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

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ABSTRACT

The second phase of the Japanese Whale Research Program under Special Permit in the North Pacific (JARPN II) was planed with the aim to study the feeding ecology and ecosystem of common minke, Bryde's and sperm whales and their prey species. The first feasibility survey of the JARPN II was conducted in sub-areas 7, 8 and 9 from 29 July to 21 September 2000, using three sighting/sampling vessels (SSVs), one scientific echo-sounder survey vessel, one trawl survey vessel and one research base ship. The scientific echo-sounder survey vessel also acted as a dedicated sighting vessel. The total searching effort by the SSVs was 7,284 n.miles during which 68 common minke, 188 Bryde's and 400 sperm whales were sighted. The number of individuals sampled was 40 common minke, 43 Bryde's and five sperm whales. The whales sampled were examined on board the research base ship. Prey species found in the stomach content were Japanese anchovy, walleye Pollock and Japanese common squid in common minke whale; Japanese anchovy and krill in Bryde's whale and deep-sea squid and some fishes in the sperm whale. The possibility of direct and indirect competition between these whale species and commercial fisheries, is discussed.

INTRODUCTION

The Japanese Whale Research Program under Special Permit in the North Pacific (JARPN) was conducted between 1994 and 1999. The original objectives of the JARPN was to elucidate the stock structure of the western North Pacific common minke whale, especially (1) to investigate whether the W-stock exist and (2) whether sub-stocks exist within the O stock (Government of Japan, 1994). After two feasibility surveys in 1994 and 1995, the full scale JARPN survey started in 1996. An additional objective, the elucidation of the feeding ecology of the western North Pacific common minke whale, was added later in 1996 (Government of Japan, 1996). In relation to this additional objective it was learnt during the JARPN surveys that the common minke whales consume considerable amount of fish species such as Pacific saury and Japanese anchovy, which are target species of commercial fisheries in Japan.

Interaction between marine mammals and fisheries has become to be a topic of great interest. Northridge (1984) carried out a world review of these interactions. According to Tamura and Ohsumi (1999), a considerable amount of marine fish resources are consumed by cetaceans in the world. The authors emphasized that further examination of both feeding ecology of cetaceans and interaction between cetaceans and commercial fisheries, should be conducted.

In February 2000 an IWC/SC JARPN review workshop was carried out. The aims of the workshop were: a) review methods and results of the JARPN, b) assess the further potential of existing data and c) evaluate whether the main objectives of JARPN had been achieved. The workshop considered as a success the study on feeding ecology of the common minke whale. Results on this topic showed that most of whales pursued single prey species aggregations and that the main prey species changed seasonally and geographically. For example Japanese anchovy was the main prey species in May/June and saury was the main prey species in July/August. It should be noted that these species are the main target of commercial fisheries in Japan. The estimated prey consumption by common minke whales was comparable to that of the commercial fisheries. The workshop agreed that, if ecological studies are to be conducted in the area, the sampling regime must be designed to allow for a quantitative estimation of temporal and geographical variation in diet. It was also recommended that acoustic and trawl surveys should be conducted concurrently with future whale surveys, if possible (IWC, 2000).

With regard to the study on stock structure, results obtained from most of the approaches used suggested no evidence for additional stock structure in the western North Pacific common minke whale. However, a mtDNA analysis showed certain degree of heterogeneity, which was attributed to samples taken in the western part of sub-area 9 in 1995. The workshop agreed that in the light of these results, the possibility of the existence of some group of common minke whales to the east of Japan that differed from the 'O' stock could not be ruled out. To further clarify this issue the workshop recommended several additional analysis, most of them involving alternative stratification of data, and additional sampling in sub-area 9 (IWC, 2000).

The Government of Japan developed a new research plan for the study of cetaceans and ecosystem in the western North Pacific, the Japanese Whale Research Program under Special Permit-Phase II (JARPN II), (Government of Japan, 2000). JARPN II involves two feasibility surveys, one conducted in 2000 and the second in 2001. By taking into consideration the results of the feasibility surveys, a full research program would be starting from 2002. The overall goal of the 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 emphasis of JARPN II is on the ecosystem surrounding cetaceans, then samples and data related to cetaceans, prey species and oceanographic conditions are to be collected. The target species of the JARPN II are the common minke, Bryde's and sperm whales (Government of Japan, 2000).

The first feasibility survey of JARPN II was carried out from 29 July to 21 September 2000. In this paper we present an outline of the 2000 feasibility survey. Related to this research program there were two additional surveys conducted before and one conducted after the 2000 JARPN II feasibility survey. Information on these surveys is given in Appendix I.

The main text of this report describes the JARPN II 2000 survey with special emphasis on the whale research component. The co-operative study on ecosystem and oceanographic surveys are mentioned only briefly in the main text. Details of the oceanographic surveys, prey species survey and progress on modeling are given in Appendices II, III and IV, respectively.

MATERIALS AND METHOD

Research area

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

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 in by-products. *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. One of the SSVs (*Yushin Maru*) was also engaged in oceanographic surveys.

The *Kyoshin Maru No. 2* (KS2: 368GT) worked as an echo sounder survey vessel as well as a dedicated sighting vessel (SV). This vessel also conducted plankton net sampling and oceanographic surveys.

The *Shunyo Maru* (SYO: 396GT) worked as a trawl survey vessel. This vessel also conducted oceanographic observations.

Research components

In this survey, two main components are identified:

- Co-operative survey on the prey species and ecosystem research

  Vessels: Six research vessels (NM, YS1, K01, T25, KS2 and SYO)

  Research area: seven small blocks within sub-area 7 designed by taking into consideration previous data on surface temperature (Fig. 2).

Research periods: first period between 3 and 11 August involving small blocks 1, 2 and 3 and second period between 22 and 31 August involving small blocks 4, 6 and 7 (Table 1).

- Whale survey

  Vessels: Five research vessels (NM, YS1, K01, T25 and KS2 joined the survey as a dedicated sighting vessel)

  Research area: sub-areas 7 and 9.

  Research period: first period between 1 and 2 August near to small block 6 in sub-area 7, second period between 13 and 20 August in sub-area 9 and third period between 1 and 16 September involving small blocks 1, 2, 3, 4 and 5 in sub-area 7 (Table 1).

Cruise track line

Co-operative survey

In the co-operative survey on ecosystem research seven small blocks were defined using satellite information on surface temperature (Fig. 2). The source of this information was the homepage of the Tohoku National Fisheries Research Institute in Tohoku Region.

Allocation of the vessels was determined in the following manner. On the predetermined track line the KS2 conducted the echo sounder survey using as well as conducting the sighting survey under passing mode. The SYO followed the path of KS2. If KS2 detected the occurrence of prey species by echo sounder then the SYO conducted the trawl survey at the target depth to identify the prey species.

Whale survey

In the whale survey the track line and the allocation of vessels was set in similar manner as in previous JARPN surveys (Fujise *et al.*, 1995, 1996, 1997, 2000; 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 common minke whales and sea conditions.

Furthermore a 'Special Monitoring Survey' (SMS) was conducted in an area where the number of common minke 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. The track line of the SV was also similar to those of the SSVs.

The research course consisted of one main track and two parallel tracks established six n.miles apart on both sides. In the SMS the distance between the main and parallel tracks was set at four n.miles, considering efficiency of sampling.

The way points of the main course for the total survey are shown in Appendix V.

Trawl and echo sounder surveys (co-operative survey)

The prey species survey involved echo sounder survey (KS2) and a trawl survey (SYO). Echo sounder recording was made normally on the designed track line. Three types of trawl hauls were made: normal, target and night trawl hauls. The normal trawl haul was conducted at the scheduled time and location. The target trawl haul was conducted after the echo sounder survey indicated the occurrence of prey species. In such case the SYO conducted trawling at the target depth in which the prey species was detected by the echo sounder. The prey species were identified from the catches by the trawling. The night trawl haul was that conducted at a time after sunset on the same point of the normal trawling in daytime.

Sighting surveys

Sighting procedure was similar as in the previous surveys of JARPN (Fujise *et al.*, 1995, 1996, 1997, 2000; Ishikawa *et al.*, 1997; Zenitani *et al.*, 1999). In the research area sighting was conducted under closing mode in two modalities, *NSC* and *NSS modes*. The criteria for using either of these modalities were based on 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 criteria for conducting survey 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 two n.miles or more and wind speed of four or below). The *NSS mode* was used under more critical weather conditions but under which the sample of whale was possible. These two modalities were recorded separately for future analysis. Also an

ASP mode was used (closing mode under normal sighting conditions but without sampling). During the transit the *NSP mode* was adopted (passing mode under normal sighting conditions without sampling).

Closing was made mainly on sightings of common minke, Bryde's or sperm whales or on schools that looked like these species. Furthermore it was planned that closing was made on other large whale species, 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 and sperm whales

Sampling activities were conducted with the aim to take 100 common minke whales, 50 Bryde's whales and 10 sperm whales. Most of the schools of these species sighted on the trackline were approached for sampling. Sampling effort was applied after the established survey hours (06:00-19:00), if sample of whales 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).

Experiments

The following experiments and observations were conducted on board the SSVs (YS1, K01 and T25):

- Sighting distance and angle experiments to examine the precision of sighting data
- Biopsy experiment
- Photo-id experiment
- Oceanographic survey using CTD (YS1)

The following experiments and observations were conducted on board the SV (KS2):

- Sighting distance and angle experiment to examine the precision of sighting data.
- Biopsy experiment.
- Photo-id experiment
- Oceanographic survey using CTD, XCTD and EPCS.
- Feasibility study to estimate abundance of prey species of common minke and other large whale species using an echo sounder system.
- Feasibility study for sampling prey species of common minke and other large whale species.

Observations of marine debris in the research area were made from the wheelhouse of the research mother ship (*NM*) (mainly during transit). Marine debris was also investigated in the stomach contents of the common minke, Bryde's and sperm whales sampled.

Observations were made and several data were collected on the performance of rifle and harpoons as secondary means for killing the animal. These observations were conducted onboard of both the research base and the SSVs.

RESULTS

Survey period

The JARPN II survey was conducted from 29 July to 21 September 2000 (55 days including transit). The research was carried from 1 August to 16 September 2000 (47 days).

Searching distance

The total searching distance by the SSV was 7,284 n.miles. The figures for sub-areas 7 and 9 were 6,093.4 n.miles and 1,190.6 n.miles, respectively. The total searching distance by the SV was 1,012.2 n.miles in sub-area 7 (Table 2).

Sightings of common minke, Bryde's and sperm whales

Sighting and sampling vessels (SSVs)

The number of sightings of different species is shown in Tables 3a, 3b and 3c for all area, sub-area 7 and sub-area 9, respectively.

A total of 66 sightings (68 individuals) of common minke whales were made, consisting of 31 primary (31 individuals) and 35 secondary (37 individuals) sightings. There were 142 sightings (188 individuals) of Bryde's whale, consisting of 87 primary (111 individuals) and 55 secondary (77 individuals) sightings. A total of 165 sightings (400 individuals) of sperm whale were made, consisting of 112 primary (225 individuals) and 53 secondary (175 individuals) sightings.

Fig. 3 shows the distribution of sightings of common minke and Bryde's whales made by the SSVs in sub-areas 7 and 9. Common minke whales were sighted in both sub-areas 7 and 9. Bryde's whales were sighted only in offshore waters of sub-area 7. In this sub-area remarkable segregation between these two species was observed. Sightings of common minke whales were concentrated along the coast of Japan. In contrast sightings of Bryde's whales were concentrated in offshore waters of sub-area 7.

Fig. 4 shows the distribution of sightings of sperm whale in sub-area 7. This species was widely distributed in this sub-area. The exception was the coastal small blocks 1, 2 and 5 where sperm whales were not sighted.

Dedicated sighting vessel (SV)
The number of sighting by species made by the SV is shown in Table 4. A total of 4 primary sightings (4 individuals) of common minke whales were made. In the case of the Bryde's whale 22 sightings (29 individuals) were made consisting of 15 primary (21 individuals) and 7 secondary (8 individuals) sightings. A total of 19 sightings (49 individuals) of sperm whale was made consisting of 15 primary (45 individuals) and 4 secondary (4 individuals) sightings.

Sightings of other large whale species
Sighting and sampling vessels (SSVs)
Most of the sightings of other large baleen whale species such as blue (20 schools/25 individuals), fin (14 schools/16 individuals), sei (18 schools/33 individuals) and humpback whales (2 schools/4 individuals) were made in sub-area 9 (Tables 3a, 3b and 3c).

Dedicated sighting vessel (SV)
No other large whale species was sighted by the SV (Table 4).

Prey species survey
Details of the prey species survey are described in Appendix III. Below is a brief summary of the results of the prey species survey.

Echo-sounder survey and plankton net sampling
Table 5 shows a summary of the echo-sounder survey and plankton net sampling. Echo-sounder survey was conducted by KS2 in a total of 1,284 n.miles. Forty-four Maruchi net (simple cylinder-cone plankton net, 0.334 mm mesh at the cod end) and fourty-two bongo net (0.335 mm mesh) were conducted by KS2.

Trawl survey
Fig. 5 shows the point location of the normal, target and night trawl hauls. Twenty-five normal trawl hauls, fourteen target trawl hauls and five night trawling hauls were conducted by SYO.

Relationship between echo-sounder and trawl surveys
Fig. 6 shows the relationship between echo-sounder and trawl surveys. Distribution of SA at shallow waters seems to correspond to the distribution of Japanese anchovy as deduced by the results of the trawl survey.

Sampling of common minke, Bryde's and sperm whales
Tables 6 and 7 shows the number of whales sampled in each sub-area or small block, for each research component and period.

A total of 40 common minke whales was sampled, 34 during the whale survey component and 6 during the co-operative survey component (Table 6). The six whales sampled during the co-operative survey were from small blocks 1 and 2. If we consider the sub-areas, 24 were sampled in sub-area 7 and 16 in sub-area 9. The figure of 40 whales consisted of 35 males and 5 females.

A total of 43 Bryde's whales were sampled in sub-area 7, 23 during the whale survey component and 20 during the co-operative survey component. The whales sampled during the co-operative survey component were from small blocks 4 and 7 (Table 6). The figure of 43 whales consisted of 21 males and 22 females, including one mother/calf pair.

A total of five sperm whales were sampled in sub-area 7, one during the whale survey component and four during the co-operative survey component. During the co-operative survey component the sperm whales were sampled from small blocks 1, 4, 6 and 7 (Table 6). The figure of five animals consisted of three males and two females.

Geographical distribution of common minke and Bryde's whale samples is shown in Fig. 7 based on the sighting positions. Such distribution was in concordance with the pattern of distribution of sightings. There is a clear segregation in the pattern of distribution of common minke and Bryde's whales.

Fig. 8 shows the distribution of sperm whale samples based on the sighting positions. The sampling covered only sub-area 7.

Experiments

Photographic records of natural marks
During the survey, photo-id experiments were conducted by *Kyoshin Maru No. 2* on two blue whales. Photographs taken are being examined.

Biopsy sampling trial for Bryde's and sperm whales
Table 8 shows the result of biopsy skin sampling for Bryde's and sperm whales. A total of three Bryde's whales and 19 sperm whales were targeted for biopsy sampling by the SSVs and SV. There were 8 and 35 shoots, of which 2 and 17 hit the whale body of Bryde's and sperm whales, respectively. As a result, one and nine biopsy skin samples were collected from these species, respectively.

Distance and angle experiment
This experiment was conducted on 1 August and 9 September by the SSVs and SV, respectively. A total of 392 trials (288 for the SSVs and 104 for the SV) was made.

Oceanographical surveys
XCTD survey was conducted by *Kyoshin Maru No.2* from 3 August to 9 September. A total of 10 stations was conducted. This vessel was also engaged in CTD surveys from 9 August to 16 September. A total of 18 stations was conducted. This vessel conducted EPCS survey for 51 days.

Yushin Maru was also engaged in CTD surveys between 8 August and 15 September 2000. A total of 43 stations was conducted.

Observation of marine debris
Observation of marine debris from the bridge of the research base vessel (NM) was conducted during three periods. Transit from home port to the research area (30 July- 1 August), during transit between sub-area 7 and sub-area 9 (11-12 July and 21 July) and during the return from the research area to home port (17-18 September). The total period of observation was 86h and 30min. On the other hand, observation of marine debris in the stomach contents of whales was conducted and numerous artifacts were found. Details on these observations will be reported in the future.

Whale killing method
Observations were made and several data were collected on the performance of rifle and harpoons as secondary means for killing the animal. A summary of those observations and data will be presented in the future.

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

Table 9 summarizes the biological data and samples obtained from the common minke, Bryde's and sperm whales sampled during the 2000 JARPN II feasibility survey. A total of 55 items are listed in the table. These items are related to the studies conducted under the three main objectives of the JARPN II: feeding ecology and ecosystem, stock structure and environmental effects on cetaceans and marine ecosystem.

By-products

After biological research and tissue sampling was completed, all the whales were processed according to the provisions established in the Article VIII of the International Convention for the Regulation of Whaling. Total by-product was 573,377.6 kg (115,826.0 kg for common minke whale; 423,695.5 kg for Bryde's whale and 33,856.1 kg for sperm whale).

Preliminary analyses of biological data
In this section, results of some preliminary analyses of biological data collected during the 2000 JARPN II feasibility survey, are presented.

Sex ratio and maturity rate
Table 10 shows the reproductive status, sex ratio and maturity rate of common minke whales, by sub-area and sex. Similar to the finding of previous JARPN surveys, the proportion of males is high. In sub-area 9 all common minke whales sampled were males. Maturity rate was higher in females in sub-area 7. In males maturity rate was higher in sub-area 9.

Table 11 shows the reproductive status, sex ratio and maturity rate of Bryde's whales in sub-area 7, by small block and sex. The proportion of males in the total sample is around 50%. Among small blocks maturity rate varied from 37.5% to 81.8% in males and from 50.0% and 75% in females.

Body length and body weight
Table 12a shows the mean and ranges of body length in the common minke whale samples, by sex, sub-area and period. The body length distribution of common minke whale samples is shown in Fig. 9, by sex and sub-area. The mean male body length in sub-area 7 is 6.7m while that in sub-area 9 is higher (7.3m). The mean body length of female in sub-area 7 is 7.7m.

Table 12b shows the mean and ranges of body weight in the common minke whale samples, by sex, sub-area and period. The body weight distribution of common minke whale samples is shown in Fig. 10, by sex and sub-area. The mean male body weight in sub-area 7 is 3.5t while that in sub-area 9 is higher (4.4t). The mean body weight of female in sub-area 7 is 5.5t.

Table 13a shows the mean and ranges of body length in the Bryde's whale samples taken in sub-area 7, by sex and small block. The body length distribution of Bryde's whale samples is shown in Fig. 11, by sex. The mean male body length is 12.0m and that in female is 12.4m.

Table 13b shows the mean and ranges of body weight in the Bryde's whale samples, by sex and small block. The body weight distribution of Bryde's whale samples is shown in Fig. 12, by sex. The mean male body weight is 14.1t and that in female is 16.4t.

Anomaly testis
In the present survey 14 of 25 mature common minke whales (56%) showed anomaly testes. This rate is remarkably higher than those found in the previous JARPN surveys, though the number of samples is not sufficient. In the present survey no immature animal showed such anomaly.

Regarding Bryde's whale only one of 12 mature male Bryde's whales (8.3%) showed anomaly testes. No immature male showed such anomaly.

Prey species of common minke, Bryde's and sperm whale
A summary of the prey species found in the stomach content of common minke, Bryde's and sperm whales is shown in Table 14. Common minke whales sampled in the 2000 feasibility survey fed on five species: one krill species, one squid species and three fish species. In sub-area 9 they fed mainly on Japanese anchovy while in sub-area 7 they fed on Walleye pollock, Japanese common squid and Japanese anchovy.

Bryde's whales fed on four species: one krill species and three fish species. The main prey species of the Bryde's whale in the 2000 feasibility survey was the Japanese anchovy.

Sperm whale fed mainly on deep sea squids. Twenty-three squid species and one fish species were identified in the stomachs of the sperm whales sampled.

Forestomach contents weight in common minke and Bryde's whale
Fig. 13 shows the frequencies of the first stomach weight in the common minke whale samples, by sub-area and prey species. The range of fore stomach content weight varied from 0.0 kg to 160 kg. These values expressed as percentage of body weight had a maximum of 3.0% (Fig. 14).

Fig. 15 shows the frequencies of the first stomach weight in the Bryde's whale samples, by prey species. The range of fore stomach content weight varied from 0.0kg to 541 kg. These values expressed as percentage of body weight had a maximum of 2.9% (Fig. 16).

Body length frequency of Japanese anchovy ingested by common minke and Bryde's whales
Figs. 17 and 18 shows the length frequency distribution (fork length) of Japanese anchovy ingested by common minke and Bryde's whales, respectively. The fork length ranged from 120 to 135 mm with a single mode at 128 mm in small block 1. The fork length of Japanese anchovy ingested by Bryde's whale ranged from 43 to 143 mm with a single mode at 74 mm in small block 4. The fork length frequencies of Japanese anchovy ingested by common minke whale, Bryde's whale, and those sampled by the trawl survey were almost same.

The stomach contents of sperm whales
Table 15 shows a summary of the quantitative analysis of stomach content in five sperm whales. They fed mainly on deep sea squids during daytime. The range of stomach content weight was from 77.4 kg to 236.7 kg. The maximum % of body weight was 0.8% - 1.0 %.

DISCUSSION

Prey species of common minke, Bryde's and sperm whales

Common minke whale
From the JARPN surveys from 1994 to 1999 it was revealed that Japanese anchovy was the most important prey species of common minke whales in May and June, while Pacific saury was the most important one in July and August (Tamura and Fujise, 2000). In the 2000 JARPN II feasibility survey, which was conducted in August and September, common minke whales consumed mainly Japanese anchovy, a species identified as a important prey in previous JARPN surveys. In addition they also consumed considerable amount of walleye pollock and Japanese common squid in sub-area 7.

In the present survey the Pacific saury was scarcely represented in the stomach of common minke whales. As mentioned above, the major prey species in both sub-areas 7 and 9 was the Japanese anchovy. In the survey in sub-area 9 no whales were sighted at water temperature of 12°-13°C, which is the range of surface temperature where the Pacific saury distribute. Most of the sightings of common minke whales were made at surface temperature in the range of 18°-19°C and the stomach content of the common minke whales sampled was Japanese anchovy. On the other hand lower catches of Pacific saury by the commercial fishery was reported for 1998 and 1999. Then, a change of food habitat of common minke whale is one of the possible explanations.

Bryde's whale
Previously krill and some small schooling fish such as Japanese anchovy and Japanese pilchard have been reported as prey species of the Bryde's whale in the North Pacific (Nemoto, 1959; Kawamura, 1980). The prey species identified during the 2000 feasibility survey were the Japanese anchovy (main) and some of krill.

The body length of the Japanese anchovy consumed by the Bryde's whales was different from that of Japanese anchovy consumed by the common minke whales. Bryde's whale fed on smaller fishes (7-8 cm of fork length) in comparison to those fed by the common minke whales (12-13cm of fork length). These differences in size seem to reflect the geographic distribution of the Japanese anchovy. Fig. 18 shows the body length frequencies of Japanese anchovy in the stomach of common minke and Bryde's whales in comparison to those observed in the catches by the trawl survey in small blocks 1 and 4. There is a clear concordance between the length of fishes observed in the trawl survey and that observed in the stomach of whales within a same small block. Those values observed in small block 1 (common minke whale) are larger than those observed in small block 4 (Bryde's whale).

Sperm whale
Previous studies have indicated that the prey species of the sperm whale is are mainly mesopelagic squids, which are not targeted by commercial fishery (Kawakami, 1976, 1980; Okutani *et al.*, 1976; Okutani and Satake, 1978). However sardines, salmon (*Onchorhynchus gorbusha*), Pacific saury and Chub mackerel, which are important commercial fishes in the western North Pacific, have been also indicated as prey species of the sperm whale (Kawakami, 1980).

From the 2000 JARPN II feasibility survey the following information was obtained: (1) sperm whales feed mainly on deep-sea squids. Some of these are reported as prey species of the sperm whale for the first time; (2) Squids found in the sperm whale stomach are relatively fresh suggesting that sperm whale feed on these prey during daytime; (3) At least one fish species (walleye pollock) was identified in the diet of the sperm whale. However the information on feeding ecology of the sperm whale is limited by the small sample size.

The possibility of direct competition between common minke whale and fisheries

Fujise *et al.* (1997) showed a relationship between distribution of common minke whales and fishing ground of Pacific saury in summer near the Pacific side of Hokkaido. In the 2000 feasibility survey the Pacific saury was scarcely represented in the stomach of common minke whales. In this year they fed mainly on Walleye pollock and Japanese common squid, which are also important target species of commercial fisheries in Japan. Then these results suggest a relationship between common minke whales and Walleye pollock and Japanese common squid in summer in the western North Pacific, in addition to the relationship between common minke whale and Pacific saury fishery alredy suggested by previous studies.

The possibility of indirect competition between Bryde's whale and skipjack tuna

Fig. 19 shows the fishing grounds of skipjack tuna (fishery grounds of pole and line fishery and round haul net fishery) and the positions of Bryde's whales sightings in sub-area 7 in the survey conducted during 24 August and 5 September 2000.

Most of the Bryde's whales sightings occurred near to these fishing grounds. The Bryde's whales sampled near the fishing grounds fed mainly on the Japanese anchovy and a low proportion of these whales had the stomach empty. In contrast most of whales sampled far from the fishing grounds had the stomach empty. It is known that the skipjack tuna feed on the Japanese anchovy (Kawasaki, 1965). Then it is suggested a possible relationship between Bryde's whales and skipjack tuna in summer in the western North Pacific. More data are needed to investigate further this possible competition between Bryde's whale and skipjack tuna in the region.

The sightings of large baleen whales in the sub-area 9

Fig. 20 shows the distribution of sightings of blue, fin, sei and humpback whales in sub-area 9. In that sub-area a considerable number of sightings were made. Table 16 shows the number of sightings and density indices (DI: whales sighted per 100 n.miles searching) sub-area 9. For comparison information from previous JARPN surveys in 1994, 1995 and 1997, are included. In the 2000 feasibility survey remarkably higher DI are found for only 8 days of survey. However area surveyed is limited within sub-area 9 and wider surveys are need to investigate further the occurrence and distribution of large whale species in this sub-area.

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Table 1. Outline of 2000 JARPN II survey

Research	Research periods	Days	Sub-area	small block	Research ships
Whale survey (first period)	**Aug. 1-2, 2000**	**2**	**7**	**nearly 6**	**NM, YS1, K01, T25**
Cooperative survey (first period)	**Aug. 3-11, 2000**	**9**	**7**	**2, 1, 3**	**NM, YS1, K01, T25, SYO. KS2**
	Aug. 3-5	3		2	
	Aug. 6-10	5		1	
	Aug. 11	1		3	
Whale survey (second period)	**Aug. 13-20, 2000**	**8**	**9**	**-**	**NM, YS1, K01, T25, KS2**
Cooperative survey (second period)	**Aug. 22-31, 2000**	**10**	**7**	**4, 6, 7**	**NM, YS1, K01, T25, SYO, KS2**
	Aug. 22-26	5		4	
	Aug. 27-29	3		7	
	Aug. 30-31	2		6	
Whale survey (third period)	**Sep. 1-16, 2000**	**16**	**7**	**1, 2, 3, 4, 5**	**NM, YS1, K01, T25, KS2**
	Sep. 2	1		5	
	Sep. 3-4	2		2, between 2 and 5	
	Sep. 5-6	1.5		3	
	Sep. 6-10	4.5		between 3 and 4	
	Sep. 11	1		3	
	Sep. 12-16	4		1	
Total	**Aug. 1-Sep. 16**	**47**			**NM, YS1, K01, T25, SYO. KS2**

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.1* (K01)
Trawl survey vessel : *Shunyo Maru* (SYO)

Table 2. Searching distances made by the three sighting/sampling vessels (YS1, K01 and T25) and dedicated sighting vessel (KS2) in the 2000 JARPN II survey.

Sub-area	Period	Searching distance (n.miles)			
		NSC	ASP	NSS	Combined
SSVs					
7	7/30-8/11 8/22-9/16	4137.9	1119.6	835.9	6093.4
9	8/13-20	635.6	28.1	526.9	1190.6
Combined	7/30-9/16	4773.5	1147.7	1362.8	7284.0
SV(KS2)					
7	8/2-9/5	-	1012.2	-	1012.2

Table 3a. Number of sightings of large cetacean (no. schools/no. individuals) made by three sighting/sampling vessels in the 2000 JARPN II survey (Total area: 7/30-9/16).

Whale 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	20	20	24	25	5	5	3	3	6	6	0	0	8	9	31	31	35	37	66	68
Like common minke whale	1	1	1	1	2	2	0	0	0	0	0	0	1	1	3	3	2	2	5	5
Blue whale	3	4	2	2	14	18	0	0	0	0	0	0	1	1	17	22	3	3	20	25
Fin whale	2	3	1	1	9	9	0	0	0	0	0	0	2	3	11	12	3	4	14	16
Sei whale	3	3	0	0	13	27	2	3	0	0	0	0	0	0	16	30	2	3	18	33
Bryde's whale	39	46	25	33	0	0	0	0	48	65	0	0	30	44	87	111	55	77	142	188
Humpback whale	0	0	0	0	1	3	0	0	0	0	0	0	1	1	1	3	1	1	2	4
Sperm whale	75	143	19	83	20	24	6	16	17	58	8	26	20	50	112	225	53	175	165	400
Unidentified large cetacean	12	16	6	8	11	12	1	1	3	3	2	2	5	5	26	31	14	16	40	47

Table 3b. Number of sightings of large cetacean (no. schools/no. individuals) made by three sighting/sampling vessels in the 2000 JARPN II survey (Sub-area 7: 7/30-8/11,8/22-9/16).

Whale 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	11	11	13	14	4	4	3	3	0	0	0	0	1	1	15	15	17	18	32	33
Like common minke whale	1	1	1	1	0	0	0	0	0	0	0	0	1	1	1	1	2	2	3	3
Bryde's whale	39	46	25	33	0	0	0	0	48	65	0	0	30	44	87	111	55	77	142	188
Sperm whale	46	107	13	76	1	1	2	10	15	56	8	26	17	46	62	164	40	158	102	322
Unidentified large cetacean	1	1	4	5	0	0	0	0	3	3	2	2	4	4	4	4	10	11	14	15

Table 3c. Number of sightings of large cetacean (no. schools/no. individuals) made by three sighting/sampling vessels in the 2000 JARPN II survey (Sub-area 9: 8/13-8/20).

Whale 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	9	9	11	11	1	1	0	0	6	6	0	0	7	8	16	16	18	19	34	35
Like common minke whale	0	0	0	0	2	2	0	0	0	0	0	0	0	0	2	2	0	0	2	2
Blue whale	3	4	2	2	14	18	0	0	0	0	0	0	1	1	17	22	3	3	20	25
Fin whale	2	3	1	1	9	9	0	0	0	0	0	0	2	3	11	12	3	4	14	16
Sei whale	3	3	0	0	13	27	2	3	0	0	0	0	0	0	16	30	2	3	18	33
Humpback whale	0	0	0	0	1	3	0	0	0	0	0	0	1	1	1	3	1	1	2	4
Sperm whale	29	36	6	7	19	23	4	6	2	2	0	0	3	4	50	61	13	17	63	78
Unidentified large cetacean	11	15	2	3	11	12	1	1	0	0	0	0	1	1	22	27	4	5	26	32

Table 4. Number of sightings of large cetacean (no. schools/no. individuals) made by dedicated sighting vessel (KS2) in the 2000 JARPN II survey (Total area: 8/2-9/5).

Whale species	ASP			
	Primary		Secondary	
	Sch.	Ind.	Sch.	Ind.
Common minke whale	4	4	0	0
Like common minke whale	1	1	1	1
Bryde's whale	15	21	7	8
Sperm whale	15	45	4	4
Unidentified large cetacean	33	39	8	13

Table 5. Summary of prey species surveys

Research Items	type	effort
<KS2>		
Echo-sounder survey		1,284 n.miles
Net sampling	Bongo	42 points
	Maruchi	44 points
XCTD		points
EPCS		hours
<SYO>		
Trawl	Target	14 points
	Normal	25 points
	Night	5 points

Table 6. Summary of whale sampling in the 2000 JARPN II survey

Research type		Research periods	Sub-area	Small block	Whale samples		
					Common minke	Bryde's	Sperm
Whale survey	First	Aug. 1-2, 2000	7		0	4	-
	Second	Aug. 13-20, 2000	9		16	0	0
	Third	Sep. 2	7	(5)	1	0	0
		Sep. 3-4	7	(2, 2-5)	0	0	0
		Sep. 5-6	7	(3)	0	0	1
		Sep. 6-10	7	(3-4)	0	19	0
		Sep. 11	7	(3)	0	0	0
		Sep. 12-16	7	(1)	17	0	0
					34	23	1
Cooperative (ecosystem) survey	First	Aug. 3-5	7	2	5	0	0
		Aug. 6-10	7	1	1	0	1
		Aug. 11	7	3	0	0	0
	Second	Aug. 22-26	7	4	0	14	1
		Aug. 27-29	7	7	0	6	1
		Aug. 30-31	7	6	0	0	1
					6	20	4
2000 JARPN II					40	43	5

Table 7. Number of samples taken by small blocks

Sub-area	Small block	Whale samples		
		Common minke	Bryde's	Sperm
7	1	18	0	1
	2	5	0	0
	3	0	0	1
	4	0	14(+19)	1
	5	1	0	0
	6	0	4	1
	7	0	6	1
		24	43	5
9	-	16	0	0
Total		40	43	5

Table 8. Summary of biopsy skin sampling for Bryde's and sperm whales in the 2000 JARPN 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)
Bryde's whale	SSVs	3	3	8	2	1	2h32m	0.125	0.500
Sperm whale	SSVs	7	15	29	15	8	5h53m	0.276	0.533
	SV	3	4	6	2	1		0.167	0.500

Table 9. Summary of biological data and samples collected during the 2000 JARPN II survey

Samples and data	Common minke whale			Bryde's whale			Sperm whale		
	M	F	T	M	F	T	M	F	T
Body length and sex	35	5	40	21	22	43	3	2	5
External body proportion	35	5	40	21	22	43	3	2	5
Photographic record and external character	35	5	40	21	22	43	3	2	5
Diatom film record and sampling	35	5	40	21	22	43	3	2	5
Standard measurements of blubber thickness (eleven points)	35	5	40	21	22	43	3	2	5
Detailed measurements of blubber thickness (fourteen points)	10	2	12	10	4	14	0	0	0
Body weight	35	5	40	21	22	43	3	2	5
Body weight by parts	10	2	12	10	4	14	3	2	5
Blubber, muscle, liver and heart tissues for DNA study	35	5	40	21	22	43	3	2	5
Muscle, liver and heart tissues for isozyme analysis	35	5	40	21	22	43	3	2	5
Muscle, liver and kidney tissues for heavy metal analysis	35	5	40	21	22	43	3	2	5
Blubber, muscle, liver and kidney tissues for organochlorine analysis	35	5	40	21	22	43	3	2	5
Tissues for lipid analysis	10	2	12	10	4	14	3	2	5
Tissues for endocrine disrupters analysis	35	5	40	21	22	43	3	2	5
Muscle and liver for chemical analysis	35	5	40	21	22	43	3	2	5
Muscle, blubber and intestin content for energy flow analysis	10	2	12	21	22	43	3	2	5
Lung, spleen and testis for virus test	35	5	40	21	22	43	3	2	5
Mammary grand; lactation status, measurement and histological sample	0	5	5	0	22	22	0	2	2
Collection of maternal milk sample	0	0	0	0	1	1	0	0	0
Uterine horn; measurement and endometrium sample	0	5	5	0	22	22	0	2	2
Uterine mucus for sperm detection	0	0	0	0	21	21	0	2	2
Collection of ovary	0	5	5	0	22	22	0	2	2
Photographic record of foetus	2	1	3	3	4	9*1	0	0	0
Foetal sex (identified by visual observation)	2	1	3	3	4	7	0	0	0
Foetal length and weight	2	1	3	3	4	9*1	0	0	0
External measurements of foetus	2	1	3	3	4	7	0	0	0
Collection of foetus	0	0	0	0	1	3*1	0	0	0
Testis and epididymis; weight and histological sample	35	0	35	21	0	21	3	0	3
Smear samples from testis and epididymis tissues	0	0	0	21	0	21	3	0	3
Urine sample for sperm detection	0	0	0	12	0	12	2	0	2
Collection of serum sample	35	5	40	21	22	43	2	2	4
Whole blood samples from umbilical cord	0	3	3	0	5	5	0	0	0
Serum samples from umbilical cord	0	0	0	0	3	3	0	0	0
Stomach content, conventional record	35	5	40	21	22	43	3	2	5
Volume and weight of stomach content in each compartment	35	5	40	21	22	43	3	2	5
Measurement of gastric juice pH	6	0	6	10	4	14	2	0	2
Stomach contents for feeding study	33	5	38	13	14	27	3	2	5
Record of external parasites	35	5	40	21	22	43	3	2	5
Collection of external parasites	10	0	10	18	16	34	1	2	3
Record of internal parasites	35	5	40	21	22	43	3	2	5
Collection of internal parasites	1	0	1	5	4	9	3	2	5
Earplug for age determination	35	5	40	21	22	43	1	2	3
Tympanic bulla for age determination	35	5	40	21	22	43	0	0	0
Maxillally teeth for age determination	0	0	0	0	0	0	3	2	5
Largest baleen plate for morphologic study and age determination	35	5	40	21	22	43	0	0	0
Largest baleen plate for stable isotopes	35	5	40	21	22	43	0	0	0
Baleen plate measurements (length and breadth)	34	5	39	21	21	42	0	0	0
Length of each baleen plate series	34	5	39	21	22	43	0	0	0
Vertebral epiphyses sample	35	5	40	21	22	43	3	2	5
Number of vertebrae	35	5	40	21	22	43	3	2	5
Number of ribs	35	5	40	21	22	43	3	2	5
Brain weight	10	2	12	14	11	25	3	2	5
Skull measurement (length and breadth)	34	5	39	21	22	43	3	2	5
Collection of skull	0	0	0	0	0	0	0	1	1
Collection of whole skeleton	0	0	0	0	1	1	1	0	1

*1 including fetuses of sex unidentified

Table 10. Compositon of sex and sexual maturity of common minke whales collected by the 2000 JARPN II survey.

Sub- area		Male			Female					Sex ratio	Maturity		Pregnancy
		Imm.	Mat.	Total	Imm	Rest.	Preg.	Unk	Total	(% males)	Male	Female	rate*)
7	first	2	3	5	0	0	1	0	1	83.3	60.0	100	100
		(33.3)	(50.0)	(83.3)	(0.0)	(0.0)	(16.7)	(0.0)	(16.7)				
	second	6	8	14	0	1	2	1	4	77.8	57.1	100	66.7
		(33.3)	(44.4)	(77.8)	(0.0)	(5.6)	(11.1)	(5.6)	(22.2)				
	Combined	8	11	19	0	1	3	1	5	79.2	57.9	100	75.0
		(33.3)	(45.8)	(79.2)	(0.0)	(4.2)	(12.5)	(4.2)	(20.8)				
9		2	14	16	0	0	0	0	0	100.0	87.5	-	-
		(12.5)	(87.5)	(100.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)				
Combined		10	25	35	0	1	3	1	5	87.5	71.4	100	75.0
		(25.0)	(62.5)	(87.5)	(0.0)	(2.5)	(7.5)	(2.5)	(12.5)				

*) Apparent pregnancy rate

Table 11. Compositon of sex and sexual maturity of Bryde's whales collected by the 2000 JARPN II survey.

Sub-area	small	Male			Female						Sex ratio	Maturity		Pregnancy
	block	Imm.	Mat.	Total	Imm	Rest.	Preg.	Lact.	P&L	Total	(% males)	Male	Female	rate*)
7	6	2	0	2	1	0	0	0	1	2	50.0	0.0	50.0	100
		(50.0)	(0.0)	(50.0)	(25.0)	(0.0)	(0.0)	(0.0)	(25.0)	(50.0)				
	7	1	1	2	2	0	2	0	0	4	33.3	50.0	50.0	100.0
		(16.7)	(16.7)	(33.3)	(33.3)	(0.0)	(33.3)	(0.0)	(0.0)	(66.7)				
	4 (E)	4	2	6	1	3	4	0	0	8	42.9	33.3	87.5	57.1
		(28.6)	(14.3)	(42.9)	(7.1)	(21.4)	(28.6)	(0.0)	(0.0)	(57.1)				
	4 (L)	2	9	11	2	2	3	1	0	8	57.9	81.8	75.0	50.0
		(10.5)	(47.4)	(57.9)	(10.5)	(10.5)	(15.8)	(5.3)	(0.0)	(42.1)				
Combined		9	12	21	6	5	9	1	1	22	48.8	57.1	72.7	62.5
		(20.9)	(27.9)	(48.8)	(14.0)	(11.6)	(20.9)	(2.3)	(2.3)	(51.2)				

*) Apparent pregnancy rate

Table 12. Statistics of body length (m) and body weight (ton) of common minke whales in each sub-area

a. Body length (m)

Sub area	period	Male					Female				
		Mean	S.D.	Min	Max	n	Mean	S.D.	Min	Max	n
7	first	6.63	1.07	4.83	7.55	5	8.52		8.52	8.52	1
	second	6.67	0.95	4.70	7.82	14	7.46	0.21	7.17	7.65	4
	Combined	6.66	0.95	4.70	7.82	19	7.67	0.51	7.17	8.52	5
9		7.31	0.74	4.71	7.75	16					0

b. Body weight (ton)

Sub area	period	Male					Female				
		Mean	S.D.	Min	Max	n	Mean	S.D.	Min	Max	n
7	first	3.29	1.18	1.35	4.45	5	6.65		6.65	6.65	1
	second	3.63	1.34	1.25	5.40	14	5.20	0.97	3.90	6.05	4
	Combined	3.54	1.28	1.25	5.40	19	5.49	1.06	3.90	6.65	5
9		4.41	0.96	1.30	5.45	16					0

Table 13. Statistics of body length (m) and body weight (ton) of Bryde's whales in each small- area

a. Body length (m)

Sub area	Small block	Male Mean	Male S.D.	Male Min	Male Max	Male n	Female Mean	Female S.D.	Female Min	Female Max	Female n
7	6	11.6	0.4	11.3	11.8	2	12.3	1.4	11.3	13.3	2
	7	12.1	1.6	11.0	13.2	2	12.5	1.6	10.8	14.1	4
	4E	11.6	1.1	10.3	13.2	6	12.5	1.1	10.5	13.8	8
	4L	12.3	0.7	10.6	13.2	11	12.2	1.7	8.5	13.6	8
Comined		12.0	0.9	10.3	13.2	21	12.4	1.3	8.5	14.1	22

b. Body weight (ton)

Sub area	Small block	Male Mean	Male S.D.	Male Min	Male Max	Male n	Female Mean	Female S.D.	Female Min	Female Max	Female n
7	6	11.9	0.4	11.6	12.3	2	14.1	4.6	10.8	17.3	2
	7	14.5	5.0	11.0	18.0	2	16.4	6.4	9.2	23.5	4
	4E	13.2	4.2	8.7	18.5	6	16.9	3.9	9.4	21.0	8
	4L	15.0	2.2	9.6	18.0	11	16.4	5.2	6.3	21.9	8
Comined		14.1	3.1	8.7	18.5	21	16.4	4.6	6.3	23.5	22

Table 14. Prey species found in stomach of common minke, Bryde's and sperm whales sampled by the JARPN II survey including previous JARPN surveys.

	English name	Scientific name
Common minke whale		
Copepods		*Neocalanus cristatus**
Krill		*Euphausia pacifica*
		*Thysanoessa inermis**
		*T. inspinata**
		*T. longipes**
Squid	Japanese common squid	*Todarodes pacificus*
Pisces	Pacific saury	*Cololabis saira*
	Japanese anchovy	*Engraulis japonicus*
	Walleye pollock	*Theragra chalcogramma*
	Japanese pilchard	*Sardinops melanostictus**
	Chub mackerel	*Scomber japonicus**
	Japanese pomfret	*Brama japonica**
	Pink salmon	*Oncorhynchus gorbuscha**
	Coho salmon	*O. kisutch**
	Daggertooth	*Anotopterus pharao**
	Japanese sand lance	*Ammodytes hexapterus**
Bryde's whale		
Krill		*Euphausia pacifica*
Pisces	Japanese anchovy	*Engraulis japonicus*
	Russell's scad	*Decapterus russelli*
	Chub mackerel	*Scomber japonicus*

:* identified by the JARPN surveys during 1994 and 1999.

	English name	Scientific name
Sperm whale		
Pisces		*Laemonema longipes*
	Walleye pollock	*Theragra chalcogramma***
		*Macrouridae***
Squid		*Gonatus berryi*
		G. pyros
		G. middendorffi
		Eogonatus tinro
		Gonatopsis borealis
		Chiroteuthis imperator
		C. calyx
		Enoploteuthis chuni
		Ancistrocheirus lesueuri
		Galiteuthis pacifica
		Taonius pavo
		Megalocranchia maxima
		Onychoteuthis borealijaponica
		O. banksi
		Moroteuthis loennbergi
		M. robusta
		Histioteuthis dofleini
		H. meleagroteuthis
		Discoteuthis discus
		Architeuthis martensi
		Taningia danae
		Octopoteuthis sicula
		Alloposus mollis
		*Ommastrephes bartrami***

**: these prey species were identified by their beaks or otholiths

Table 15. Summary of the information on stomach contents in sperm whales sampled during JARPN II survey (n=5).

No.	Small block	Sampling date	Sighting time	Sighting position N. Lat.		E. Long.		Length (m)	Weight (t)	Sex	Weight of s. c. (kg)*	Ratio of body weight (%)	Freshness of s. c.
1	1	2000.8.06	12.03	41	10	144	7.7	11.3	19.7	M	196.6	1.0	fff
2	4	2000.8.22	12.03	40	45.4	149	25.9	12.8	30.4	M	236.7	0.8	fff
3	7	2000.8.28	11.36	37	0	148	14.3	11.6	21.4	F	170.0	0.8	ff
4	6	2000.8.31	11.11	37	30.3	144	46.3	8.8	10.2	M	46.8+	0.5+	fff
5	3	2000.9.05	9.03	39	59.4	144	2.6	8.2	7.5	F	77.4	1.0	ff

* : Including forestomach, fundas and third stomach contents

s. c.: : stomach contents

Table 16. Comparison of numbers of large baleen whales sighted in the sub-area 9 during the JARPN surveys (1994-1999) and JARPN II survey (2000).

Whale species	Survey year	Searching (days)	Distance (n.miles)	NSC		NSS		OE		Combined		DI	SR
				Sch.	Ind.	Sch.	Ind.	Sch.	Ind.	Sch.	Ind.		
Blue whale	1994	65	6980.1	3	4	3	6	7	9	13	13	0.19	0.20
	1995	71	11843.9	7	18	1	1	4	5	12	12	0.10	0.17
	1997	44	8258.4	2	2	2	2	0	0	4	4	0.05	0.09
	2000	**8**	**1190.6**	**5**	**6**	**14**	**18**	**1**	**1**	**20**	**25**	**2.10**	**3.13**
Fin whale	1994	65	6980.1	7	12	12	16	2	5	21	21	0.30	0.32
	1995	71	11843.9	18	24	0	0	0	0	18	18	0.15	0.25
	1997	44	8258.4	7	9	0	0	1	3	8	8	0.10	0.18
	2000	**8**	**1190.6**	**3**	**4**	**9**	**9**	**2**	**3**	**14**	**16**	**1.34**	**2.00**
Sei whale	1994	65	6980.1	10	16	2	3	1	1	13	13	0.19	0.20
	1995	71	11843.9	13	18	1	1	4	6	18	18	0.15	0.25
	1997	44	8258.4	10	11	11	16	4	5	25	25	0.30	0.57
	2000	**8**	**1190.6**	**3**	**3**	**15**	**30**	**0**	**0**	**18**	**33**	**2.77**	**4.13**

DI: Density indices (whales sighted per 100 n.miles searching)
SR : Sighting rate (whales sighted per survey day)

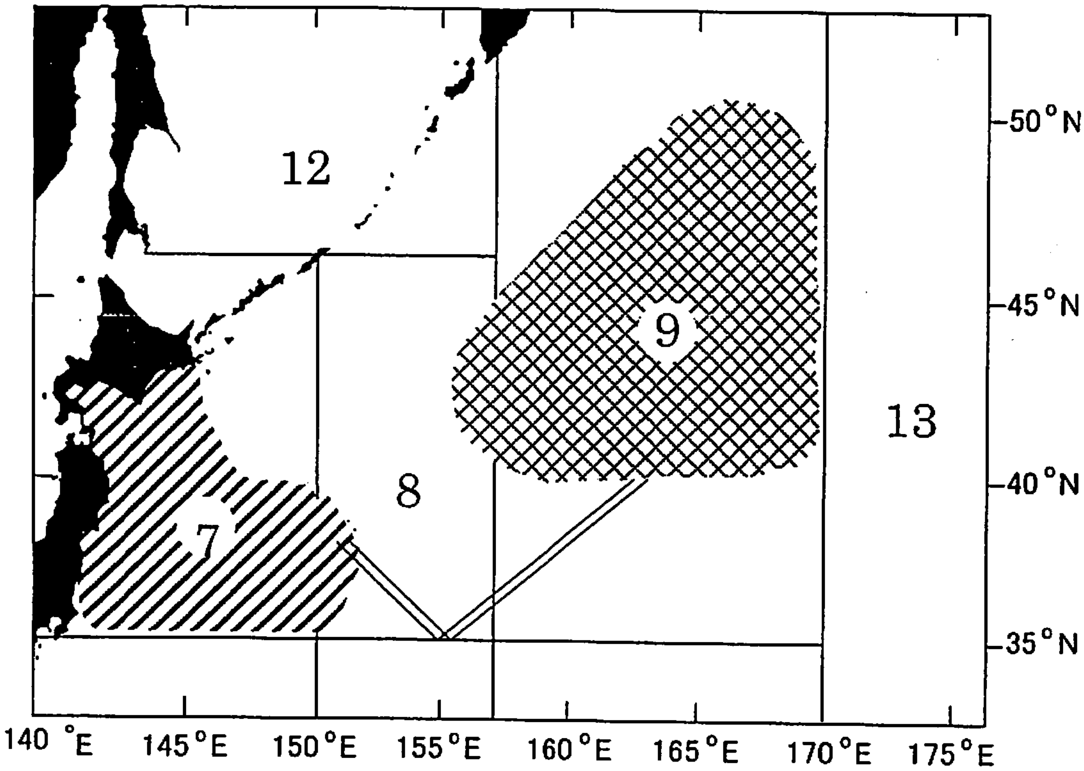


Fig. 1. Map showing the IWC sub-areas and the general research area of the 2000 feasibility JARPN II survey.

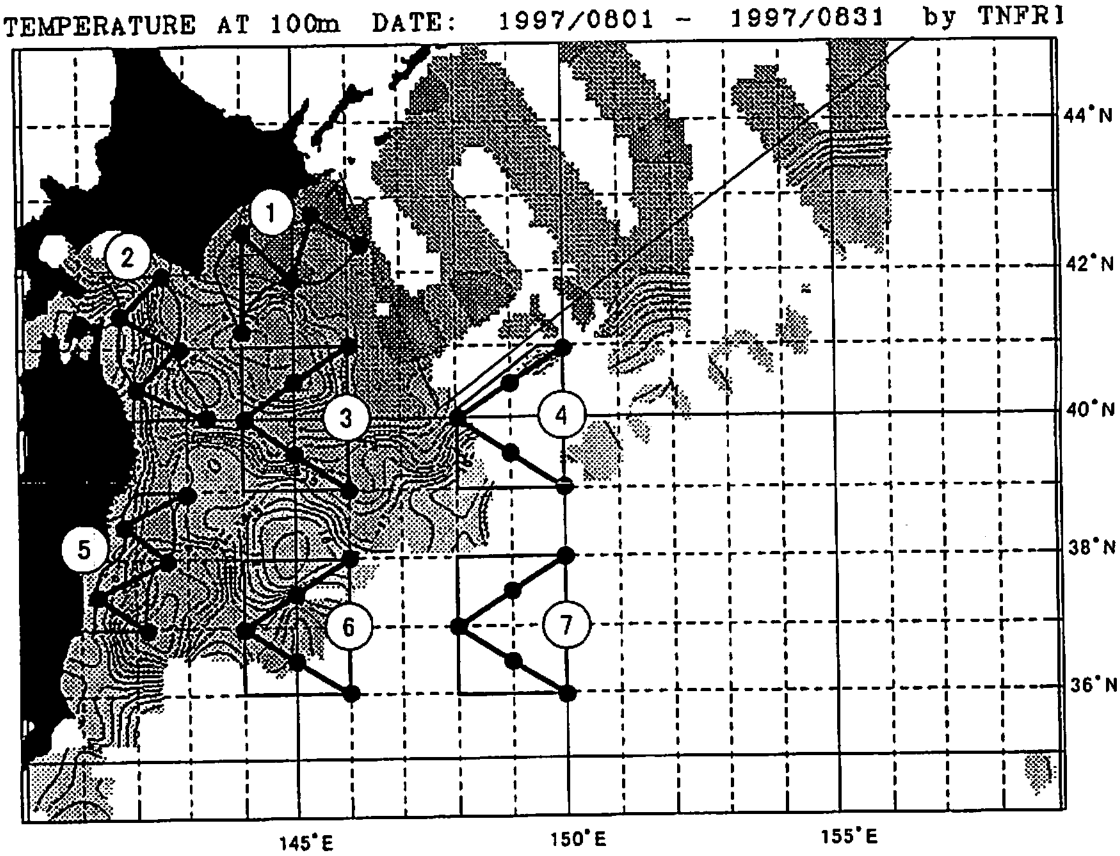


Fig. 2. Seven small blocks designed for the co-operative survey of JARPN II in year 2000.

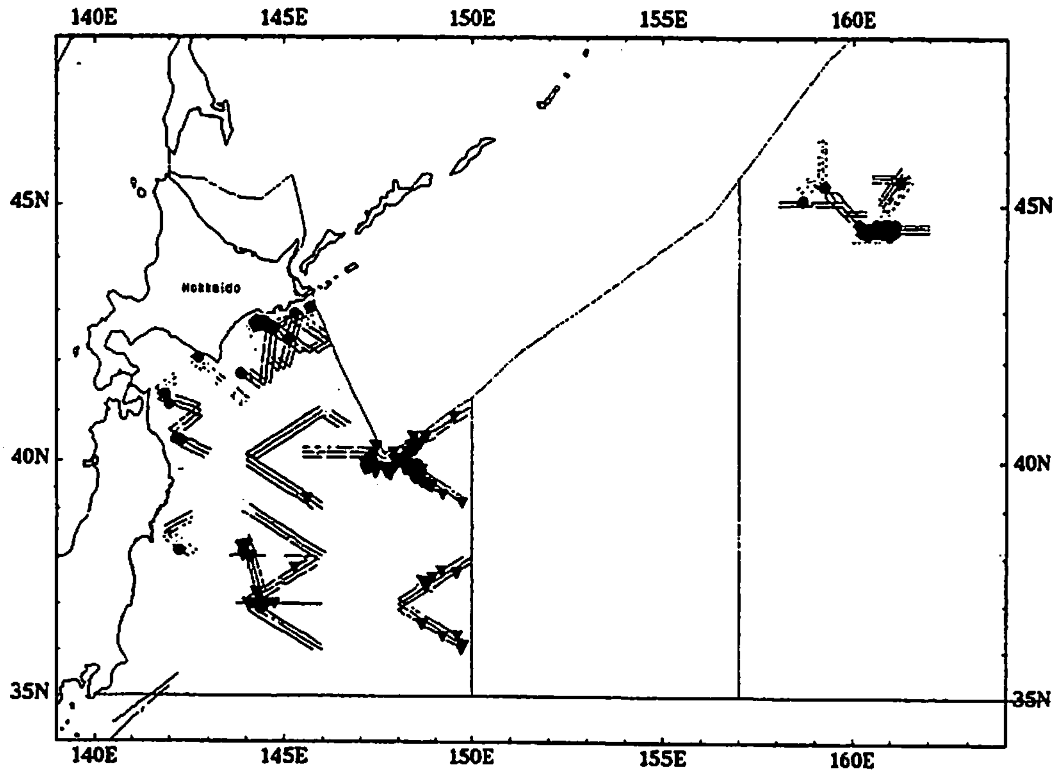


Fig. 3. Track – line covered by the 3 sighting/sampling vessels (SSV_S) during the 2000 JARPN II survey (-: NSC+ASP mode; ...: NSS mode) and position of the sightings of the common minke(●) and Bryde's (▼) whales.

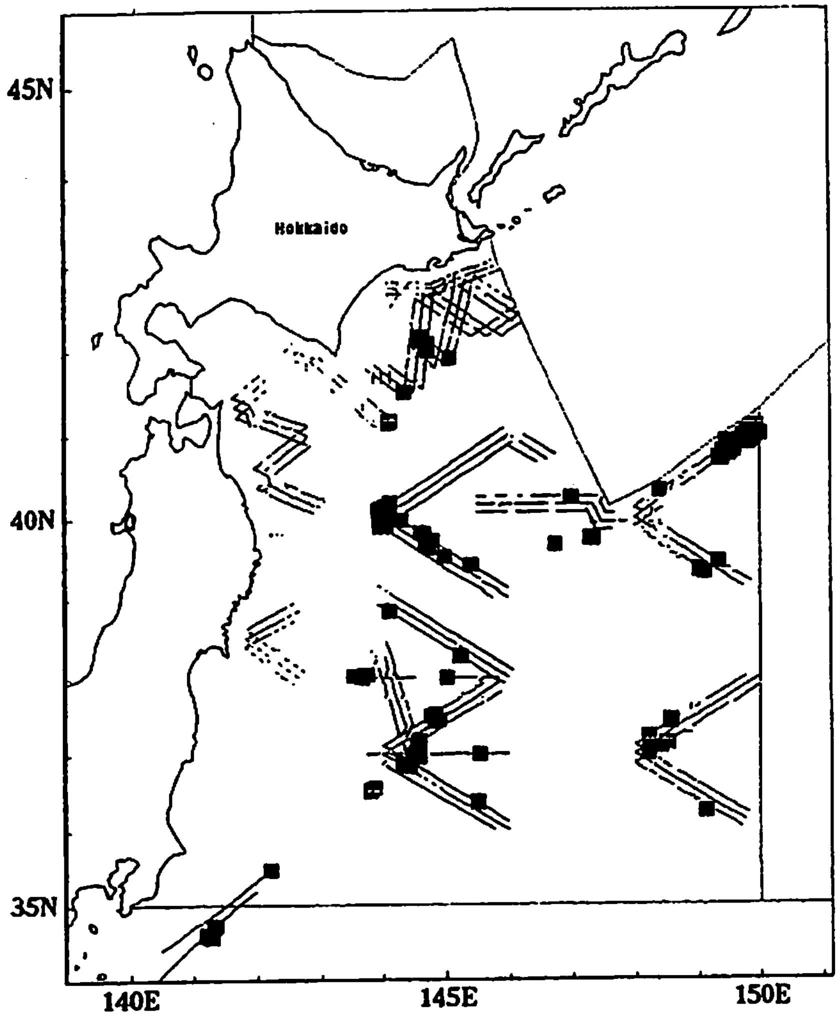


Fig. 4. Trackline covered by the 3 sighting/sampling vessels (SSVs) in sub-area 7 during the 2000 JARPN Ⅱ survey and position of the sightings of the sperm whale (-: NSC+ASP mode; ...: NSS mode).

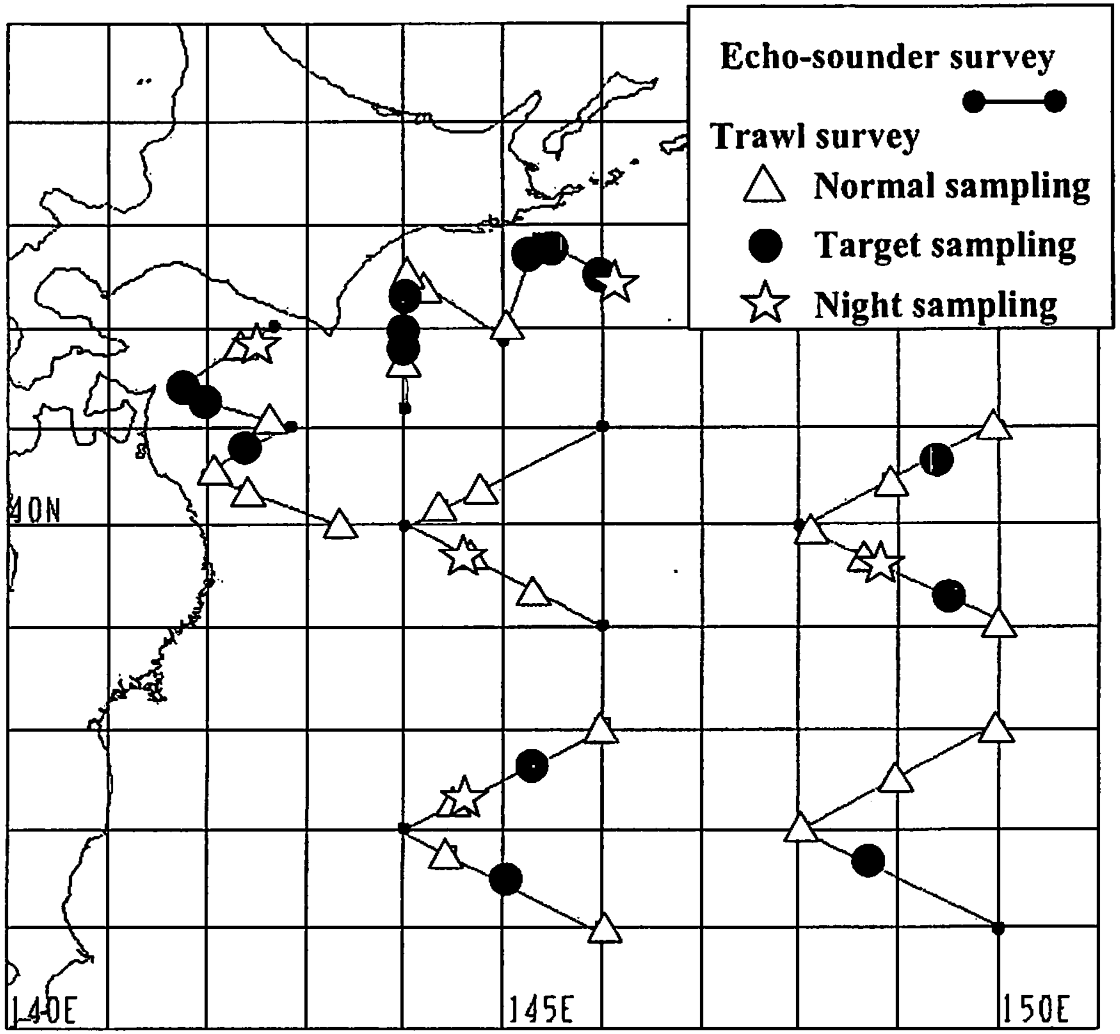


Fig. 5. Outline of the prey species survey in JARPN II 2000.

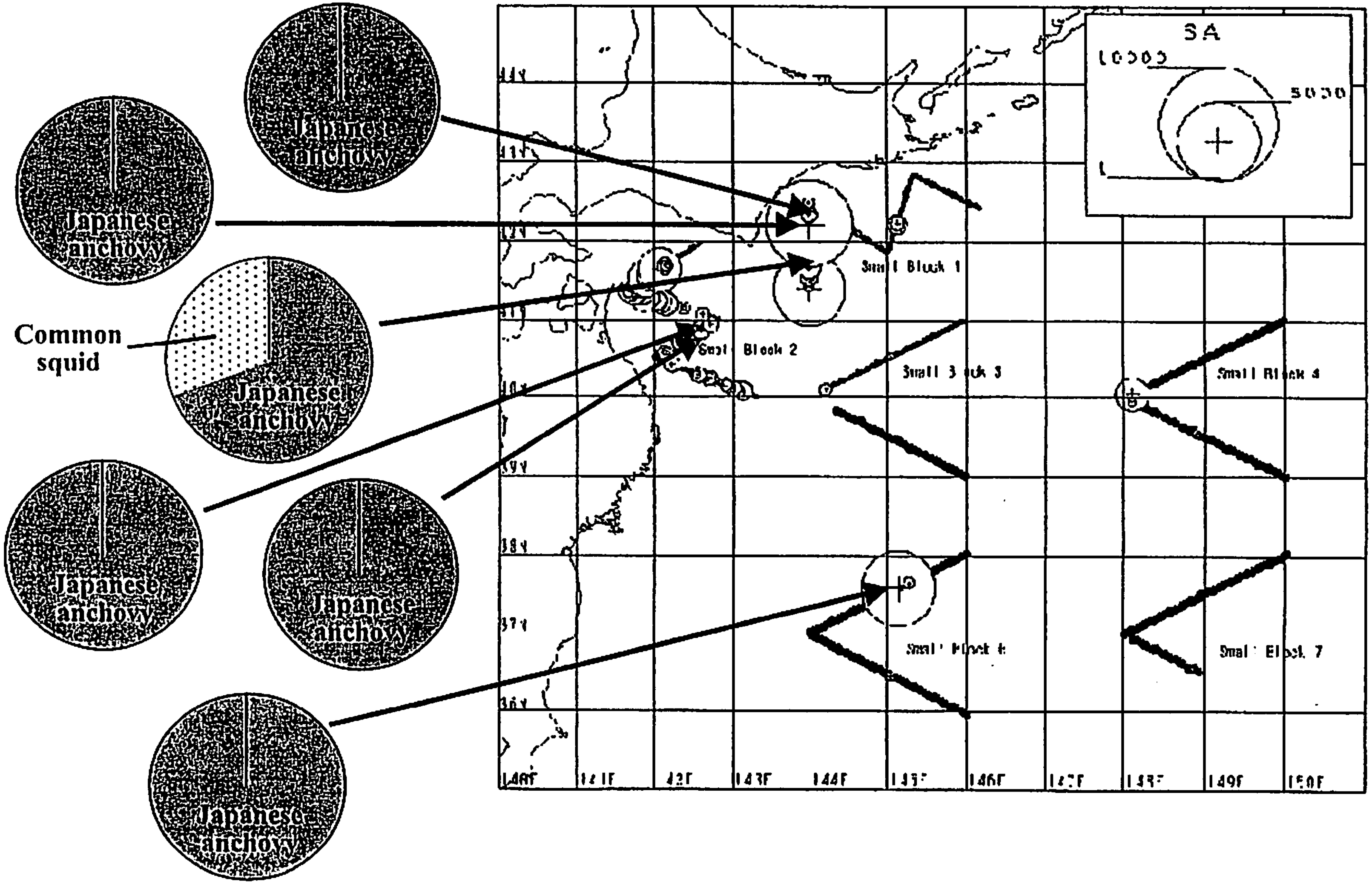


Fig. 6. Distribution of Japanese anchovy as suggested by the results of echo-sounder and trawl survey in JARPN II 2000.

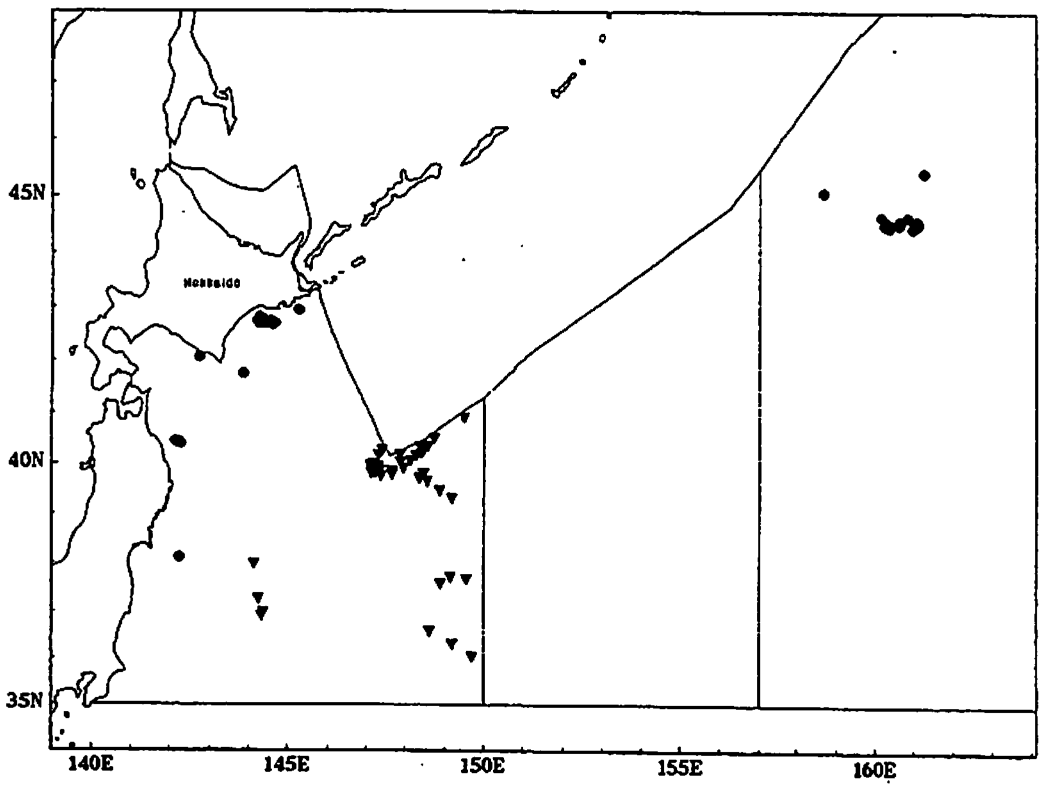


Fig. 7: Geographical position of common minke (●) and Bryde's (▼) whales sampled in the 2000 JARPN II survey, based on the sighting position.

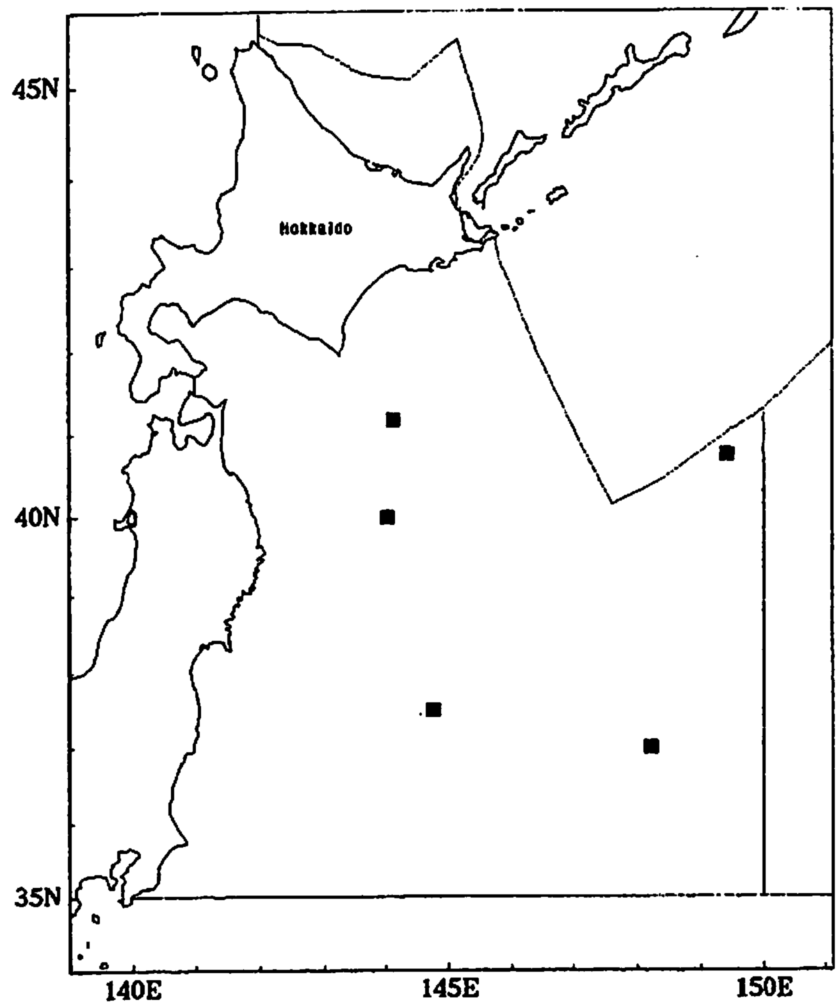


Fig. 8. Geographical position of the sperm whale sampled in the 2000 JARPN II survey, based on the sighting position.

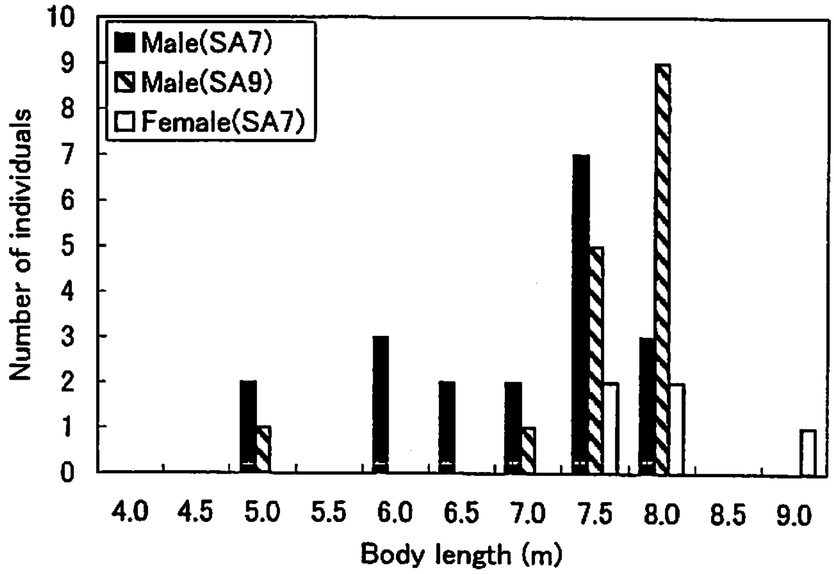


Fig. 9. Body length frequency of the samples of common minke whales taken in the 2000 JARPN II survey, by sex and sub-area.

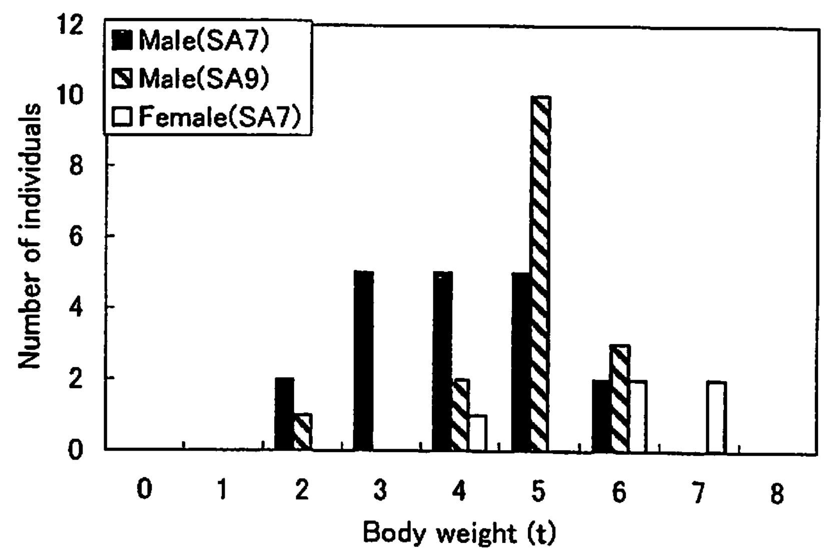


Fig. 10. Body weight frequency of the samples of common minke whales taken in the 2000 JARPN II survey, and sub-area.

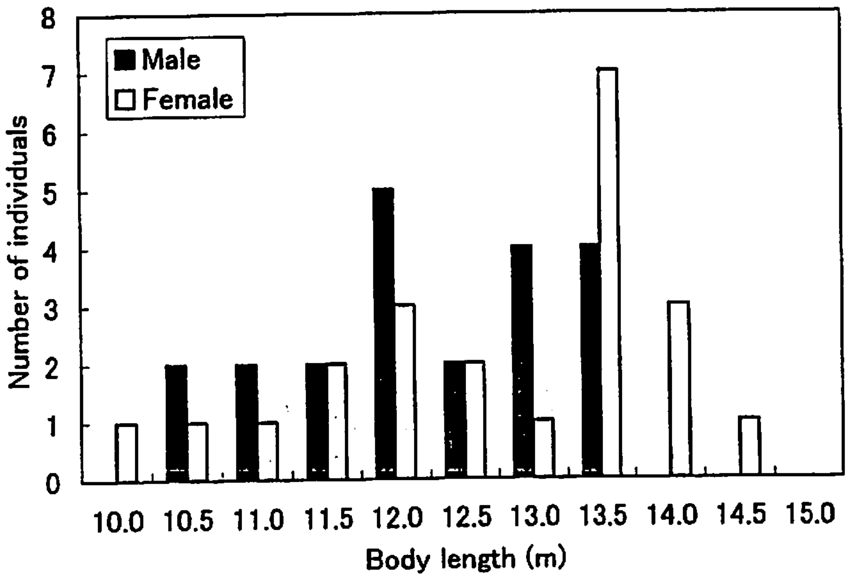


Fig. 11. Body length frequency of the samples of Bryde's whales taken in the 2000 JARPN II survey, by sex.

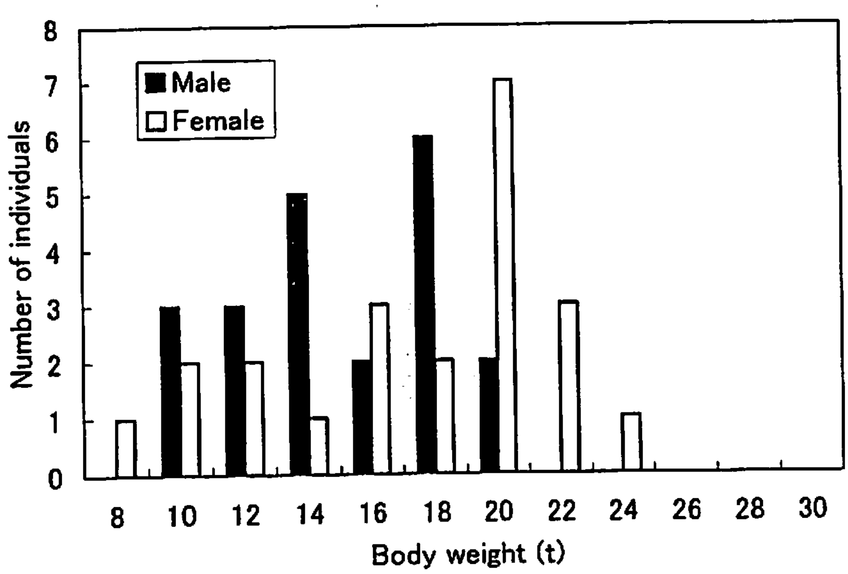
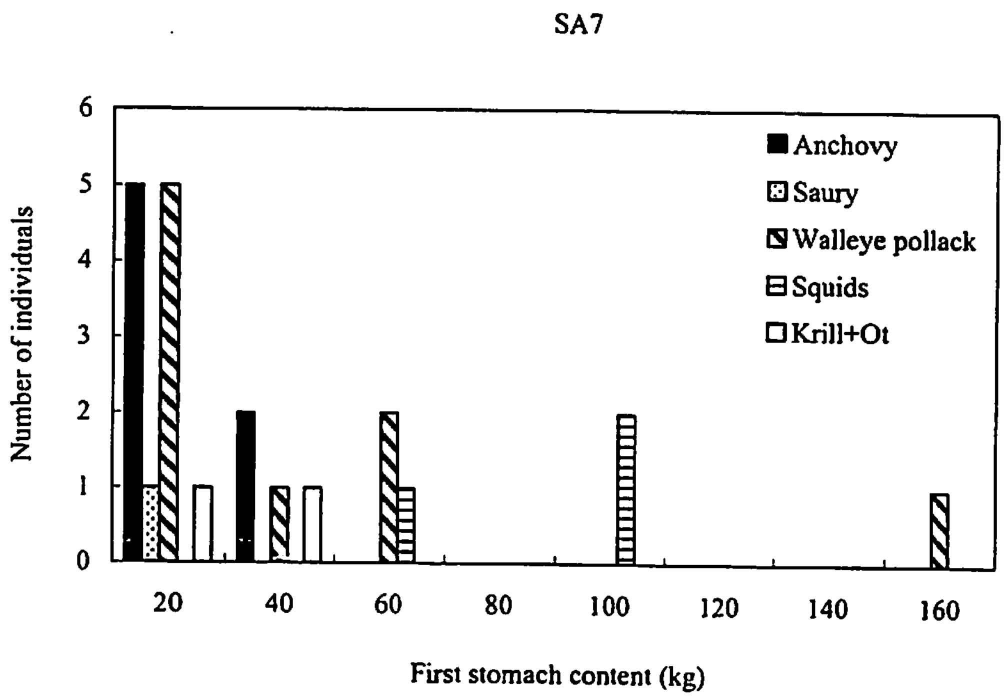


Fig. 12. Body weight frequency of the samples of Bryde's whales taken in the 2000 JARPN II survey, by sex.



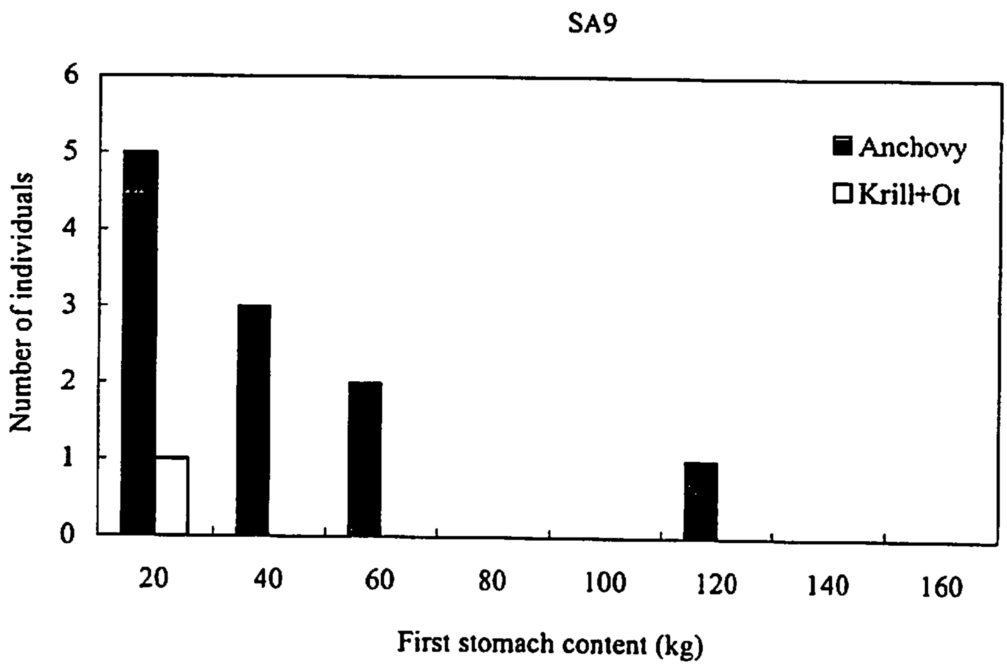
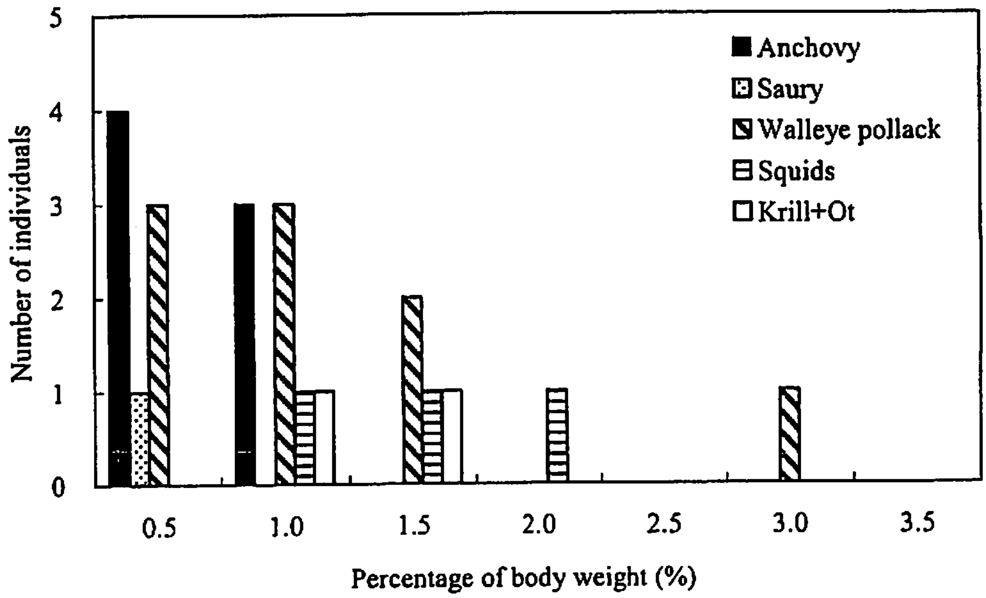


Fig. 13. Distribution of the stomach content weight (first stomach) in the samples of common minke whale taken during the 2000 JARPN II survey, by prey species (upper figure: sub-area 7; lower figure: sub-area 9).

SA7



SA9

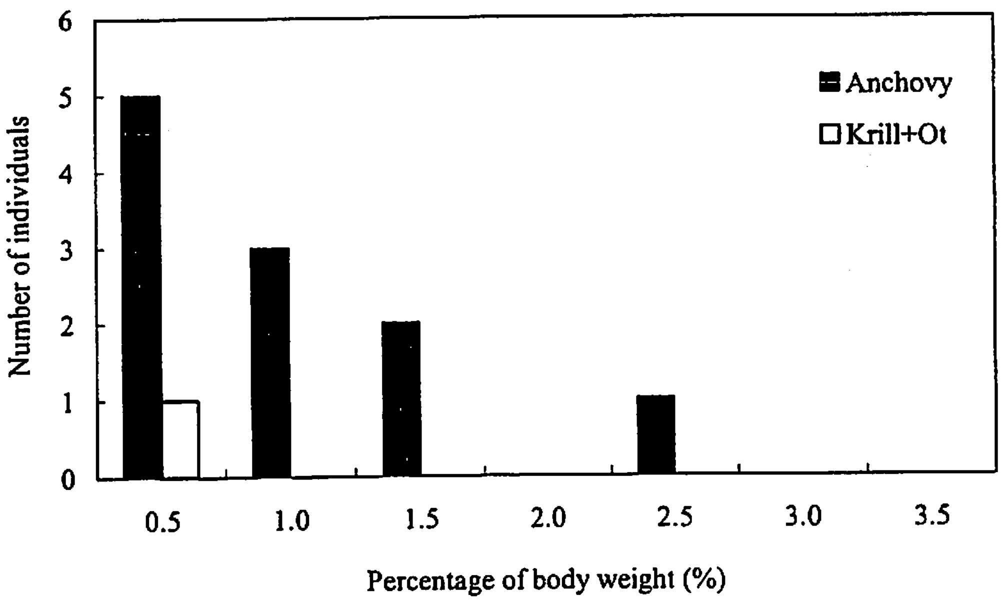


Fig. 14. Distribution of the feeding rate (weight of first stomach content/body weight × 100) in the samples of common minke whales taken during the 2000 JARPN II survey, by prey species (upper figure: sub-area 7; lower figure: sub-area 9).

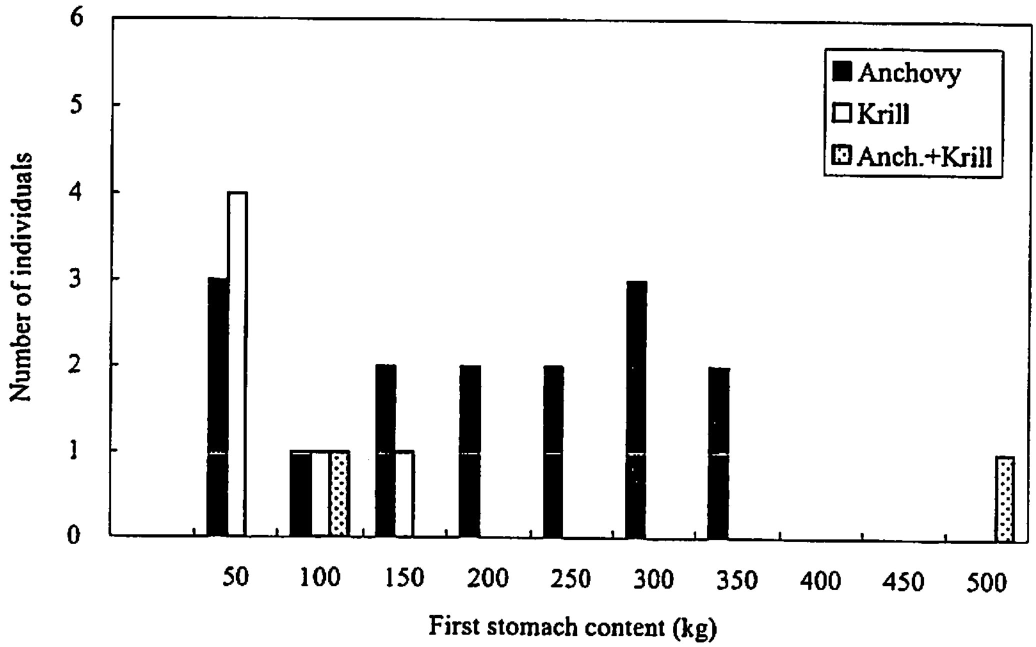


Fig. 15. Distribution of the stomach content weight (first stomach) in the samples of Bryde's whale

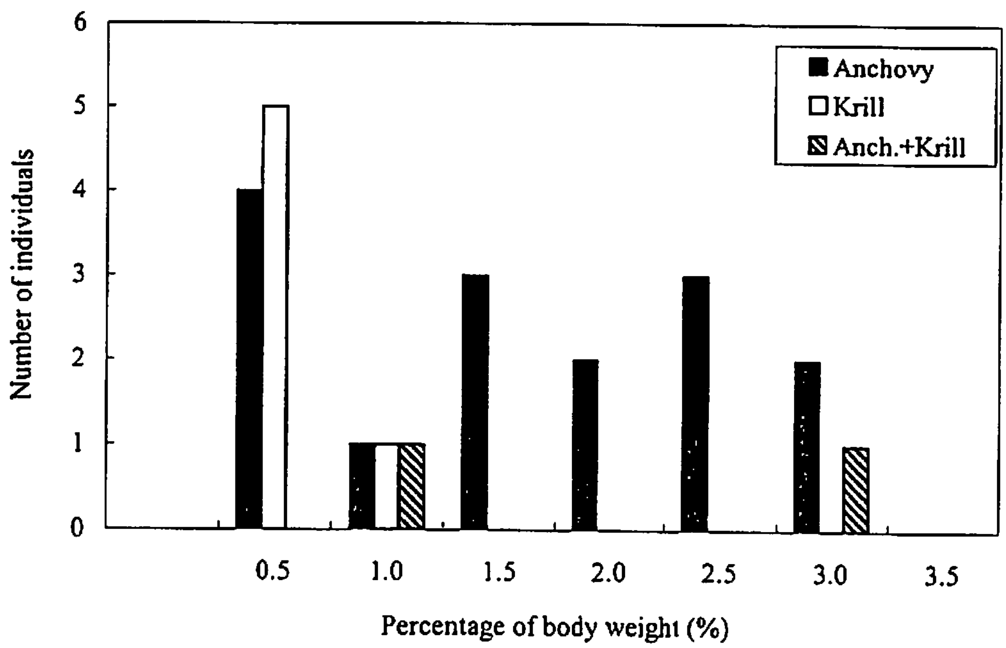


Fig. 16. Distribution of the feeding rate (weight of first stomach content / body weight × 100) in the samples of Bryde's whales taken during the 2000 JARPN II survey, by prey species.

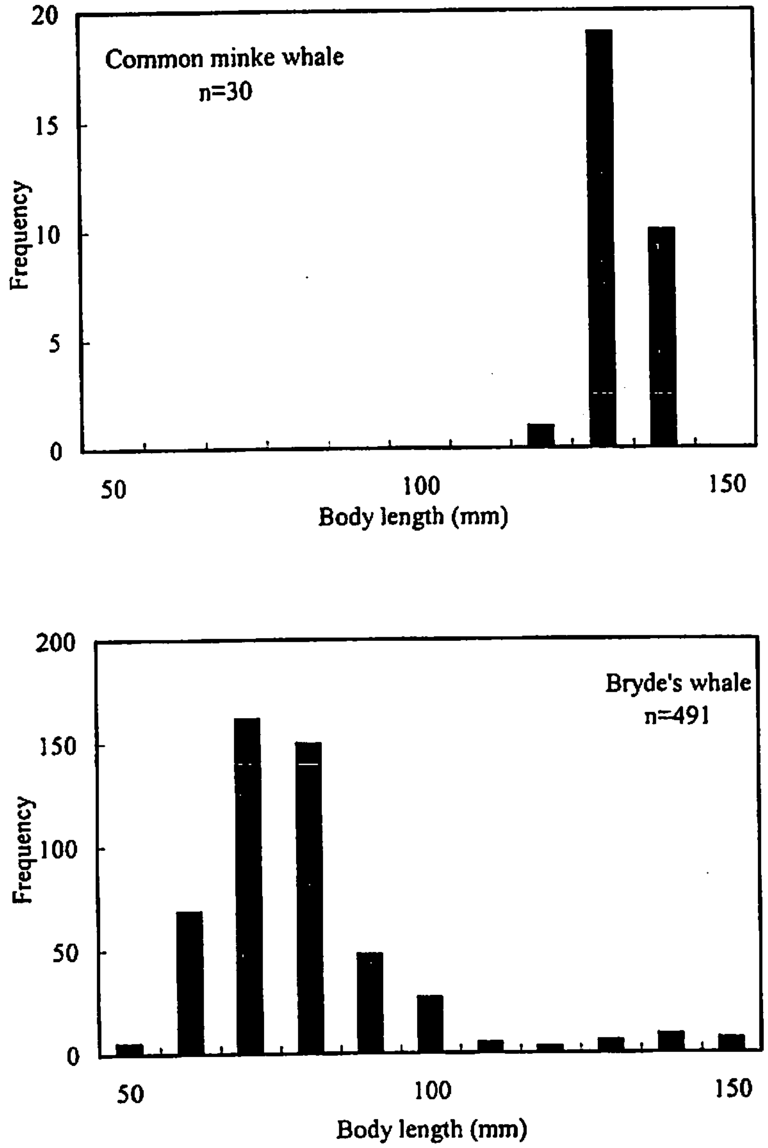


Fig. 17. Body length distribution of the Japanese anchovy found in the stomach content of common minke (upper figure) and Bryde's (lower figure) whales.

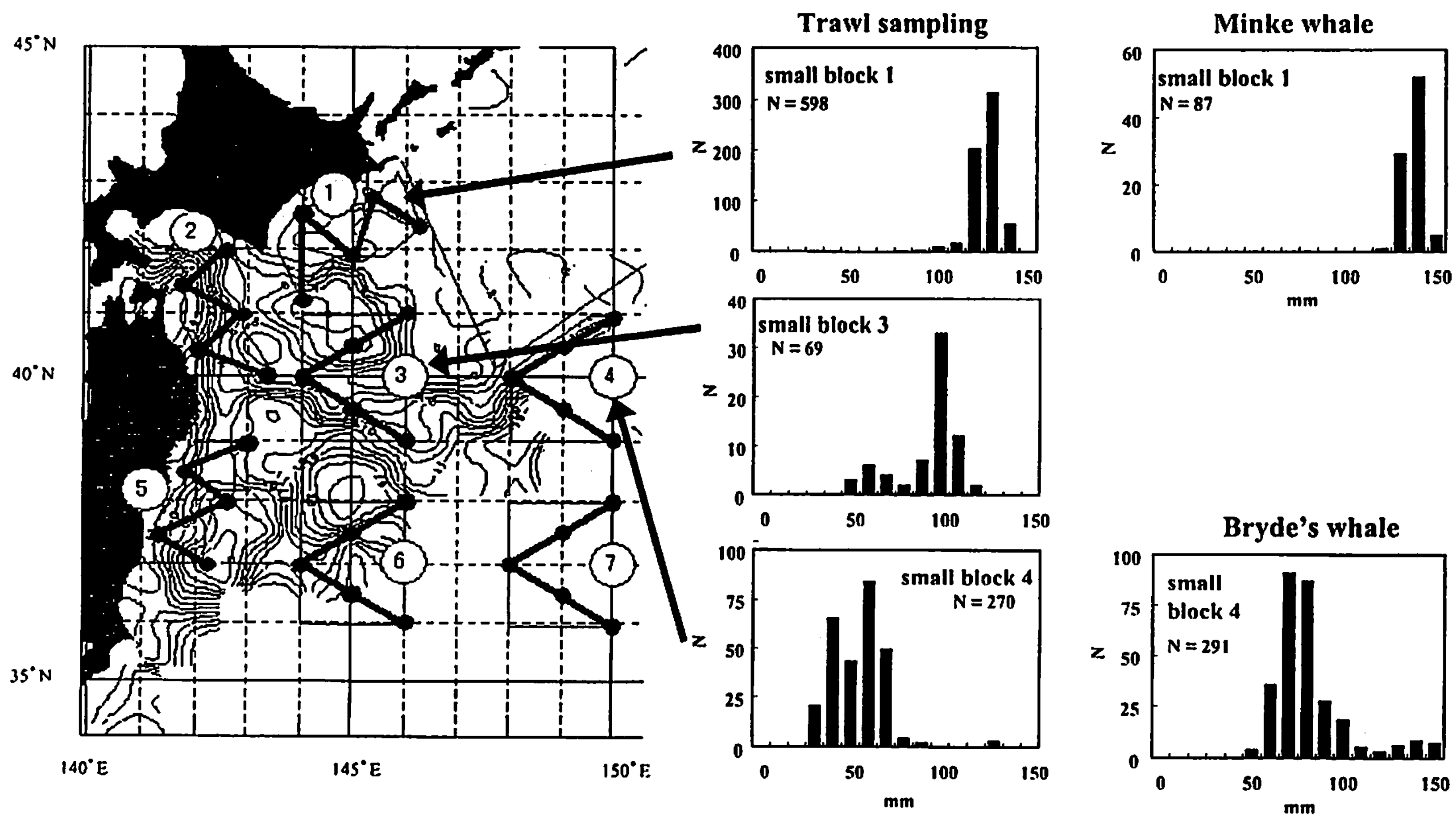


Fig. 18. Comparison of length frequencies of Japanese anchovies collected by trawling and from stomach contents of common minke and Bryde's whales in each small block.

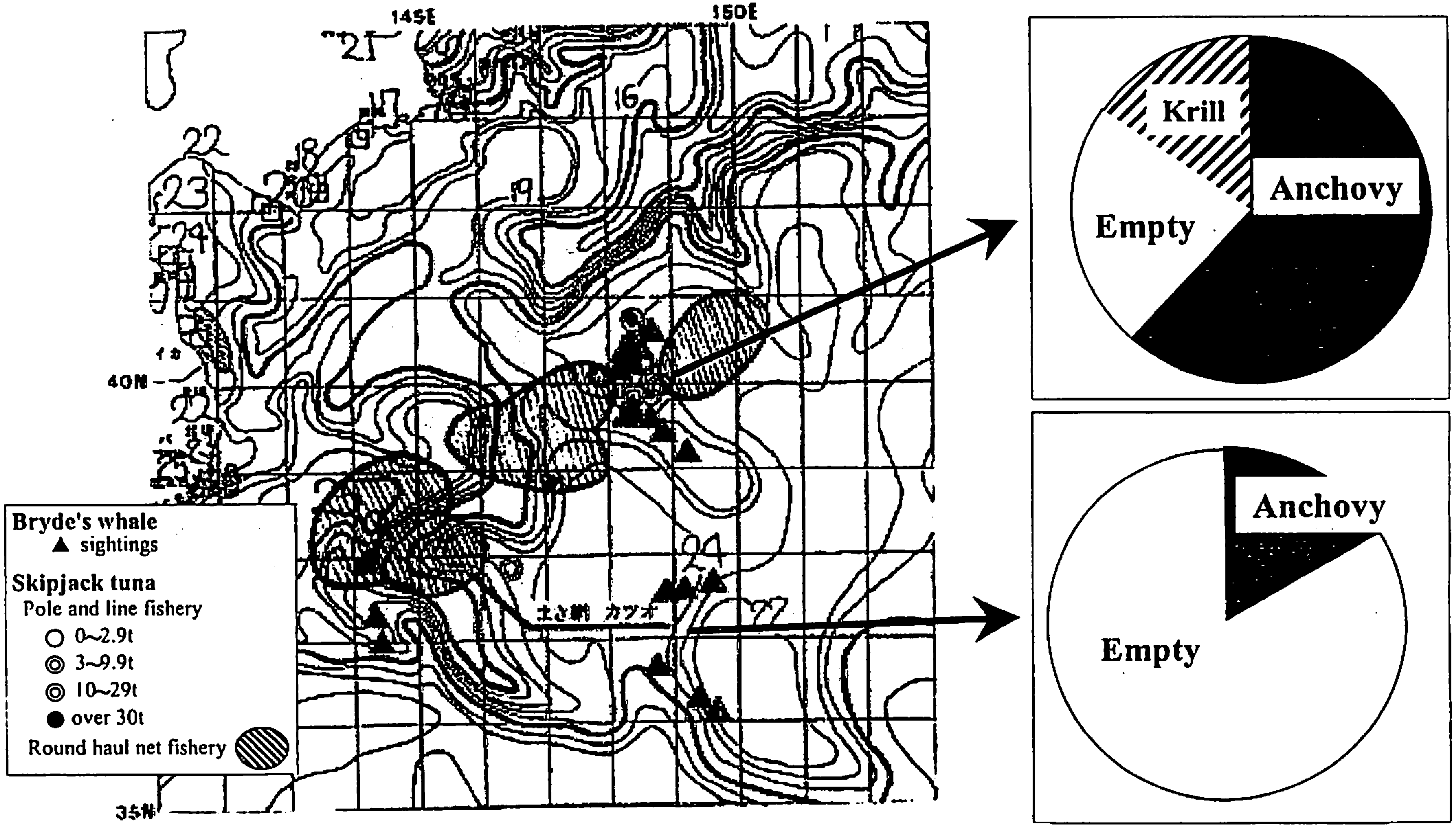


Fig. 19. Distribution of Bryde's whales and fishing grounds of skipjack tuna and the stomach contents of Bryde's whales.

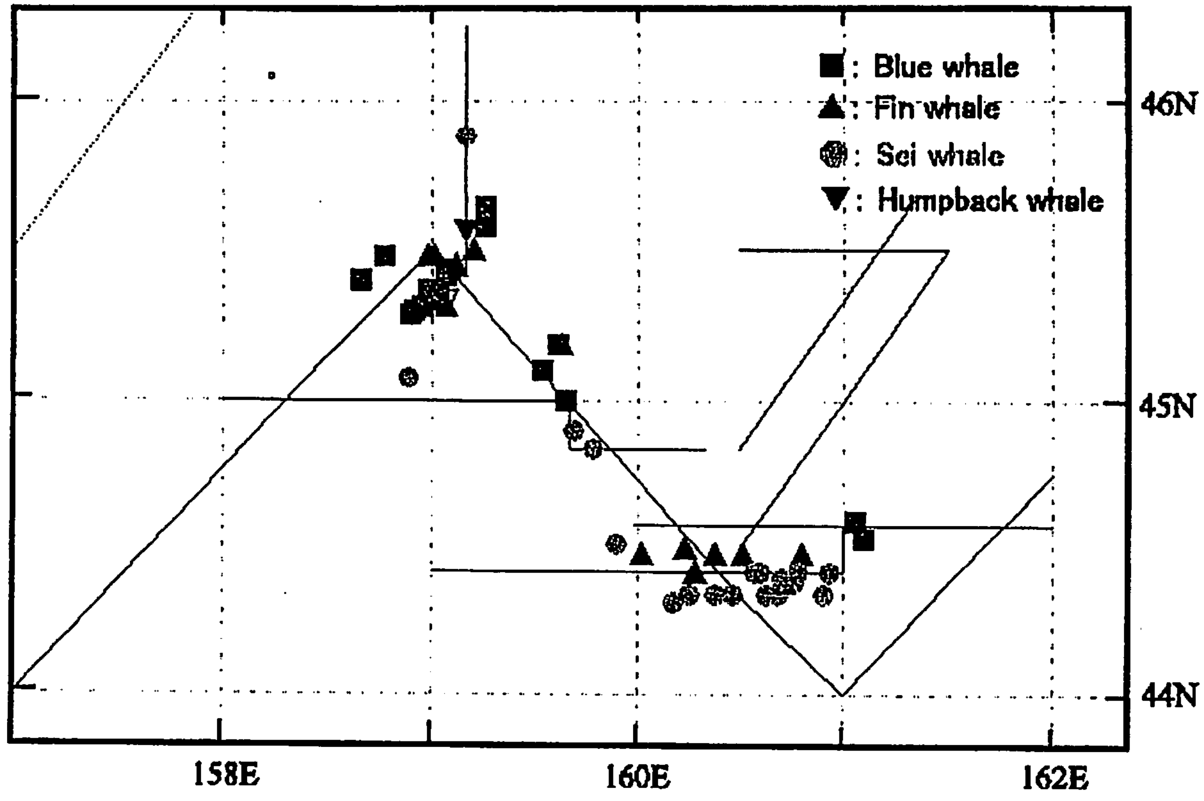


Fig. 20. Sighting position of large baleen whales in sub-area 9.

Appendix I

A brief summary of the surveys conducted by the *Yushin Maru*, *Kyoshin Maru No. 2* and *Torishima*

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Apart from the main JARPN II survey, which includes sampling of common minke, Bryde's and sperm whales, other three sighting surveys (related to this research program) were conducted previous (two surveys) and after (one survey) the main JARPN II survey in 2000.

This appendix presents an outline of these surveys. More details, including results of data analysis, will be presented in future.

A. Whale sighting survey by *Yushin Maru*

1. Research vessel: *Yushin Maru*.

2. Research period: From 6 June to 5 July.

3. Researchers: K. Matsuoka, K. Kiwada.

4. Survey area: Sub-area 7.

5. Objectives:

    5.1 Study of whale distribution.
    5.2 Experiment on satellite telemetry.
    5.3 Experiment on biopsy sampling.
    5.4 Experiment on photo-identification.

6. Results:

    6.1. Searching distances: 1,280.5 n. miles including of 184.3 n.miles covered during transit to and from the research area.

    6.2. Sightings of whales: Table 1 shows the list number of sightings, by species.

    6.3 Experiments:

        6.3.1 Biopsy skin sampling: One biopsy sample taken from a Bryde's whale.

        6.3.2 Natural marks: Photographs were taken on two schools of humpback whale involving three individuals whale.

        6.3.3 Satellite telemetry: Trials were conducted for a period of 17h35m on the following species: Common minke whale (13 sch/13 ind); Bryde's whale (4/5); fin whale (1/1); humpback whale (2/3) and sperm whale (2/2). Unfortunately there was no attachment in these trials

        6.3.4 Oceanographic observations: A total of 22 CTD was covered. A total of 30 days was used for the EPCS survey.

B. Whale sighting survey by *Kyoshin Maru No.2*

1. Research vessel : *Kyoshin Maru* No.2

2. Research period: From 12 to 30 July 2000

3. Researchers: H. Murase, K. Kiwada

4. Survey area: Sub-area 7

5. Objectives:

   5.1 Study on whale distribution
   5.2 Experiment on satellite telemetry
   5.3 Experiment on biopsy sampling
   5.4 Experiment on photo-identification

6. Results:

   6.1. Searching distances: A total of 804.0 n. miles of searching distances was covered.

   6.2. Sightings of whales: Table 2 shows the number of sightings, by species.

   6.3 Experiments

      6.3.1 Biopsy skin sampling: Five biopsy samples were obtained from Bryde's whales and three from sperm whales.

      6.3.2 Natural marks: No recorded

      6.3.3 Satellite telemetry: No recorded

      6.3.4 Oceanographic observations: A total of 16 CTD and 1 XCTD stations was covered. The EPCS survey was conducted for 19 days.

      6.3.5 Echo sounder survey:

C. Survey on feeding and breeding ecology of large cetaceans in winter by *Torishima*

1. Research vessel: *Torishima* (426GT, 1600HP)

2. Research period: From 10 November to 25 December 2000

3. Researcher: H. Yoshida

4. Survey area: Waters surrounding Ogasawara Islands, Japan (24°-30°N;140°-150°E)

5. Objectives:

   5.1 Observation on feeding and breeding ecology of large cetaceans
   5.2 Distribution of whales
   5.3 Experiment on satellite telemetry
   5.4 Experiment on biopsy sampling

6. Results

6.1 Searching distances: A total of 2,266.9 n. miles of searching distance (including 160.3 n. miles covered in transit to and from the research area) was covered.

6.2 Sighting of whales: Table 3 shows the number of sightings, by species.

6.3 Experiments

6.3.1 Observation on feeding and breeding ecology: Swimming behavior of 15 schools of sperm whales was observed for 16h55m and of a school of sei whale for 1h3m.

6.3.2 Satellite telemetry: 13 trials were conducted on the sperm whale (3sch/23 ind) including a period of 5h32m. There was no attachment.

6.3.3 Biopsy sampling: Biopsy trials were conducted for 8h54m on the following species: sperm whale (5 sch/6 ind, 16 trials/ 2 samples), sei whale (1 sch/2 ind, 6 trials/ no sample).

Table 1: Number of large cetacean sightings made by the *Yushin Maru*, by species (animals/schools).

Species	Primary sightings	Secondary sightings	Total
Common minke whale	19/18	9/9	28/27
Like common minke whale	2/2	0/0	2/2
Bryde's whale	13/10	2/2	15/12
Fin whale	1/1	0/0	1/1
Humpback whale	3/2	0/0	3/2
Sperm whale	151/36	9/5	160/41
Unidentified large cetacean	2/2	1/1	3/3

Table 2: Number of large cetacean sightings made by the *Kyoshin Maru No. 2*, by species (animals/schools).

Species	Primary sightings	Secondary sightings	Total
Common minke whale	3/3	0/0	3/3
Like common minke whale	0/0	1/1	1/1
Bryde's whale	18/15	7/6	25/21
Sperm whale	15/4	29/5	44/9
Unidentified large cetacean	0/0	4/4	4/4

Table 3: Number of large cetacean sightings made by the *Torishima*, by species (animals/schools).

Species	Primary sightings	Secondary sightings	Total
Sei whale	2/1	0/0	2/1
Sperm whale	33/10	17/5	50/15
Unidentified large whale	4/3	2/1	6/4

Appendix II

Oceanographic conditions in the Kuroshio-Oyashio Inter-frontal zone in August 2000

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INTRODUCTION

The Kuroshio, which is one of the strongest west-boundary current of subtropical gyre with warm high-salinity water, flows northward from the offshore area of the Philippine to the waters off Japan. The Oyashio flows southward 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. Distributions of water masses and fronts in August 2000, when the co-operative whale and prey surveys of JARPN II were conducted, will be described.

METHODS

Hydrographic observations with a conductivity-temperature-depth profiler (CTD; Neil Brown Mark ⅢB) and an expendable CTD (XCTD) were carried out in the Kuroshio-Oyashio Inter-frontal Zone using *R/V Shunyo-Maru* and *Kyoshin-Maru No. 2*, respectively. Salinity compensation for CTD data was done using water sampling data at three CTD stations.

The oceanographic conditions in August 2000 were analyzed by Tohoku National Fisheries Research Institute (TNFRI), who used quasi-real-time data from several cooperative organs and prefectures, that was Fisheries 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 when 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 spreading from Kuroshio Extension is defined 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

Fig.1 shows the Temperature-Salinity diagrams using CTD and XCTD station data. Water masses in the research area have characteristics of warm high-salinity water (the Kuroshio water in the right part of Fig.1), cold low-salinity water (the Oyashio water in the lower part of Fig. 1) and the mixed water of the Kuroshio water and Oyashio water. The observation points were distributed in these water masses characterized by the Kuroshio water to the Oyashio water.

Fig.2 shows the 200 m depth temperature map and the schematic hydrographic map in August 2000, presented by TNFRI. The Kuroshio Extension northern limit at the first crest was 36° N (upper panel in Fig.2), which is near the mean location although it fluctuated from 33.2° N to 40.0° N in resent 47 years. The Kuroshio warm-core ring off Sanriku was located at 38° 40'N and144° 20'E with 200 m temperature of 12-15℃ (upper panel in Fig.2). Another warm-core ring off Hokkaido was located at 42° 40'N and 148° 20'E with 200 m temperature of 4-5℃ (upper panel in Fig.2). The northern limit of the warm water spread from the Kuroshio Extension shifts northward from March to November. Its position in August 2000 was at 39° 40'N on 144° 20'E, north of 40° 40'N at 148° 30'E line, north of 40° 40'N on 150° 40'E line and north of 42° 20'N on 154° 20'E line (lower panel in Fig. 2). Tsugaru warm water spread eastward to 142° 50'E along 41° N line (lower panel in Fig. 2). The southern limit of the first Oyashio Intrusion was located at 39° 50'N and 143° 40'E (lower panel in Fig. 2) which was approximately mean location of its fluctuation from 35.4° N to 42.5° N in resent 37 years. The southern limit of the second Oyashio Intrusion was 38° 30'N and 146° 30'E which was also approximately mean location.

White and black circles on the lower panel in Fig. 2 denote XCTD and CTD stations observed from *R/V Shunyo-Maru* and *Kyoshin-Maru No. 2*, respectively. Stations in the cold area southeast of Hokkaido were distributed in the Oyashio area. Stations along 40° N were in the Oyashio front. Stations near the Tsugaru Strait in the western part of this figure were distributed around the front of the Tsugaru warm water and the Oyashio water. Other stations in the southern area were distributed from the Kuroshio Extension to the warm water spread from the Kuroshio Extension.

Fig.3 shows the vertical temperature sections along 144-146° E and 148-150° E. Southern part of the 144-146° E section (upper panel in Fig. 3) was the Kuroshio area that was indicated by a typical slope of thermocline. Southern part of the 148-150° E section (lower panel in Fig. 3) shows the meander of the Kuroshio Extension, that was westward flow around 37° -37° 30'N and eastward flow around 36° 30'N and 38° -38° 30'N in this section. The Kuroshio warm-core ring was indicated by the deeper thermocline structure like a bowl shape in the 37-38° N along the 144-146° E section. Another bowl shape thermocline structure was also shown around 40° 30'N in the 148-150° E section (lower panel in Fig. 3) but this structure was caused by meandering of warm water spreading from the Kuroshio Extension. In the northern area of 40° N along the 144-146° E section (upper panel in Fig. 3) and of 41° N in the 148-150° E section (lower panel in Fig. 3), there was the Oyashio water shown by the cold water less than 5℃ and shallow thermocline.

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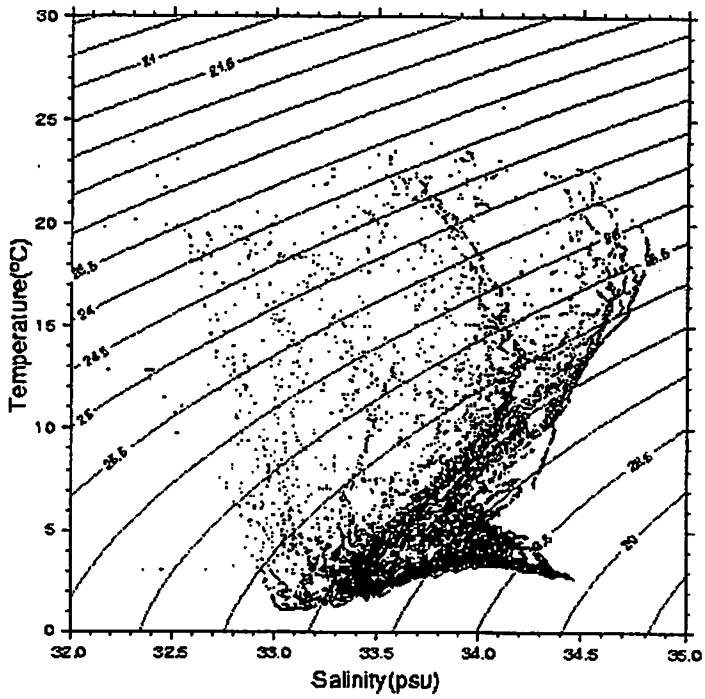

Fig. 1. Temperature-Salinity diagrams using CTD and XCTD station data in August 2000 from *R/V Shunyo-Maru* and *Kyoshin-Maru No. 2*, respectively. Each thin line in this figure denotes a density line of sigma-t.

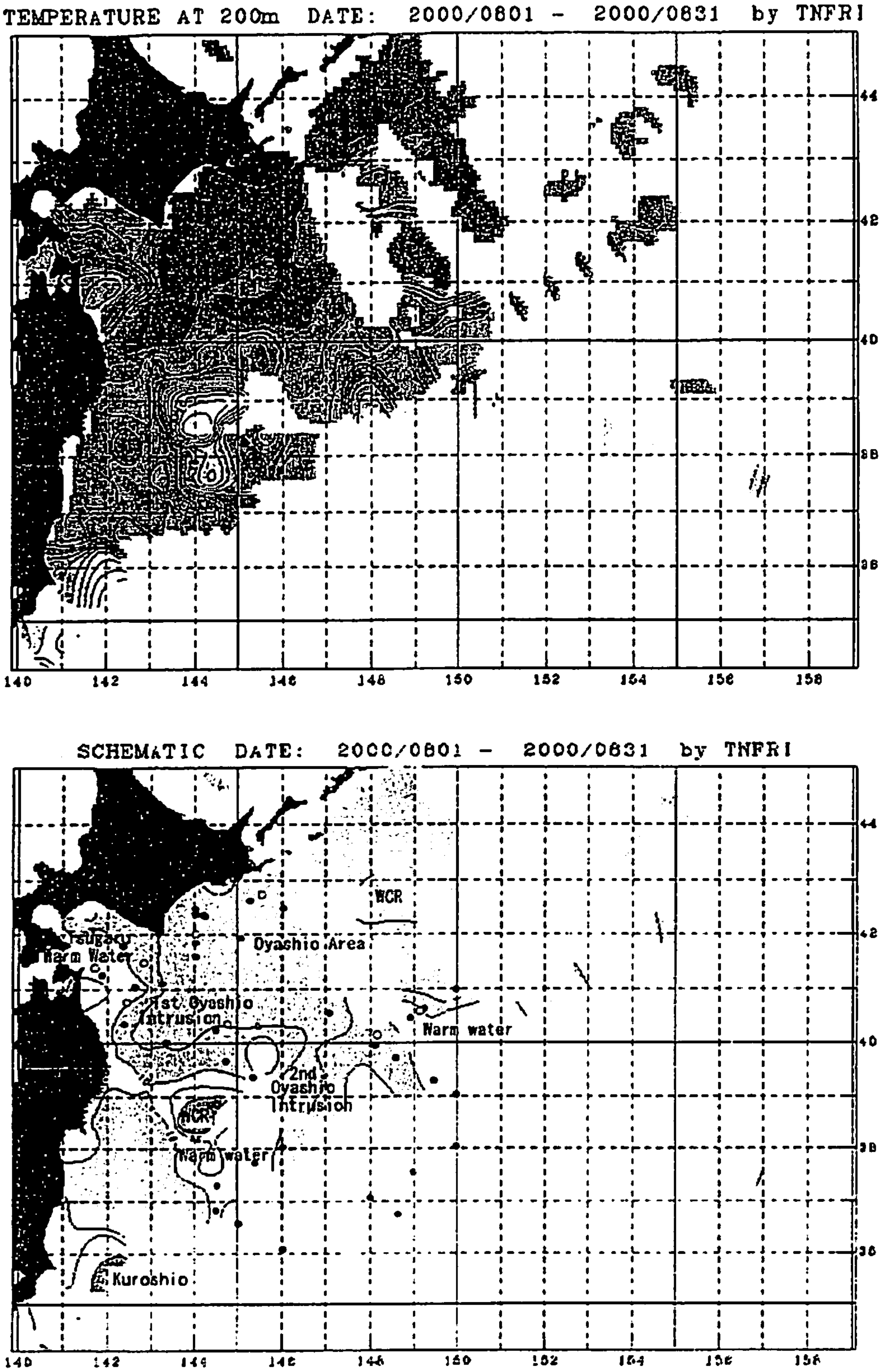

Fig. 2. 200 m temperature map (upper panel) and schematic hydrographic map (lower panel) in Tohoku area, northwestern Pacific, in August 2000. (Presented by Tohoku national research institute.) Block and white circles in the lower panel show CTD and XCTD stations, which were observed from *R/V Shunyo-Maru* and *Kyoshin-Maru No. 2*, respectively. In the lower panel, blue area shows the Oyashio, yellow area denotes the warm water spread from the Kuroshio Extension, the red area in south of 36° N is the Kuroshio Extension and the red area around 38° 30'N, 144° E is the Kuroshio warm-core ring.

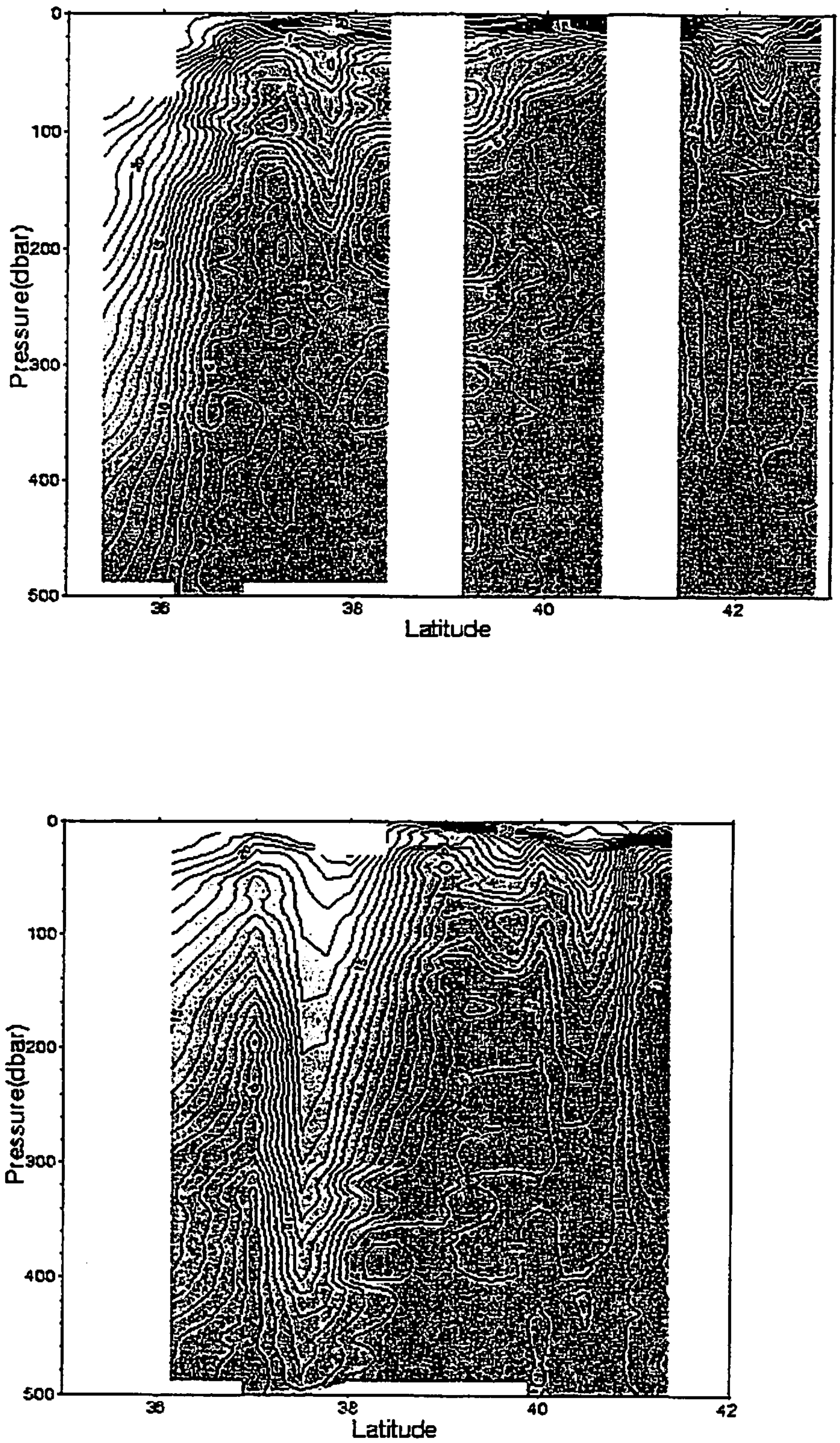

Fig. 3. Temperature sections along 144-146 ° E (upper panel) and 148-150 ° E (lower panel), observed in August 2000 from *R/V Shunyo-Maru* and *Kyoshin-Maru No. 2*.

Appendix III

Preliminary results and suggestions on the prey survey component of JARPN II in 2000

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ABSTRACT

The cooperative whale and prey surveys were conducted in August 2000 in Sub-area 7 east of Honsyu, Japan. Seven small blocks with a zigzag track line were set. Three vessels were engaged in the whale survey; sighting and sampling surveys. The forestomach and main stomach contents of sampled common minke, Bryde's and sperm whales were examined on the research base ship. Two vessels were engaged in the prey survey using midwater trawl and quantitative echo sounder. The acoustic survey using a quantitative echo sounder (Simrad EK500 at 38, 120 and 200 kHz) was carried out with the targeting trawlings to identify the species of the marks on the echo sounder. Also trawlings were made at predetermined stations independently from the acoustic survey. Two plankton nets were used to collect zooplanktons. Oceanographic observations were made with CTD down to 500m or XCTD. Also the cetacean sighting survey was conducted from one of the prey survey vessels. A total of 1,284 nautical miles acoustic data were acquired. Japanese anchovy and krills were abundant with the distribution patterns reflecting the oceanographic structure. Most of the nighttime trawl catches consisted of fishes dominated by Lanternfishes, followed by squids. Large-size Japanese anchovy (9-14cm) was dominant in the northern area while small-size (around 5 cm) were dominant in the southern area. Relatively few common minke whales were distributed in the northern area and fed exclusively on Japanese anchovy. Pacific saury was not found in the stomachs. Bryde's whales were concentrated to the southern area and fed on both krills and Japanese anchovy. Sperm whales were found commonly in almost all area and fed mainly on deep-sea squids. Based on the results in 2000, suggestions to the research methods are made.

INTRODUCTION

The Japanese Whale Research Program under Special Permit in the North Pacific (JARPN) was conducted between 1994-1999. The main objective was to clarify the stock structure of common minke whales in the western North Pacific. 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 concurrently with future whale surveys. 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. The overall goal 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 will be on feeding ecology, involving the studies on prey consumption by cetaceans, prey preference of cetaceans and ecosystem model. Prey preference of cetaceans is inevitable to most ecosystem models and estimated with the cooperative whale and prey surveys. As the cooperative whale and prey surveys are conducted for the first time in the western North Pacific, a two-year feasibility study is planned. The whale survey is conducted to collect diet of common minke, Bryde's and sperm whales, and the prey survey mainly for the former two cetaceans. In this document, the preliminary results of the prey survey in 2000 are presented, and suggestions to the research methods are made.

MATERIALS AND METHOD

Survey area and research vessels

The area for the cooperative whale and prey surveys was Sub-area 7 east of Honsyu, Japan (Fig. 1). Within the survey area, seven small blocks (ca. 50x100 or 100x100 square miles) were set mainly based on the information on the sea surface temperature just before the survey. In each small block, a zigzag track line was set systematically. The cooperative survey was conducted in August 2000 with two periods; first from 2 to 11 August 2000 and second from 22 to 31 August 2000. Three vessels; *Yushin-Maru* (YS1: 720GT), *Kyo-Maru No. 1* (K01: 812GT) and *Toshi-Maru No. 25* (T25: 739GT) were engaged in the whale survey; sighting and sampling surveys. Stomach contents of sampled common minke, Bryde's and sperm whales were examined on the research base ship, *Nisshin-Maru* (NM: 7,575GT). Two vessels; *Kyoshin-Maru No. 2* (KS2: 368GT) and *Shunyo-Maru* (SYO: 396GT) were engaged in the prey survey; KS2 for the acoustic survey as well as XCTD castings and plankton net samplings, and SYO for two types of mid-water trawlings and for CTD observations. During the daytime, KS2 steamed at 10-11 knots along the track line while conducting cetacean sightings. SYO followed KS2 at the distance of 1-2 nautical miles so that SYO could cast a mid-water trawl targeting to marks on the echogram on board KS2 to identify the species of the marks.

Acoustic data acquisition

A quantitative echo sounder (Simrad EK500 with software version 5.30) was used on board KS2 to acquire acoustic data with operating frequency at 38, 120 and 200 kHz. The transducers were hull-mounted at the depth of 4.3 m from the surface. Each transducer was covered with a 40 mm polycarbonate acoustic and the hydraulic oil filled the space between the transducer surfaces and the acoustic windows. Calibrations were carried out off the coast of Kushiro, Hokkaido just before the survey (27 July 2000) using the copper sphere technique described in EK 500 operation manual (Simrad, 1997). Data were stored with the aid of Simrad BI 500 post processing system.

Mid-water trawlings

Two types of trawlings were made; targeting and predetermined trawlings. The targeting trawlings were made to identify the species when dense marks were detected by the echo sounder during the acoustic survey. The net was towed at the depth of the marks for 30 minutes to 1 hour. Another type of trawlings was made at predetermined stations in each small block during the daytime. The predetermined trawlings were made to estimate prey abundance independently from the acoustic survey. Acoustic abundance estimation is difficult for some prey species, as the back scattering from cephalopods is low and Pacific saury mainly occurs in the surface layer. The predetermined trawls were towed for one hour; 20 minutes at each depth zone (0–30m, 30– 60m and 60–90m). Also nighttime trawlings were made at some of the daytime stations to sample meso-pelagic fishes and squids that showed diurnal migration. The nighttime trawlings were conducted about 1 hour after the sunset. For both types of trawlings, the same trawl net was used with the opening mouth of 30x30m and a liner (17.5mm mesh) attached to the cod end. Scammer Transducers were attached to near the mouth to monitor the net condition. Towing speed was 3-4 knots. Catches were sorted into species and weighed. For the major species 100 animals were sampled at random and the length was measured. Also frozen samples were taken for the studies at the laboratory.

Acoustic data analyses

Acoustic data were analyzed with the aid of SonarData Echoview (version 2.10.51) software at the laboratory. In principle, marks on the echo sounder were identified based on the trawl catches especially from targeting trawlings. For fishes, data collected at 38 kHz were used with the threshold set at -60dB and the depth range from 7m to 100m was analyzed. For Japanese anchovy that was the most common fish, shape and intensity of marks were also used for species identification (Fig. 2). The integration was made at an interval of one nautical mile by 10 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). As is shown in Fig. 3, echo marks were 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*), this ΔSv value was applied to. Species identification was based on ΔSv for preliminary analysis. The integration was made at an interval of one nautical mile by 50 m depth zone.

Plankton net samplings

Two plankton nets were used to collect zooplankton,; The Maruchi net (simple cylinder-cone plankton net, 0.334 mm mesh at the cod end) and the bongo net (0.335 mm mesh). Plankton net samplings were made at depths down to 100m in concordance with the trawlings. The Maruchi net was towed vertically at the speed of 40cm/s. The bongo net was towed at a depth where biological scatter was recorded on the echo sounder or obliquely from the depth to the surface. Samples were preserved in 10 % formalin for species identification at the laboratory. For each of krills and copepods 100 animals were sub-sampled at each station for length measurement.

Oceanographic observations

After trawlings, oceanographic observations were made with CTD (Neil Brown Mark ⅢB) down to 500m on board *Shunyo-Maru* or XCTD (Tsurumi Seiki Co. Ltd.) on board *Kyoshin-Maru No. 2*. Salinity compensation for CTD data and analysis of oceanographic conditions were made at the laboratory.

Cetacean sightings

KS2 conducted cetacean sightings as well as the three vessels for the whale survey. KS2 steamed on the track line in the passing mode so that acoustic data could be collected systematically. Only when the whale(s) seemed to be common minke or Bryde's whales, the vessel closed to those to confirm the species. In this document abundance and distribution of cetaceans were analyzed preliminarily with the data from KS2.

Stomach contents of cetaceans

The forestomach and main stomach contents of common minke, Bryde's and sperm whales sampled were examined. Samples were frozen or preserved in 10 % formalin. Stomach contents were sorted into species at the laboratory. If fresh prey was found in stomach contents, up to 100 individuals were sub-sampled and the length was measured. Preliminary results of examination of stomach contents were used in this appendix.

RESULTS AND DISCUSSION

A summary of the cooperative whale and prey surveys was shown on Table 1. Time difference between the whale and prey surveys was less than a week at most 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 was set at 13 hours. Generally, the survey started at 6:00 and end at 19:00.

Abundance and distribution of prey

Small block 5 could not be surveyed because of the time constraint. Total of 1,284 nautical miles acoustic data were acquired. Targeting trawlings were made 14 times. In targeting trawlings most catches were Japanese anchovy except three cases (two in small block 1 and one in small block 7) and other prey was rarely caught. Fig. 4 shows the magnitude of S_A (the mean backscattering area per square nautical miles; $m^2/n.\ mile^2$) of Japanese anchovy along the track lines with the tables for average S_A by depth zone in each small block. In small block 2 off the Tsugaru Strait, the values of S_A were constantly high with higher average S_A at depths above 40m. Sporadically higher values of S_A were found in small blocks 1, 3, 4 and 6, especially at depths above 20 m. Few Japanese anchovy was distributed in small area 7. Fig. 5 shows the magnitude of S_A of krills along the track lines with the tables for average S_A by depth zone in each small block. Among several species of krills found in the survey area, only *E. pacifica* is known to form large swarms. The values of S_A were constantly high in small block 1, 2 and 3, and sporadically higher in small blocks 4 and 6. Few krills were recorded in small block 7. Average S_A was high at depths around 200m in most small blocks.

Catches from predetermined trawlings

Predetermined trawlings were made 24 times in the daytime (Table 2). Japanese anchovy was dominant fish species. Yellowtail (*Seriola quinqueradiata*) and chub mackerel (*Scomber japonicus*) were caught in small block 1 while Japanese horse mackerel (*Trachurus japonicus*) and chub mackerel were caught in small block 2. Fishes other than Japanese anchovy was rarely caught in small blocks 3, 4, 6, and 7. Japanese common squid (*Todarodes pacificus*) was dominant among cephalopods in small blocks 1, 2 and 3. The catches of cephalopods other than Japanese common squid were small.

Nighttime trawlings were made 5 times, once at each small block, except small block 1 (Table 2). Most of the catches consisted of fishes dominated by Lanternfishes. Ten to thirty five percent consisted of cephalopods. Higher catches of lanternfishes and cephalopods were observed in small block 1 in the Oyashio area and lowest in small block 2 located around the continental shelf break. Species composition of lanternfishes and cephalopods in each small block was well reflecting oceanographic structure. In small block 1, half of the catch is accounted for by northern lampfish (*Stenobrachius leucopsarus*: sub-arctic species), followed by Bigfin lanternfish (*Symbolophorus californiensis*: transitional species). In small block 2, California headlightfish (*Diaphus theta*: sub-arctic species) consisted of half of the catch, followed by Brokenline lanternfish (*Lampanyctus jordani*: sub-arctic species), Northern lampfish and Japanese lanternfish (*Notoscopelus jaonicus*: transitional species). California headlightfish and Warming's lantern fish (*Ceratoscopelus warmingii*), both temperate species, dominated the catch in small block 3 while Warming's lantern fish was dominant in small block 4. Japanese common squid and boreal clubhook squid (*Onychoteuthis borealijaponica*) were dominant in the catches, both of them are distributed in transitional zone between Oyashio and Kuroshio Current. Enoploteuthids were dominant in small blocks 2, 3 and 4. Striped squid (*Eucleoteuthis luminosa*) were dominant in small blocks 3 and 6.

Length frequency of prey

Length frequency of Japanese anchovy in each small block was shown on Fig. 6. Large size classes (9-14cm) were dominant in small blocks 1, 2 and 3 while small size classes (around 5cm) were dominant in small block 4. Both groups were taken in small block 6 and no fish in small block 7. Small- to large-sized Japanese common squid were taken in small blocks 1, 2, and 3 with length range 10–29 cm, 3–20cm and 11–23cm, respectively (Fig. 7). Smaller size group less than 10cm was observed only in small block 2.

Plankton

Total of 44 and 42 hauls were made with Maruchi and Bongo nets, respectively (Table 3). Occurrence of krill and copepod species in each small block was shown on Tables 4 and 5, respectively. 17 species of krill and 21 species of copepods were recorded. Length frequency of isada krill in each small area was shown on Fig. 8. One mode was observed between 1-5 mm in almost all small blocks. Another less dominant mode could be detected at 10-12cm especially in the northern small blocks. As larger krills were found in the stomachs of whales and adhered to the trawl net, avoidance to those plankton nets might occur. Length frequency of copepods in each small block was shown on Fig. 9. Mode was 2 mm in each small block while some large animals (>5 mm) were observed in small blocks 1, 3 and 4.

Distribution of cetaceans

Sighting survey was conducted for a total of 1012 nautical miles by KS2 during the prey survey (Table 1). Summary of cetacean sightings conducted by KS2 during the prey survey was shown on Table 6. Primary sighting positions of common minke, Bryde's, like-Bryde's and sperm whales are shown in Fig. 10. Common minke whales were found less frequently and limited to the northern area; small blocks 1 and 2, as the result of the northern migration in this season. Bryde's whales (including like-Bryde's) were concentrated to the southern area; small blocks 4 and 7. Sperm whales were found commonly in all small blocks except small block 2.

Stomach contents of cetaceans

Preliminary results of examination of stomach contents of common minke, Bryde's and sperm whales sampled during the cooperative survey were shown in Table 7. Sighting positions and major stomach contents of sampled whales were shown in Fig. 11. Common minke whales fed exclusively on Japanese anchovy during the co-operative whale and prey survey period while walleye pollock and Japanese common squid were found in the stomachs of common minke whales caught off Hokkaido in September after the co-operative survey period. Bryde's whales fed on both krills and Japanese anchovy in and around small block 4, but most stomachs were empty in small block 7 where a few Japanese anchovy and krills occurred. Sperm whales mainly fed on squid, most of them were deep-sea species. Length frequency of Japanese anchovy in the stomachs of common minke and Bryde's whales was shown in Fig. 12. While common minke and Bryde's whales fed on large and small Japanese anchovy, respectively, this is mainly due to the size segregation of Japanese anchovy; that is, large animals in the northern area and small ones in the southern area.

Oceanographic conditions

Small block were located in the characteristic water masses and/or fronts (Fig. 13); Small block 1 in the cold low-salinity Oyashio area, small blocks 3 and 4 in the Oyashio front, small block 2 around the front of the Tsugaru warm water and the Oyashio water, and small blocks 6 and 7 in and north of the warm high-salinity Kuroshio Extension. More details of oceanographic conditions are described in Appendix III of this document.

Prey preference of cetaceans

The prey survey in August 2000 showed that Japanese anchovy and krills were abundant with the distribution patterns reflecting the oceanographic structure. On the other hand Pacific saury did not occur in the survey area, possibly due to the delay of migration. From the whale survey relatively few common minke whales were distributed in the northern area and fed exclusively on Japanese anchovy. Pacific saury was not found in the stomachs although it was most important prey for common minke whales in July and August in the JARPN (Tamura and Fujise, 2000). Bryde's whales were concentrated to the southern area and fed on both krills and Japanese anchovy. Thus the first cooperative whale and prey surveys showed that common minke and Bryde's whales feed on the most abundant prey in the upper layer. As the size of Japanese anchovy from stomachs and trawl catches was almost same, those two baleen whales fed on Japanese anchovy regardless of the size. Common minke and Bryde's whales did not feed on meso-pelagic fishes and squids, while they migrate into the upper layer at night and are important prey of many marine mammals (Ohizumi, 1998). This can be explained by that common minke and Bryde's whales usually do not feed at night. Prey preference is the key parameter in most ecosystem models. As diets of common minke whales varied spatially and temporally (Haug et. al., 1995; Tamura and Fujise, 2000), the cooperative whale and prey surveys should be continued at least for several years to estimate the prey preference of cetaceans quantitatively.

Suggestions to the research methods

In 2000, 24 common minke and 43 Bryde's whales were sampled in sub-area 7 while the planed sample sizes were 50 for respective species. Those samples were concentrated to particular areas; small block 1 for common minke whales (18), and in and outside small block 4 for Bryde's whales (33). So the number of samples was unsatisfactory in other small blocks. First of all, the number of small blocks should be decreased to, say 4-5. The location of small blocks could be decided directly on the distribution of whales estimated from the pre-sighting survey as well as the oceanographic conditions. Also some special survey boxes should be set within high whale density areas. In this survey the small blocks were set as ca. 50x100 or 100x100 square miles. After the two-year feasibility study, the size of small blocks will be discussed and, if necessary, will be adjusted.

The acoustic survey with targeting trawlings was generally successful. During the whale survey in sub-area 7 in September, walleye pollock and Japanese common squid were found in common minke whale stomachs, but the marks on the echo sounder were not identified directly by targeting trawlings as SYO left the survey area. Therefore the prey survey should be conducted as concurrently as possible with the whale survey. For identification of krills (also species and size), Maruchi and Bongo nets are not enough because of net avoidance. A smaller mid-water trawl net such as IKMT would be desirable. Predetermined trawlings should be continued for squids and Pacific saury, and even for Japanese anchovy. While the prey survey in the two-year feasibility study is designed for common minke and Bryde's whales, trawlings down to ca. 500m would be desirable to collect information on prey of sperm whales.

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Table 1. Summary of the prey survey.

Small Block	Prey survey period	Cetacean survey period	No. of trackline	Fixed distance (n.mile)	Distance covered by echo sounder (n.mile)	Cetacean survey searching distance (n.mile)	No. of taget trawl point	No. of daytime trawl station	No. of nighttime trawl station	No. of sampled minke whale (ind.)	No. of sampled Bryde's whale (ind.)	No. of sampled sperm whale (ind.)
1	5-7 Aug. & 31 Aug.*	7 Aug.	4	325.6	249.0	196.4	6	4	1	1	0	1
2	2-4 Aug.	3-5 Aug.	4	232.9	219.0	163.6	3	5	1	5	0	0
3	8 Aug. & 5 Sep.	5 Aug. & 5 Sep.	2	219.5	192.0	159.2	0	3	1	0	0	1
4	22-24 Aug.	22-26 Aug.	2	219.5	206.0	160.2	2	5	1	0	14	1
5	No survey was conducted because of time constrait.											
6	27-29 Aug.	31 Aug.	2	226.1	251.0	198.3	2	4	1	0	0	1
7	25-26 Aug.	27-29 Aug.	2	226.1	167.0	134.5	1	3	0	0	6	1
Total	17 days	14 days	16	1449.7	1284.0	1012.2	14	24	5	6	20	5

*Only first trancect was covered on 31 August, 2000.

Table 2. Summary of result of trawling during the prey survey.

Total catch weight (kg) in each sampling station excluding night sampling. +: > 0.1kg.

Bold line: Target sampling data.

<Day-time survey>

Stn no.	Date, 2000	Time (horizontal tow)	Locality	Sampling depth (m)	Japanese anchovy	Other fishes	Common squid	Other squids	Jelly fish	Total
Small block 2										
T1	2-Aug	0955-1110	40-00.4N, 143-21.4E	0-100	0	0.1	0	0	1.2	1.3
T2	2-Aug	1634-1755	40-20.8N, 142-24.2E	0-100	+	+	0.5	0	0.7	1.2
T3	3-Aug	0938-1052	40-32.9N, 142-05.8E	0-100	+	0	+	+	2.6	2.6
T4	3-Aug	1257-1327	40-44.9N, 142-24.3E	0-30	41.0	0	0.2	+	0.2	41.4
T5	3-Aug	1715-1829	41-03.0N, 142-37.9E	0-100	99.9	0.4	0.4	+	1.0	101.7
T6	4-Aug	0821-0856	41-14.7N, 141-58.4E	70-100	+	+	1.8	+	2.4	4.2
T7	4-Aug	1148-1218	41-22.5N, 141-43.2E	0-30	9.0	0.2	0	0	20.0	29.2
T8	4-Aug	1640-1754	41-49.5N, 142-23.4E	0-100	+	+	+	0	1.5	1.5
Small block 1										
T10	5-Aug	0935-1047	41-38.2N, 143-59.7E	0-100	5.2	0	0	0	+	5.2
T11	5-Aug	1259-1329	41-56.9N, 143-59.8E	0-30	64.6	0.2	29.0	0	0.4	94.2
T12	5-Aug	1617-1647	42-20.9N, 144-00.0E	0-30	367.0	+	+	0	0	367.0
T13	6-Aug	0812-0925	42-22.4N, 144-11.4E	0-100	105.4	1.8	0.5	0	0.9	108.6
T14	6-Aug	1506-1618	41-59.0N, 145-02.0E	0-100	+	3.4	0	0	1.2	4.6
T15	6-Aug	0833-0903	42-40.3N, 145-16.5E	30-60	0	0	0	0	0	+
T16	6-Aug	1123-1153	42-45.8N, 145-28.1E	0-30	+	0	0	+	+	+
T17	7-Aug	1502-1602	42-29.7N, 146-00.9E	0-30	0	*	0	0	0	*
Small block 3										
T19	8-Aug	1312-1342	40-22.9N, 144-46.4E	0-30	2.1	0	3.2	0	0.8	6.1
T20	8-Aug	1613-1725	40-11.3N, 144-22.0E	0-100	+	0.0	2.2	0	0.3	2.5
Small block 4										
T22	22-Aug	0742-0854	40-58.9N, 149-58.7E	0-100	+	+	0	+	+	+
T23	22-Aug	1300-1330	40-39.8N, 149-19.7E	0-30	+	+	0	+	1.2	1.2
T24	22-Aug	1635-1747	40-27.4N, 148-54.5E	0-100	+	+	0	+	+	+
T25	23-Aug	1302-1414	39-56.1N, 148-07.8E	0-100	+	+	0	+	+	+
T26	23-Aug	1755-1909	39-40.3N, 148-37.8E	0-100	0.1	+	0	+	1.2	1.3
T28	24-Aug	1242-1312	39-15.0N, 149-29.6E	30-60	+	+	0	+	+	+
T29	24-Aug	1708-1820	38-58.5N, 150-00.0E	0-100	+	+	0	+	+	+
Small block 7										
T30	25-Aug	0732-0852	37-58.8N, 149-58.7E	0-100	0	+	0	+	0.8	0.8
T31	25-Aug	1418-1530	37-29.3N, 148-58.3E	0-100	0	+	0	+	+	+
T32	26-Aug	0918-1030	36-59.9N, 148-01.8E	0-100	0	+	0	0	0.1	0.1
T33	26-Aug	1427-1457	36-39.5N, 148-41.8E	0-30	0	+	0	+	+	+
Small block 6										
T34	27-Aug	0738-0854	35-59.9N, 146-00.6E	0-100	0.0	+	0	+	+	+
T35	27-Aug	1613-1743	36-28.7N, 145-02.2E	0-30	5.2	+	0	0	+	5.2
T36	28-Aug	0935-1053	36-45.7N, 144-27.7E	0-100	0.0	+	0	0	+	+
T37	28-Aug	1634-1753	37-15.4N, 144-31.5E	0-100	+	+	0	0	0.4	0.4
T39	29-Aug	1023-1123	37-38.2N, 145-16.7E	0-30	43.8	+	0	0	0	43.8
T40	29-Aug	1601-1717	38-01.0N, 146-00.3E	0-100	0.3	+	0	0	0.3	0.6
Small block 3										
T41	30-Aug	1118-1230	39-19.8N, 145-18.2E	0-100	0.0	+	0	0	1.6	1.6
T42	30-Aug	1636-1749	39-40.6N, 144-39.6E	0-100	+	+	0	+	0.7	0.7
Small block 1										
T44	31-Aug	1056-1156	41-48.1N, 144-00.0E	0-30	216.7	*	0	0	0	216.7
T45	31-Aug	1643-1757	42-29.4N, 144-01.6E	0-100	2.4	*	0	0	+	2.4

<Night-time survey>

Stn no.	Date, 2000	Time (horizontal tow)	Locality	Sampling depth (m)	Japanese anchovy	Other fishes	Common squid	Other squids	Jelly fish	Total
Small block 2										
T9	4-Aug	2011-2123	41-49.6N, 142-23.3E	0-100	0.0	17.0*	0.0	0.0	0.7	17.7
Small block 1										
T18	7-Aug	1946-2058	42-30.2N, 146-00.5E	0-100	+	94.7	1.7	16.5	0.1	113.0
Small block 4										
T27	23-Aug	2036-2148	39-40.0N, 148-38.3E	0-100	0.8	79.8	0.0	9.5	0.5	91.0
Small block 6										
T38	28-Aug	2046-2203	37-15.8N, 144-32.3E	0-100	0.0	93.2	0.0	19.4	0.0	93.2
Small block 3										
T43	30-Aug	2043-2205	39-40.5N, 144-39.7E	0-100	0.0	63.0	0.0	11.2	0.4	75.0

Table 3. Summary of plankton net sampling.

St. #	Trawl St. #	Date	Time	Lat.	Long.	Hauling method (Maruchi)	Sampling depth (Maruchi)	Hauling method (Bongo)	Sampling depth (Bongo)	Note
Small Block 2										
St. 1	T1	2-Aug	9:45	39-59.9N	143-20.4E	Vertical	158~0	Oblique	77~0	
St. 2	T2	2-Aug	17:00	40-19.9N	142-25.8E	Vertical	160~0	-	-	No Bongo sample
St. 3	T3	3-Aug	9:06	40-33.4N	142-05.7E	Vertical	118~0	Oblique	89~0	
St. 4	T4	3-Aug	13:13	40-46.4N	142-26.6E	Vertical	110~0	Horizontal	31~17	
St. 5	T5	3-Aug	16:45	41-03.6N	142-37.4E	Vertical	110~0	Oblique	98~0	
St. 6	T6	4-Aug	8:11	41-14.9N	141-58.7E	Vertical	117~0	Oblique	113~0	
St. 7	T7	4-Aug	12:01	41-23.6N	141-42.6E	Vertical	115~0	-	-	No Bongo sample
St. 8	T8	4-Aug	16:07	41-49.5N	142-24.2E	Vertical	109~0	-	-	No Bongo sample
St. 9	T9	4-Aug	19:55	41-51.1N	142-27.0E	Vertical	103~0	Horizontal	31	
Small Block 1										
St.10	T10	5-Aug	9:08	41-40.7N	144-00.0E	Vertical	100~0	Oblique	35~0	
St.11	T11	5-Aug	12:50	42-01.3N	144-00.0E	Vertical	107~0	Horizontal	11~10	
St.12	T12	5-Aug	16:03	42-24.3N	143-59.9E	Vertical	109~0	Oblique	30~0	
St.13	T13	6-Aug	7:43	42-22.6N	144-11.2E	Vertical	104~0	Horizontal	34~31	
St.14	T14	6-Aug	14:36	41-57.8N	145-02.9E	Vertical	104~0	Horizontal	61~43	
St.15	T15	7-Aug	8:03	42-40.9N	145-16.7E	Vertical	106~0	Horizontal	52~46	
St.16	T16	7-Aug	11:11	42-44.7N	145-31.1E	Vertical	104~0	Horizontal	13~9	
St.17	T17	7-Aug	14:48	42-28.3N	146-03.9E	Vertical	100~0	Horizontal	15~14	
St.18	T18	7-Aug	19:53	42-28.3N	146-02.9E	Vertical	109~0	Horizontal	36~31	
Small Block 3										
St.19	T19	8-Aug	12:55	40-21.5N	144-43.9E	Vertical	103~0	Horizontal	17~11	
St.20	T20	8-Aug	16:00	40-09.8N	144-19.2E	Vertical	97~0	Horizontal	15~10	
Small Block 4										
St.21	T22	22-Aug	7:04	41-00.0N	149-59.8E	Vertical	100~0	Horizontal	30	
St.22	T23	22-Aug	12:41	40-38.0N	149-15.6E	Vertical	100~0	-	-	No Bongo sample
St.23	T24	22-Aug	16:06	40-27.0N	148-53.6E	Vertical	100~0	Horizontal	15	
St.24	No trawl	23-Aug	-	-	-	-	-	Horizontal	225	Only Bongo
St.25	T25	23-Aug	12:48	39-54.0N	148-08.0E	Vertical	290~0	Oblique	400~300	
St.26	T26	23-Aug	17:05	39-41.0N	148-37.8E	Vertical	100~0	Horizontal	40~30	
St.27	T27	23-Aug	20:19	39-41.2N	148-37.3E	Vertical	110~0	Horizontal	30~20	
St.28	T28	200/8/24	12:09	39-14.7N	149-30.3E	Vertical	85~0	Horizontal	40~0	
St.29	T29	200/8/24	16:40	38-59.0N	150-00.1E	Vertical	100~0	Horizontal	425~270	
Small Block 7										
St.30	T30	25-Aug	7:01	38-00.1N	150-00.3E	Vertical	90~0	Horizontal	50~45	
St.31	T31	25-Aug	13:44	37-30.1N	148-59.3E	Vertical	90~0	Horizontal	550~500	
St.32	T32	26-Aug	8:32	36-56.5N	147-59.9E	Vertical	100~0	Oblique	55~0	
St.33a	T33	26-Aug	14:21	36-38.8N	148-43.5E	Vertical	90~0	Oblique	10~5	
St.33b		26-Aug	-	-	-	-	-	Oblique	420~0	Only Bonogo
Small Block 6										
St.34	T34	27-Aug	7:05	35-59.7N	146-00.2E	Vertical	90~0	Oblique	45~0	
St.35	T35	27-Aug	15:58	36-29.5N	145-00.6E	Vertical	90~0	Oblique	45~0	
St.36	T36	28-Aug	9:05	36-46.4N	144-26.6E	Vertical	100~0	Oblique	40~0	
St.37	T37	28-Aug	16:06	37-16.2N	144-31.3E	Vertical	150~0	Oblique	50	
St.38	T38	28-Aug	20:19	37-15.7N	144-31.5E	Vertical	100~0	Oblique	50~10	
St.39	T39	29-Aug	10:13	37-38.4N	145-18.0E	Vertical	100~0	Oblique	20~0	
St.40	T40	29-Aug	15:23	37-59.9N	146-00.8E	Vertical	70~0	Oblique	70~0	
Small Block 3										
St.41	T41	30-Aug	10:52	39-21.1N	145-18.0E	Vertical	100~0	Horizontal	30	
St.42	T42	30-Aug	16:05	39-40.7N	144-40.2E	Vertical	100~0	Horizontal	25	
St.43	T43	30-Aug	20:20	39-40.5N	144-40.0E	Vertical	100~0	Oblique	20~0	
Small Block 1										
St.44	T44	31-Aug	10:51	41-48.6N	144-00.6E	Vertical	80~0	Oblique	30~0	
St.45	T45	31-Aug	16:10	42-30.6N	144-00.4E	Vertical	100~0	Oblique	250~150	

Table 4. Occurrence of krill species in each small block.

	Small Block					
Species	1	2	3	4	6	7
Thysanopoda aequalis						O
Thysanopoda tricuspidata					O	O
Euphausia diomedeae				O		
Euphausia gibboides				O	O	O
Euphausia hemigibba	O		O	O		
Euphausia mutica						
Euphausia pacifica	O	O	O	O	O	O
Euphausia pseudoigibba				O		
Euphausia recurva			O	O	O	O
Euphausia similis	O		O	O		
Euphausia tenera				O		
Euphausia spp.	O	O	O	O	O	O
Thysanoessa inermis		O				
Thysanoessa inspinata		O		O		
Thysanoessa longipes	O	O	O	O	O	O
Thysanoessa spp.	O	O	O	O	O	O
Tessarabrachion oculatum	O	O		O	O	O
Nematocelis tenella				O		
Nematocelis spp.	O			O	O	O
Nematobrachion flexipes					O	O
Nematobrachion spp.				O		
Stylocheiron spp.				O	O	O
# of Spp.	8	7	7	17	11	11

Table 5. Occurrence of copepod species in each small block.

	Small Block					
Species	1	2	3	4	6	7
Euchirella rostrata						O
Nannocalanus minor		O				
Calanus pacificus	O	O	O	O	O	O
Neocalanus cristatus	O	O	O	O		
Neocalanus plumchrus	O	O	O	O	O	
Mesocalanus tenuicornis	O	O	O	O	O	O
Candacia bipinnata		O	O		O	
Clausocalanus arcuicornis				O	O	O
Pseudocalanus minutus	O	O		O	O	O
Rhincalanus nasutus				O		O
Eucalanus attenuatus					O	O
Eucalanus bungii	O	O	O	O	O	O
Eucalanus mucronatus				O	O	O
Euchaeta rimana					O	O
Metridia pacifica	O	O	O	O	O	
Paracalanus parvus		O	O		O	O
Scolecithrix danae					O	O
Oithona plumifera		O			O	
Coryucaeus speciosus			O		O	
Saphirina opalina					O	
Oncaea venusta f.typica						O
# of Spp.	7	11	9	10	16	13

Table 6. Summary of cetacean sightings conducted by KS2 during the prey survey.

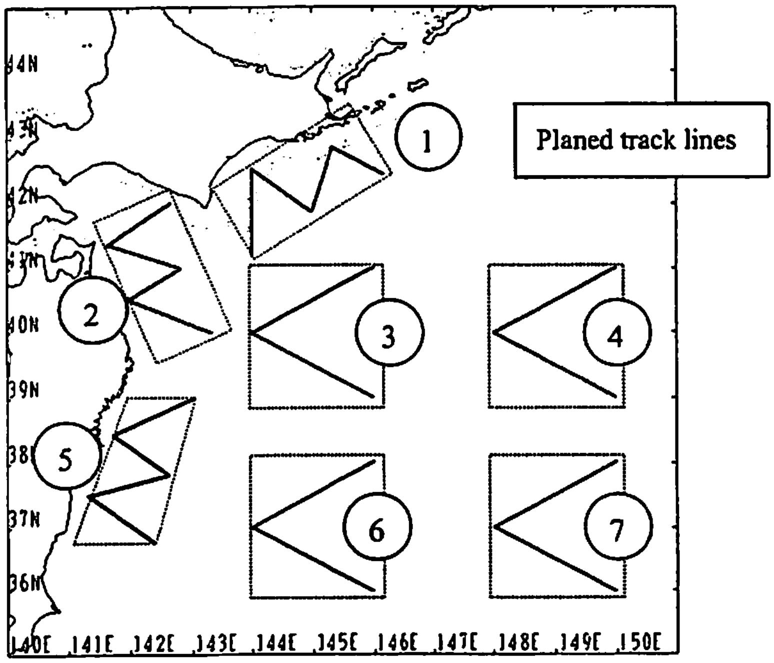
Species	Primary		Secondary	
	Group	Animal	Group	Animal
Minke whale	4	4	0	0
Like Minke	1	1	1	1
Bryde's whale	15	21	7	8
Like Bryde's	31	37	0	0
Sperm whale	15	45	4	4
Unidentified larege cetacean	2	2	8	13

Table 7. Stomach contents of minke, Bryde's and sperm whales sampled during the cooperative survey.

Minke whales	Common name	Scientific name
Pisces	Japanese anchovy	*Engraulis japonicus*

Bryde's whales		
Krill		*Euphausia pacifica*
Pisces	Japanese anchovy	*Engraulis japonicus*
	Russell' scad	*Decapterus russelli*
	Chub mackerel	*Scomber japonicus*

Sperm whales		
Pisces		*Laemonema longipes*
Squid	Berry armhook squid	*Gonatus berryi*
	Fiery armhook squid	*G. pyros*
		G. middendorffi
		Eogonatus tinro
	Boreopacific armhook squid	*Gonatopsis borealis*
		Chiroteuthis imperator
		C. calyx
		Enoploteuthis chuni
	Sharpear enope squid	*Ancistrocheirus lesueuri*
		Galiteuthis pacifica
		Taonius pacifica borealis
		Megalocranchia maxima
	Boreal clubhook squid	*Onychoteuthis borealijaponica*
	Common clubhook squid	*O. banksii*
	Japanese hooked squid	*Moroteuthis loennbergii*
	Robust clubhook squid	*M. robusta*
		Histioteuthis dofleini
		H. meleagroteuthis
		Discoteuthis discus
	Giant squid	*Architeuthis martensi*
	Dana octopus squid	*Taningia danae*
		Octopoteuthis sicula
		Alloposus mollis



(Depth counters: 200m and 1000m)

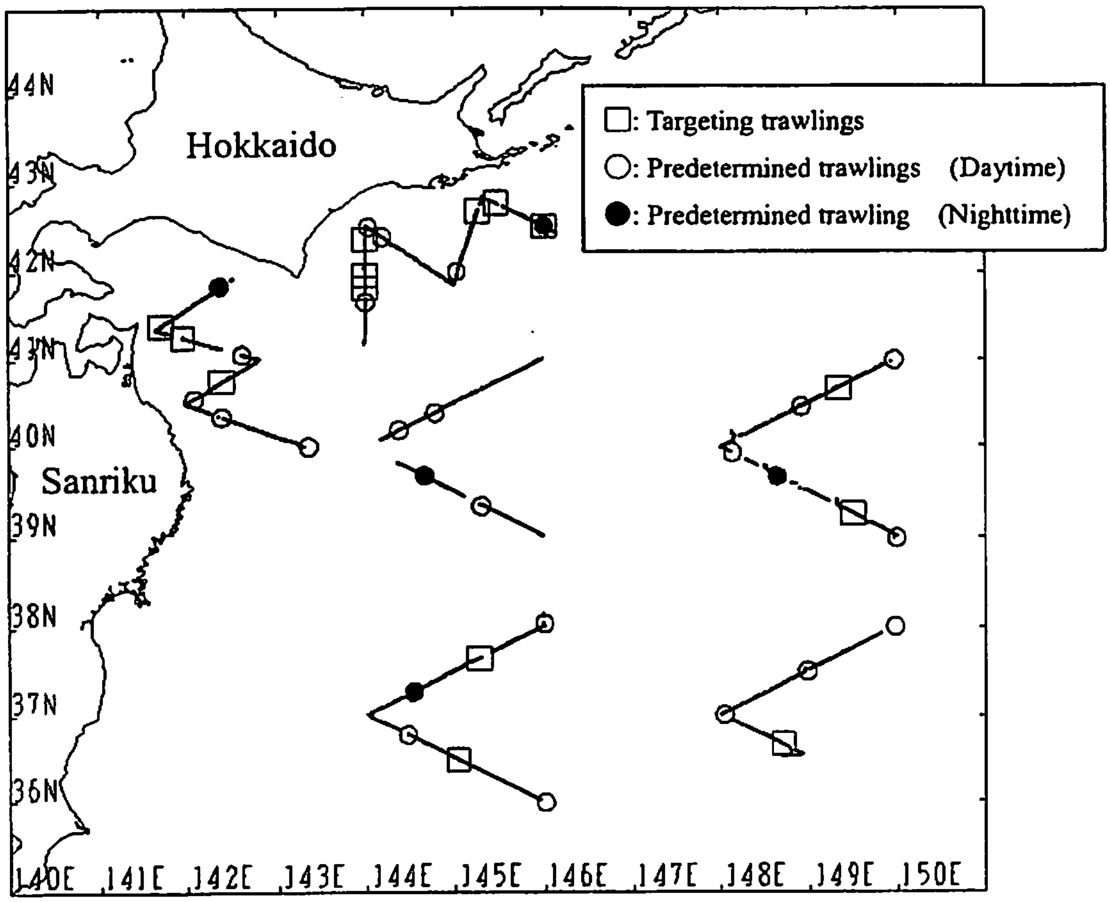


Fig.1. Survey area, small blocks, track lines and trawling positions.

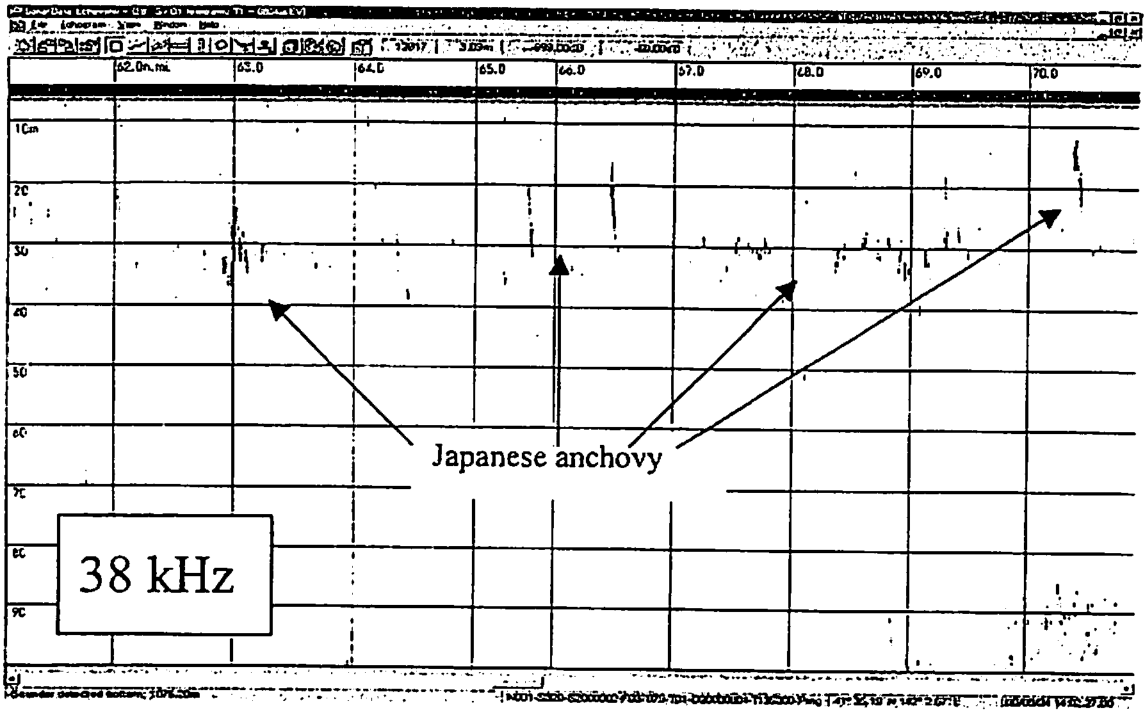


Fig. 2. Marks of Japanese anchovy on the echo sounder during the daytime.

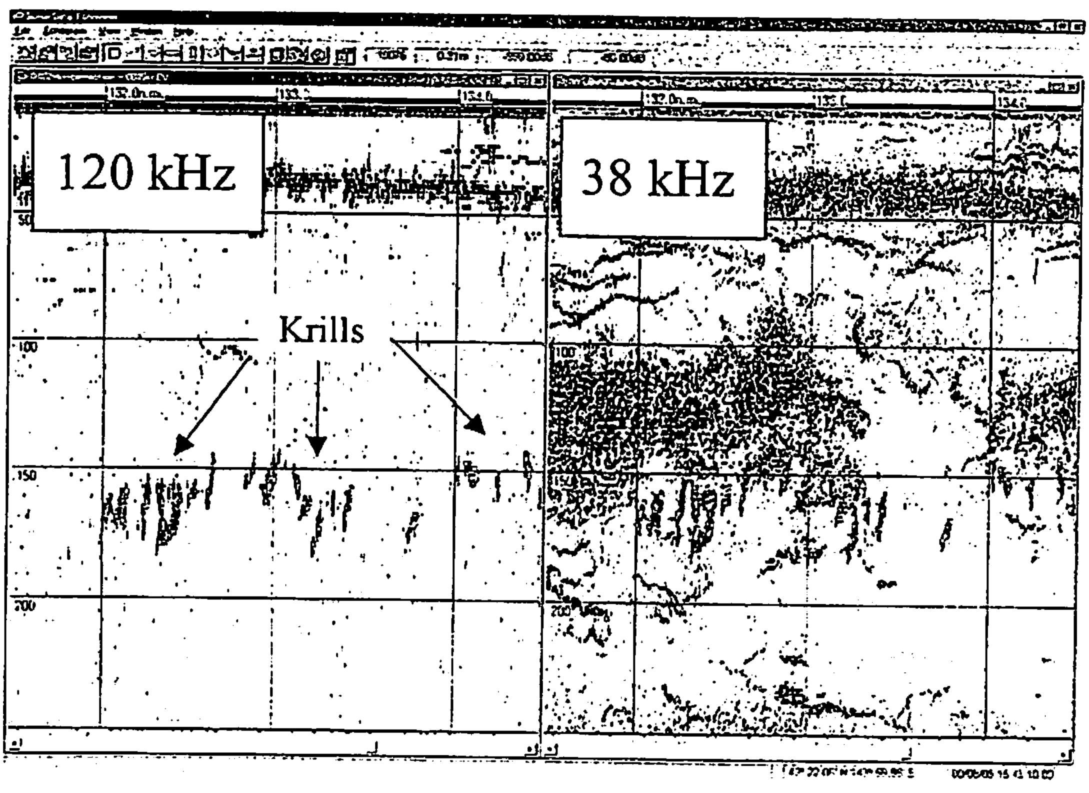


Fig. 3. The difference of marks of krills between 120 kHz and 38 kHz.

Small block 1 (Surveyd dist. = 249 n.miles)

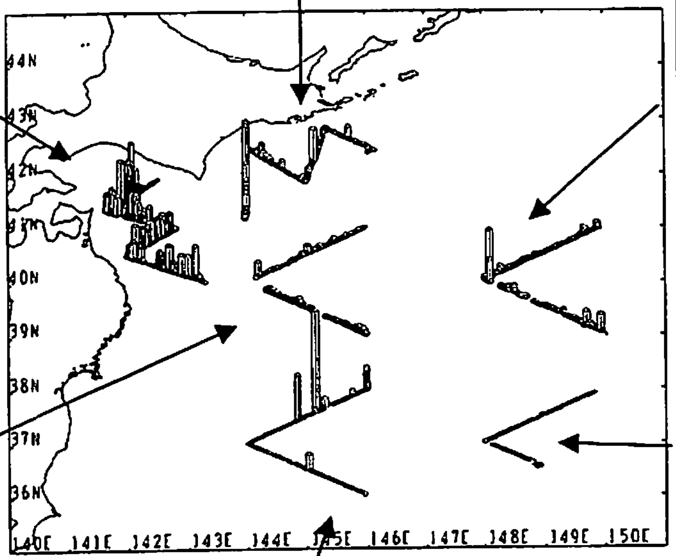
Depth	Total SA	SA/n.mile
7~10m	2025.00	8.13
10~20m	10858.15	43.61
20~30m	438.80	1.76
30~40m	0.00	0.00
Sum	11296.95	45.37

Small block 2 (Surveyed dist. = 219 n.miles)

Depth	Total SA	SA/n.mile
7~10m	770.12	3.52
10~20m	14530.80	66.35
20~30m	8593.83	39.24
30~40m	8086.08	36.92
Sum	31980.84	146.03

Small block 4 (Survey dist. = 206 n.mile)

Depth	Total SA	SA/n.mile
7~10m	3453.28	16.76
10~20m	1262.16	6.13
20~30m	59.39	0.29
30~40m	0.00	0.00
Sum	4774.83	23.18



Small block 3 (Surveyed dist. = 192 n.miles)

Depth	Total SA	SA/n.mile
7~10m	855.65	4.46
10~20m	145.10	0.76
20~30m	233.18	1.21
30~40m	79.89	0.42
Sum	313.07	6.84

Small block 7 (Surveyed dist. = 167 n.miles)

Depth	Total SA	SA/n.mile
7~10m	0.00	0.00
10~20m	0.00	0.00
20~30m	0.00	0.00
30~40m	0.00	0.00
Sum	0.00	0.00

Small block 6 (Surveyed dist. = 251 n.miles)

Depth	Total SA	SA/n.mile
7~10m	4092.40	16.30
10~20m	9148.69	36.45
20~30m	36.83	0.15
30~40m	281.77	1.12
Sum	13559.69	54.02

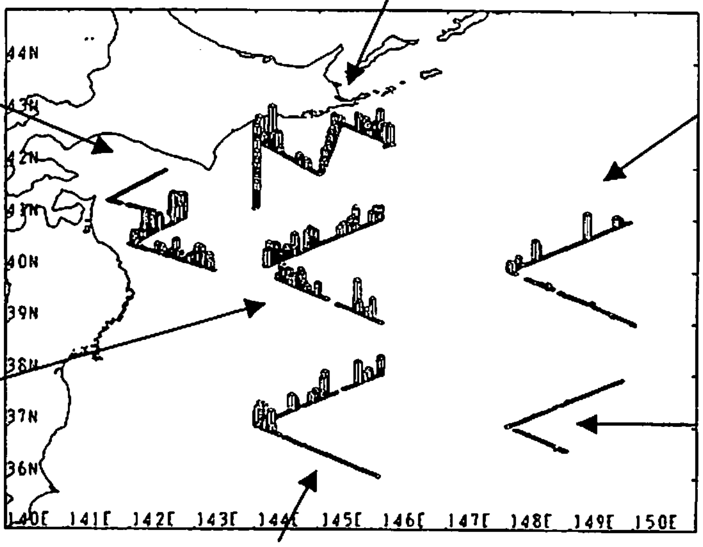
Fig. 4. S_A of Japanese anchovy in each small block. Bars denoting magnitude of S_A.

Small block 1 (Surveyd dist. = 249 n.miles)

Depth	Total SA	SA/n.mile
50~100m	0.00	0.00
100~150m	250.32	1.01
150~200m	16300.99	65.47
200~250m	13472.78	54.11
Sum	17053.28	68.49

Small block 2 (Surveyed dist. = 219 n.miles)

Depth	Total SA	SA/n.mile
50~100m	5.45	0.02
100~150m	2155.65	9.84
150~200m	8138.32	37.16
2[illegible]0m	6753.86	30.84
[illegible]	17053.28	77.87



Small block 3 (Surveyed dist. = 192 n.miles)

Depth	Total SA	SA/n.mile
50~100m	44.11	0.23
100~150m	2666.78	13.89
150~200m	10079.04	52.49
200~250m	5983.31	31.16
Sum	18773.23	97.78

Small block 4 (Survey dist. = 206 n.mile)

Depth	Total SA	SA/n.mile
50~100m	0.00	0.00
100~150m	615.99	2.99
150~200m	1074.31	5.22
200~250m	1230.79	5.97
Sum	2921.08	14.18

Small block 7 (Surveyed dist. = 167 n.miles)

Depth	Total SA	SA/n.mile
50~100m	0.00	0.00
100~150m	0.00	0.00
150~200m	0.00	0.00
200~250m	0.00	0.00
Sum	0.00	0.00

Small block 6 (Surveyed dist. = 251 n.miles)

Depth	Total SA	SA/n.mile
50~100m	1.81	0.01
100~150m	222.67	0.89
150~200m	1647.46	6.56
200~250m	7559.57	30.12
Sum	9431.52	37.58

Fig. 5. S_A of krills in each small block. Bars denoting magnitude of S_A.

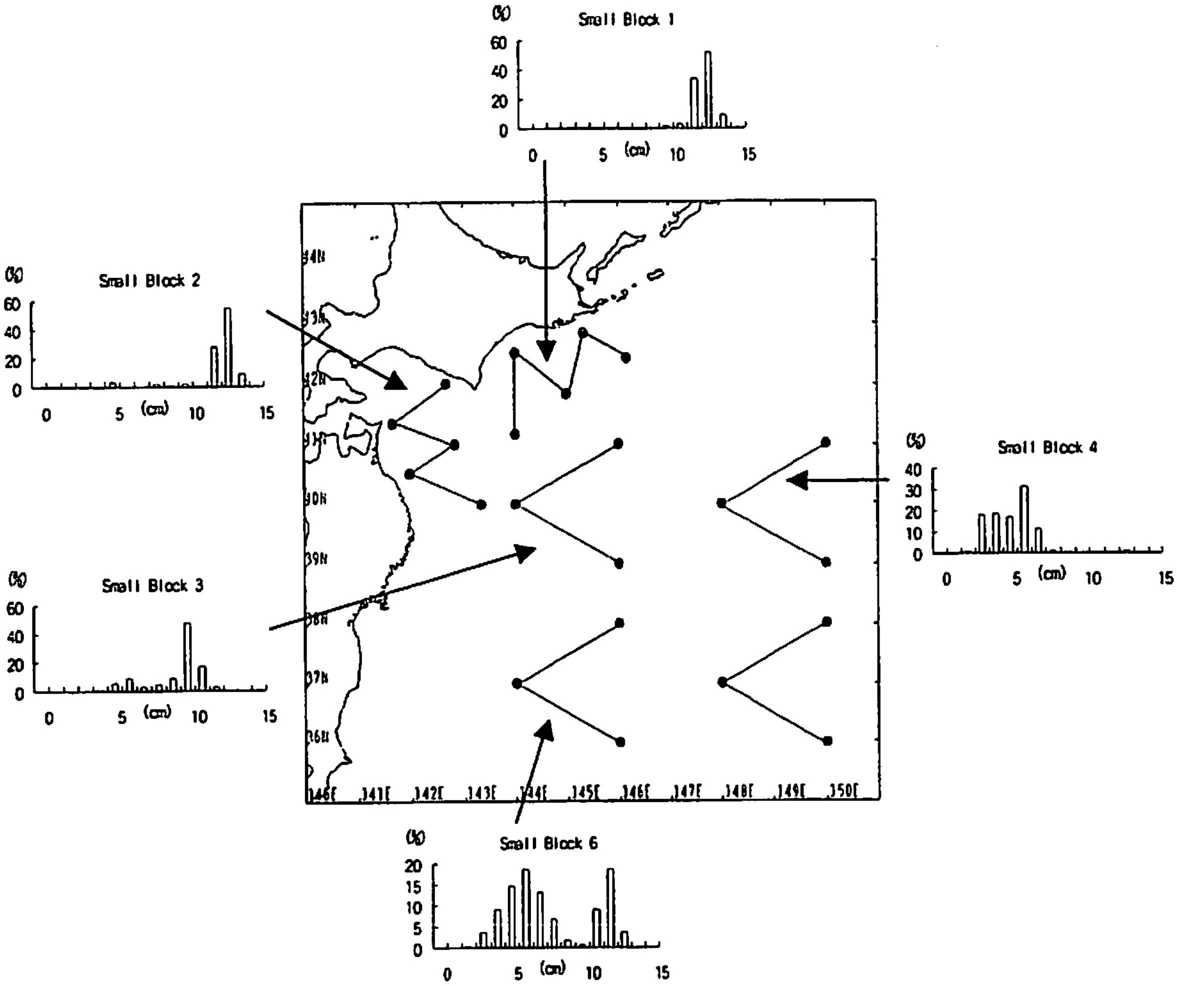


Fig. 6. Length frequency of Japanese anchovy in each small block.

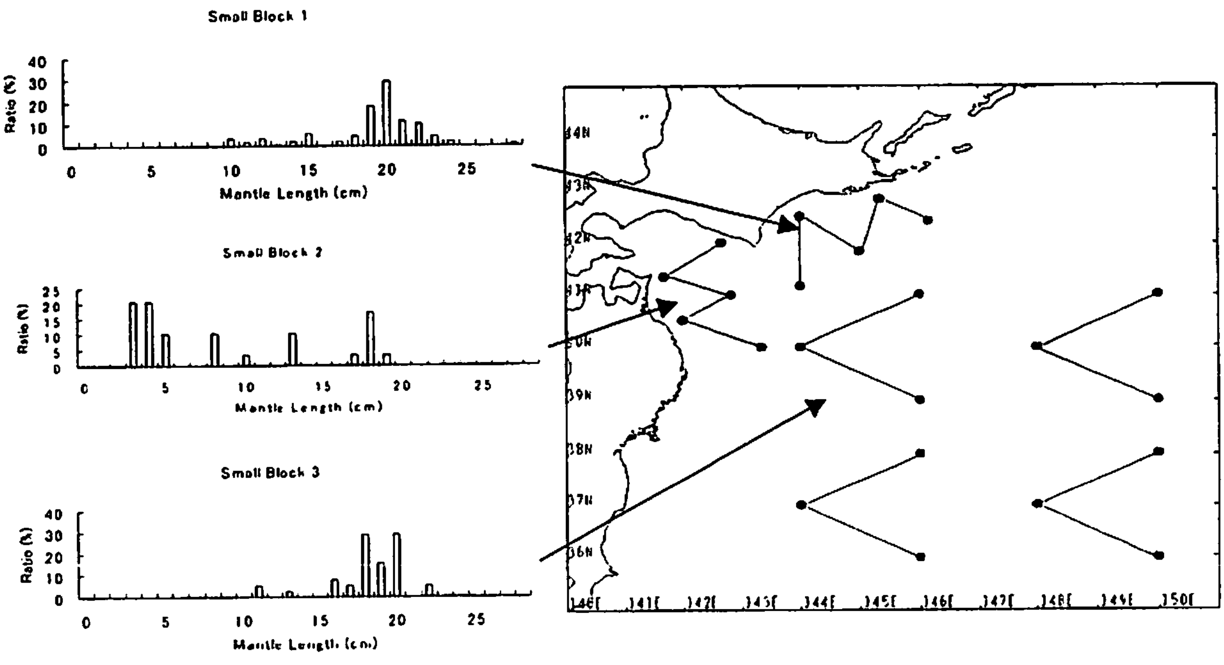
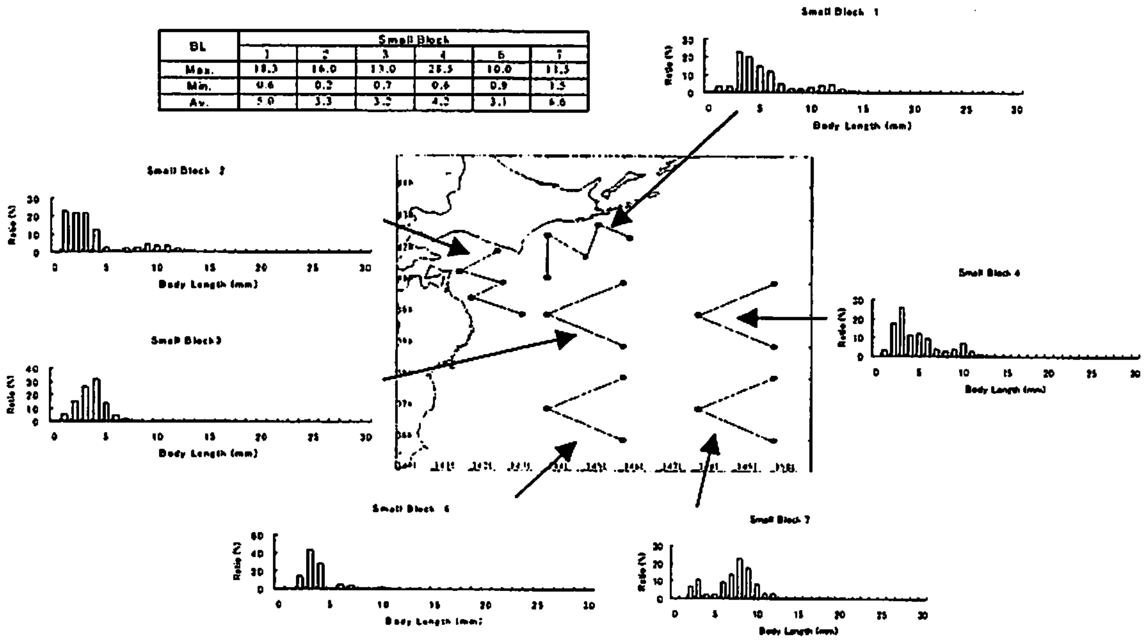
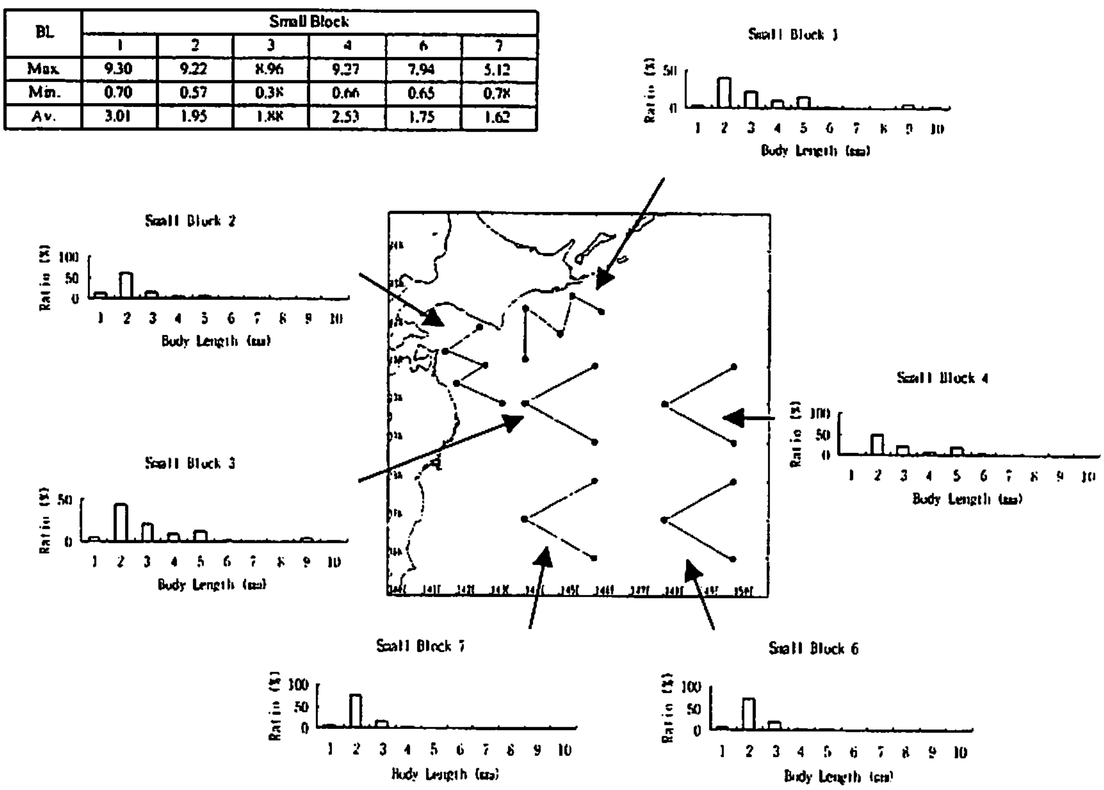


Fig. 7. Length frequency of Japanese common squid in each small block.



BL	Small Block					
	1	2	3	4	6	7
Max.	18.3	16.0	13.0	25.5	10.0	11.5
Min.	0.6	0.2	0.7	0.6	0.9	1.5
Av.	5.0	3.3	3.2	4.2	3.1	6.6

Fig. 8. Length frequency of isada krills in each small block.



BL	Small Block					
	1	2	3	4	6	7
Max.	9.30	9.22	8.96	9.27	7.94	5.12
Min.	0.70	0.57	0.38	0.66	0.65	0.78
Av.	3.01	1.95	1.88	2.53	1.75	1.62

Fig. 9. Length frequency of copepods in each small block.

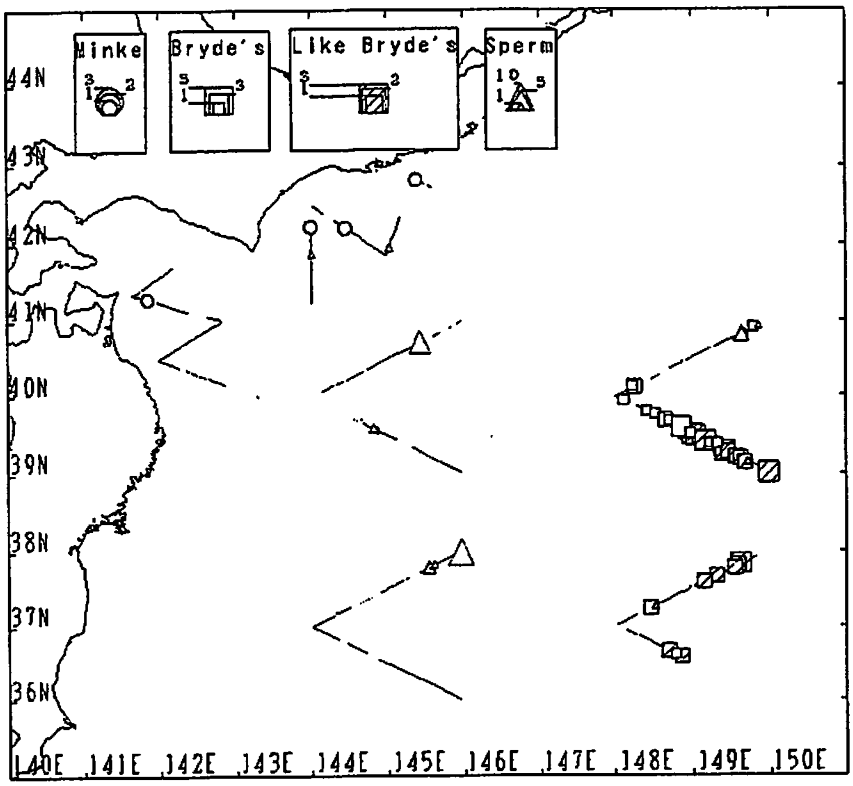


Fig 10. Sighting positions of minke, Bryde's like Bryde's and sperm whale.

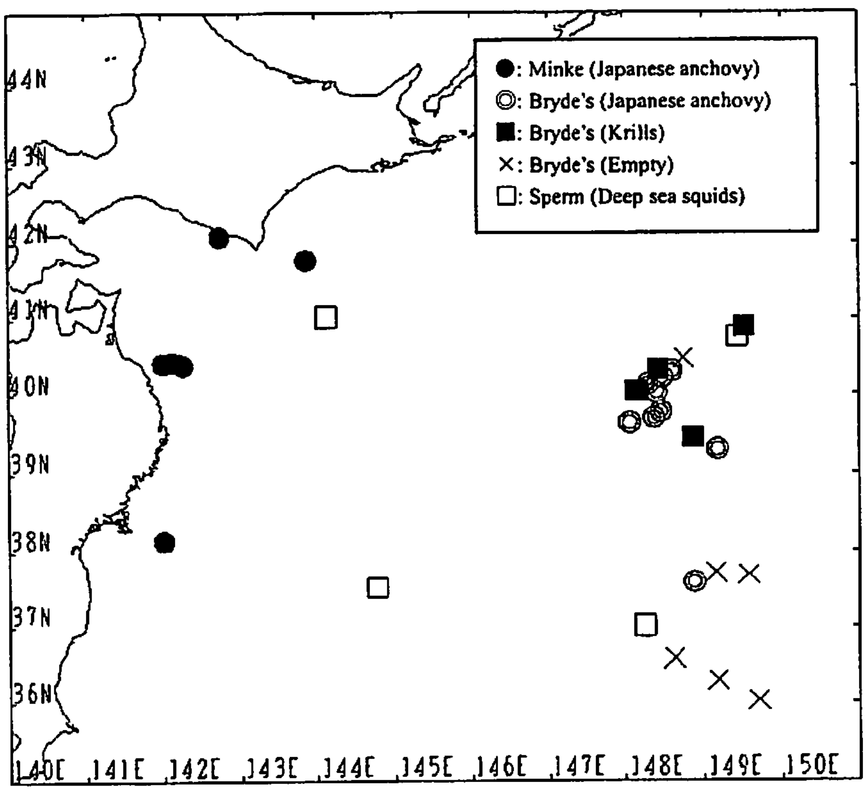


Fig. 11. Main stomach contents of sampled minke, Bryde's and sperm whales.

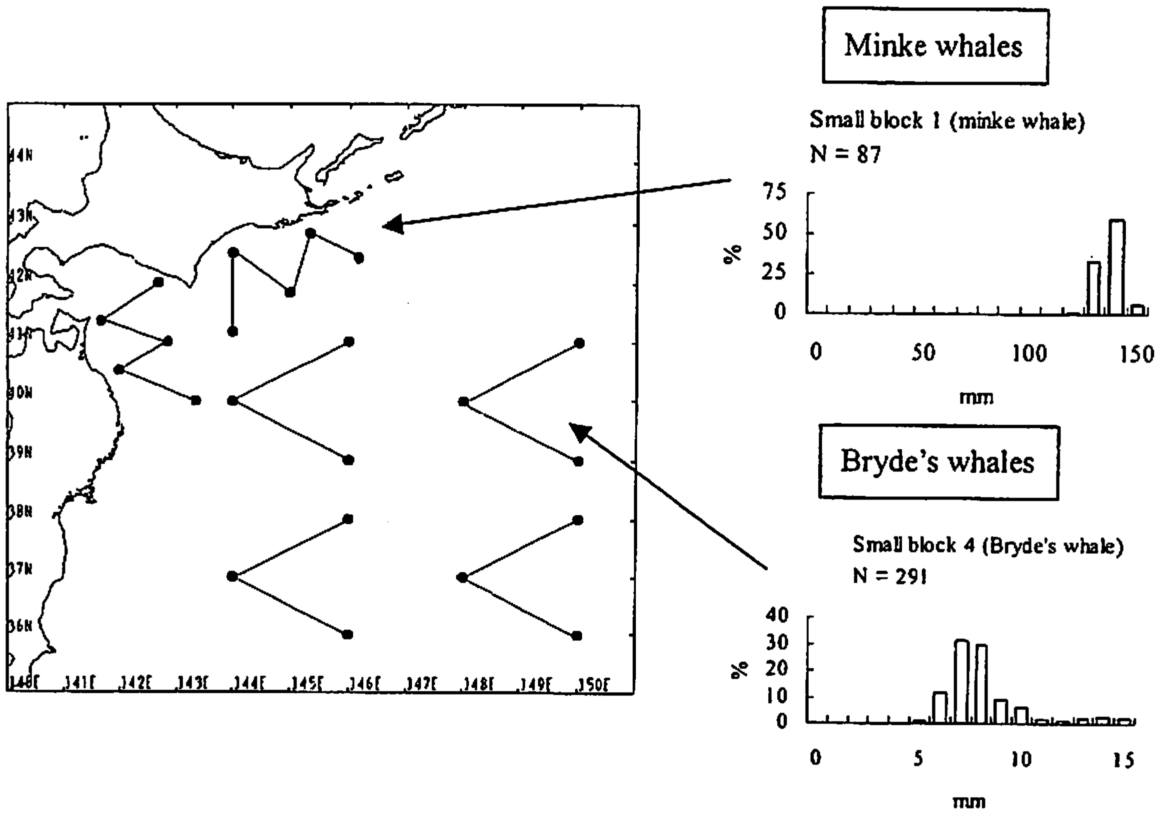


Fig. 12. Length frequency of Japanese anchovy from minke and Bryde's whales.

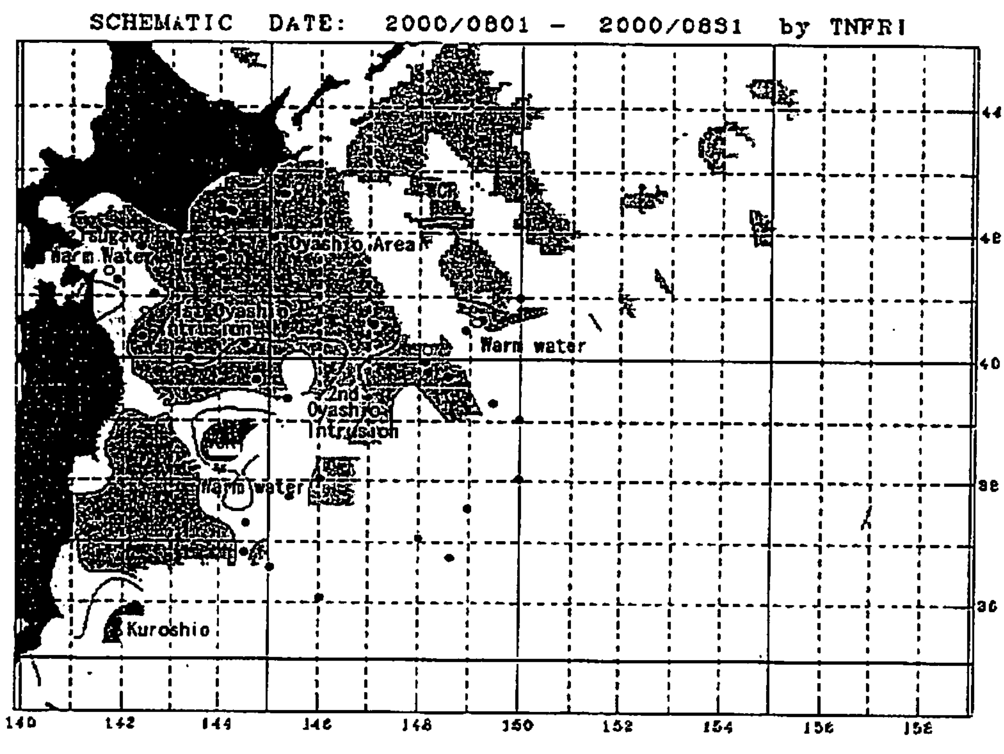


Fig. 13. Schematic hydrographic map in the western North Pacific in August 2000.

Appendix IV

Recent progress in the development of ecosystem model for JARPN II

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JARPN II (The Cetacean Studies in the Western North Pacific under Special Permit) started in 2000 as the two-year feasibility study (The Government of Japan, 2000). The overall goal 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 top priority is on feeding ecology and ecosystem studies consisting of prey consumption by cetaceans, prey preference of cetaceans and ecosystem model. The ecosystem model suitable to the western North Pacific is now being developed based on the two types of well-known models; Ecopath and MULTSPEC. As explained at the 52nd IWC/SC, Ecopath model was analyzed first and then investigation of MULTSPEC-type models will start from the simple case because the MULTSPEC-type model need more sophisticated biological parameters. The results analyzed with Ecopath are submitted to the 53rd IWC/SC as a document (SC/53/O9). Following is the summary of the document.

The family of Ecopath models are broadly used and applied to examine the aquatic ecosystem. Ecopath is the static mass-balance trophic model that can include more components than other ecosystem models. Ecosim can assess how the temporal change of fisheries has an effect on the ecosystem. Ecospace, including spatial dynamic analyses, is the extension of Ecopath and Ecosim. The Ecopath model in the western North Pacific was constructed and analyzed for the first time as part of JARPN II. The objective is to examine the usefulness of model and to check the competition between whales and fisheries.

Another objective is to investigate the roles of cetaceans in the ecosystem. 30 species groups are selected. Because Ecosim was very sensitive to vulnerability (defined as 0.0-1.0), each simulation was carried out for vulnerability = 0.3 and 0.6. It was tried to estimate changes of each biomass for next 50 years under the several scenarios. The scenarios included the fishing rate = 0 or doubled for whales and fishes (Figs. 1 and 2). Although the model still includes several parts to be improved, the analyses indicated that the change of cetacean biomass resulted in the substantial change of the fish biomass under higher value of the vulnerability. In fitting the model to the available time series data of some fishes, the vulnerability seemed to be higher. This means competition between whales and fisheries is likely to happen in the western North Pacific. Removal of common minke and sperm whale showed a large impact in the ecosystem while removal of Bryde's whale little effect. As the information on the parameters such as the diet composition of whales is limited, more accurate analyses by the model could be expected as JARPNproceeds.

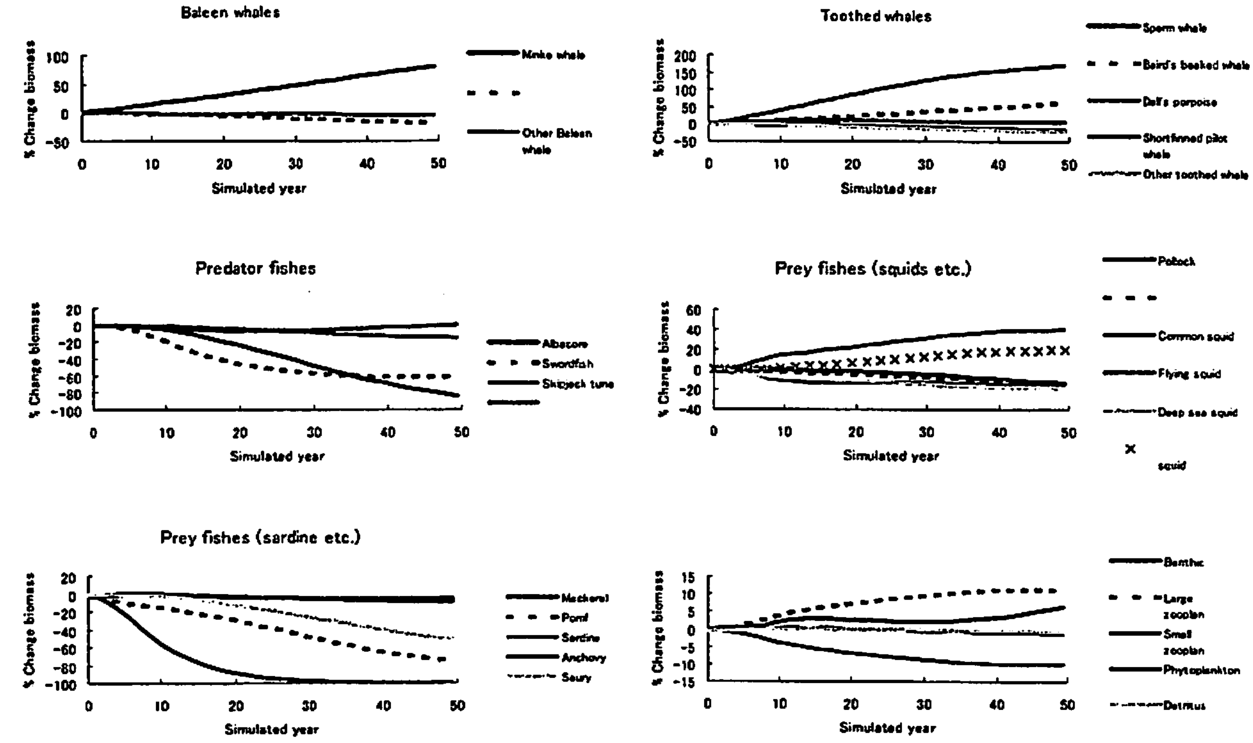

Fig. 1. The change of relative biomass without catches for whales during future 50 years (v = 0.6).

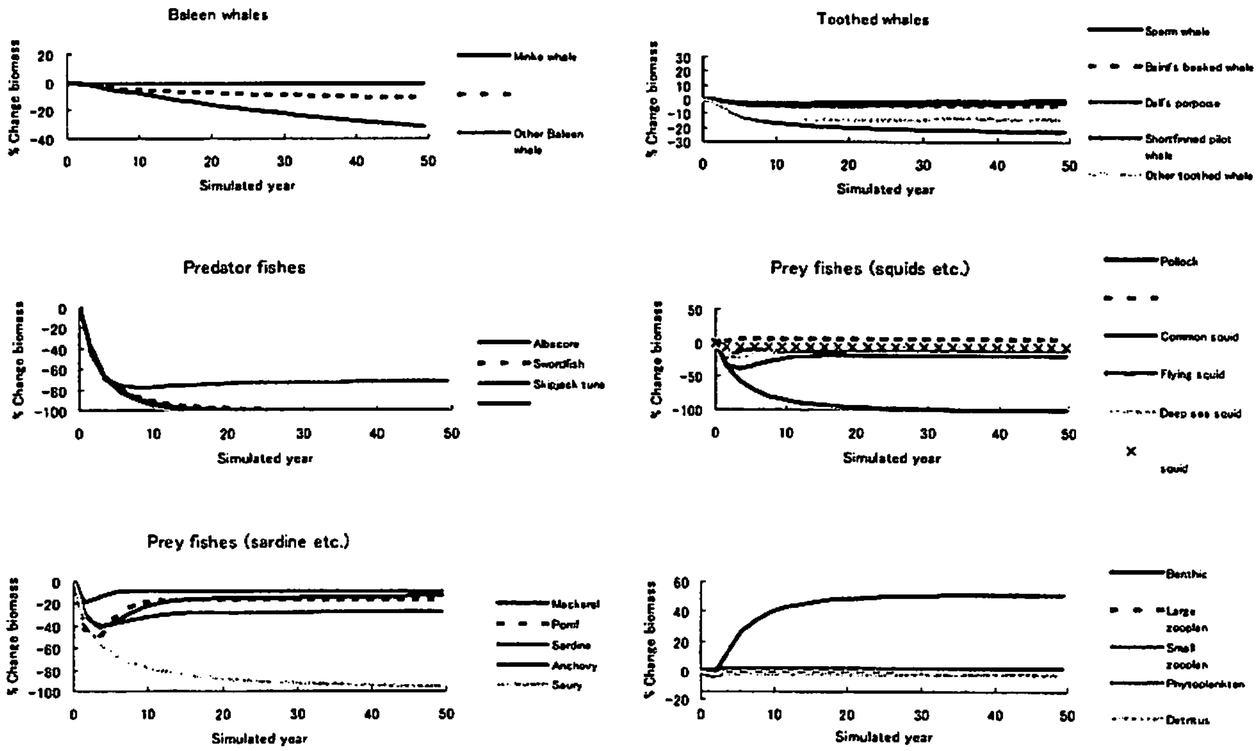

Fig. 2. The change of relative biomass with doubled fishing rate for fishes during future 50 years (v = 0.3).

Appendix V

Way point (WP) information for the tracks of the 3 sighting/sampling vessels (SSVs) during the 2000 JARPN II feasibility survey.

	M COURSE								A COURSE			B COURSE		
	Latitude		Longitude		Leg No.	Vessel	Date	Time	Vessel	Date	Time	Vessel	Date	Time
Sub-area 7 (small area 2)														
WP210	40.00	N	143.20	E	209	YS1	8/3	8:30	T25	8/3	8:30	K01	8/3	8:30
WP209	40.00	N	142.00	E	208	YS1			T25	8/3	18:17	K01	8/3	15:09
WP208	41.00	N	142.49	E	207	T25	8/4	11:46	YS1	8/4	12:12	K01	8/4	10:38
WP207	41.20	N	141.40	E	206	T25	8/4	18:11	YS1	8/4	18:17	K01	8/4	17:15
WP206	42.00	N	142.40	E		K01	8/5	13:45	YS1	8/5	13:41	T25	8/5	13:09
WP230	42.00	N	142.40	E	230	K01	8/5	13:45	YS1			T25	8/5	13:42
WP231	41.10	N	144.00	E		YS1	8/6	12:14	K01	8/6	11:34	T25	8/6	11:48
Sub-area 7 (small area 1)														
WP201	41.10	N	144.00	E	201	YS1	8/6	12:14	K01			T25	8/6	12:09
WP202	42.30	N	144.00	E	202	T25	8/7	16:50	K01	8/7	17:00	YS1	8/7	16:17
WP203	41.50	N	145.00	E	203	K01	8/8	12:50	T25	8/8	13:29	YS1	8/8	12:24
WP204	42.50	N	145.20	E	204	YS1	8/9	7:00	T25	8/9	7:28	K01		
WP205	42.25	N	146.10	E		YS1	8/9	11:56	T25	8/9	11:20	K01	8/9	11:32
WP241	42.25	N	146.10	E	241	YS1	8/9	11:56	T25	8/9	11:39	K01	8/9	12:01
WP242	42.10	N	145.40	E	242	YS1	8/9	14:34	T25	8/9	15:22	K01	8/9	13:38
WP243	42.40	N	144.40	E	243	T25	8/10	8:48	YS1	8/10	9:05	K01	8/10	8:50
WP244	41.30	N	144.30	E	244	T25	8/10	15:42	YS1	8/10	15:44	K01	8/10	15:42
WP245														
Sub-area 7 (small area 3)														
WP211	41.00	N	146.00	E	211	K01	8/11	7:00	YS1	8/11	7:00	T25	8/11	7:00
Sub-area 9														
WP261	44.00	N	157.00	E	261	K01	8/13	7:10	T25	8/13	7:00	YS1		
WP262	45.30	N	159.00	E		K01	8/14	10:44	T25	8/14	11:16	YS1	8/14	10:16
Sub-area 9														
WP901-A	45.25	N	159.10	E	901	K01	8/14	12:24	T25	8/14	12:13	YS1	8/14	12:26
WP902-A	46.15	N	159.10	E		K01			T25			YS1		
Sub-area 9														
WP911-B	44.35	N	161.00	E	911	T25			YS1	8/16	7:59	K01		
WP912-B	44.35	N	160.00	E		T25			YS1			K01		
Sub-area 9														
WP921-C	44.35	N	162.00	E	921	K01	8/17	7:00	YS1	8/17	7:00	T25	8/17	7:00
WP922-C	44.35	N	161.00	E	922	K01	8/17	11:27	YS1	8/17	11:36	T25	8/17	11:33
WP923-C	44.25	N	161.00	E	923	K01	8/17	13:05	YS1	8/17	12:45	T25	8/17	12:47
WP924-C	44.25	N	159.50	E		K01			YS1			T25		
Sub-area 9														
WP931-D	44.30	N	160.30	E	931	YS1	8/18	7:05	K01	8/18	7:06	T25	8/18	7:09
WP932-D	45.30	N	161.30	E	932	YS1	8/18	15.12	K01	8/18	16:14	T25	8/18	14:51
WP933-D	45.30	N	160.30	E		T25	8/19	10:04	K01	8/19	10:05	YS1	8/19	10:26
Sub-area 9														
WP941-E	45.40	N	161.20	E	941	T25	8/19	14:00	K01	8/19	14.37	YS1	8/19	14:05
WP942-E	44.50	N	160.30	E		T25			K01			YS1		
Sub-area 9														
WP951-F	44.50	N	160.20	E	951	K01	8/20	7:00	YS1	8/20	7:00	NO VESSEL		
WP952-F	44.50	N	159.40	E	952	K01			YS1			NO VESSEL		
WP953-F	45.00	N	159.40	E	953	K01	8/20	11:45	YS1	8/20	11:29	NO VESSEL		
WP954-F	45.00	N	158.00	E		K01			YS1			NO VESSEL		
Sub-area 7 (small area 4)														
WP214	41.00	N	150.00	E	214	YS1	8/22	6:45	NO VESSEL			K01	8/22	6:45
WP215	40.00	N	148.00	E	215	T25	8/25	11:28	YS1			K01	8/25	10:46
WP216	39.00	N	150.00	E		K01			YS1			T25		
Sub-area 7 (small area 7)														
WP225	38.00	N	150.00	E	225	YS1	8/27	8:00	K01	8/27	8:30	T25	8/27	9:00
WP226	37.00	N	148.00	E	226	T25	8/28	10:24	K01	8/28	10:35	YS1	8/28	10:22
WP227	36.00	N	150.00	E		K01			T25			YS1		
Sub-area 7 (small area 6)														
WP224	36.00	N	146.00	E	223	YS1	8/30	7:15	T25	8/30	7:37	K01	8/30	8:05
WP223	37.00	N	144.00	E	222	YS1	8/30	18:02	T25	8/30	18:13	K01	8/30	18:07
WP222	38.00	N	146.00	E		T25			YS1			K01		
Sub-area 7														
WP961-G	38.00	N	146.00	E	961	K01	9/1	7:15	YS1	9/1	7:15	T25	9/1	7:15
WP962-G	39.00	N	143.40	E		K01			YS1			T25		

Appendix II: Cont.

	M COURSE									A COURSE			B COURSE		
	Latitude		Longitude		Leg No.	Vessel	Date	Time		Vessel	Date	Time	Vessel	Date	Time
Sub-area 7 (small area 5)															
WP219	38.00	N	142.40	E	218	YS1	9/2	7:30		K01	9/2	7:30	T25	9/2	7:30
WP218	38.30	N	141.50	E	217	YS1	9/2	14:16		K01	9/2	14:33	T25	9/2	13:51
WP217	39.00	N	143.00	E		YS1				K01			T25		
Sub-area 7															
WP971-H	39.00	N	142.20	E	971	T25	9/4	11:00		K01	9/4	11:08	YS1	9/4	11:00
WP972-H	40.09	N	142.20	E		T25				K01			YS1		
Sub-area 7 (small area 3)															
WP212	40.00	N	144.00	E	211	K01	9/5	6:55		T25	9/5	6:55	YS1	9/5	6:55
WP211	41.00	N	146.00	E		YS1	9/6	8:56		T25	9/6	8:37	K01	9/6	8:07
Sub-area 7															
WP981-I	41.00	N	146.00	E	981	YS1	9/6	8:56		T25	9/6	9:44	K01	9/6	8:58
WP982-I	40.25	N	147.11	E		YS1	9/6	13:50		T25	9/6	14:22	K01	9/6	13:36
Sub-area 7															
WP986-J	40.10	N	145.30	E	986	T25	9/7	6:50		YS1	9/7	6:50	K01	9/7	6:50
WP987-J	40.10	N	147.20	E	987	T25	9/7	14:01		YS1	9/7	14:08	K01	9/7	13:17
WP988-J	39.57	N	147.28	E		T25	9/7	15:23		YS1	9/7	16:42	K01	9/7	16:00
Sub-area 7															
WP991-K	39.50	N	147.10	E	991	K01				YS1			T25		
WP992-K	39.50	N	148.20	E		YS1				K01			T25		
Sub-area 7 (small area 3)															
WP213	39.00	N	146.00	E	212	T25	9/11	6:55		K01	9/11	6:55	YS1	9/11	6:55
WP212	40.00	N	144.00	E		T25	9/11	17:24		K01	9/11	17:19	YS1	9/11	17:15
Sub-area 7 (small area 1)															
WP001-L	42.00	N	143.35	E	001	K01	9/12	7:00		T25	9/12	7:00	YS1	9/12	7:00
WP002-L	42.41	N	144.11	E		K01	9/12	17:55		T25			YS1		
WP004-L	42.44	N	144.10	E	004	YS1	9/13	7:00		T25	9/13	7:00	K01	9/13	7:00
WP005-L	42.44	N	144.50	E	005	T25	9/14	11:35		YS1	9/14	12:25	K01	9/14	11:38
WP006-L	43.00	N	145.50	E		T25	9/14	17:12		YS1			K01	9/14	17:20
WP008-L	42.59	N	145.46	E	008	K01	9/15	6:55		YS1	9/15	6:55	T25	9/15	6:55
WP009-L	42.44	N	144.50	E	009	K01	9/15	14:14		YS1	9/15	14:24	T25	9/15	14:37
WP010-L	42.44	N	144.00	E		YS1	9/16	12:28		K01	9/16	12.08	T25	9/16	12:47
WP011-L	42.32	N	144.00	E	011	YS1	9/16	13:22		K01	9/16	13:42	T25	9/16	13:01