0		244.0
	7N	Aug. 19			
		Aug. 20 - 23			
	8N	Aug. 24	111.2		111.2
	8S	Aug. 25 - 28	240.5		240.5
	8N	Aug. 29-Sept. 6	255.0		255.0
	7	Sept. 6 - 8	84.4		84.4
	Combined	June 5 - Sept. 8, 2002	3,716.6	95.6	3,812.2

Table 3. Number of sightings of large whales (no. schools/no. individuals) made by three sighting/sampling vessels in the 2002JARPN II survey (Total area: July 1 - Sept. 18).

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	59	63	61	65	6	6	2	2	3	3	0	0	2	2	68	72	65	69	133	141
Like minke whale	2	2	4	4	2	2	1	1	0	0	0	0	0	0	4	4	5	5	9	9
Blue whale	22	30	6	7	0	0	0	0	0	0	0	0	0	0	22	30	6	7	28	37
Fin whale	20	29	8	12	3	3	0	0	2	2	0	0	1	1	25	34	9	13	34	47
Sei whale	75	138	21	36	6	8	3	4	9	17	2	2	1	2	90	163	27	44	117	207
Bryde's whale	38	50	35	46	9	10	7	7	5	7	2	4	4	5	52	67	48	62	100	129
Humpback whale	2	2	3	3	0	0	0	0	0	0	0	0	2	3	2	2	4	4	6	6
Right whale	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	1
Sperm whale	150	305	40	85	42	82	23	80	3	3	0	0	1	1	195	390	64	166	259	556
Unidentified large cetacean	4	4	36	52	2	2	1	1	2	3	2	2	5	6	8	9	44	61	52	70
Unidentified cetacean	32	32	17	17	16	20	3	3	1	1	0	0	1	1	49	53	21	21	70	74

Table 4. List of cetacean species and number of sightings (no. schools/no. individuals was made by dedicated sighting vessel (KS2) in the 2002JARPN II survey.

Cetacean species	ASP				OE	
	Primary		Secondary		Secondary	
	Sch.	Ind.	Sch.	Ind.	Sch.	Ind.
Common minke whale	3	6	0	0	3	3
Like minke whale	1	1	0	0	1	1
Blue whale	4	6	0	0	0	0
Fin whale	6	6	1	2	0	0
Sei whale	42	73	5	9	0	0
Bryde's whale	49	64	4	4	1	1
Humpback whale	2	3	0	0	1	1
Sperm whale	55	74	7	12	4	6
Unidentified large cetacean	24	24	26	26	3	3
Unidentified cetacean	14	16	2	2	0	0

Table 5. Summary of whale sampling in the 2002JARPN II survey.

Research type	Research periods	Sub-area (small block)	Whale samples			
			Common minke	Bryde's	Sei	Sperm
Whale survey (first period)	July 5 - 17, 2002	9	1		23	
Cooperative survey (first period)	July 17 - Aug. 1, 2002	8+9	20	14	13	
	July 18 - 25, 2002	8+9 (North)	20		12	
	July 27-29, 2002	8+9 (South)		14		
	July 30 - Aug. 1, 2002	8+9 (Middle)			1	
Whale survey (second period)	Aug. 2 - 6, 2002	9, 8	12			
	Aug. 2 - 3, 2002	8				
	Aug. 4, 2002	9	5			
	Aug. 5 - 6	8	7			
Cooperative survey (second period)	Aug. 7 - 17, 2002	7 (7MO)		2		5
	Aug. 7 - 12, 2002	7 (7MO)		1		5
	Aug. 15 - 17, 2002	7 (7MO)		1		
Whale survey (third period)	Aug. 13 - Sept. 18, 2002	7, 8, 9	67	34	3	
	Aug. 13 - 14, 2002	7 (7SO)		1		
	Aug. 18 - 21, 2002	7 (7N)	6			
	Aug. 22 - 26, 2002	7		3		
	Aug. 27 - Sept. 2, 2001	8		30	3	
	Sept. 3 - 5, 2002	9	6			
	Sept. 5 - 7, 2002	8	1			
	Sept. 7 - 18, 2002	7 (7N)	54			
Total	July 5 - Sept. 18, 2002		100	50	39	5

Table 6. Summary of biological data and samples collected during the 2002 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	85	15	100	15	24	39	25	25	50	2	3	5
External body proportion	85	15	100	15	24	39	25	25	50	2	3	5
Photographic record and external character	85	15	100	15	24	39	25	25	50	2	3	5
Diatom film record and sampling	85	15	100	15	24	39	25	25	50	2	3	5
Standard measurements of blubber thickness (eleven points)	85	15	100	15	24	39	25	25	50	2	3	5
Detailed measurements of blubber thickness (fourteen points)	18	3	21	13	3	16	8	5	13	0	2	2
Body weight	85	15	100	15	24	39	25	25	50	2	3	5
Body weight by parts	18	3	21	13	3	16	8	5	13	0	2	2
Blubber tissues for DNA study	85	15	100	15	24	39	25	25	50	2	3	5
Muscle, liver and heart tissues for isozyme analysis	85	15	100	15	24	39	25	25	50	2	3	5
Blubber, muscle, liver and kidney tissues for heavy metal analysis	85	15	100	15	24	39	25	25	50	2	3	5
Blubber, muscle, liver and kidney tissues for organochlorines analysis	85	15	100	15	24	39	25	25	50	2	3	5
Tissues for lipid analysis	18	3	21	13	3	16	8	5	13	0	2	2
Blubber, muscle and liver tissues for stable isotope analysis	85	15	100	15	24	39	25	25	50	2	3	5
Tissues for chemical analysis	85	15	100	15	24	39	25	25	50	2	3	5
Tissues for various analysis	85	15	100	15	24	39	25	25	50	2	3	5
Muscle, blubber and intestine content for energy flow analysis	18	3	21	3	13	16	8	5	13	0	2	2
Intestine contents for prey species identification	6	0	6	3	6	9	2	3	5	2	3	5
Tissues for virus test	85	15	100	15	24	39	25	25	50	2	3	5
Muscle and blood samples for hemoprotein analysis	2	0	2	0	2	2	1	1	2	0	2	2
Tissues for osmoregulation study	26	4	30	7	10	17	12	9	21	2	3	5
Heart tissue for comparative anatomical study	1	0	1	0	0	0	0	0	0	0	0	0
Mammary grand; lactation status, measurement and histological sample	0	15	15	0	24	24	0	25	25	0	3	3
Collection of maternal milk sample	-	0	0	-	0	0	-	1	1	-	0	0
Uterine horn; measurement and endometrium sample	0	15	15	0	24	24	0	25	25	0	3	3
Uterine mucus for sperm detection	0	0	0	0	24	24	0	25	25	0	3	3
Collection of ovary	0	15	15	0	24	24	0	25	25	0	3	3
Photographic record of foetus	-	4	4	-	18	18	-	10	10	-	0	0
Foetal sex (identified by visual observation)	-	4	4	-	18	18	-	9	10[*1]	-	0	0
Foetal length and weight	-	4	4	-	18	18	-	10	10	-	0	0
External measurements of foetus	-	4	4	-	18	18	-	9	9	-	0	0
Collection of foetus	-	4	4	-	18	18	-	10	10	-	0	0
Testis and epididymis; weight and histological sample	85	-	85	15	-	15	25	-	25	2	-	2
Smear samples from testis and epididymis tissues	0	-	0	15	-	15	25	-	25	2	-	2
Urine sample for sperm detection	0	-	0	9	-	9	12	-	12	2	-	2
Collection of serum sample	85	15	100	15	24	39	24	25	49	2	3	5
Collection of whole blood sample	85	15	100	15	24	39	24	25	49	2	3	5
Whole blood samples from umbilical cord	-	1	1	-	17	17	-	6	6	-	0	0
Stomach content, conventional record	85	15	100	15	24	39	25	25	50	2	3	5
Volume and weight of stomach content in each compartment	85	15	100	15	24	39	25	25	50	2	3	5
Stomach contents for feeding study	85	15	100	15	24	39	25	25	50	2	3	5
Record of external parasites	85	15	100	15	24	39	25	25	50	2	3	5
Collection of external parasites	10	1	11	12	13	25	15	18	33	1	3	4
Record of internal parasites	85	15	100	15	24	39	25	25	50	2	3	5
Collection of internal parasites	0	0	0	1	6	7	0	0	0	0	0	0
Earplug for age determination	85	15	100	15	24	39	25	25	50	0	0	0
Tympanic bulla for age determination	85	15	100	15	24	39	25	25	50	0	0	0
Maxillally teeth for age determination	-	-	-	-	-	-	-	-	-	2	3	5
Largest baleen plate for morphologic study and age determination	85	15	100	15	24	39	25	25	50	-	-	-
Largest baleen plate for stable isotopes	85	15	100	15	24	39	25	25	50	-	-	-
Baleen plate measurements (length and breadth)	85	15	100	15	24	39	25	25	50	-	-	-
Length of each baleen plate series	85	15	100	15	24	39	25	25	50	-	-	-
Vertebral epiphyses sample	85	15	100	15	24	39	25	25	50	2	3	5
Number of vertebrae	85	15	100	15	24	39	25	25	50	2	3	5
Number of ribs	85	15	100	15	24	39	25	25	50	2	3	5
Brain weight	17	3	20	12	3	15	8	5	13	0	2	2
Skull measurement (length and breadth)	84	15	99	15	24	39	24	25	49	2	3	5
Collection of skull	0	0	0	0	0	0	0	0	0	0	0	0
Collection of whole skeleton	0	0	0	0	0	0	1	0	1	0	0	0

[*1] including a fetus of sex unidentified

Table 7. Summary of biopsy skin sampling for some baleen whale species in the 2002JARPN II survey

Whale species	Ship	Number of experiments (A)	Targeted individuals (B)	Number of trials (C)	Number of hit (D)	Number of samples (E)	Effort (hr) (F)	sample per trial (E)/(C)	sample per hit (E)/(D)
Blue whale	SSVs	16	20	22	8	1	10h54m	0.05	0.13
	SV	1	1	0	0	0			
Humpback whale	SSVs	2	2	1	0	0	58m		
Right whale	SSVs	1	1	0	0	0	34m		
Fin whale	SSVs	1	2	0	0	0	21m		
Minke whale	SSVs	1	1	1	1	1	6m	1.00	1.00
Bryde's whale	SSVs	4	4	2	1	1	2h12m	0.50	1.00
Sei whale	SSVs	11	14	21	11	8	7h55m	0.38	0.73

Table 8. Summary of photo ID for blue, humpback, right and sei whales in the 2002JARPN II survey

Whale species	Ship	Number of experiments (A)	Targeted individuals (B)	Number of trials (C)
Blue whale	SSVs	16	18	16
	SV	1	1	0
Humpback whale	SSVs	2	2	2
Right whale	SSVs	1	1	0
Sei whale	SSVs	3	3	3

Table 9. Statistics of body length (m) of common minke whales collected by the 2002JARPN II survey.

Sub-area	Period	Latitudinal range	Male					Female				
			Mean	S.D.	Min	Max	n	Mean	S.D.	Min	Max	n
7 (coastal)	Before CS (8/13-24)	North of 41N (7N)	7.51	0.25	7.07	7.80	5	8.11	-	-	-	1
	After CS (9/8-19)	North of 41N (7N)	7.18	0.85	4.52	8.15	42	6.07	1.18	4.51	8.25	12
	Total		7.22	0.82	4.52	8.15	47	6.22	1.31	4.51	8.25	13
8+9 (offshore)	Before CS (7/5-17)	40-43N (8N+9N)	7.72	-	-	-	1					0
	CS (7/18-30)	North of 41N (8N+9N)	7.47	0.19	7.31	7.73	3					0
		43-45N (8N+9N)	7.36	0.78	4.62	7.97	15	8.21	0.01	8.20	8.21	2
		Total	7.38	0.72	4.62	7.97	18	8.21	0.01	8.20	8.21	2
	After CS (7/31-8/9/7)	43-45N (8N+9N)	7.58	0.25	7.24	8.07	19					0
	Total		7.49	0.54	4.62	8.07	38	8.21	0.01	8.20	8.21	2
Combined			7.34	0.72	4.52	8.15	85	6.49	1.40	4.51	8.25	15

CS: Co-operative surveys for ecosystem study

Table 10. Statistics of body length (m) of Bryde's whales collected by the 2002JARPN II survey.

Sub-area	Period	Latitudinal range	Male					Female				
			Mean	S.D.	Min	Max	n	Mean	S.D.	Min	Max	n
7 (coastal)	CS (8/7-12)	37-38N (7SO)	9.93	-	-	-	1					0
	After CS (8/13-24)	37-38N (7SO)	11.11	0.81	10.10	12.08	3	11.43	1.38	9.10	12.63	4
	Total		10.81	0.87	9.93	12.08	4	11.43	1.38	9.10	12.63	4
8+9 (offshore)	CS (7/18-30)	37-40N (8S+9S)	11.45	0.94	9.74	12.62	8	12.67	1.03	10.57	13.76	6
	After CS (8/25-9/7)	37-40N (8S+9S)	11.08	1.33	9.31	13.12	13	11.70	1.41	9.32	14.00	15
	Total		11.23	1.21	9.31	13.12	21	11.98	1.38	9.32	14.00	21
Combined			11.16	1.17	9.31	13.12	25	11.89	1.40	9.10	14.00	25

CS: Co-operative surveys for ecosystem study

Table 11. Statistics of body length (m) of sei whales collected by the 2002 JARPN II survey.

Sub-area	Period	Latitudinal range	Male					Female				
			Mean	S.D.	Min	Max	n	Mean	S.D.	Min	Max	n
8+9 (offshore)	Before CS (7/5-17)	40-45N (8N+9N)	13.27	0.81	11.21	14.38	10	14.43	1.23	11.33	15.80	13
	CS (7/18-30)	North of 45N (8N+9N)					0	14.97	-	-	-	1
		43-45N (8N+9N)	13.44	0.24	13.02	13.59	4	13.82	0.93	12.25	15.18	7
		40-43N (8N+9N)					0	14.82	-	-	-	1
		Total	13.44	0.24	13.02	13.59	4	14.06	0.93	12.25	15.18	9
	After CS (8/25-9/7)	37-43N (8NS+9NS)	14.22	-	-	-	1	15.32	0.58	14.73	15.90	2
Combined			13.38	0.72	11.21	14.38	15	14.37	1.14	11.33	15.90	24

CS: Co-operative surveys for ecosystem study

Table 12. Biological data of sperm whales collected by the 2002JARPN II survey.

Specimen No.	Sub-area	Sampling date	Sighting position				Body length (m)	Sex	Foetus
			Lat.		Long.				
S001	7	7-Aug	39-22.9	N	147-46.6	E	10.27	F	none
S002	7	7-Aug	39-15.2	N	147-41.4	E	8.42	M	
S003	7	8-Aug	38-4.8	N	147-12.2	E	8.71	F	none
S004	7	8-Aug	38-2.1	N	147-7.1	E	10.40	F	none
S005	7	8-Aug	38-1.5	N	147-4.7	E	10.10	M	

Table 13. Prey species found in stomach of common minke, Bryde's, sei and sperm whales sampled by the JARPNII surveys in 2002.

Whale species		Prey species
Common minke whale	Krill	Krill*
	Squid	Japanese common squid*
	Pisces	Japanese anchovy*
		Pacific saury*
		Walleye pollock*
		Salmonidae
		Barracudas
Bryde's whale	Pisces	Larva of anchovy*
		Japanese anchovy*
		Chub mackerel
		Puffers
		Jacks
Sei whale	Copepods	Copepods*
	Krill	Krill*
	Pisces	Japanese anchovy*
		Pacific saury*
		Chub mackerel
		Lantern fishes
	Squids	Japanese common squid
		Hocked squids

*: dominant prey species

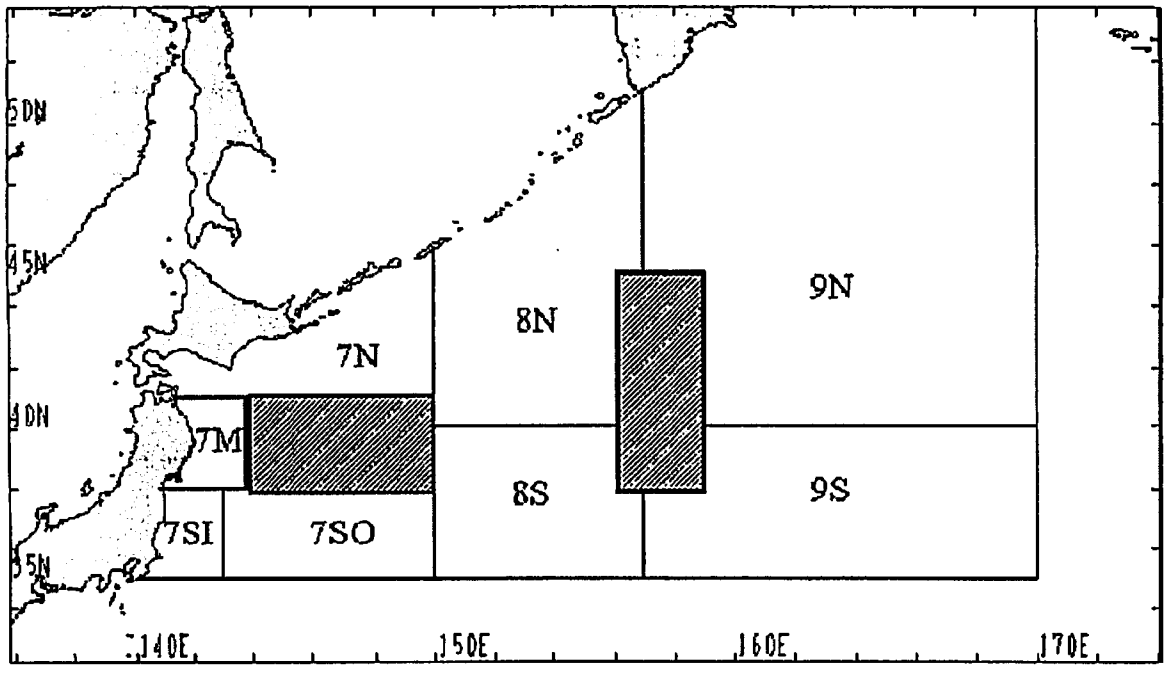

Fig. 1. Map showing the research area and strata of the JARPN II full-scale program in 2002. Shaded block indicate the block for the co-operative survey for ecosystem study (concurrent survey).

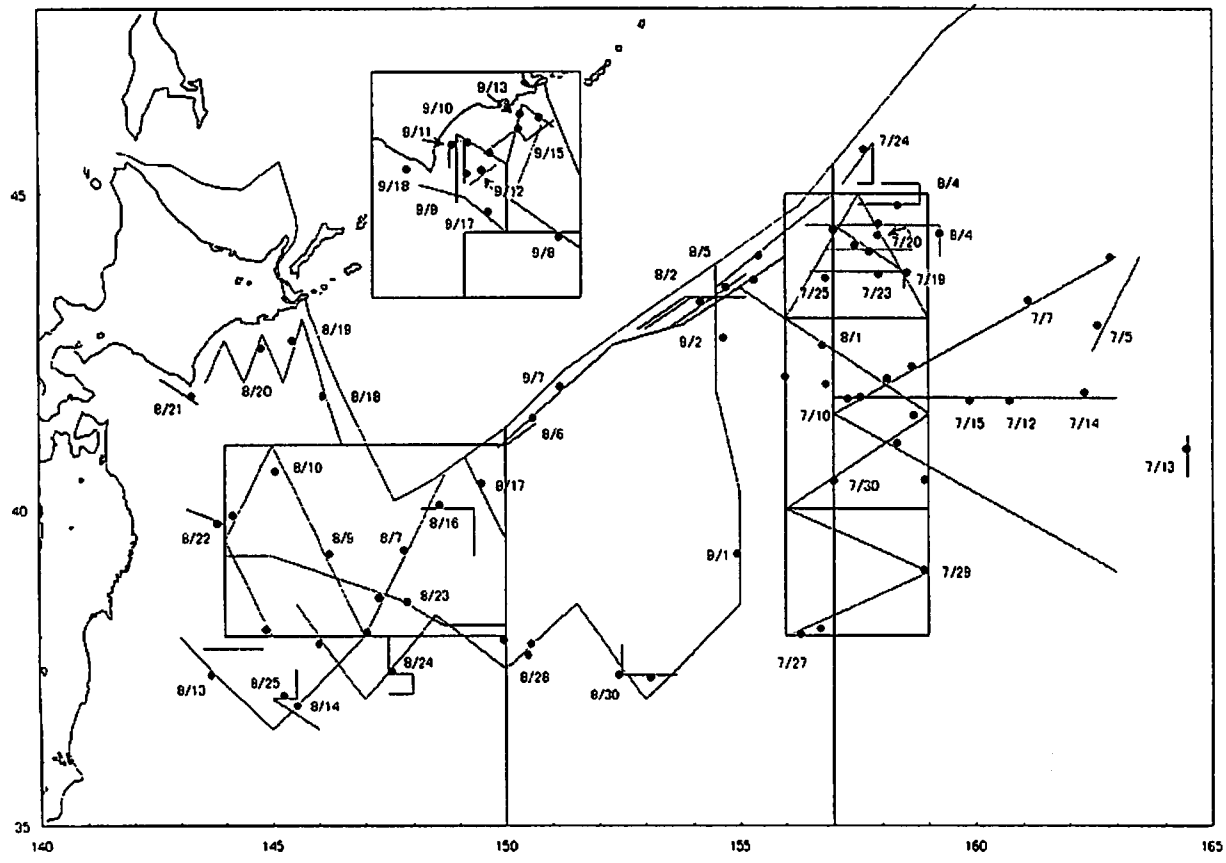

Fig. 2. Track-lines in the 2002 JARPNII survey (mark indicating noon position of *Nisshin Maru*).

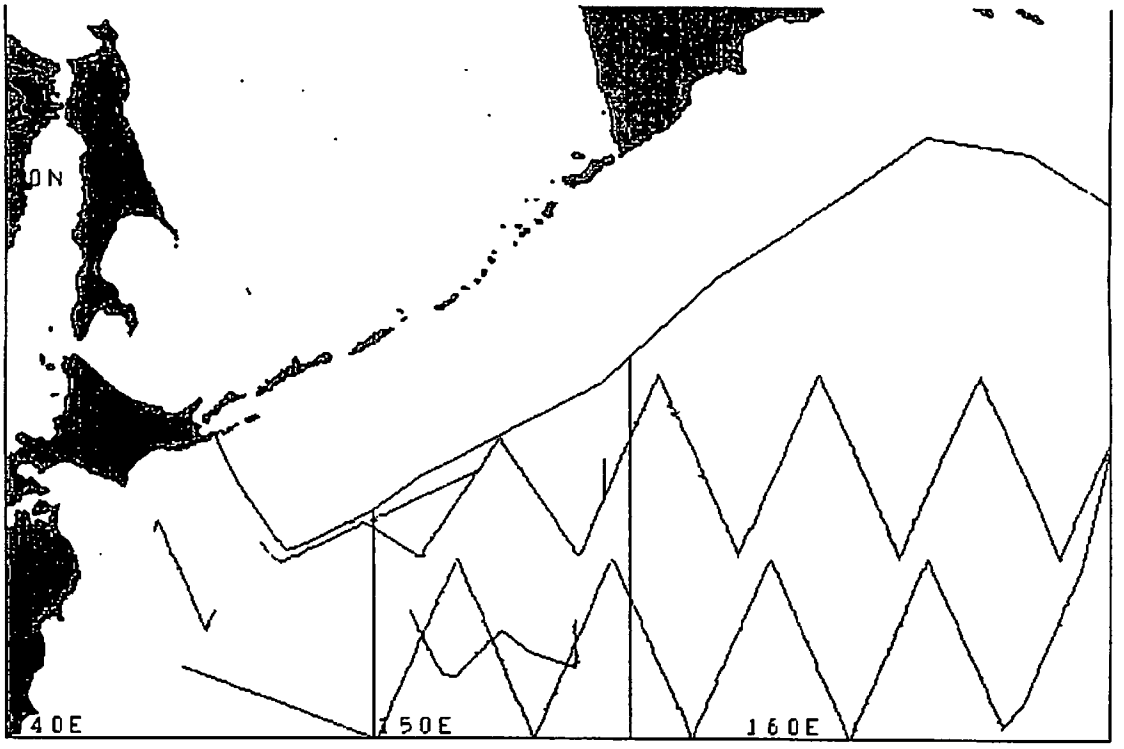

Fig. 3. Outline of the cruise track-line of a dedicated sighting vessel *Kyoshin Maru No.2* in the 2002 JARPNII cruise.

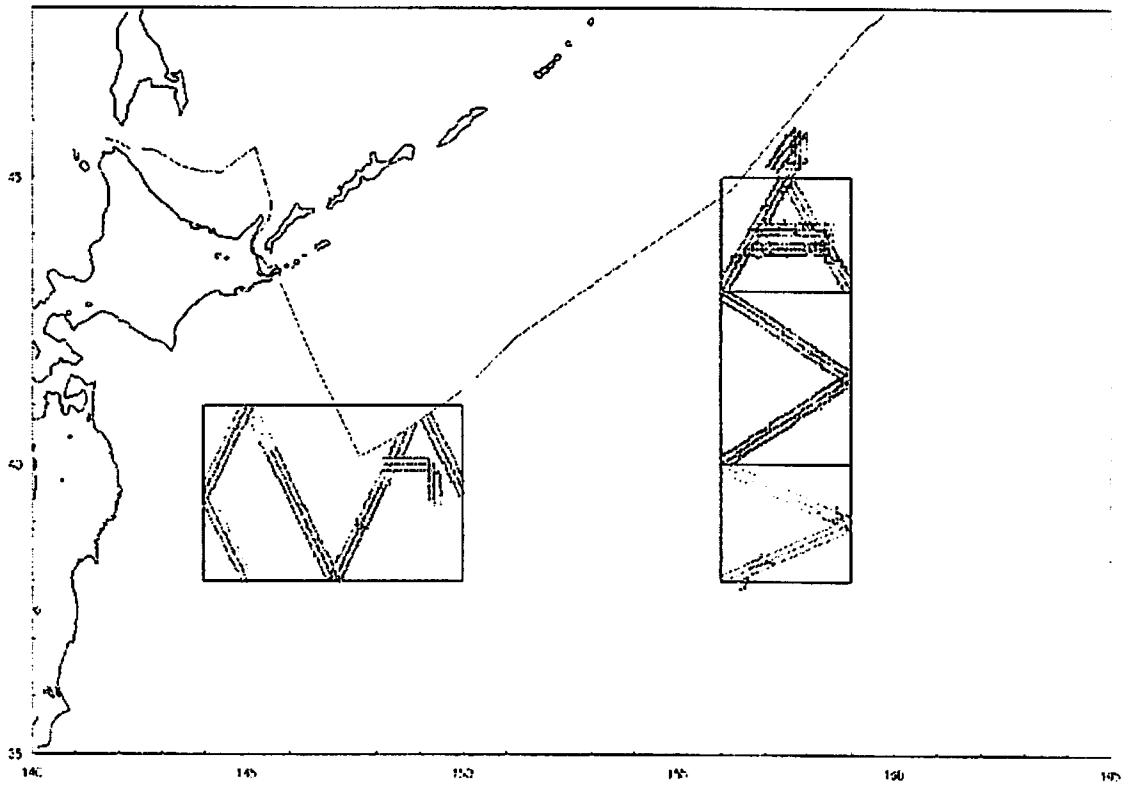

Fig. 4. Track-line covered by the three sighting/sampling vessels (SSVs) during the co-operative ecosystem survey of the 2002 JARPN II.

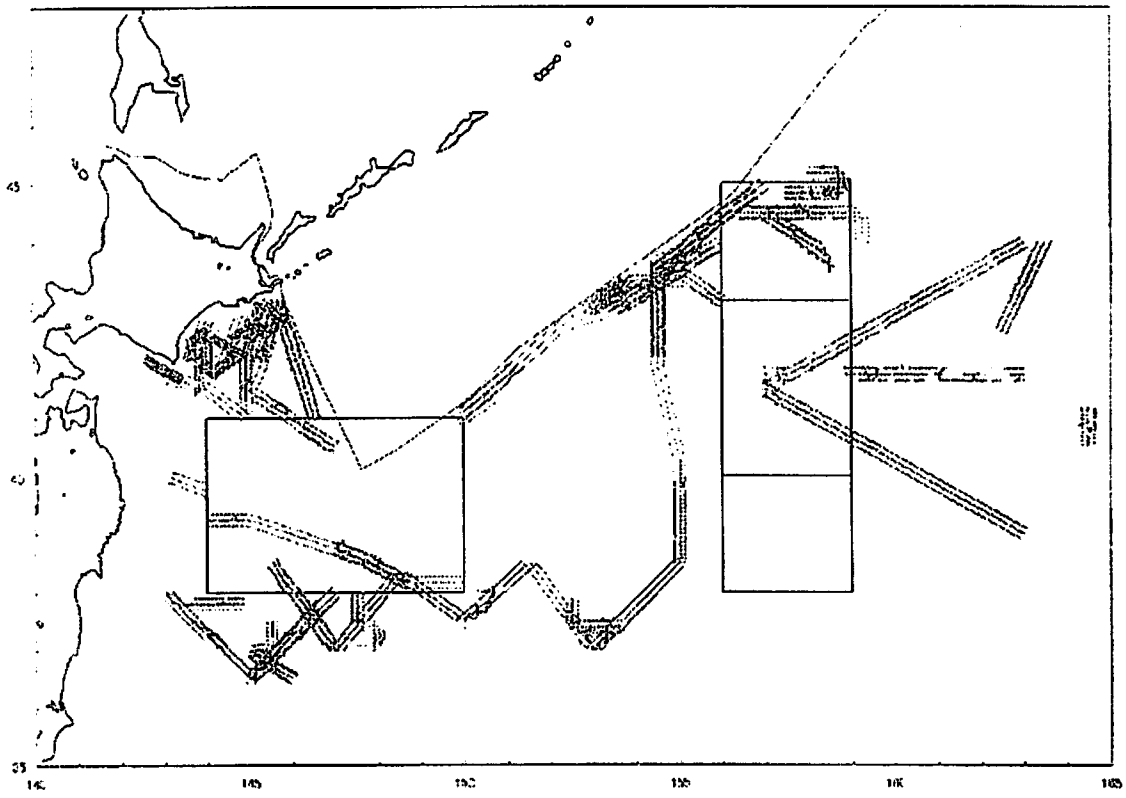

Fig. 5. Track - line covered by the three sighting/sampling vessels (SSVs) during the whale survey of the 2002 JARPN II.

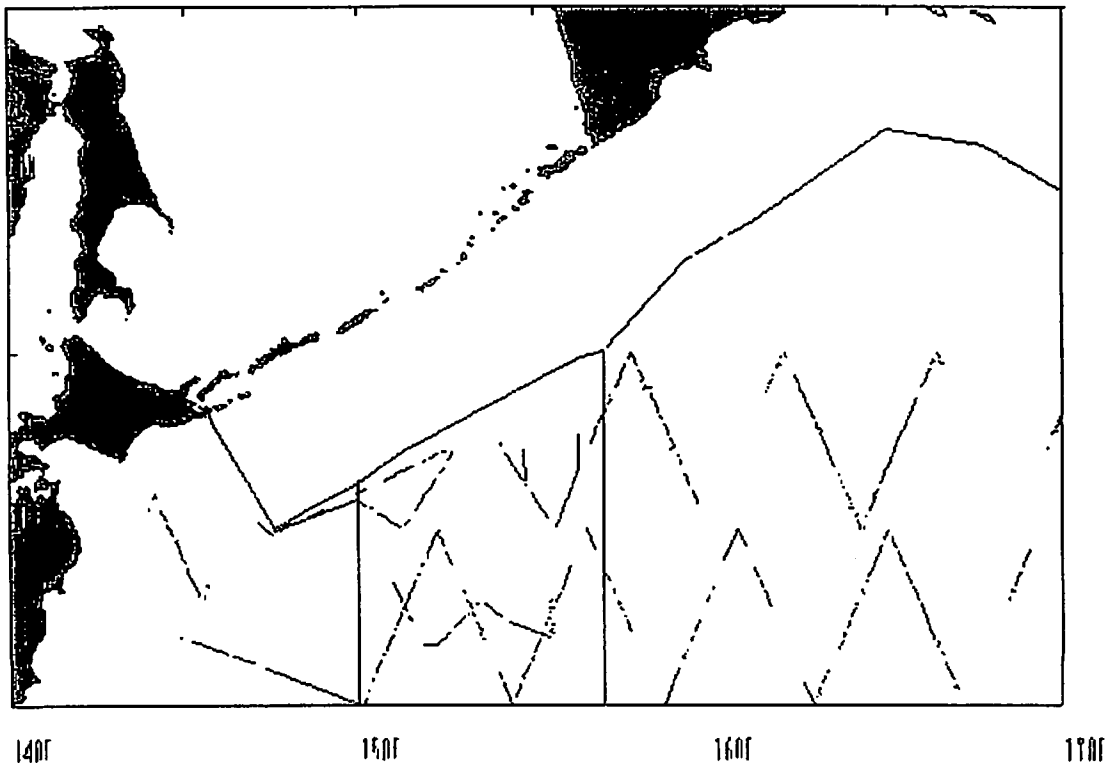

Fig. 6. Track-line covered by the dedicated sighting vessels (SV) during the whale survey of the 2002 JARPN II.

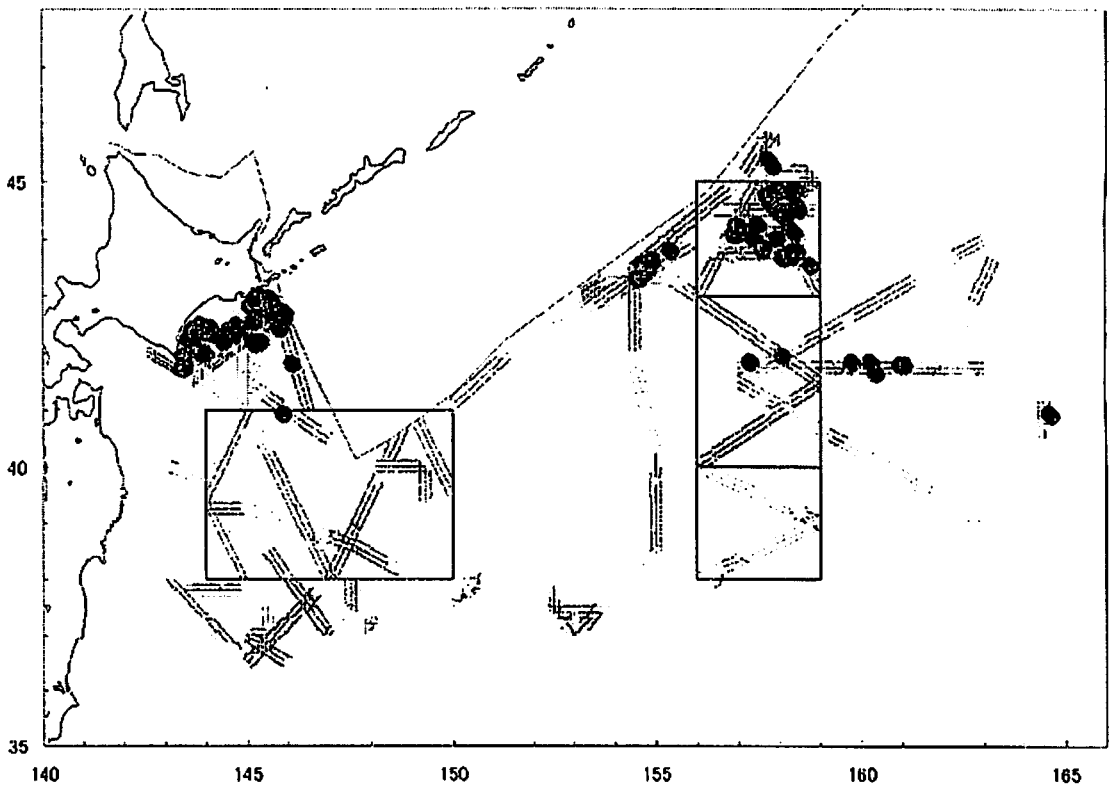

Fig. 7. Position of the sightings of the common minke whales made by the SSVs (●: common minke whale).

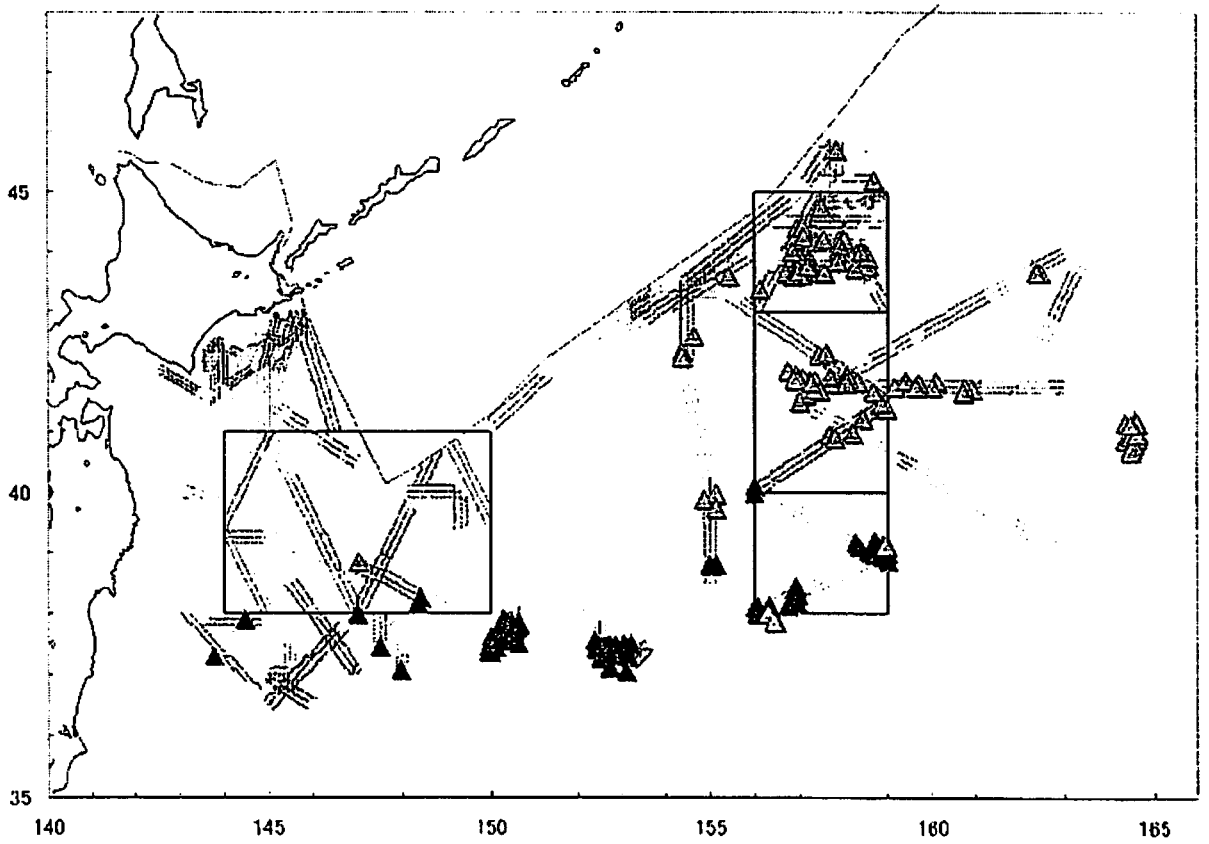

Fig. 8. Position of the sightings of the Bryde's and sei whales made by the SSVs (▲: Bryde's whale, and △ : sei whale).

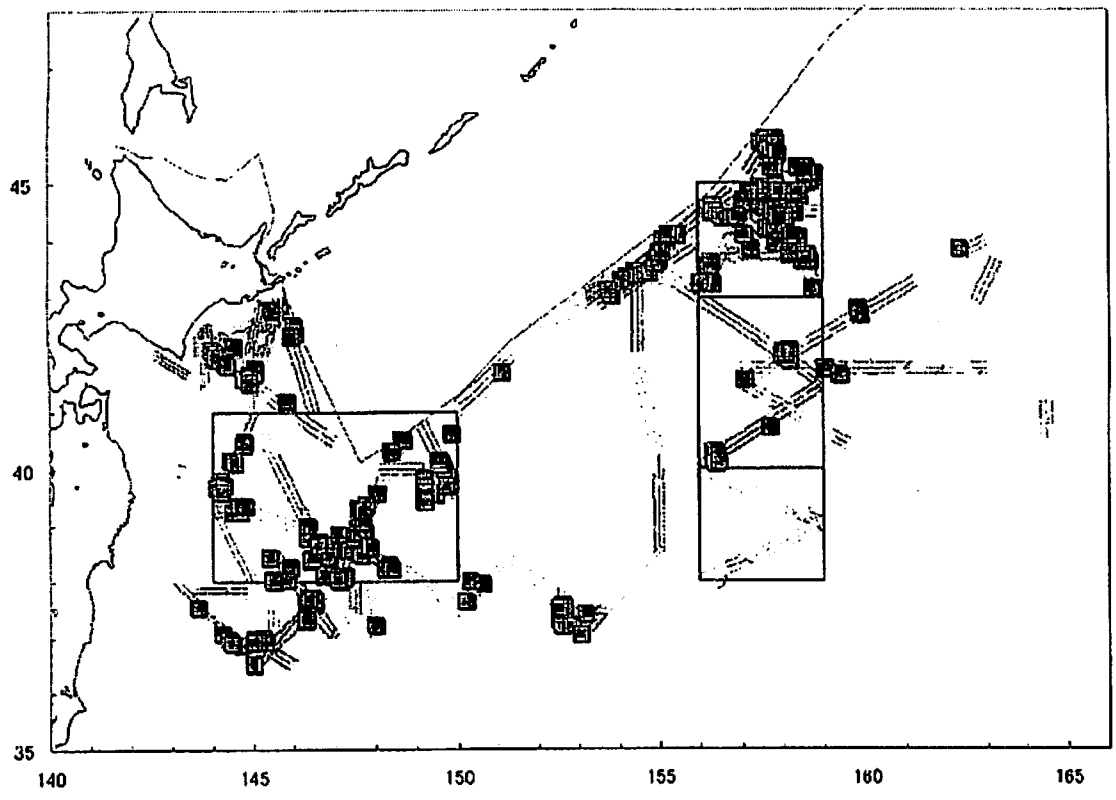

Fig. 9. Position of the sightings of the sperm whales made by the SSVs (■: sperm whale)

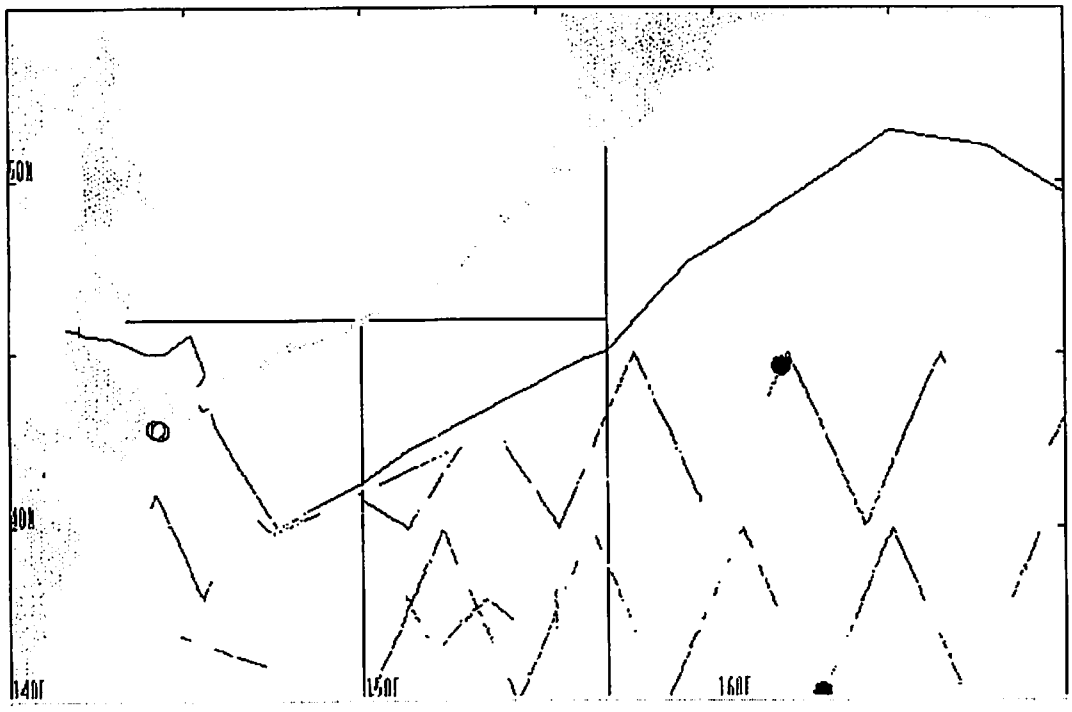

Fig. 10. Position of the sightings of the minke whales made by the SV (●: primary sightings, ○: secondary sightings).

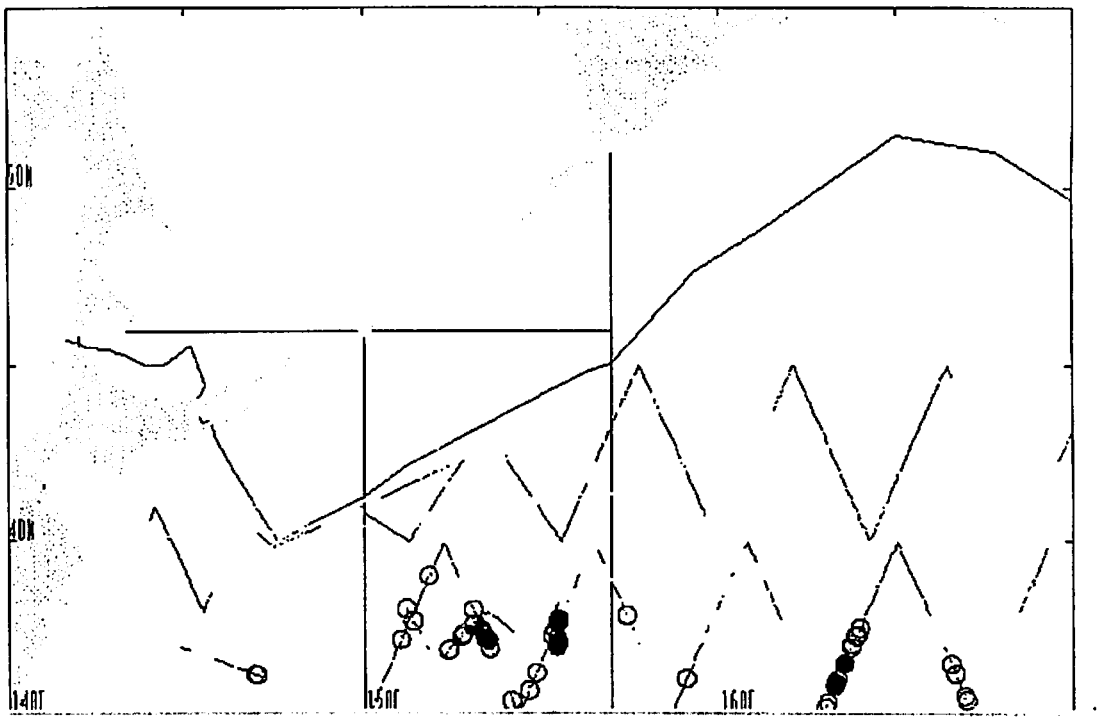

Fig. 11. Position of the sightings of the Bryde's whales made by the SV (○: primary sightings, ●: secondary sightings).

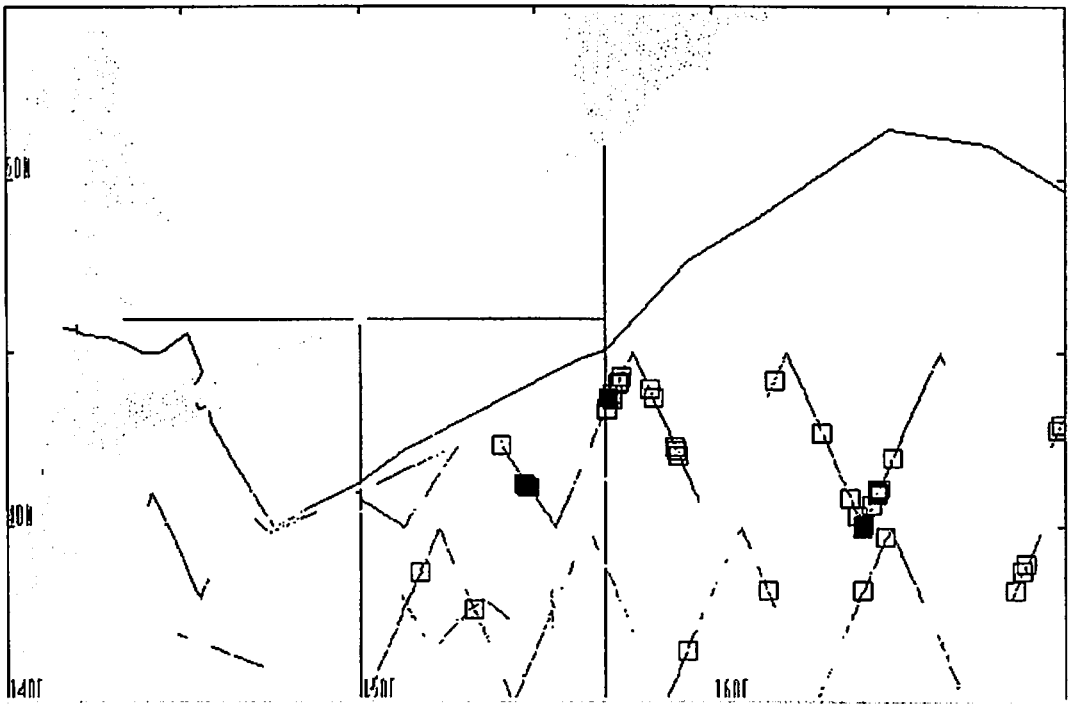

Fig. 12. Position of the sightings of the sei whales made by the SV (□: primary sightings, ■: secondary sightings).

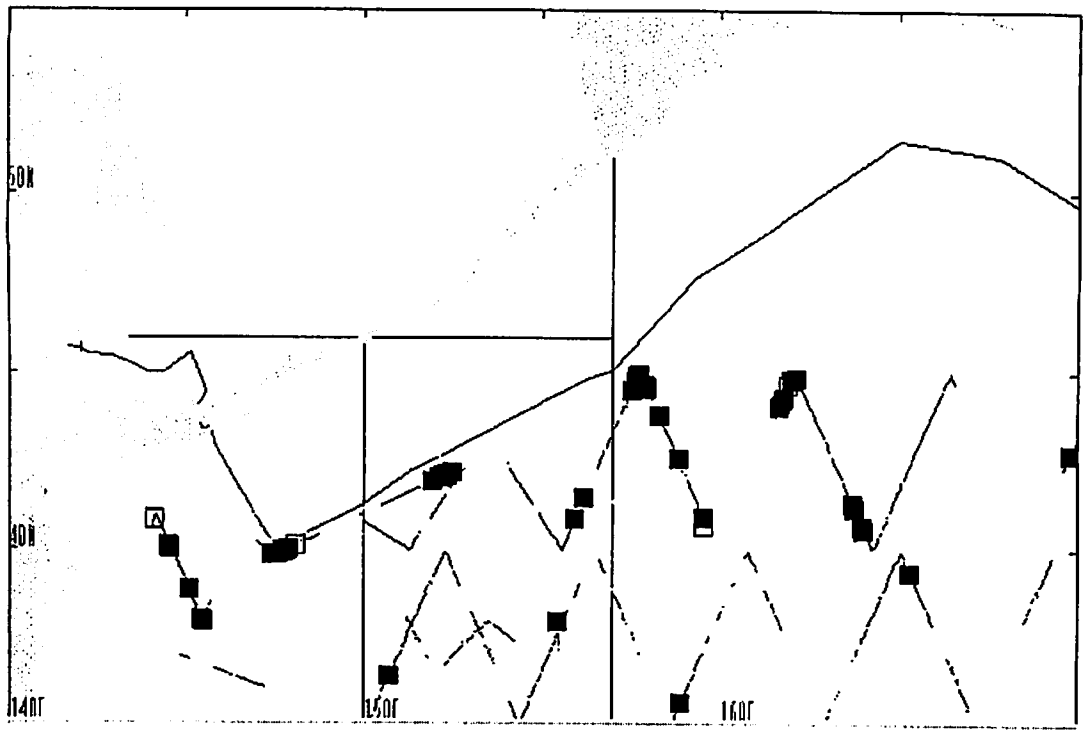

Fig. 13. Position of the sightings of the sperm whales made by the SV (■: primary sightings, □: secondary sightings).

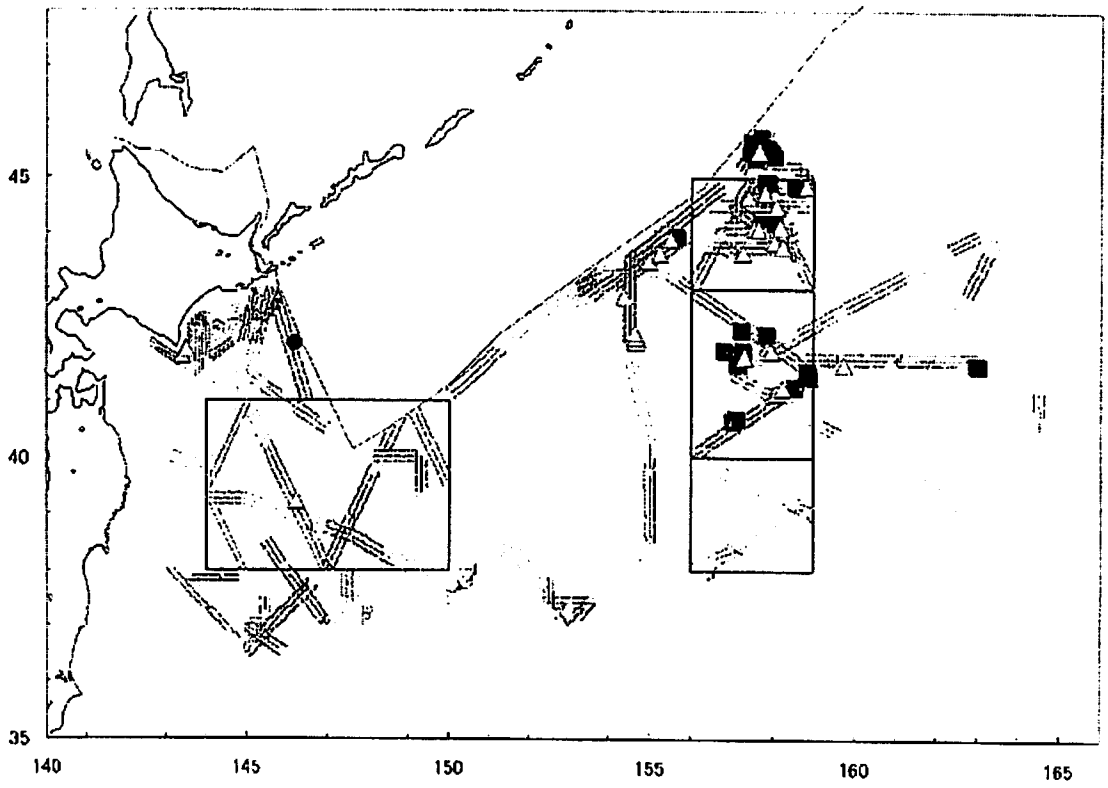

Fig. 14. Position of the sightings of the blue, fin and right whales made by the SSVs (■: blue whale, △: fin whale, and ●: right whale).

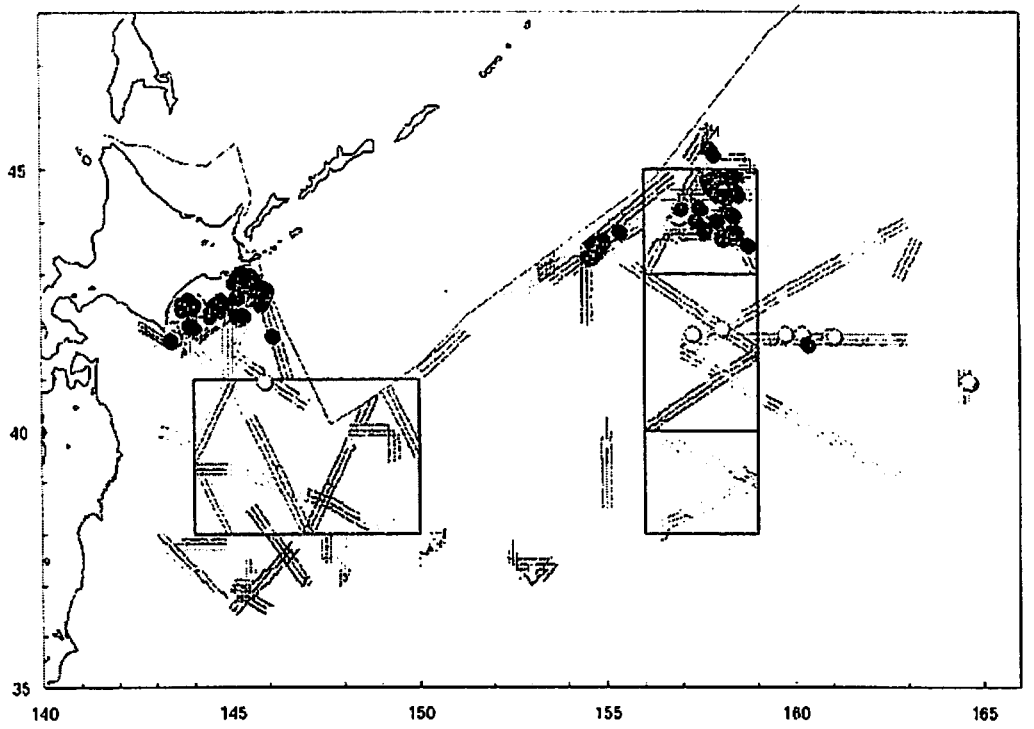

Fig. 15. Comparison of positions of the sightings and samplings of the common minke whales (●: sighted and sampled, ○: sighted only).

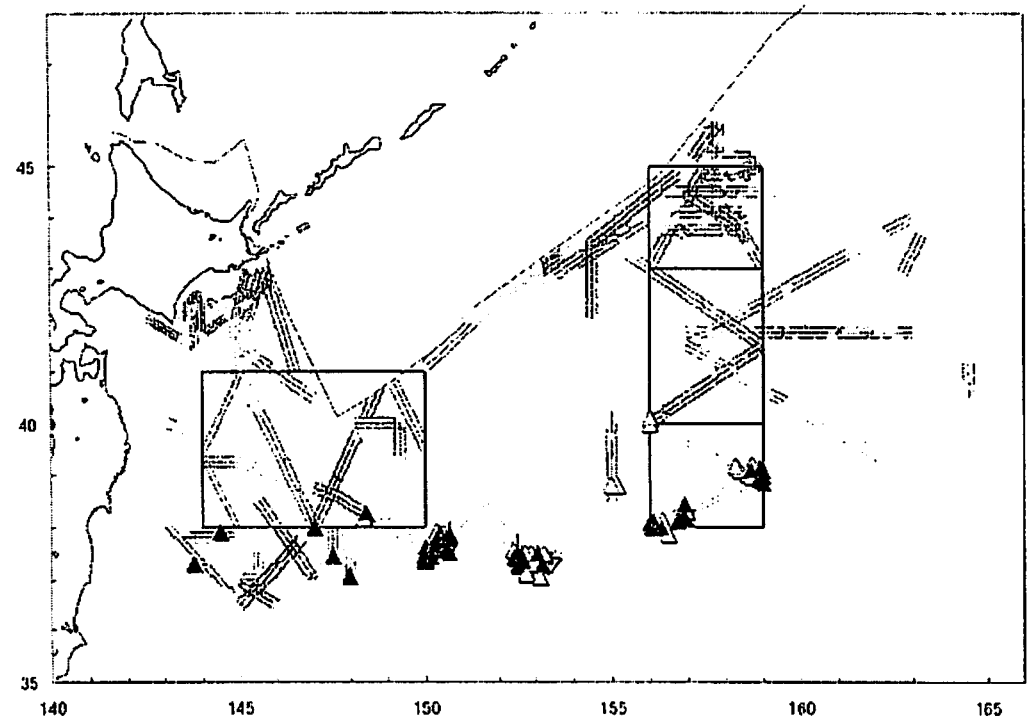

Fig. 16. Comparison of positions of the sightings and samplings of the Bryde's whales (▲: sighted and sampled, △: only sighted).

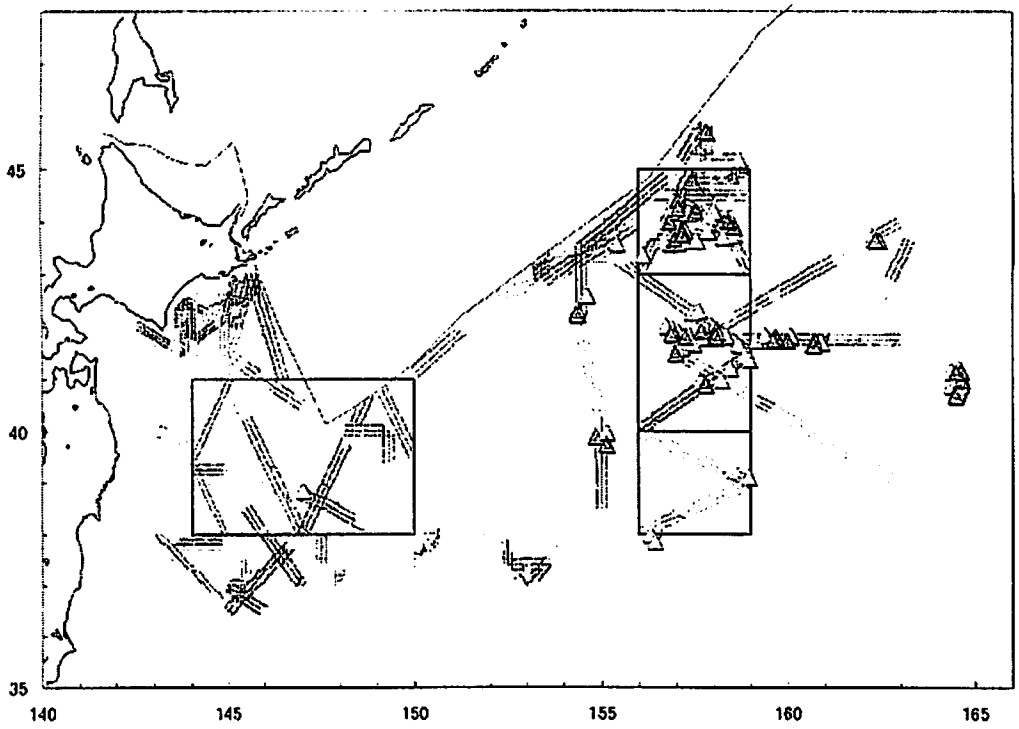

Fig. 17. Comparison of positions of the sightings and samplings of the sei whales (▲: sighted and sampled, △: sighted only).

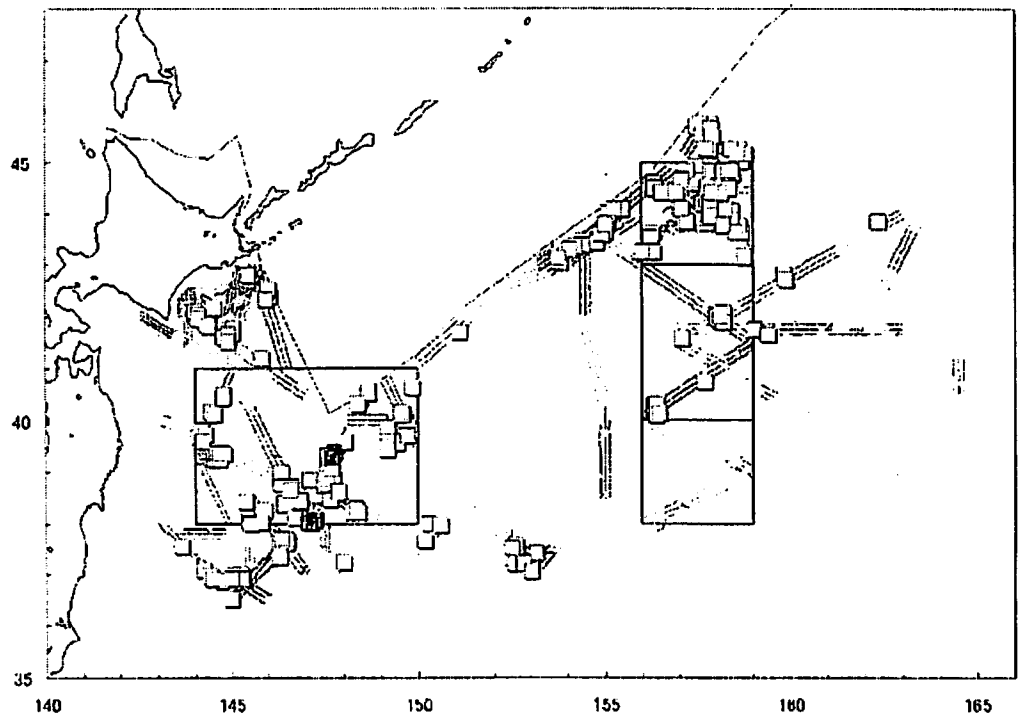

Fig. 18. Comparison of positions of the sightings and samplings of the sperm whales (■: sighted and sampled, □: sighted only).

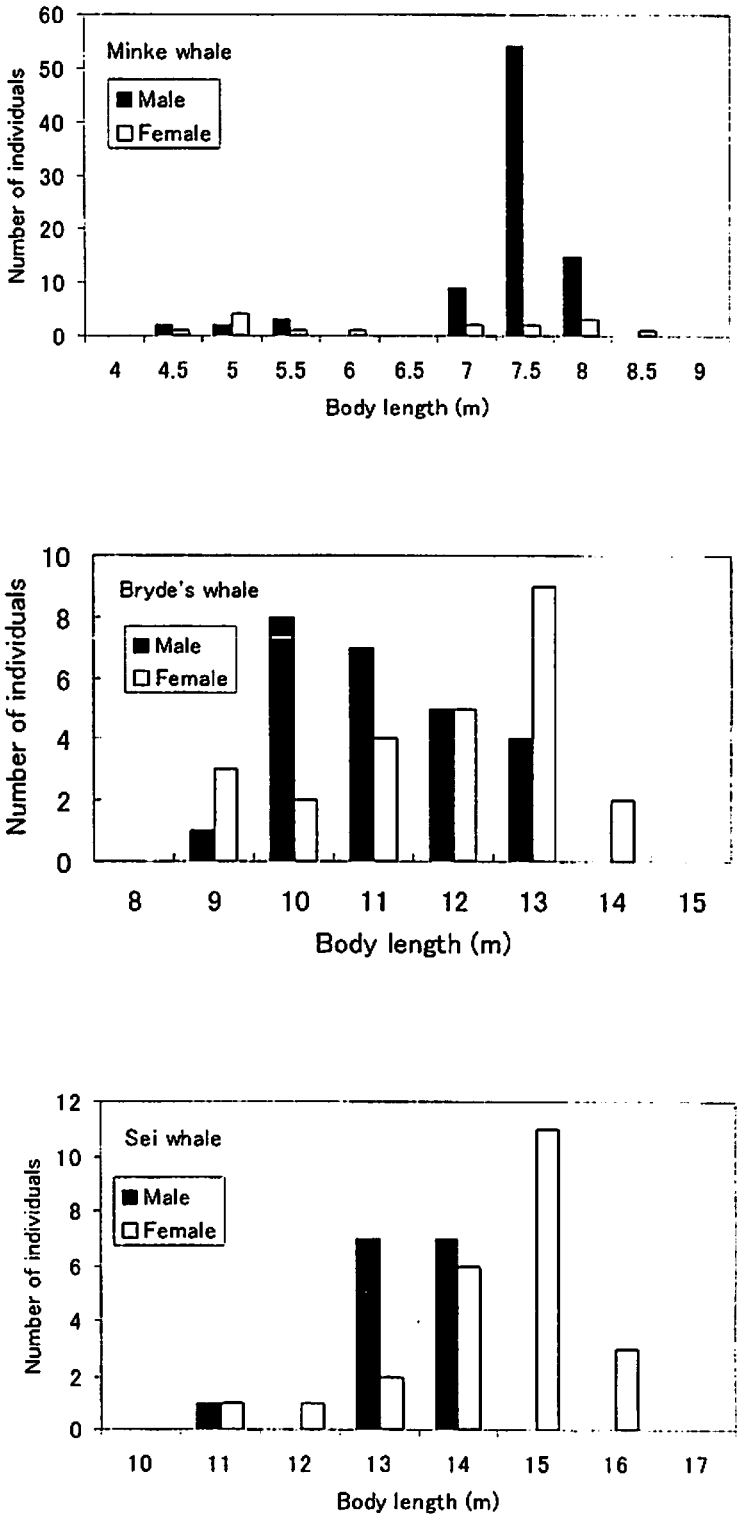

Fig. 19. Comparison of frequencies of body length of common minke, Bryde's and sei whales.

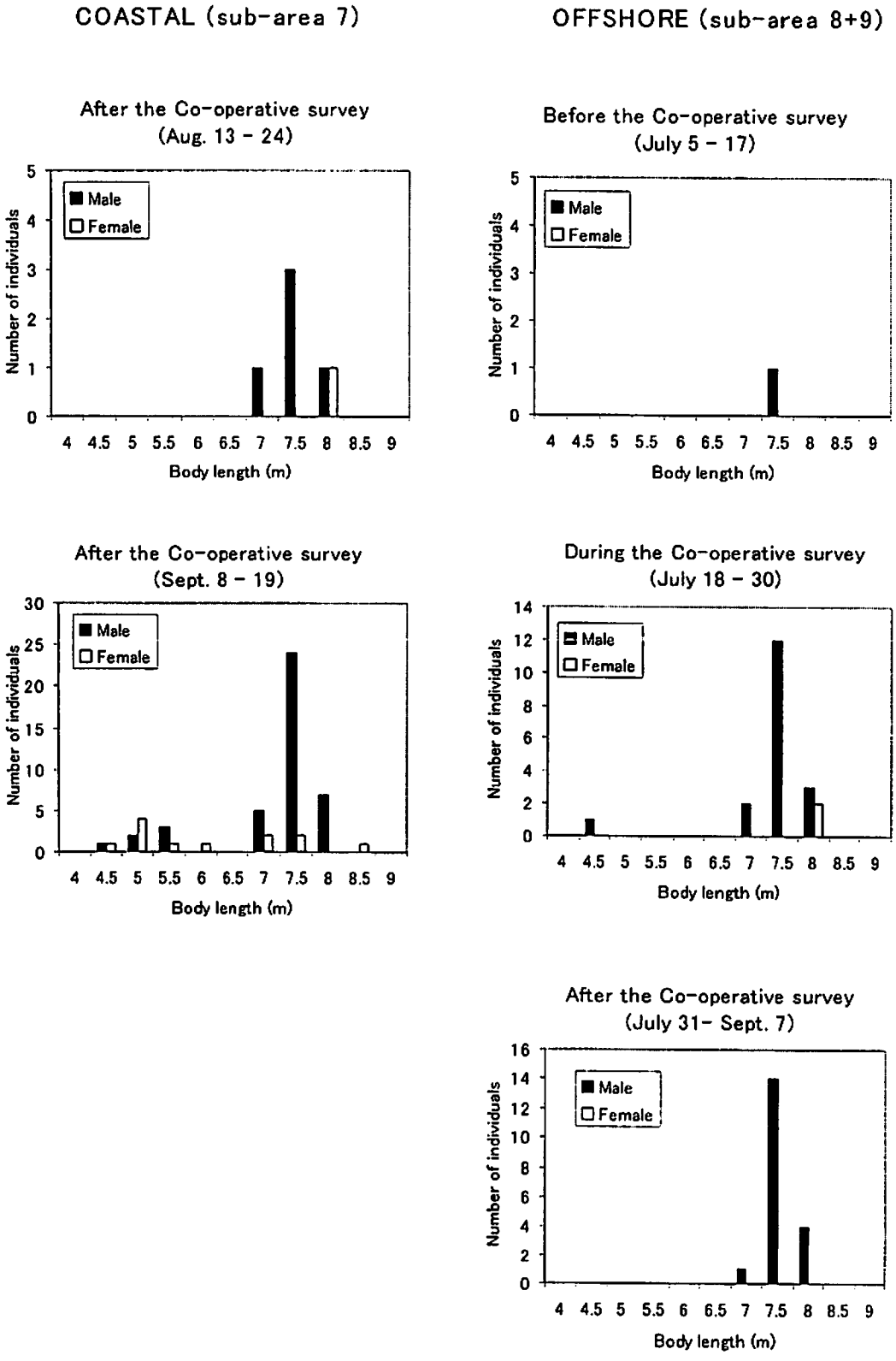

Fig. 20. Comparison of frequencies of body length of common minke whales in each spatial and temporal group.

APPENDIX 1.

Preliminary results of the prey survey of JARPN II (offshore componet) in 2002

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ABSTRACT

A prey survey was conducted concurrently with the whale survey in Sub-areas 7, 8 and 9, off the coast of eastern Honsyu, Japan in July and August 2002 as a part of offshore component of 2002 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 within the Sub-areas. A trawler-type research vessel, Shunyo-maru equipped with the quantitative echosounder was 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 detect the distribution patterns. Species compositions of acoustical backscatterings were identified using midwater trawl and plankton nets. In addition, predetermined trawls were towed at predetermined stations independently from the acoustic survey. Two types of nets (IKMT and NORPAC-net) were used to collect micro nektons and zooplanktons. Oceanographic observations were made with CTD down to 500m at 25 points. Trawlings were made at 24 stations. IKMT and NORPAC net were towed at 18 and 13 stations, respectively. Four major cetacean preys, Japanese anchovy, Pacific saury, krills 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 and Pacific saury, 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. 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. 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 2002 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 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 2002 were presented.

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 special blocks, Special Blocks A (SB-A) and B (SB-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 quantitative echosounder, midwater trawl, Isaacs-Kidd midwater trawl (IKMT) and NORPAC net 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 net. .

Survey timing and survey hours

The cooperative survey was conducted from July to August with two periods; first from July 17 to 26 in SB-A and second from August 2 to 9.2002 in SB-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 6:00 and end at 19:00.

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 Kushiro (August 1 2002) 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 3-4 knots. 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. 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 trawls were conducted at predetermined stations in each block in daytime and in limited times at night. The purpose of the predetermined trawls was to estimate the abundance and distribution patterns of cephalopods and neustnic organisms such as Pacific saury (*Cololabis saira*) that are difficult to detect by the echosounder. Three different depth layers were sampled at predetermined trawl stations; 0-10m (surface) 0-100m and 0-200m (mid-water). Surface predetermined trawls were conducted in northern part of SB-A where Pacific saury was abundant. Nighttime trawls were conducted once per each block to examine day-night difference of prey species composition. Daytime trawls were towed before nighttime trawls were tow on 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 preditermined 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 and weight 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 micro nekton and Plankton

In addition to the trawl net, two types of nets were used to collect micronekton and zooplankton. The IKMT was mainly used to collect micro nektons and macrozooplanktons such as krill and fish larvae. NORPAC net was mainly used to collect mesozooplankton such as copepods. The IKMT was towed to identify the species compositions of biological backscattering detected by the quantitative echosounder. NORPAC net was towed at the routine and target trawl stations from 100m water depth to surface. It was also used for species identification of acoustic backscattering. 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) software at the laboratory. In principle, backscattering on the echosounder was identified based mainly on the result of trawl, IKMT and NORPAC net samplings. For fishes, data collected at 38 kHz were used with the threshold set at -60dB and the depth range from 0m 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 IKMT in this document. The integration was made at an interval of one nautical mile by 50 m depth zone. Because acoustical

characteristics of copepods had not been studies in the 2000 and 2001 feasibility studies, it was investigated by comparing the results of IKMT and NORPAC net samplings and the corresponding echogram.

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 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, IKMT and NORPAC net sampling in 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, IKMT, NORPAC 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.

SB-A in First survey period

Planed tracklines were almost surveyed using the echosounder. To identify acoustical backscattering, midwater trawls and IKMT were towed at 5 and 11 stations, respectively. Because copepods were distributed with other zooplanktons within the scattering layer in the middle part of the survey area, it was difficult to discriminate the acoustical backscattering between copepods and other zooplankton. In the northern part of the survey area, two copepods species, *Neocalanus cristatus* and *Eucalanus bungii*, formed species specific schools.

Krill mainly distributed in northern part of the survey area. Distribution water depth range of the krill was from 30 to 250m and it was correlated with water temperature. The result of IKMT suggested that *Euphauisa pacifica* was the dominant krill species.

Some fraction of school of Pacific saury was detected by the echosounder but it indicated that it was difficult to estimate the abundance of Pacific saury using echosounder because most of schools were distributed in water column shallower than transducer surface, called as surface dead zone.

Japanese anchovy distributed throughout the survey area but the size frequencies were different between southern and northern part of the area.

SB-B in the second survey period

Due to the time constrains, half of the planed tracklines in SB-B were surveyed using the echosounder. To identify acoustical backscattering, midwater trawls and IKMT were towed at 6 and 7 stations, respectively. Japanese anchovy and krill were abundant prey species in SB-B. Japanese anchovy was distributed throughout SB-B but the length frequencies were different from the northern part to the southern part. Few Japanese anchovy was distributed between transition area between Oyashio and Kuroshio. In addition to length frequencies difference by region, Japanese anchovy also showed length frequencies differentiation by water depth column. For example, the station number ST-34, two midwater trawl hauls were made to identify species compositions of acoustical backscattering at the water depth range 30-60m and 100-120m. At 30-60m, Japanese anchovy larvae were caught whereas Japanese anchovy larvae and juvenile were caught at 100-120m. The results suggested that Japanese anchovy could differentiate distribution water depth by growth stage but this results should be examined further using multiple opening/closing net and environmental sampling system (MOCNESS) in future.

Three species of krill, *Euphausia pacifica*, *E. similis* and *Thysanoessa inspinata* formed distinctive schools by species. *E. pacifica* was mainly distributed in Oyashio water whereas *E. similis* distributed in Kuroshio water. Those distribution patters will be examined in detail considering oceanographic conditions.

Trawls at predetermined stations

SB-A in the first survey period

Midwater predetermined trawls were conducted at 3 stations (one 0-200m water depth station and two 0-100m stations) in SB-A in first period. Initial midwater predetermined trawl towing plan was that trawls were towed for 60miuntues from 0m to 200m water depth (15minutes tow at every 50m water depth step). At station number ST-MT-1, the trawl was towed from 0-200m but the major samples were gelatinous zooplanktons. In addtion to the results, most of cetacean preys were considered to be distributed in upper 100m water depth, the depth of midwater predetermined trawl was changed to 0-100m. No dominant fish was identified in the samples. Pacific saury was the dominant samples at the surface routine trawl stations where the SSTs were less than 15°C. Lanternfish was dominant species in night time trawl samples.

SB-B in the second survey period

Midwater routine trawls were conducted at 4 stations. Japanese anchovy was dominant species. Japanese anchovy was also the dominant species at night followed by lanternfish.

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Table 1. List of waypoints.

First period

WP	Lat.	Long	Course	Distance (n.mile)
P1	40-00N	156-00E	66	149.6
P2	41-00N	159-00E	294	147.7
P3	42-00N	156-00E	66	145.8
P4	43-00N	159-00E	294	143.8
P5	44-00N	156-00E	66	141.9
P6	45-00N	159-00E	295	70.2
P7	45-30N	157-30E		
			Total	799.0

Second period

WP	Lat.	Long	Course	Distance (n.mile)
P11	41-00N	144-00E	166	185.9
P12	38-00N	145-00E	15	185.9
P13	41-00N	146-00E	166	185.9
P14	38-00N	147-00E		
			Total	557.7

Table 2. Itinerary of the survey

Date	Event
7/14	Depart Shimizu, Japan
7/17	Start first half survey period
7/26	End first half survey period
7/30	Arrive Kushiro, Japan
8/1	Depart Kushiro. Conducting echosounder calibration.
8/2	Start second half survey period
8/9	End second half survey period
8/12	Arrive Shimizu

Table 3. Summary of the survey.

Survey period	Prey surevey date	Whale survey date	No. of trackline	No. of taget trawl stations	No. of Daytime routine trawl stations	No. of nighttime routine trawl stations	No. of IKMT stations	No. of NORPAC stations	No. of CTD stations	No. of sampled sei whales (ind.)	No. of sampled Bryde's whales (ind.)	No. of sampled common minke whales (ind.)
1st period	7/17-26	7/18-25 7/30-8/1	6	5	7	1	11	6	15	9	6	4
2nd period	8/2-9	8/7-17	4	6	4	1	7	7	10	0	0	0

Table 4. Results of IKMT and NORPAC net tows in Special Block A.

IKMT

Station name	Date	Routine(R) /Target(T)	Deployment positon		Major sampled species			
			Lat.	Long.				
ST-02-IK	2002/7/17	T	40-12.7N	156-38.0E	Gelatinous zooplankton	Euphausiids		
ST-05-IK	2002/7/19	T	41-13.4N	158-19.5E	Gelatinous zooplankton			
ST-06-IK	2002/7/19	T	41-37.6N	157-08.3E	Gelatinous zooplankton	*Neocalanus cristatus*		
ST-08-IK	2002/7/21	T	42-22.7N	157-07.8E	Gelatinous zooplankton	*Euphausia pacifica*	*Neocalanus cristatus*	*Themisto pacifica*
ST-10-IK	2002/7/21	T	42-33.6N	157-45.1E	Gelatinous zooplankton			
ST-12-IK	2002/7/22	T	43-11.5N	158-25.9E	Copepods			
ST-14-IK-1	2002/7/23	T	43-39.7N	157-01.9E	Gelatinous zooplankton			
ST-14-IK-2	2002/7/23	T	43-39.4N	157-02.0E	Gelatinous zooplankton	*Eupahausia pacifica*	*Themitso pacifica*	
ST-18-IK	2002/7/24	T	44-12.8N	156-38.6E	Gelatinous zooplankton	*Eupahausia pacifica*	*Neocalanus cristatus*	*Themitso pacifica*
ST-22-IK-1	2002/7/26	T	45-16.4N	158-14.1E	*Eucalanus bungii*	*Sagitta elegans*		
ST-22-IK-2	2002/7/26	T	45-17.4N	158-13.4E	*Neocalanus cristatus*	*N. plumchrus /flemingeri*		

NORPAC net

Station name	Date	Routine(R) /Target(T)	Deployment positon		Major sampled species			
			Lat.	Long.				
ST-11-NP-1	2002/7/22	T	43-00.8N	158-57.9E	Gelatinous zooplankton	Neocalanus cristatus	N. plumchrus /flemingeri	
ST-11-NP-2	2002/7/22	T	43-00.8N	158-57.9E	*Neocalanus cristatus*	*N. plumchrus /flemingeri*		
ST-15-NP	2002/7/23	P	43-42.4N	156-53.43E	Gelatinous zooplankton	*Neocalanus cristatus*	*N. plumchrus /flemingeri*	
ST-16-NP	2002/7/24	P	44-00.3N	155-59.5E	*Neocalanus cristatus*	*N. plumchrus /flemingeri*	*Themisto pacifica*	*Sagitta elegans*
ST-20-NP	2002/7/26	P	45-00.0N	158-00.2E	Gelatinous zooplankton	*Neocalanus cristatus*	*Eucalanus bungii*	
ST-22-NP	2002/7/26	P	45-15.6N	158-14.3E	Gelatinous zooplankton	*Neocalanus cristatus*	*N. plumchrus /flemingeri*	*Sagitta elegans*

Table 5. Results of IKMT and NORPAC net tows in Special Block B

IKMT

Station name	Date	Routine(R) /Target(T)	Deployment positon		Major sampled species			
			Lat.	Long.				
ST-24-IK	2002/8/2	T	40-01.4N	144-19.4E	Copepods?			
ST-26-IK	2002/8/3	T	38-35.0N	144-49.2E	*Euphausia similis*			
ST-28-IK	2002/8/4	T	38-06.6N	145-04.5E	*Euphausia similis*			
ST-30-IK	2002/8/5	T	39-26.4N	145-30.7E	*Euphausia pacifica*	*Neocalanus cristatus*	*Themisto pacifica*	
ST-31-IK	2002/8/6	T	40-20.0N	145-46.5E	*Euphausia pacifica*	*Neocalanus cristatus*	*N. plumchrus /flemingeri*	*Themisto pacifica*
ST-33-IK	2002/8/7	T	39-45.6N	146-25.1E	*Thysanoessa sp.?*	*Neocalanus cristatus*	*N. plumchrus /flemingeri*	*Sagitta elegans*
ST-35-IK	2002/8/8	T	38-33.9N	146-47.8E	Gelatinous zooplankton	*Chaetognatha*		

NORPAC net

Station name	Date	Routine(R) /Target(T)	Deployment positon		Major sampled species			
			Lat.	Long.				
ST-25-NP-1	2002/8/3	P	39-37.8N	144-24.4E	Copepods	Chaetognatha		
ST-25-NP-2	2002/8/3	P	39-37.8N	144-24.4E	Copepods	Chaetognatha		
ST-29-NP	2002/8/5	P	38-54.8N	145-18.1E	Copepods	Chaetognatha		
ST-32-NP-D	2002/8/6	P	40-45.4N	146-05.3E	*Neocalanus cristatus*	*N. plumchrus /flemingeri*	*Themisto pacifica*	*Sagitta elegans*
ST-32-NP-N	2002/8/6	P	40-45.3N	146-05.5E	*Neocalanus cristatus*	*N. plumchrus /flemingeri*	*Themisto pacifica*	*Sagitta elegans*
ST-34-NP	2002/8/8	P	38-41.3N	146-44.3E	Gelatinous zooplankton	Copepods		
ST-37-NP	2002/8/9	P	38-00.0N	147-00.0E	Copepods			

Table 6. Results of target and predetermined trawls in Special Block A.

Daytime predetermined midwater trawl (0-200m)

Station name	Date	Deployment position		Major sampled species (kg). "+" represents less than 0.01kg.					
		Lat.	Long.	*Engraulis japonicus*	*Cololabis saira*	*Scomber japonicus*	Myctophids	Cephalopods	Gelatinous zooplankton
ST-01MT	2002/7/17	40-03.6N	159.09.9E	0.01			0.02	0.04	

Daytime predetermined midwater trawl (0-100m)

Station name	Date	Deployment position		Major sampled species (kg). "+" represents less than 0.01kg.					
		Lat.	Long.	*Engraulis japonicus*	*Cololabis saira*	*Scomber japonicus*	Myctophids	Cephalopods	Gelatinous zooplankton
ST-04-MT	200/7/18	40-30.2N	157-30.6E	+				+	0.60
ST-13-MT-D	2002/7/22	43-15.4N	158-14.3E	0.01	0.01	0.16		0.04	1.00

Daytime predetermined surface trawl (0-20m)

Station name	Date	Deployment position		Major sampled species (kg). "+" represents less than 0.01kg.					
		Lat.	Long.	*Engraulis japonicus*	*Cololabis saira*	*Scomber japonicus*	Myctophids	Cephalopods	Gelatinous zooplankton
ST-09-MT	2002/7/21	42-32.4N	157-38.4E		3.94			0.18	0.09
ST-15-MT	2002/7/23	43-42.4N	156-53.2E	0.17	4.80			0.01	
ST-16-MT	2002/7/24	44-00.5N	155-58.8E		61.60				
ST-20-MT	200/7/26	45-00.2N	159-00.4E	0.01	47.00			0.02	0.21

Nighttime predetermined trawl (0-100m)

Station name	Date	Deployment position		Major sampled species (kg). "+" represents less than 0.01kg.					
		Lat.	Long.	*Engraulis japonicus*	*Cololabis saira*	*Scomber japonicus*	Myctophids	Cephalopods	Gelatinous zooplankton
ST-13-MT-N	2002/7/22	43-15.4N	158-14.6E				1.05	0.01	1.60

Target trawl

Station name	Date	Deployment position		Major sampled species (kg). "+" represents less than 0.01kg.					
		Lat.	Long.	*Engraulis japonicus*	*Cololabis saira*	*Scomber japonicus*	Myctophids	Cephalopods	Gelatinous zooplankton
ST-03-MT	2002/7/17	40-15.0N	156-46.4E	0.02			+	0.00	0.13
ST-07-MT	2002/7/20	42-06.2N	156-18.3E				0.04	+	6.90
ST-17-MT	2002/7/24	44-09.1N	156-19.9E	4.25	3.08				
ST-19-MT	2002/7/25	44-59.0N	158-57.5E		324.50			0.01	
ST-21-MT	2002/7/26	45-02.4N	158-48.4E		1.79			0.01	

Table 7. Results of target and predetermined trawls in Special Block B.

Daytime predetermined midwater trawl (0-100m)

Station name	Date	Deployment position		Major sampled species (kg). "+" represents less than 0.01kg.					
		Lat.	Long.	*Engraulis japonicus*	*E. japonicus* (Juvenile&larvae)	*Scomber japonicus*	Mesopelagic fish	Other fish	Cephalopoda
ST-23-MT	2002/8/2	40-28.8N	144-10.8E	34.79		0.24			
ST-29-MT	2002/8/5	38-55.1N	145-18.6E					0.09	0.08
ST-32-MT-D	2002/8/6	40-45.2N	146-06.1E	139.82		0.28		0.02	1.68
ST-37-MT	2002/8/9	38-00.1N	147-00.2E		0.69			0.03	0.01

Nighttime predetermined trawl (0-100m)

Station name	Date	Deployment position		Major sampled species (kg). "+" represents less than 0.01kg.					
		Lat.	Long.	*Engraulis japonicus*	*E. japonicus* (Juvenile&larvae)	*Scomber japonicus*	Mesopelagic fish	Other fish	Cephalopoda
ST-32MT-N	2002/8/6	40-45.2N	146-05.8E	490.44			138.06	41.07	18.10

Target trawl

Station name	Date	Deployment position		Major sampled species (kg). "+" represents less than 0.01kg.					
		Lat.	Long.	*Engraulis japonicus*	*E. japonicus* (Juvenile&larvae)	*Scomber japonicus*	Mesopelagic fish	Other fish	Cephalopoda
ST-25-MT	2002/8/3	39-39.6N	144-29.0E	12.45					
ST-27-MT	2002/8/4	38-09.9N	144-59.2E		0.28			0.01	0.01
ST-34-MT-1	2002/8/8	38-41.3N	146-44.3E		1.75			0.01	+
ST-34-MT-2	2002/8/8	38-40.3N	146-42.9E		3.31		0.04	0.01	
ST-36-MT	2002/8/9	38-02.3N	146-55.3E		0.01		0.01	0.07	0.02
ST-38-MT	2002/8/9	38-08.6N	146-54.6E	17.21					

Table 8. Results of CTD casts.

First period survey

Station name	Date	Deploy time (UTC+10:00)	Deployment positon		Depth (m)
			Lat.	Long.	
ST-01	2002/7/17	10:18	40-03N	156-09	500
ST-03	2002/7/17	17:31	40-15N	156-46E	500
ST-04	2002/7/18	9:38	40-28N	157-28E	500
ST-06	2002/7/19	17:48	41-39N	157-07E	500
ST-07	2002/7/20	15:51	42-08N	156-26E	500
ST-08	2002/7/21	9:10	42-23N	157-11E	500
ST-09	2002/7/21	12:00	42-31N	157-37N	500
ST-11	2002/7/22	10:03	43-01N	158-57E	500
ST-13	2002/7/22	19:34	43-16N	158-15E	500
ST-15	2002/7/23	14:49	43-42N	156-53E	500
ST-16	2002/7/24	8:26	44-00N	155-59E	500
ST-18	2002/7/24	16:51	44-11N	156-35E	500
ST-20	2002/7/26	7:43	45-00N	159-00E	500
ST-22	2002/7/26	15:07	45-14N	158-14E	500
ST-98	2002/7/28	17:45			2500

Second period survey

Station name	Date	Deploy time (UTC+10:00)	Deployment positon		Depth (m)
			Lat.	Long.	
ST-25	2002/8/3	9:23	39-37N	144-24E	500
ST-26	2002/8/3	18:04	38-35N	144-47E	500
ST-28	2002/8/4	14:32	38-08N	145-02E	500
ST-29	2002/8/5	8:11	38-55N	145-18E	500
ST-30	2002/8/5	15:18	39-28N	145-29E	500
ST-32	2002/8/6	15:43	40-45N	146-05E	500
ST-33	2002/8/7	13:25	39-48N	146-24E	500
ST-34	2002/8/8	12:10	38-43N	146-46E	500
ST-37	2002/8/9	12:48	38-00N	146-59E	500
ST-99	2002/8/2	6:25	41-00N	144-00E	2500

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	8/1/2002	8/1/2002	8/1/2002
Latitude	42°53N	42°53N	42°53N
Logitude	144°12E	144°12E	144°12E
Referecne target			
TS	-33.60 dB	-39.20 dB	-40.50 dB
TS deviation	5.0 dB	5.0 dB	5.0 dB
Minimum distance	23.00 m	19.00 m	16.00 m
Maximum distance	26.00 m	24.00 m	19.00 m
Transducer			
Transducer type	ES38B	ES70-11	ES120-7
Transducer serial No.	30128	29897	29415
Frequency	38000 Hz	70000 Hz	120000 Hz
Gain	26.10 dB	21.50dB	26.14 dB
Athwartship angle sensitivity	21.90	13.00	21.00
Athwartship Beam angle	6.98 deg	11.48 deg	7.29 deg
Athwartship Offset angle	-0.03 deg	-0.09 deg	0.14 deg
Alongship angle sensitivity	21.90	13.00	21.00
Alongship beam angle	6.95 deg	11.83 deg	7.28 deg
Alongship offset angle	0.00 deg	-0.07 deg	-0.08 deg
Sa correction	0.00 dB	0.00dB	0.00 dB
Beamtype	Split	Split	Split
Two way beam angle	-20.7 dB	-16.6 dB	-20.4 dB
Depth	0.00 m	0.00 m	0.00 m
Transceiver			
Transceiver type	GPT 38 kHz 0090720120f 1 ES38B	GPT 70 kHz 009072017 1e5 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	1000 W
Sample interval	0.190 m	0.190 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	-50.0 dB	-60.0 dB
Maximum beam compensation	6.0 dB	6.0 dB	6.0 dB
Maximum phase deviation	2.0	2.0	2.0
Minimum echolength	80 %	80 %	80 %
Maximum echolength	180 %	180 %	180 %
Environment			
Water temperature	9.35°C	9.35°C	9.35°C
Salinity	32.79 PSU	32.79 PSU	32.79 PSU
Absorption coefficient	9.3 dB/km	21.4 dB/km	34.7 dB/km
Sound velocity	1485.0 m/s	1485.0 m/s	1485.0 m/s
Beam model results			
Transducer gain	26.08 dB	21.82 dB	25.30 dB
Athwartship Beam angle	7.05 deg	11.51 deg	7.50 deg
Athwartship Offset angle	-0.04 deg	-0.08 deg	-0.15 deg
Alongshipship Beam angle	7.10 deg	11.60 deg	7.54 deg
Alongshipship Offset angle	-0.01 deg	0.09 deg	0.19 deg
Sa correction	-0.72 dB	-0.59 dB	-0.42 dB

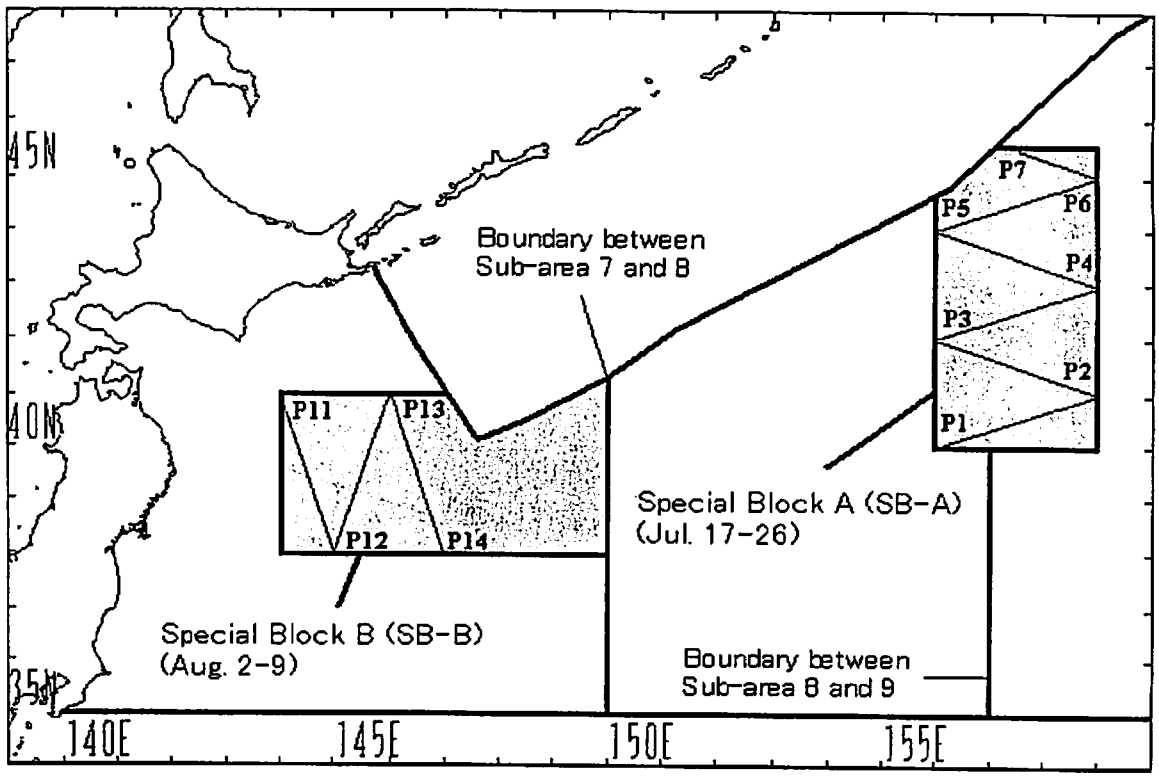

Fig. 1 Survey area and planed tracklines.

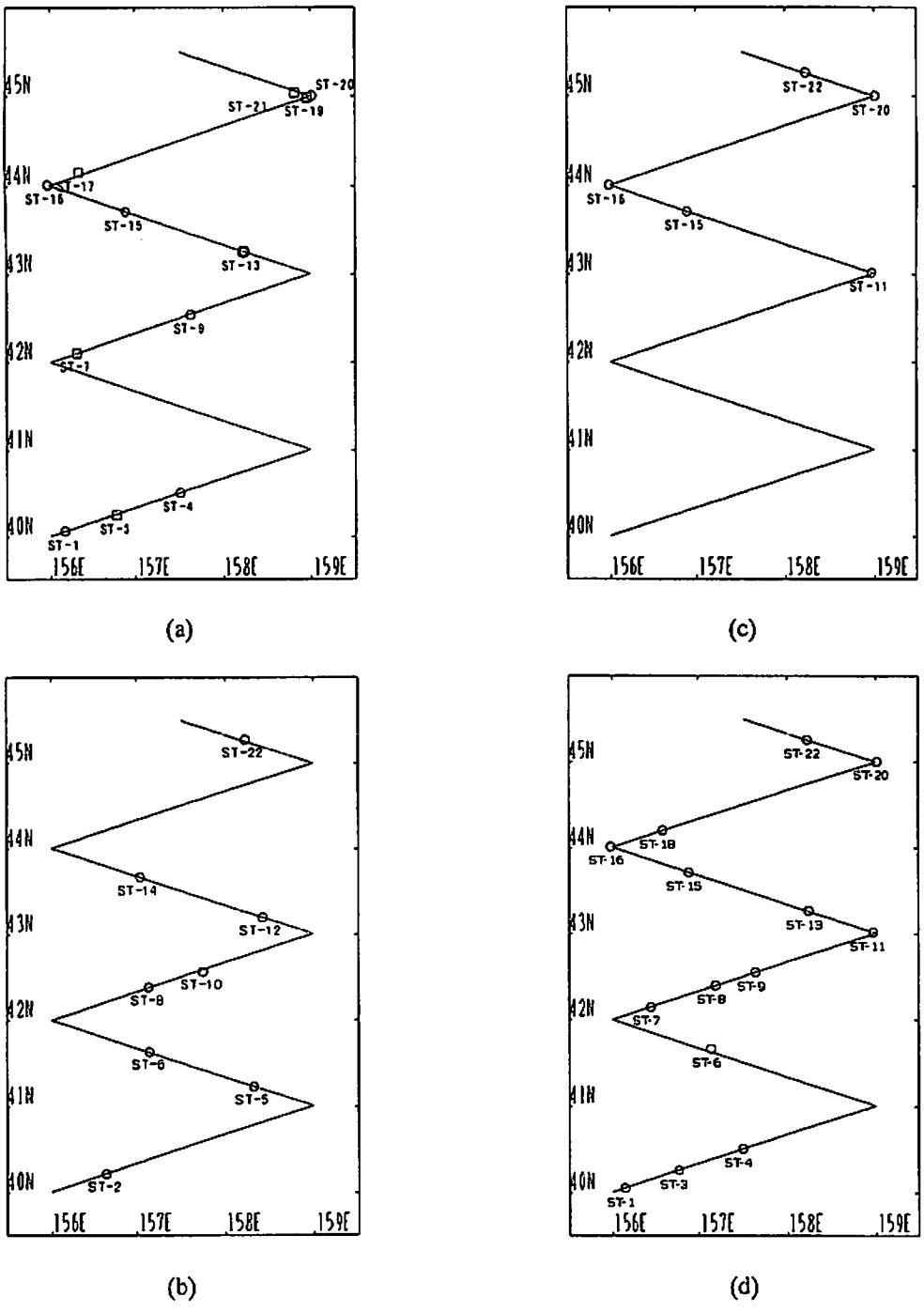

Fig. 2. Positions of trawl (a), IKMT(b), NORPAC net (c) and CTD casts (d) in Special Block A. In (a), ○, □, ◎ represent routine trawl, representing target trawl, day and nighttime trawl positions.

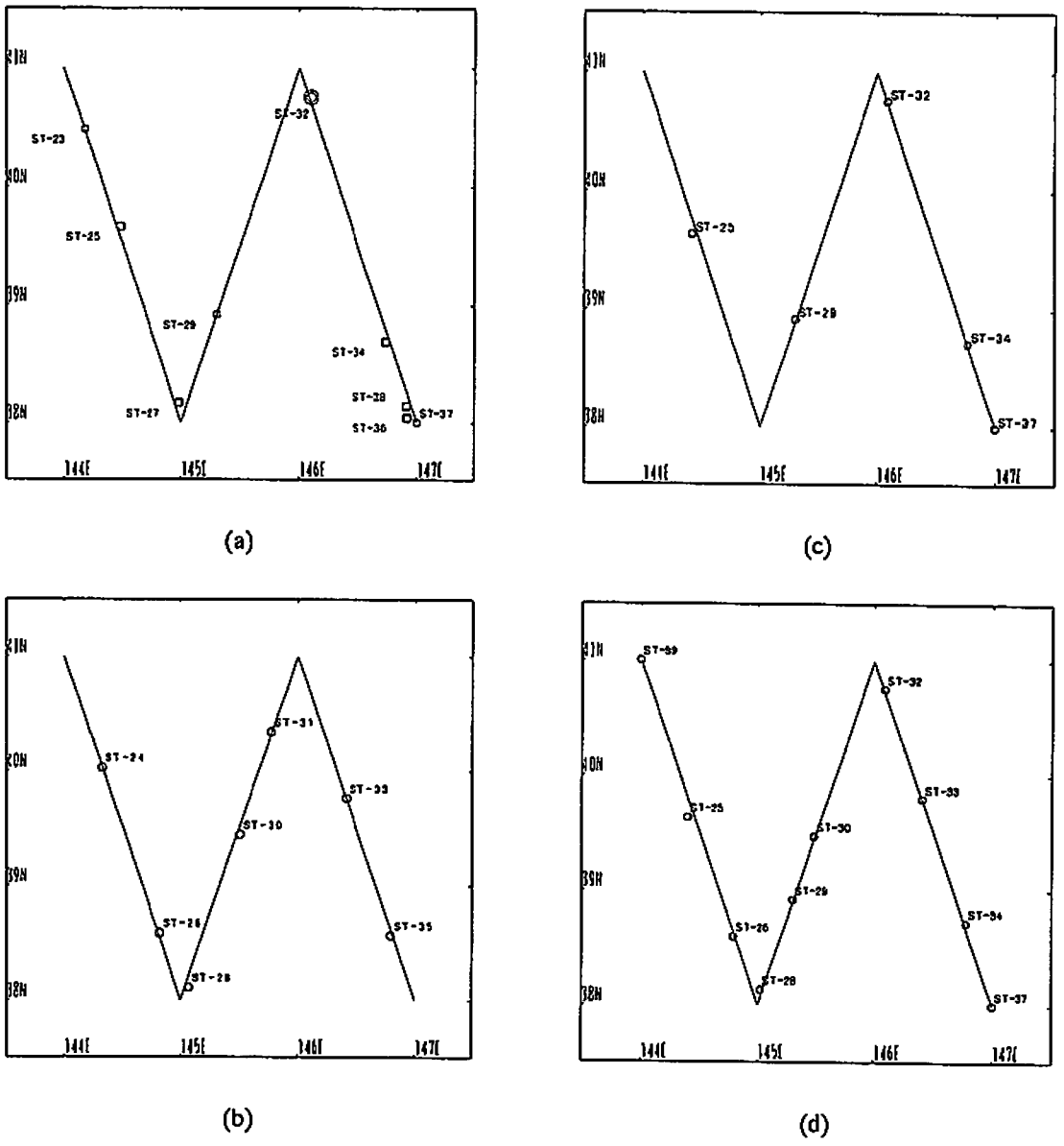

Fig. 3. Positions of trawl (a), IKMT(b), NORPAC net (c) and CTD casts (d) in Special Block B. In (a), ○, □, ◎ represent routine trawl, representing target trawl, day and nighttime trawl position