Cruise Report of the Japanese Whale Research Program under a Special Permit in the North Pacific (JARPN) in 1996 with Some Preliminary Analyses of Data Collected During the 1994-1996 JARPN Surveys

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ABSTRACT

The Japanese Whale Research Program under Special Permit in the North Pacific (JARPN) survey in 1996 was conducted in parts of sub-areas 7, 8 and 11 as defined by the North Pacific Minke Whale Management Trials. The survey was carried out using one research base and three sighting/sampling vessels, which searched a total of 12,088 n.miles. During the survey the following large cetacean species were sighted: minke whale (171 schools/177 individuals), blue whale (two schools/ three individuals), fin whale (fourteen schools/23 individuals), sei whale (twelve schools/17 individuals), humpback whale (two schools/three individuals), Bryde's whale (23 schools/27 individuals) and sperm whale (358 schools/533 individuals). From the total minke whales sighted, 135 schools (137 individuals) were approached for sampling resulting in the catch of 77 animals, 63 males and 14 females. We conducted preliminary biological analyses using samples and data obtained in this survey and during the 1994 and 1995 surveys in sub-area 9. We also summarize the results on stock structure obtained so far using different methodologies. Mature males were dominant in sub-areas 8 and 9. In the coastal sub-areas 7 and 11, apart this component, mature females and immature animals of both sexes were present in a relatively high proportion. Pollutant, ecological markers, morphometric and genetic studies conducted using material from JARPN failed to find evidence for the occurrence of a hypothetical W stock in the offshore sub-area 9. Then these results are consistent with the hypothesis that minke whales from sub-areas 7 and 9 belong to a single stock, the O stock. In sub-area 11 both J and O stocks animals are present and there is a temporal mixing among them. With regard the feeding ecology of the minke whale, which is a newly added research objective in 1996, the dominant prey species in sub-areas 7, 8 and 9 (in the Pacific side) is the Pacific saury. Location of the sightings of minke whale by the JARPN surveys are closely related with the distribution of feeding grounds of this fish species. In sub-area 11 the krill is the dominant prey species of the minke whale.

INTRODUCTION

The JARPN (Japanese Whale Research Program under Special Permit in the North Pacific) was designed by the Government of Japan (Government of Japan, 1994) with the aim to elucidate the stock structure of the western North Pacific minke whale. The first survey was conducted in 1994 as a feasibility study, and the actual survey started in 1995. The objective of this program is directly related with the questions on stock identity derived from the Working Group on North Pacific Minke Whale Management Trials (IWC, 1994). It was necessary to clarify (1) whether the W-stock exist and (2) whether sub-stocks exist within the O stock.

In 1994 and 1995, the researches were conducted in a part of sub-area 9 (157° E -170° E) (Fujise *et al.*, 1995, 1996). A total of 121 whales were sampled during these cruises. The results of different analyses for these samples revealed the following: 1) mature male animals were dominant in the samples, few mature females and immature animals were found in this sub-area (Fujise *et al.*, 1995, 1996); 2) most of eight foetuses collected from pregnant females showed conception dates similar to that of O stock animals (Fujise *et al.*, 1995, 1996); 3) similar accumulation levels of heavy metals and organochlorines were observed in sub-areas 7 and 9 (Fujise, 1996); 4) analysis of external measurements of minke whales could not detect substantial differences between sub-areas 7 and 9 (Fujise and Kato, 1996); 5) mtDNA haplotypes composition of minke whales in sub-area 9 was similar to that of individuals taken in sub-area 7 by past Japanese coastal whaling operations (Goto and Pastene, 1997a); 6) allozyme analysis revealed no significant differences between sub-areas 7 and 9 (Wada, 1996).

None of the studies showed evidences supporting the occurrence of a hypothetical 'W' stock in sub-area 9 and the results obtained were consistent with the hypothesis that whales from sub-area 7 and 9 belong to the same stock (the O stock). Given these results derived from the surveys in sub-area 9 in 1994 and 1995, the Government of Japan decided to address the question of sub-stock structure within the O stock (Government of Japan, 1996).

In addition, the research plan for the 1996 JARPN incorporated a new objective related with the feeding ecology of the minke whales (Government of Japan, 1996). In the western North Pacific, dramatic changes in the availability of pelagic fish stocks (from sardine to Pacific saury) occurred during 1980s and 1990s. These fish species are major food sources for minke whales. This interaction should be investigated. The information on feeding ecology is also important for interpretation of results on pollutants, parasites, and stable isotope analyses. Because they are primarily originated in the whale's food. To cover such objective, in addition to Japanese specialists, a Norwegian scientist with experience in feeding ecology studies in the North Atlantic minke whale, also participated in the 1996 surveys.

In this report we present an outline of the 3rd cruise of the JARPN, which was conducted from 7 July to 17 September in 1996. We also present the results of preliminary biological analyses of data obtained during three JARPN surveys (1994-1996).

OUTLINE OF THE 1996 JARPN SURVEY

Research area and survey period

The research area was defined as parts of sub-areas 7, 8 and 11 established by the IWC,

excluding the EEZ zones of foreign countries. Furthermore sub-area 7 was divided into east (7E, no past commercial operation) and west (7W, one of the traditional whaling grounds). The boundary between 7E and 7W was defined by a line linking the following three points: 35° N; 143° E, 40° N; 145° E, 42° N; 146° 32'E. Fig. 1 shows these sub-areas of 1996 survey. Survey periods in each sub-area are shown below:

Sub-area	First period	Second period	Third period	
8	16 Jul. - 7 Aug.	7-13 Aug.	8-13 Sept.	35 days
7E	7 - 12 Jul.	13-15 Jul.	6-7 Sept.	11 days
7W	24 Aug. - 4 Sept.	4-5 Sept.		13 days
11	15 - 22 Aug.			8 days

The survey in the first period covered the whole sub-area 7E (north of 35°N). However, no minke whales were observed in the area between 35°N to 40°N in this period. Then, the surveys in the second and third periods were focused to the northern part of the sub-area (north of 40°N).

By the same reason, the survey in sub-area 8 was concentrated in the northern part (north of 40°N) in the first period. In the second period, the effort was applied further north in this sub-area (north of 42°N) because the southern part was almost covered by higher surface temperatures (18°C or more) and no sightings of minke whales had been recorded in the first period. In the third period effort was applied near to the northern boundary of this sub-area (because the higher probability of sighting minke whales).

In the sub-area 11 the survey was conducted in the whole sub-area.

The survey in the sub-area 7W targeted the northern part (north of 41°N) in the first period. In the second period, the survey targeted the northeastern part.

Research vessels

Same as in the previous survey in 1995 (Fujise *et al.*, 1996), *Nisshin Maru* (7,440GT) was used as a research base. The base commanded the research and engaged in biological examination of whale samples and of by-products. Three sighting/sampling vessels (SSVs): *Kyo Maru No.1* (812.08GT), *Toshi Maru No. 25* (739.92GT) and *Toshi Maru No. 18* (758.33GT), conducted sighting activities, sampling of minke whales and various experiments and observations as mentioned below. Furthermore, *Toshi Maru No. 25* engaged in oceanographic observations using XBT and in the collection of information on sea and weather conditions.

Cruise trackline

The setting manner of the cruise trackline was similar to that of the previous JARPN survey (Fujise *et al.*, 1996). The zigzag-shaped trackline was established on an arbitrary basis in each sub-area and research period, taking into consideration previous sighting information of minke whales and sea conditions. Furthermore, 'special monitoring survey (SMS)' was conducted in area where the amount of minke whales was expected to be large. Trackline in the SMS was designed to be separated from the above original trackline.

The cruise track (main course) is shown in Fig. 2 where the noon positions of the research base in each survey period are specified. The waypoints of the trackline designed are shown in Table 1. In this table the date in which the fleet passed the actual waypoints, are shown.

As in the previous JARPN survey, the research course consisted of three tracks, one main track established as in the above procedure and two parallel sub-tracks established six n.miles

apart on both sides. In the SMS, the distance between the tracks was set at four n.miles considering efficiency of sampling. Three SSVs were allocated to these tracks, and the allocation was changed every research day.

Sighting surveys

Searching procedure was similar as in the previous surveys of JARPN (Fujise *et al.*, 1995, 1996). Searching was conducted under a closing mode. Furthermore, two modes of sighting surveys were adopted (*BC and BS mode* surveys) by taking into consideration the sea condition at the time of the searching. The condition to conduct surveys under *BC mode* are similar to those established in Japanese sighting surveys conducted by the National Research Institute of Far Seas Fisheries (i.e. visibility of 2 n.miles or more and wind velocity 4 or below). The *BS mode* survey was conducted in survey conditions different from these indicated for the *BC mode* but under which, the collection of whale samples was possible. These two mode surveys are recorded separately for future analysis.

Closing was made mainly on minke whale sightings or on schools which looked like minke whales. Furthermore, closing was made on large whales species sightings, such as blue, humpback, right, fin and sperm whales. In this cases, closing were made in order to confirm species and school size, and in order to conduct some experiments.

Sampling of minke whales

Sampling activities were conducted with the aim to take 100 minke whales. All the minke whales sighted on the trackline, were approached for sampling. Furthermore, sampling effort was applied outside the established research hours (06:00-19:00), if collection of whale samples was considered as possible.

For schools at least two animals, numbering was made to all the minke whales in the school, to set sampling order randomly in accordance with the table of random numbers (Kato *et al.*, 1989). As in the previous JARPN survey the sampling was made in co-operation with three sighting/sampling vessels in this survey (Fujise *et al.*, 1996).

Experiments

On board the SSVs, the following experiments and observations were conducted:

1. Estimation of distances and angles for examination of the precision of sighting data,
2. Biopsy sampling on minke whales,
3. Satellite tagging on minke whales,
4. Photographing of natural marks for blue, humpback and right whales,
5. Behaviour patterns of blue, fin and sperm whales,
6. Oceanographic survey by means of XBT.

On board the research base, observation of marine debris were conducted from the wheelhouse. Marine debris was also investigated in the stomach contents of minke whales sampled. Furthermore, humane killing experiments were conducted onboard of both the research base and the SSVs.

RESULTS

Searching distance

The research days in sub-areas 7E, 7W, 8 and 11 were 11, 13, 35 and 8 days, respectively. The

total searching distance was 12,088.0 n.miles with 74.1% of the distance made under *BC mode* survey. Searching distances in each sub-area were 2,649.2 n.miles for sub-area 7E, 2,387.4 n.miles for sub-area 7W, 5,751.7 n.miles for sub-area 8 and 1,299.7 n.miles for sub-area 11.

The searching under *BC mode* and *BS mode* are shown in Figs. 3 and 4, respectively. In sub-areas 7E, 7W and 11, 80% or more of the distance were made under *BC mode* survey. In contrast, this value in sub-area 8 was only 64.3 %, because of bad weather condition (Appendix 1). The searching distances by one degree is also shown in Tables 2 and 3 for *BC* and *BS modes*, respectively.

Distribution of minke whales

Table 4 shows the cetacean species sighted during the 1996 JARPN, by survey mode and sub-area. A total of 171 schools/177 animals of minke whales was sighted (primary: 94/95; secondary: 77/82). Of the primary sightings, 44 schools/45 animals (47% of the total) were sighted in sub-area 11, although searching effort in this sub-area was only 10.8 % of the total searching distance. In the sub-area 7W, 25 schools/25 animals were primary sightings in 1,928 n.miles of searching under *BC mode*.

The distribution of minke whales and 'like minke whales' sighted during the survey is shown in Fig. 5. Tables 5 and 6 show the number of schools of minke whale sighted as primary sighting by searching mode by one degree in the research area. The density index (DI: the number of schools found per 100 n.miles searched under *BC mode*) by one degree is shown in Table 7. Relative high-density (DI: 2.96-7.45) was found in the area between 143°E and 144°E, and 44°N and 45°N in sub-area 11, on the eastern edge of Kitami Yamato Bank. A high index was also found in 41°N-143°E (DI: 4.54), located off Erimo Point and correspond to a mixing zone of Oyashio and Kuroshio Currents. Low density was observed in the offshore sub-areas 7E and 8.

The DI in sub-areas 7E, 7W, 8 and 11 was 0.05, 1.30, 0.72, and 3.67, respectively. Excepting for the sub-area 11, the DI values were similar or relatively lower than those for sub-area 9 found during the surveys in 1994 and 1995 (1994: 0.29-0.82, 1995: 0.41-1.45).

Distribution of other whale species

Fig. 6 shows the sighting distribution of large baleen whales such as blue, fin, sei, Bryde's and humpback whales. Only two schools of blue whales (three animals) were found in the area between 41-43°N in sub-area 8. A total of 14 schools/23 animals of fin whales was sighted, of which 9 schools/13 animals were found in the third period (September) in sub-areas 7E and 8. These whales were distributed mainly in the eastern part of sub-area 8. Large number of Bryde's whales (23 schools/27 animals) and some of sei whales were observed in the area 37-38°N, 148-150°E in sub-area 7E. Sei whales were also sighted together with Bryde's whales in July, but in September they were found in the northern part of sub-area 8. Only two schools of humpbacks were found. One was a pair of calf and mother (estimated body length was 4.0 and 13.3m) sighted in the area around WP102 (37°30'N, 150°E). The other was a single individual found in sub-area 7W.

Fig. 7 shows the distribution of sightings of sperm and Baird's beaked whales. A total of 358 schools/533 animals of sperm whales was sighted. The sperm whales were distributed in the offshore area, and no whales were found in sub-area 11 and western part of sub-area 7W. A total of 42 schools/305 animals of Baird's beaked whale were sighted. In contrast to sperm whales, Baird's beaked whales were found in coastal area such as sub-areas 7W and 11. Few whales were sighted in sub-area 8 (2 schools / 7 animals).

Sampling of minke whales

As noted above, a total of 171 schools / 177 animals of minke whales was found throughout the research period. Of them 135 schools (137 animals) were targeted for sampling, resulting in the catch of 77 minke whales. Fig. 8 shows the geographical location of sampled whales. Excepting for the western part of sub-area 11, distribution of minke whale samples were almost similar to those of their sightings. In sub-area 11, designed samples size was 30 animals. Sampling activities in this sub-area was terminated in the course of the survey, as the unexpected large number of sightings made in this sub-area. After sampling the 30 whales only sighting activity was conducted and effort was made to collect biopsy samples. Finally two skin biopsy samples were collected from two individuals.

Table 8 shows the number of minke whales sighted and sampled and their efficiencies, by sub-area. Technical sampling efficiency (the rate of sampling of targeted individuals) in this survey was 0.56 (range: 0.51- 1.00). This value was similar to that of the 1994 JARPN (sub-area9: 0.49), and lower than that of the 1995 JARPN (sub-area 9: 0.72). True sampling efficiency (the percentage of sampled individuals in all the sighted individuals) was 0.44. This value was similar to that of the 1994 JARPN (0.44) and considerable lower than that of the 1995 JARPN (0.66).

There were 60 individuals for which chasing was made but not taken, and the reasons for the failure are listed in Table 9. In the case of eleven animals (15.9%) the cause was lost sight of animals before chasing. Most of reason for missing whales during chasing was due to whale behaviours such as long diving and/or quick mobile behaviours. This reason comprised 54.5% of the failures. In sub-area 7W another reason of failures was missing the whales while waiting to finish biological survey on the research base.

Experiments and oceanographical surveys

Recording of natural marks

Photographs of natural marks were taken in the range of three n.miles in perpendicular distance to the trackline. The target species were the blue, humpback and right whales, sighted as primary sighting. This experiment was made with due consideration to the research time itinerary. As result, photographs of natural marks were obtained on one blue whale and one humpback whale.

Biopsy sampling experiment

A total of 9 schools/9 animals of minke whales was targeted for biopsy sampling experiment in sub-area 11. A total of 287 minutes was spent in this experiment. There were eight chances to shoot, of which four cases hit the whale body, with two biopsy skin samples being collected from two whales. These tissues were analysed in the mtDNA study.

Experiment to estimate distance and angle

The experiment was made using the same procedure as in the sighting surveys in the North Pacific. The full-scale experiment was conducted on 17-18 August after a rehearsal of the experiment on 7 July. A total of 192 trials were made.

Observation of behaviour in large whale species

In the case of blue, fin and sperm whales sightings, research schedule was adjusted to conduct observations on behaviour patterns and record their swimming direction, diving time and

feeding activities. This observation was conducted for 2 schools/6 animals of fin whales and 3 schools/4 animals of sperm whales. For fin whales a total of 30 times of surfacing of the whales was recorded during 106 minutes in sub-area 8. For sperm whales the observation was made in sub-area 7E, and their behaviour was recorded in 17 times during 49 minutes.

Experiment to attach satellite tagging

Efforts were made for attaching satellite tag on the body of minke whale. This experiment has been performed on the Antarctic minke whales (Nishiwaki *et al.*, 1995) with the intention to collect information such as migration pattern. As in the previous JARPN survey, it was planned to attach the tag only on one whale as a preliminary experiment. The experiment was conducted on 21 August in sub-area 11 but the objective could not be reached.

XBT observation

XBT castings and other oceanographic observations were conducted at a total of 65 points during 7 July and 13 September on board *Toshi Maru No.25*.

Observation of marine debris

Observation of marine debris was conducted on the bridge of the research base during the transit between sub-areas, and during the return. Observation totalled 54 hours and 30 minutes. Furthermore, Numerous artefacts were found in the stomach of minke whales sampled. Details on this will be reported in future.

Humane killing

Observations were made and several data were collected on the performance of rifle and harpoons as secondary measure for killing the animal. A summary of those observation and data will be presented during the 49th IWC Technical Committee meeting.

Biological research

Minke whales sampled were retrieved into the research base and biological researches (measurements and sample collections) were conducted. Table 10 shows major biological research items and the number of animals examined. Items related to the elucidation of stock structure, such as genetics, morphology, morphometry, osteology, ecology, parasite, pollution and other related items, now being surveyed in the Antarctic, were made.

In the previous two JARPN researches, the presence of *Anisakis* sp. and many other parasites were identified in the minke whales and it was expected that the research on parasites would contribute significantly to the elucidation of stock structure, especially on sub-stocks, of minke whales -- which is the major objective of the present research. As same as in the previous survey, one of us, a parasitologist (A.U.) got on board the fleet in the present research, and conducted special studies.

Products

After biological sampling was completed, all the whales were processed according to the provisions of Convention, Article VIII. Total production from all of the sampled whales was 210t (Table 11).

PRELIMINARY ANALYSES OF BIOLOGICAL INFORMATION OBTAINED DURING THE JARPN SURVEYS

Data and samples collected during the 1996 survey are analysed by experts in each field after the fleet returned to Japan. Some of the results by these studies are presented in this meeting separately. In this section, some preliminary analyses of biological data such as body length, maturity, foetal length, stomach contents and parasites are presented using data obtained from the 1996 JARPN surveys as well as including the previous JARPN surveys during 1994 and 1995 (Fujise *et al.*, 1995, 1996.).

Sex ratio and maturity status

Table 12 shows the sex ratio, the maturity rate and maturity composition in each sub-area. Fig. 9 compares the composition of sexual status of samples between sub-areas. At present time, histological examination of gonads have not been completed, especially for testis of samples in the 1996 JARPN survey. Then these animals were determined as mature or immature by taking into consideration the weight of testis. In sub-area 9, of a total of 121 minke whales caught 109 were males. Sex ratio was markedly biased toward male. Similar trend of sex ratio was observed in sub-areas 8 and 7W. In sub-area 11, a relative high proportion of females was observed, but the proportion of male was higher (63.3%). Maturity rate in males seems to differ between coastal sub-areas 7W and 11 and offshore sub-areas 8 and 9. Most of the male samples in the offshore sub-areas were mature. In the coastal sub-areas the proportion of mature males lower than that in offshore sub-areas. Maturity rate for females are around 50 – 60% in these sub-areas. This geographical difference may be caused by the segregation by sex similar to that reported for the Antarctic and North Atlantic minke whales.

Body length and length distribution

Table 13 shows the values of body length of minke whales sampled during three surveys of the JARPN by sex and sub-area. The mean body length in males was 7.4m for offshore sub-areas, and 7.1m for the coastal sub-areas. This is, due to that immature animals were distributed in the coastal sub-areas. On the other hand, no geographical trend of the length in female was observed because of small sample sizes in all sub-areas.

Fig. 10 shows the frequency of body length in each sub-area. Peak of the frequencies for male indicates a similar value for all of sub-areas (7.4m). Relatively high proportion of small male animals are observed in the coastal sub-areas. In contrast, females seem to have a wider range of body length in all sub-areas.

Foetus size (conception date)

In the 1996 JARPN survey, 14 females were sampled, of which nine were sexually matured. Of them seven had a foetus and the other two were resting. The body length of the seven foetuses was in the range of 44 to 127cm. A total of 15 foetuses were obtained during the JARPN surveys in 1994–1996. The list of foetuses is shown in Table 14 with biological data for their mothers. Eight foetuses were obtained in sub-area 9, one foetus in sub-areas 7E and 7W, respectively, and 5 foetuses in sub-area 11. Fig. 11 shows the relations between the sampling date and the body length of these foetuses, and those sampled in other sub-areas during the past Japanese coastal whaling. All foetuses were considered to have been conceived at roughly the same time as the Okhotsk-Western North Pacific stock (O stock)(e.g. winter breeding stock).

Anomaly in gonadal tissues of sampled whales

As reported in the previous JARPN surveys, anomaly was observed in testes of 13 males of 63 males sampled in 1996. The frequency of the anomaly for the period 1994-1996 is shown in Table 15. A total of 35 males presented abnormal testis and the percentage of this was 20.3% of all males sampled. The frequency was 20.2%, 50.0%, 14.3% and 5.3% for sub-areas 9, 8, 7W and 11, respectively. The value tends to be lower in sub-area 11. However, sample size was so small. These gonads were sampled and preserved in 10% formalin solution for closer examination in later days. The histological examinations on pathology are actually being examined. Further information on this feature will be presented near future.

Parasites

The parasitological survey was conducted as in the previous 1995 survey. Observations were mainly focused to blubber, stomachs, intestines, liver and pancreas of whales sampled. The parasite found were collected and preserved in appropriate ways to identify the species and to estimate the amount of parasite. These samples are examined by the experts in the laboratory after the fleet return to Japan. The detail of results will be presented in near future.

Table 16 shows the preliminary results of infection rate for parasite species such as Pennella, Cirripedia, Cyamus, Nematode (*Anisakis simplex*), Acanthocephala (*Bolbosoma niponicum*), Cestodes (*Diphyllobothrium macroovatum*, *Diplogonoporus balaenoptera*, *Tetrabothrius* sp.), Trematode (*Lecithodesmus goliath*) in each sub-area for JARPN surveys during 1994 and 1996. In the Pacific region, infection rate by Nematode (*Anisakis simplex*) was very high (96.8-100%), and the rate was somewhat lower in whales of sub-area 11. Similar trend was observed for the rate of Pennella. In contrast, the infection rate of Trematode (*Lecithodesmus goliath*) is lower in offshore sub-area (sub-area 9: 37.0%) than in coastal sub-areas. However, a more detailed quantitative analysis has not been completed yet. Further information will be presented in near future by parasitologists.

Feeding habit

In the 1996 survey, a Norwegian scientist participated in the cruise for a co-operative the feeding ecology study of North Pacific minke whales. The sieve system, which was already implemented in the Norwegian scientific research, was adopted for all whales sampled in the survey. By use this system, number of fish otolith were collected to identify species and to estimate the amount of actual feeding. A preliminary analysis on this issue is being prepared for the 49th IWC/SC meeting (Lindstrøm *et al.*, 1997)

The data recorded conventionally are analysed briefly in this report. The analysis covered major prey species, relative richness of forestomach, and freshness of their contents. Table 17 shows the composition of relative richness based on conventional classification of forestomach contents in 184 individuals during 1994 and 1996. Most of the whales sampled are in the small quantity category (less than 25%) or in the moderated category (25-49%). Only 6 individuals were in the full category (75-100%). Tamura *et al.* (in prep.) reported the no diurnal changes are observed for relative richness of forestomach of minke whales collected in the 1994 and 1995 JARPN surveys. This could suggest that minke whales have two or more times of feeding in a day.

Table 18 shows the major prey species in the forestomach and their frequencies in the JARPN surveys. A list of new prey species for the North Pacific minke whales in the JARPN surveys are newly added: Chub mackerel (*Scomber japonicus*), walleye pollock (*Theragra chalcogramma*), Northern Japanese sand lances (*Ammodytes hexapterus*) and Japanese common squids (*Todarodes pacificus*). However, the former two species are already reported

for the minke whales around Japan, which were collected by the past coastal whaling operations (Kasamatsu and Tanaka, 1992).

Fig. 12 compares the composition of dominant prey species for minke whales in the sub-area. In the Pacific sub-areas (sub-areas 7W, 7E, 8 and 9), Pacific saury (*Cololabis saira*) was the dominant prey species (61.5-100%), and Japanese anchovy (*Engraulis japonicus*) was the second dominant species (14.0-26.7%). In the southern Okhotsk Sea (sub-area 11), minke whales mainly feed on krill (*Euphausia pacifica*). These geographical differences of major prey species are same as the previous report for the coastal region of Japan (Kasamatsu and Tanaka, 1992). However, these authors did not report the importance of pacific saury as prey species for minke whales in the previous period (1950's to 1987). This maybe reflect the exchange of dominant species in the pelagic biocenosis of the Japanese coastal water (probably western part of North Pacific) as suggested by the previous authors.

Relationship between minke whales and fishing ground of Pacific saury

As mentioned above, it was clear that the Pacific saury was dominant prey species for minke whales in the North Pacific from the examination of their stomach contents. This relationship was also clear from information on fishing ground of the Pacific saury. Fig. 13 shows the positions of minke whales sightings in sub-area 7W in the survey conducted during 24 August and 5 September 1996. This figure also shows locations of commercial fishing grounds of Pacific saury during 22 August and 8 September 1996. The information of the fishing grounds was obtained from the Telex Nos. 27 –33 on fishing grounds off the Pacific coast of eastern Hokkaido by the Fishing Information Service Centre in Japan.

In this season, the fishing grounds were two spots off south of Erimo, and one off Kushiro and one off Nemuro in 22-25 August. After that, the spots off Erimo Point disappeared and the ground off Kushiro and Nemuro was combined and expanded until September. These fishing grounds were formed at mainly 12-13°C of surface temperatures. Most of the minke whales sightings occurred close to these fishing grounds. This event emphasised the relationship between minke whales and Pacific saury in the northwestern part of North Pacific.

DISCCUSSION

The 1996 JARPN survey targeted the sub-areas 7, 8 and 11. As a result, 77 minke whales were sampled. These samples give us new information on the current status of the stock structure of minke whales as well as other information such as pollution and food habitat. Preliminary analyses of some biological information revealed that the minke whales in the western part of Pacific area (sub-areas 7, 8 and 9) have similar reproductive cycle, food habitat and infection rate of parasite such as Anisakis. These results coincide with these of previous studies, which compared sub-areas 7 and 9: mtDNA, isozyme, accumulation of pollutants and external characters (Goto and Pastene, 1997a; Wada, 1996; Fujise, 1996; Fujise and Kato, 1996). Then these results are consistent with the hypothesis that minke whales from sub-areas 7, 8 and 9 belong to the same O stock.

In sub-area 11 it was known that animals from the J and O stocks mix in April. The mtDNA analysis using samples from the 1996 JARPN revealed the J stocks animals could be also found in this sub-area late in the season (August) (Goto and Pastene 1997b; Pastene *et al.* 1997). This requires further the investigation.

The biological analysis revealed differences between coastal and offshore sub-areas in both reproductive status of the animals and food preferences. Segregation by sex and maturity

stage had been already reported for the North Pacific minke whale (Matsuura, 1936; Omura and Sakiura, 1956; Ohsumi, 1983; Wada, 1989). This is confirmed with the analysis of JARPN samples. For example a higher proportion of mature females was observed in sub-area 11 than in the Pacific sub-areas, and in the latter sub-areas mature males were dominant.

With regard the feeding habit, the predominant prey species in sub-area 11 was the krill while in the Pacific sub-areas was the Pacific saury. It was already reported that the North Pacific minke whale fed a large variety of prey species (Omura and Sakiura, 1956; Kasamatsu and Hata, 1985; Kasamatsu and Tanaka, 1992). Differences in prey species between sub-area 11 and the other sub-areas should be taken into account for the interpretation of results of studies on parasites incidence, as well accumulation of pollutants such as Hg and PCBs. Further surveys should be conducted in sub-areas 11 and 12 before conclusion on the sub-stocks scenario hypothesis. And also the examination on the hypothesis should be conducted based on multi-field studies.

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Table 1. Summary of cruise track of the 1996 JARPN survey

Stratum	Way point			Course direction	Distance (n. miles)	Date
Sub-area 7E	WP101	35°-00'N	143°-00'E	66	371.2	7 July
(First period)	WP102	37°-30'N	150°-00'E	305	259.6	9 July
	WP103	40°-00'N	145°-29'E	54	97.7	12 July
	WP104	40°-58'N	147°-12'E			
(Second period)	WP201	41°-30'N	146°-16'E	130	47.0	13 July
	WP202	41°-00'N	147°-04'E	243	67.0	13 July
	WP203	40°-30'N	145°-45'E	109	90.8	13 July
	WP204	40°-00'N	147°-37'E	75	113.5	14 July
	WP205	40°-30'N	150°-00'E	321	38.6	15 July
	WP206	41°-00'N	149°-28'E			15 July
Sub-area 8	WP301	41°-25'N	150°-11'E	124	44.6	16 July
(First period)	WP302	41°-00'N	151°-00'E	237	54.6	17 July
	WP303	40°-30'N	150°-00'E	123	54.9	17 July
	WP304	40°-00'N	151°-00'E	57	109.4	18 July
	WP305	41°-00'N	153°-00'E	304	101.1	19 July
	WP306	41°-56'N	151°-08'E	54	159.0	20 July
	WP307	43°-29'N	154°-03'E	125	50.8	22 July
	WP308	43°-00'N	155°-00'E	236	107.1	22 July
	WP309	42°-00'N	153°-00'E	124	108.3	25 July
	WP310	41°-00'N	155°-00'E	237	109.4	30 July
	WP311	40°-00'N	153°-00'E	90	92.2	31 July
	WP312	40°-00'N	155°-00'E	57	109.4	31 July
	WP313	41°-00'N	157°-00'E	304	108.3	1 August
	WP314	42°-00'N	155°-00'E	56	107.1	2 August
	WP315	43°-00'N	157°-00'E	304	104.2	3 August
	WP316	43°-59'N	155°-02'E	54	104.2	4 August
	WP317	45°-00'N	157°-00'E			7 August
(Second period)	WP401	45°-22'N	156°-50'E	180	202.0	7 August
	WP402	42°-00'N	156°-50'E	270	25.4	9 August
	WP403	42°-00'N	156°-16'E	360	160.0	9 August
	WP404	44°-40'N	156°-16'E	234	30.3	11 August
	WP405	44°-22'N	155°-42'E	180	142.0	11 August
	WP406	42°-00'N	155°-42'E	270	25.4	12 August
	WP407	42°-00'N	155°-08'E	360	125.0	12 August
	WP408	44°-05'N	155°-08'E	234	30.5	13 August
	WP409	43°-47'N	154°-34'E	180	107.0	13 August
	WP410	42°-00'N	154°-34'E	270	25.0	
SMS-A	WPA1	42°-43'N	153°-53'E	270	37.6	23 July
	WPA2	42°-43'N	153°-02'E	360	20.0	23 July
	WPA3	43°-03'N	153°-02'E	90	45.5	24 July
	WPA4	43°-03'N	154°-04'E	180	20.0	24 July
	WPA5	42°-43'N	154°-04'E			24 July
SMS-B	WPB1	41°-45'N	154°-04'E	90	71.9	26 July
	WPB2	41°-45'N	155°-40'E	360	25.0	26 July
	WPB3	42°-10'N	155°-40'E	270	80.3	26 July
	WPB4	42°-10'N	153°-52'E	180	25.0	29 July
	WPB5	41°-45'N	153°-52'E			29 July

SMS: Special monitoring survey

Table 1. (Continued)

Stratum	Way point			Course direction	Distance (n. miles)	Date
Sub-area 11	WP501	44°-22'N	145°-12'E	23	27.2	15 August
	WP502	44°-47'N	145°-27'E	233	60.0	16 August
	WP503	44°-11'N	144°-20'E	27	83.4	17 August
	WP504	45°-25'N	145°-14'E	228	95.1	19 August
	WP505	44°-21'N	143°-35'E	20	47.9	20 August
	WP506	45°-06'N	143°-58'E	238	47.0	21 August
	WP507	44°-41'N	143°-02'E	14	38.1	21 August
	WP508	45°-18'N	143°-15'E	248	29.7	22 August
	WP509	45°-07'N	142°-36'E	351	22.3	22 August
	WP510	45°-29'N	142°-31'E			22 August
SMS-C	WPC1	44°-40'N	144°-04'E	48	29.8	20 August
	WPC2	45°-00'N	144°-35'E	180	20.0	20 August
	WPC3	44°-40'N	144°-35'E	270	22.1	20 August
	WPC4	44°-40'N	144°-04'E			20 August
Sub-area 7W	WP601	41°-49'N	141°-27'E	19	41.2	24 August
(First period)	WP602	42°-28'N	141°-45'E	166	90.8	24 August
	WP603	41°-00'N	142°-15'E	19	67.8	25 August
	WP604	42°-04'N	142°-45'E	157	58.8	25 August
	WP605	41°-10'N	143°-15'E	15	87.9	26 August
	WP606	42°-35'N	143°-45'E	167	97.6	27 August
	WP607	41°-00'N	144°-15'E	11	113.2	28 August
	WP608	42°-51'N	144°-45'E	169	113.2	30 August
	WP609	41°-00'N	145°-15'E	10	130.9	2 September
	WP610	43°-09'N	145°-45'E			4 September
(Second period)	WP701	43°-03'N	145°-31'E	175	46.1	4 September
	WP702	42°-17'N	145°-36'E	301	71.0	5 September
	WP703	42°-54'N	144°-14'E	164	71.6	5 September
	WP704	41°-45'N	144°-40'E			
SMS-D	WPD1	41°-50'N	144°-48'E	270	43.4	31 August
	WPD2	41°-50'N	143°-50'E	360	20.0	31 August
	WPD3	42°-10'N	143°-50'E	90	52.1	31 August
	WPD4	42°-10'N	145°-00'E			31 August
SMS-E	WPE1	42°-10'N	145°-14'E	360	37.0	1 September
	WPE2	42°-47'N	145°-14'E	260	49.5	1 September
	WPE3	42°-38'N	144°-08'E	180	21.0	1 September
	WPE4	42°-17'N	144°-08'E			1 September
Sub-area 7E	WP801	41°-42'N	146°-22'E	155	129.1	6 September
(Third period)	WP802	39°-45'N	147°-34'E	55	136.1	7 September
	WP803	41°-03'N	150°-00'E			
Sub-area 8	WP803	41°-03'N	150°-00'E	53	387.4	8 September
(Third period)	WP804	44°-58'N	157°-00'E	233	13.3	11 September
	WP805	44°-50'N	156°-45'E	180	38.0	11 September
	WP806	44°-12'N	156°-45'E	233	376.4	11 September
	WP807	40°-25'N	150°-00'E			

Table 2. Searching distances (n. miles) under *BC mode* survey by one degree

	Longitude																
	140° E	141° E	142° E	143° E	144° E	145° E	146° E	147° E	148° E	149° E	150° E	151° E	152° E	153° E	154° E	155° E	156° E	Total
45° N			118.5	124.3	67.1	16.2											86.0	412.1
44° N			11.4	243.1	472.3	63.7										168.1	577.4	1,536.0
43° N						25.2							5.5	246.3	293.8	377.5	105.5	1,053.8
42° N		28.4	21.3	102.9	358.3	416.7						94.5	147.8	501.8	141.0	241.7	108.5	2,162.9
41° N		61.6	358.8	220.2	306.9	27.7	247.9	3.7				26.7	11.3	131.7	118.8	125.8	11.3	1,652.4
40° N						54.1	312.0	262.0	145.8	176.6	137.0	25.8	4.4				12.1	1,129.8
39° N							7.8	102.6										110.4
38° N								89.2	46.8	7.6								143.6
37° N									51.3	258.9								310.2
36° N							143.9	132.3	13.9									290.1
35° N				89.9	65.4													155.3
Total	0.0	90.0	510.0	780.4	1,270.0	603.6	711.6	589.8	257.8	443.1	137.0	147.0	169.0	879.8	553.6	913.1	900.8	8,956.6

Table 3. Searching distances (n. miles) under *BS mode* survey by one degree

	Longitude																	
	140° E	141° E	142° E	143° E	144° E	145° E	146° E	147° E	148° E	149° E	150° E	151° E	152° E	153° E	154° E	155° E	156° E	Total
45° N					9.2	38.1												47.3
44° N					63.0	72.8										61.3	14.3	211.4
43° N														74.5	79.8	106.6	366.1	627.0
42° N		131.6	9.4	18.8	168.2	59.9						20.4	157.7	85.7	105.9	143.5	300.8	1,201.9
41° N		30.9	2.0	13.8	6.3	18.5				4.3	46.5	131.7	66.9		57.1	15.4	23.7	417.1
40° N						81.9	17.8	10.4	8.1	57.6	73.8	26.0		27.8	3.5	3.5	54.6	365.0
39° N						82.9	9.6	22.2	6.1					4.3				125.1
38° N								14.0	61.3									75.3
37° N																		0.0
36° N						7.2	8.2											15.4
35° N				12.6	26.1	2.3	4.9											45.9
Total	0.0	162.5	11.4	45.2	272.8	363.6	40.5	46.6	75.5	61.9	120.3	178.1	224.6	192.3	246.3	330.3	759.5	3,131.4

Table 4. List of cetacean species sighted during the 1996 JARPN (no. schools/no. individuals) by sub-area and searching mode.

Species	BC mode[1]		BS mode[1]		OE
	Primary	Secondary	Primary	Secondary	Secondary
	Sch. / Ind.	Sch. / Ind.	Sch. / Ind.	Sch. / Ind.	Sch. / Ind.
Sub-area 8					
Minke whale	17 / 17	2 / 2	7 / 7	2 / 2	5 / 5[2]
Like minke whale		1 / 1	1 / 1		4 / 4[3]
Blue whale	2 / 3				
Fin whale	10 / 18		1 / 1		
Sei whale	4 / 7	1 / 1	1 / 1		1 / 2
Sperm whale	172 / 207	25 / 28	32 / 34	10 / 11	9 / 10
Killer whale	10 / 65		2 / 9		1 / 5
Baird's beaked whale	2 / 7				
Unidentified Mesoplodon	3 / 6			1 / 1	
Unidentified Ziphiidae	17 / 34		6 / 9	1 / 1	1 / 3
Dall's porpoise	77 / 460	8 / 39	59 / 324	6 / 22	19 / 68
dalli type	40 / 270	4 / 19	31 / 175	3 / 7	16 / 62
truei type					1 / 1
Black type			1 / 2		
Unidentified type	37 / 190	4 / 20	27 / 147	3 / 15	2 / 5
Pacific white-sided dolphin	25 / 4,442		18 / 793	2 / 5	20 / 1,076
Right whale dolphin	8 / 920		9 / 1,690		8 / 264
Common dolphin					2 / 30
Risso's dolphin	1 / 210			1 / 5	
Unidentified pilot whales	1 / 1				
Unidentified large cetacean	6 / 8	2 / 4	1 / 1		1 / 1
Unidentified small cetacean	3 / 3	1 / 1	1 / 1		
Unidentified dolphin	59 / 929	13 / 170	30 / 203	5 / 65	1 / 2
Unidentified cetacean	35 / 38	5 / 5	17 / 18	1 / 1	4 / 4
Sub-area 7W					
Minke whale	25 / 25	22 / 22			20 / 21[4]
Like minke whale	4 / 4	1 / 1	2 / 2	1 / 1	3 / 3[5]
Sei whale	1 / 1				
Humpback whale	1 / 1				
Sperm whale	49 / 90	3 / 5	1 / 1		13 / 19
Killer whale	6 / 72		1 / 2		
Baird's beaked whale	19 / 168	2 / 11	2 / 10		
Unidentified Mesoplodon	1 / 2				
Unidentified Ziphiidae	10 / 27				
Dall's porpoise	55 / 339	4 / 30	12 / 57	1 / 5	6 / 28
dalli type	15 / 70	2 / 24			2 / 5
truei type	2 / 12				3 / 20
Black type	1 / 4				
Unidentified type	37 / 253	2 / 6	12 / 57	1 / 5	1 / 3
Pacific white-sided dolphin	7 / 1,216				1 / 300
Right whale dolphin	1 / 50				
Unidentified pilot whales	2 / 16				
Unidentified large cetacean	3 / 15			1 / 5	
Unidentified small cetacean			1 / 1		
Unidentified dolphin	21 / 450	1 / 30	5 / 30	1 / 40	
Unidentified cetacean	11 / 11	1 / 1	2 / 2	1 / 1	1 / 1

Table 4. (Continued).

Species	BC mode		BS mode		OE
	Primary	Secondary	Primary	Secondary	Secondary
	Sch. / Ind.	Sch. / Ind.	Sch. / Ind.	Sch. / Ind.	Sch. / Ind.
Sub-area 7E					
Minke whale	1 / 1				
Like minke whale	1 / 1				
Fin whale	3 / 4				
Sei whale	4 / 5				
Bryde's whale	23 / 27				
Humpback whale	1 / 2				
Sperm whale	38 / 118	1 / 2	2 / 3		3 / 5
Killer whale			1 / 5		
Cuvier's beaked whale	1 / 2				
Unidentified Mesoplodon	1 / 2				
Unidentified Ziphiidae	11 / 16		3 / 5		
Dall's porpoise	15 / 66		11 / 37	2 / 7	1 / 3
dalli type	8 / 41		4 / 12		
truei type	2 / 5				1 / 3
Unidentified type	5 / 20		7 / 25	2 / 7	
Common dolphin	30 / 2,830	2 / 8	9 / 1,230		2 / 280
Striped dolphin	16 / 2,780		4 / 390		1 / 150
Spotted dolphin	2 / 380				
Bottlenose dolphin	3 / 90				
False killer whale	2 / 17				
Risso's dolphin	6 / 55				
Unidentified pilot whales	3 / 20				
Unidentified large cetacean	1 / 1	1 / 1			
Unidentified dolphin	61 / 1,913	1 / 3	6 / 328		
Unidentified cetacean	20 / 22		3 / 3		
Sub-area 11					
Minke whale	41 / 42	11 / 11	3 / 3		15 / 19[6]
Like minke whale	2 / 2	1 / 1			2 / 2[7]
Killer whale	1 / 3	1 / 2			
Baird's beaked whale	9 / 67	6 / 31	1 / 6		1 / 5
Unidentified Ziphiidae	1 / 1				
Dall's porpoise	20 / 95	3 / 14	5 / 20		4 / 47
dalli type	6 / 36		2 / 5		3 / 32
Unidentified type	14 / 59	3 / 14	3 / 15		1 / 15
Pacific white-sided dolphin	10 / 915				
Unidentified small cetacean	2 / 17				
Unidentified dolphin	21 / 904	5 / 56			1 / 80
Unidentified cetacean	16 / 29	4 / 4	1 / 1	3 / 3	2 / 2

[1]: See text

[2]: including 3 secondary sightings (3 whales) by research base

[3]: including 1 secondary sightings (1 whales) by research base

[4]: including 9 secondary sightings (10 whales) by research base

[5]: including 2 secondary sightings (2 whales) by research base

[6]: including 7 secondary sightings (11 whales) by research base

[7]: including 1 secondary sightings (1 whales) by research base

Table 5. Distribution of primary sighting of minke whale under *BC mode* searching by one degree

A. School base

	Longitude																					
	140°E	141°E	142°E	143°E	144°E	145°E	146°E	147°E	148°E	149°E	150°E	151°E	152°E	153°E	154°E	155°E	156°E	Total
45°N			1	7	5	0											0	13
44°N			0	12	14	2										0	3	31
43°N						0							0	2	1	1	0	4
42°N		0	0	2	4	5						0	1	3	2	0	1	18
41°N		0	1	10	3	0	1	0				0	0	2	1	0	0	18
40°N						0	0	0	0	0	0	0	0				0	0
39°N							0	0										0
38°N								0	0	0								0
37°N									0	0								0
36°N							0	0	0									0
35°N				0	0													0
Total	0	0	2	31	26	7	1	0	0	0	0	0	1	7	4	1	4	94

B. individual base

	Longitude																	
	140°E	141°E	142°E	143°E	144°E	145°E	146°E	147°E	148°E	149°E	150°E	151°E	152°E	153°E	154°E	155°E	156°E	Total
45°N			1	7	5	0											0	13
44°N			0	13	14	2										0	3	32
43°N						0							0	2	1	1	0	4
42°N		0	0	2	4	5						0	1	3	2	0	1	18
41°N		0	1	10	3	0	1	0				0	0	2	1	0	0	18
40°N						0	0	0	0	0	0	0	0				0	0
39°N							0	0										0
38°N								0	0	0								0
37°N									0	0								0
36°N							0	0	0									0
35°N				0	0													0
Total	0	0	2	32	26	7	1	0	0	0	0	0	1	7	4	1	4	95

Table 6. Distribution of primary sighting of minke whale under *BS mode* searching by one degree

A. School base

	Longitude																	
	140°E	141°E	142°E	143°E	144°E	145°E	146°E	147°E	148°E	149°E	150°E	151°E	152°E	153°E	154°E	155°E	156°E	Total
45°N					0	0												0
44°N					2	1										0	0	3
43°N														1	0	0	0	1
42°N		0	0	0	0	0						0	2	2	1	0	1	6
41°N		0	0	0	0	0				0	0	0	0		0	0	0	0
40°N						0	0	0	0	0	0	0		0	0	0	0	0
39°N						0	0	0	0					0				0
38°N								0	0									0
37°N																		0
36°N						0	0											0
35°N				0	0	0	0											0
Total	0	0	0	0	2	1	0	0	0	0	0	0	2	3	1	0	1	10

B. individual base

	Longitude																	
	140°E	141°E	142°E	143°E	144°E	145°E	146°E	147°E	148°E	149°E	150°E	151°E	152°E	153°E	154°E	155°E	156°E	Total
45°N					0	0												0
44°N					2	1										0	0	3
43°N														1	0	0	0	1
42°N		0	0	0	0	0						0	2	2	1	0	1	6
41°N		0	0	0	0	0				0	0	0	0		0	0	0	0
40°N						0	0	0	0	0	0	0		0	0	0	0	0
39°N						0	0	0	0					0				0
38°N								0	0									0
37°N																		0
36°N						0	0											0
35°N				0	0	0	0											0
Total	0	0	0	0	2	1	0	0	0	0	0	0	2	3	1	0	1	10

Table 7. Density indices (no. of schools/100 n.miles) of minke whales sighted under *BC mode* searching by one degree.

	Longitude																
	140°E	141°E	142°E	143°E	144°E	145°E	146°E	147°E	148°E	149°E	150°E	151°E	152°E	153°E	154°E	155°E	156°E	Total
45°N			0.84	5.63	7.45	0.00											0.00	3.15
44°N			0.00	4.94	2.96	3.14										0.00	0.52	2.02
43°N						0.00							0.00	0.81	0.34	0.26	0.00	0.38
42°N		0.00	0.00	1.94	1.12	1.20						0.00	0.68	0.60	1.42	0.00	0.92	0.83
41°N		0.00	0.28	4.54	0.98	0.00	0.40	0.00				0.00	0.00	1.52	0.84	0.00	0.00	1.09
40°N						0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00				0.00	0.00
39°N							0.00	0.00										0.00
38°N								0.00	0.00	0.00								0.00
37°N									0.00	0.00								0.00
36°N							0.00	0.00	0.00									0.00
35°N				0.00	0.00													0.00
Total		0.00	0.39	3.97	2.05	1.16	0.14	0.00	0.00	0.00	0.00	0.00	0.59	0.80	0.72	0.11	0.44	0.94

Table 8. Numbers of minke whales sighted, targeted and sampled, and their sampling efficiencies

Sub-area	Sighted		Targeted		Sampled	Sampling efficiencies	
	Sch. (A)	Ind. (B)	Sch. (C)	Ind. (D)	Ind. (E)	Technical (E/D)	True (E/B)
8	33	33	31	31	16	0.52	0.48
7E	1	1	1	1	1	1.00	1.00
7W	67	68	59	59	30	0.51	0.44
11	70	75	44	46	30	0.65	0.40
Total	171	177	135	137	77	0.56	0.44

Table 9. Cause of failure to collect samples targeted by sub-area.
A: long diving; B: quick mobile behavior; C: rough sea condition; D: technical problems; E: missing of the targeted animal before chasing; F: other

Sub-area	Reason why whales could not be sampled						Total
	A	B	C	D	E	F	
8	6	3	0	0	3	3	15
7E	0	0	0	0	0	0	0
7W	7	8	0	1	4	9	29
11	3	4	0	1	4	4	16
Combined	16	15	0	2	11	16	60

Table 10. Summary of biological data and samples collected

Samples and data	Number of whales		
	Male	Female	Total
Body length and sex	63	14	77
External body proportion	63	14	77
Photographic record and external character	63	14	77
Diatom film record and sampling	63	14	77
Standard measurements of blubber thickness (three points)	63	14	77
Detailed measurements of blubber thickness	18	3	21
Body weight	63	14	77
Body weight by parts	18	3	21
Blubber, muscle, liver and kidney tissues for DNA study	63	14	77
Muscle, liver and heart tissues for isozyme analysis	63	14	77
Muscle, liver and kidney tissues for heavy metal analysis	63	14	77
Blubber, muscle, liver and kidney tissues for organochlorine analysis	63	14	77
Tissues for lipid analysis	18	3	21
Mammary grand ; lactation status , measurements and histlogical sample	-	14	14
Uterine horn ; measurement and endometrium sample	-	14	14
Uterine mucus for sperm detection	-	14	14
Photographic record of foetus	(1)	(6)	(7)
Foetal sex (identified by visual observation)	(1)	(6)	(7)
Foetal length and weight	(1)	(6)	(7)
External measurements of foetus	(1)	(6)	(7)
Foetal tissues for genetic study	(1)	(5)	(6)
Collection of foetus	(0)	(1)	(1)
Testis and epididymis ; weight and histrogical sample	63	-	63
Smear samples from testis and epididymis tissues	63	-	63
Urine sample for sperm detection	51	-	51
Urine sample for physiological study	5	6	11
Serum sample for physiological study	63	14	77
Stomach content, conventional record	63	14	77
Weight of stomach content in each compartment	62	14	76
Collection of stomach contents for heavy metal analysis	23	1	24
Collection of stomach contents for lipid analysis	5	0	5
Collection of external parasites	19	0	19
Collection of parasites from 1st stomach	5	1	6
Collection of parasites from 2nd stomach	19	2	21
Collection of parasites from 3rd stomach	12	1	13
Collection of parasites from 4th stomach	2	1	3
Collection of parasites from intestine	14	3	17
Collection of parasites from liver	8	1	9
Earplug for age determination	63	14	77
Tympanic bulla for age determination	62	14	76
Largest baleen plate for stock identification	63	14	77
Vertebral ephiphysis sample	63	14	77
Skull measurement (length and breadth)	61	14	75
Detailed measurement of skull	5	2	7
Detailed measurement of skull and skeleton	1	1	2

Table 11. List of by-products in the 1996 JARPN survey.

Name of by-product	Amount (kg)	Name of by-product	Amount (kg)
O-niku*	375	Throat mottled meat	1,247
O-niku* (regular)	495	Bacon (grade 1)	7,952
Ventral blubber (neck)	75	Bacon (grade 2)	27
Jaw skin (mottled)	150	Bacon (small pieces)	2,943
Jaw skin (regular)	150	Ventral blubber	770
Red meat (premium)	495	Blubber (premium)	0
Red meat (grade 1)	42,360	Blubber (grade 1)	13,234
Red meat (grade 2)	5,220	Kidney	546
Red meat (regular)	1,290	Heart	616
Small pieces (grade 1)	7,755	Pancreas	95
Small pieces (grade 2)	5,655	Esophagus	117
Small pieces (regular)	7,365	Mandibular ligaments (hard)	299
Breast meat (grade 1)	8,055	Mandibular ligaments (soft)	156
Breast meat (grade 2)	19,395	Tongue (mottled)	286
Breast meat (grade 3)	43,410	Tongue	2,678
Breast meat (regular)	810	Tongue (regular)	0
Diaphragm	975	First stomach	325
Blubber (regular)	9,450	Intestine	0
Posterior ventral blubber	10,950	Underside of blubber	2,513
Nasal plug	525	Lining of meat	1,925
Tail flukes (premium)	3,450	Testis	24
Tail flukes (regular)	500	Caudal tendon	546
Maxillary cartilage	200	Tendon	5,292

*: Muscles associated with caudal vertebra.

Table 12. Compositon of sex and sexual maturity of minke whales sampled collected by the JARPN surveys during 1994 and 1996.

Survey year	Sub-area	no. samples	Male		Female		Total	Sex ratio (% males)	Maturity	
			Imm.	Mat.	Imm.	Mat.			Male	Female
1994-1995	9	121	3 (2.5)	106 (87.6)	4 (3.3)	8 (6.6)	121 (100)	90.1	97.2	66.7
1996	8	16	1 (6.3)	15 (93.8)	- -	- -	16 (100)	100	93.8	-
	7E	1	- -	- -	- -	1 (100)	1 (100)	0	-	100
	7W	30	7 (23.3)	21 (70.0)	1 (3.3)	1 (3.3)	30 (100)	93.3	75.0	50.0
	11	30	3 (10.0)	16 (53.3)	4 (13.3)	7 (23.3)	30 (100)	63.3	84.2	63.6

Figure in parenthes indicate percentage to the total

Table 13. Mean body length of minke whales taken in the JARPN surveys during 1994 and 1996.

	Male				Female			
	Mean	S.D.	Range	n	Mean	S.D.	Range	n
1994 survey								
9	7.39	± 0.42	(6.12 - 8.09)	18	6.47	± 1.20	(4.79 - 7.55)	3
1995 survey								
9	7.38	± 0.48	(4.54 - 8.40)	91	7.54	± 0.75	(5.73 - 8.18)	9
1996 survey								
8	7.40	± 0.41	(6.42 - 7.92)	16				0
7E				0	7.93		(7.93 - 7.93)	1
7W	7.03	± 0.81	(4.66 - 7.84)	28	7.87	± 0.82	(7.29 - 8.45)	2
11	7.14	± 0.61	(5.14 - 7.67)	19	7.05	± 1.21	(4.67 - 8.29)	11
Combined	7.16	± 0.68	(4.66 - 7.92)	63	7.23	± 1.15	(4.67 - 8.45)	14

Table 14. Summary of pregnant females and their foetuses collected in the JARPN surveys during 1994 and 1996.

Sampling Date	Sub-area	Sample No.	Body length (m)	Blubber thickness (cm)	Fetus		
					Length (cm)	Weight (kg)	Sex
19 Aug. 1994	9	13	7.55	3.6	94.2	12.2	F
6 Jul. 1995	9	18	8.02	4.2	61.4	3.0	M
22 Jul. 1995	9	48	7.60	3.4	9.3	0.02	F
23 Jul. 1995	9	57	7.45	4.3	79.7	6.3	F
24 Jul. 1995	9	58	8.05	2.9	55.6	2.6	F
25 Jul. 1995	9	71	7.95	3.0	49.6	1.8	F
1 Aug. 1995	9	76	8.18	3.9	76.8	6.3	F
9 Aug. 1995	9	86	8.01	3.0	73.8	5.8	M
13 Jul. 1996	7E	1	7.93	2.9	44.3	1.1	F
18 Aug. 1996	11	30	7.57	3.7	91.5	9.7	M
18 Aug. 1996	11	32	7.95	4.0	89.6	9.1	F
19 Aug. 1996	11	37	8.05	5.0	127.0	27.4	F
19 Aug. 1996	11	38	8.02	4.0	67.8	4.7	F
20 Aug. 1996	11	43	7.92	4.4	94.8	12.7	F
3 Sep. 1996	7W	65	8.45	4.4	112.0	13.7	F

Table 15. Number of male whales with abnormal gonadal tissues, by sub-area.

Sub-area	n	Normal	Abnormal			
			Both side	(%)	One side	(%)
1994-1995						
Sub-area 9	109	87	5	(4.6)	17	(15.6)
1996						
Sub-area 8	16	8	1	(6.3)	7	(43.8)
Sub-area 7E	0					
Sub-area 7W	28	24	4	(14.3)	0	(0.0)
Sub-area 11	19	18	0	(0.0)	1	(5.3)
combined	63	50	5	(7.9)	8	(12.7)
Total	172	137	10	(5.8)	25	(14.5)

Table 16. Infection rate of parasitic worm in minke whale taken in the JARPN surveys during 1994 and 1996 in each sub-area.

Parasitic worm	Body part	11		7(W+E)		8		9		Total	
		Infected/ exmained	%	Infected/ exmained	%	Infected/ exmained	%	Infected/ exmained	%	Infected/ exmained	%
External parasite											
Pennella	Skin	12 / 29	41.4	16 / 30	53.3	13 / 16	81.3	90 / 121	74.4	131 / 196	66.8
Cirripedia	Skin	2 / 20	10.0	2 / 28	7.1	6 / 16	37.5	4 / 121	3.3	14 / 185	7.6
Cyamus	Skin	2 / 19	10.5	2 / 29	6.9	0 / 16	0.0	8 / 121	6.6	12 / 185	6.5
Endo parasite											
Nematode	Stomach	23 / 30	76.7	30 / 31	96.8	16 / 16	100.0	121 / 121	100.0	190 / 198	96.0
Acanthocephala	Small intestine	28 / 28	100.0	29 / 29	100.0	16 / 16	100.0	120 / 121	99.2	193 / 194	99.5
Cestoda	Small intestine	6 / 27	22.2	1 / 31	3.2	0 / 16	0.0	16 / 121	13.2	23 / 195	11.8
Trematode	Liver	21 / 30	70.0	28 / 31	90.3	10 / 16	62.5	37 / 100	37.0	96 / 177	54.2
Trematode	Pancreas	0 / 3	0.0	0 / 1	0.0			1 / 86	1.2	1 / 90	1.1

Table 17. Composition of relative richness of forestomach contents based on conventional classification by sub-area in the JARPN surveys during 1994 and 1996.

Survey year	Sub-area	Relative richness (%)					
		Empty	< 25%	25-49%	50-74%	75-100%	Total
1994-1995	9	6 (5.3%)	55 (48.2%)	31 (27.2%)	18 (15.8%)	4 (3.5%)	114
1996	8	0 (0.0%)	5 (33.3%)	6 (40.0%)	4 (26.7%)	0 (0.0%)	15
	7E	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (100%)	0 (0.0%)	1
	7W	3 (10.3%)	16 (55.2%)	2 (6.9%)	6 (20.7%)	2 (6.9%)	29
	11	3 (12.0%)	20 (80.0%)	2 (8.0%)	0 (0.0%)	0 (0.0%)	25

Table 18. Food species of North Pacific minke whales and their frequency of occurrence by sub-area

Food species		Sub-area										Combined	
		11**		7W**		7E**		8**		9*			
		n	(%)	n	(%)	n	(%)	n	(%)	n	(%)	n	(%)
Euphausiacea	Euphausiids (*Euphausia pacifica*)	22	(100)	10	(38.5)			2	(13.3)	7	(6.1)	41	(23.0)
	Euphausiids (*Thysanoessa* spp.)					1	(100)			6	(5.3)	7	(3.9)
Copepods	Copepods (*Neocalanus* spp.)									3	(2.6)	3	(1.7)
Sauries	Pacific saury (*Cololabis saira*)			15	(57.7)	1	(100)	11	(73.3)	88	(77.2)	115	(64.6)
Anchovies	Japanese anchovy (*Engraulis japonicus*)			4	(15.4)			4	(26.7)	16	(14.0)	24	(13.5)
Herrings	Japanese pilchard (*Sardinops melanostictus*)			1	(3.8)			1	(6.7)	5	(4.4)	7	(3.9)
Mackerels	Chub mackerel (*Scomber japonicus*)			3	(11.5)			1	(6.7)			4	(2.2)
Pomfrets	Japanese pomfret (*Brama japonica*)									4	(3.5)	4	(2.2)
Salmonids	Pink salmon (*Oncorhynchus gorbuscha*)									6	(5.3)	6	(3.4)
	Coho salmon (*O. kisutch*)									1	(0.9)	1	(0.6)
Daggertooths	Daggertooth (*Anotopterus pharao*)									1	(0.9)	1	(0.6)
Cods	Walleye pollock (*Theragra chalcogramma*)			5	(19.2)							5	(2.8)
Sand lances	Northern Japanese sand lances (Ammodytes hexapterus)	2	(9.1)									2	(1.1)
Squids	Japanese common squids (*Todarodes pacificus*)			3	(11.5)							3	(1.7)
No. whales observed		22	(100)	26	(100)	1	(100)	15	(100)	114	(100)	178	(100)

*: Date from the JARPN surveys in 1994 and 1995.

**: Data from the 1996 JARPN survey.

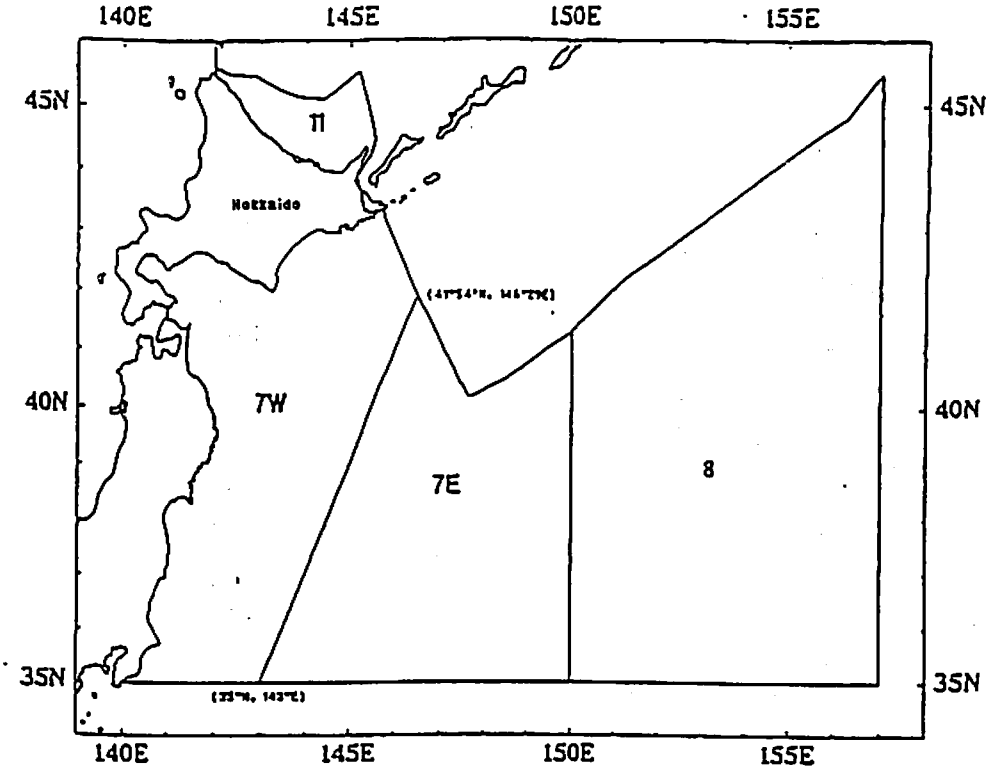


Fig. 1. Research sub-areas in the 1996 JARPN survey.

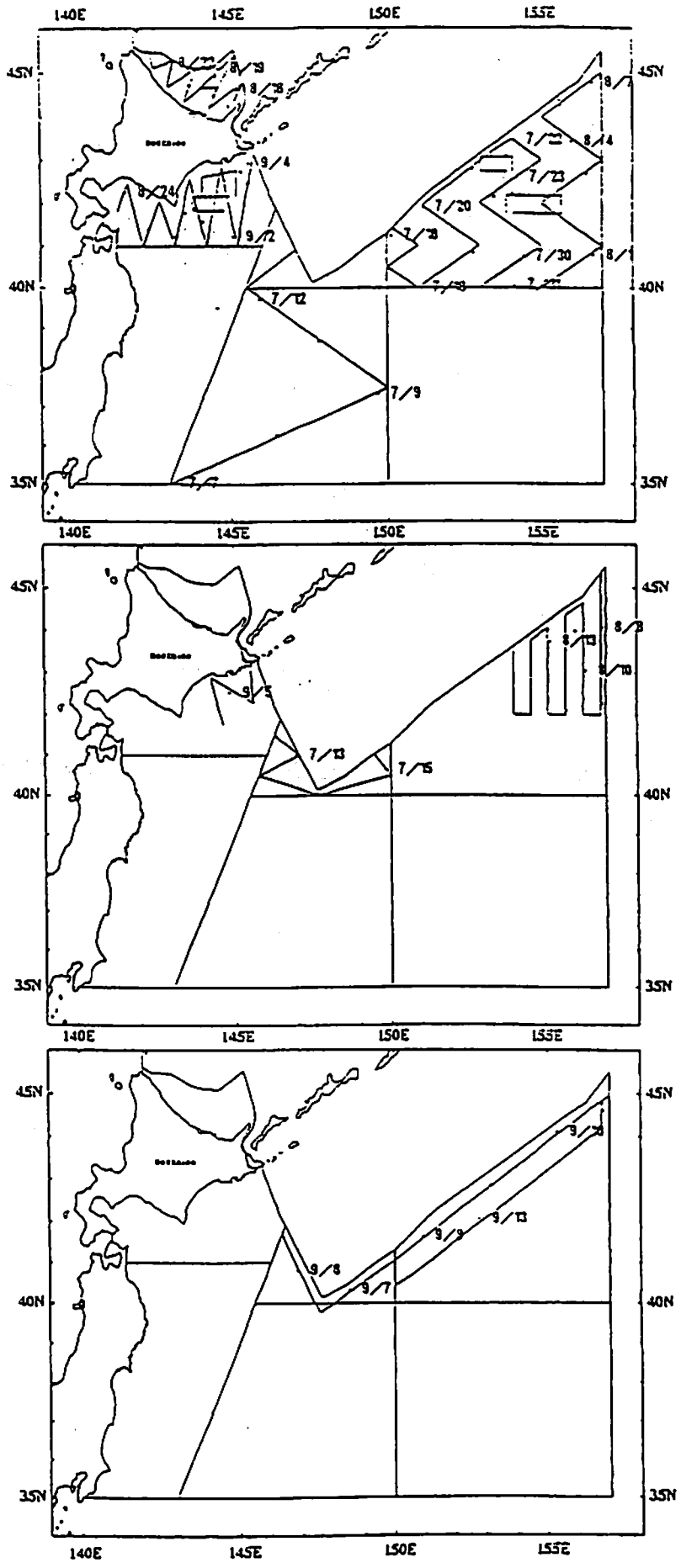


Fig. 2. Cruise track for the JARPN survey in 1996 by research period (upper: first period, middle: second period, bottom: third period). Noon positions of the research base are indicated.

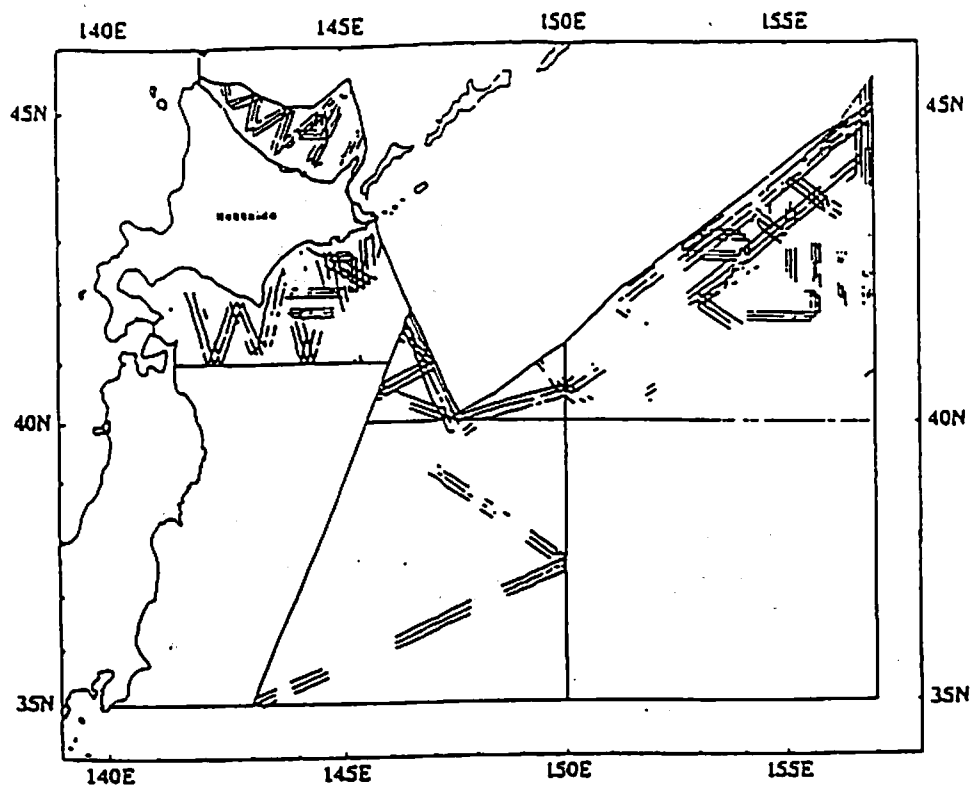


Fig. 3. Part of the cruise track conducted under *BC mode* searching (see text) during the 1996 JARPN survey.

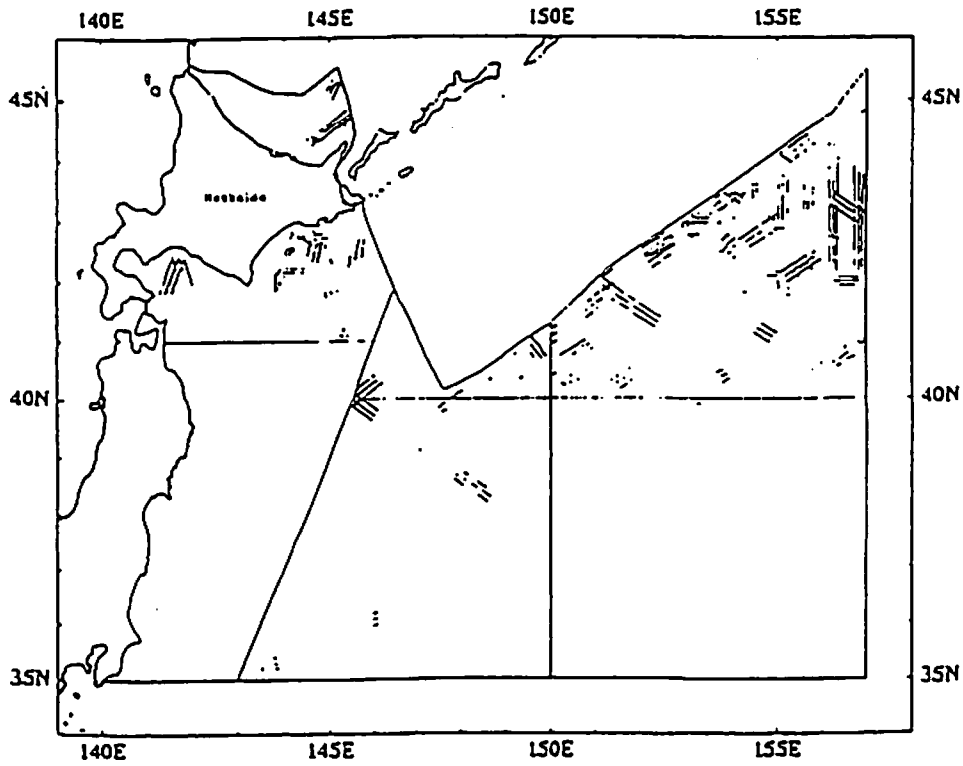


Fig. 4. Part of the cruise track conducted under *BS mode* searching (see text) during the 1996 JARPN survey.

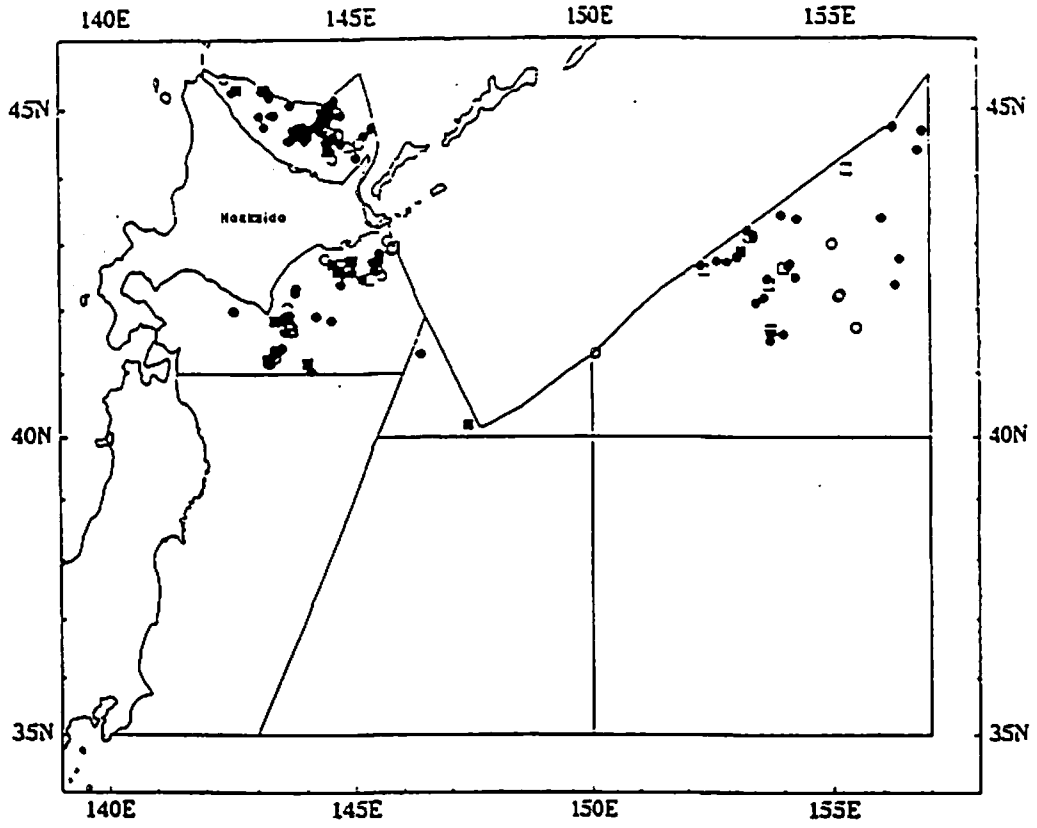


Fig. 5. Distribution of minke whales sighted by three sighting/sampling vessels during the 1996 JARPN survey. Minke whale : ● primary, ○ secondary; 'like minke whale': ■ primary, □ secondary.

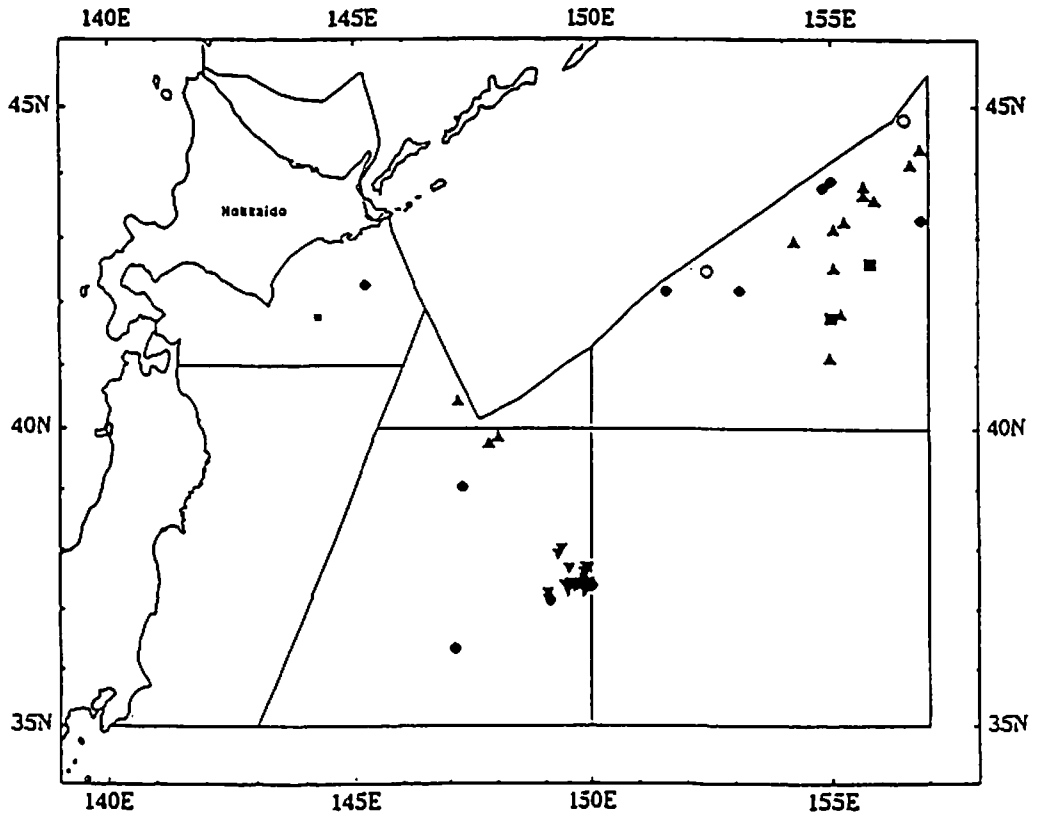


Fig. 6. Distribution of blue, fin, sei, Bryde's and humpback whales sighted by three sighting/sampling vessels during the 1996 JARPN survey. Blue whale: ■ primary; fin whale: ▲ primary; sei whale: ● primary, ○ secondary; Bryde's whale: ▼ primary, ▽ secondary; humpback whale: * primary.

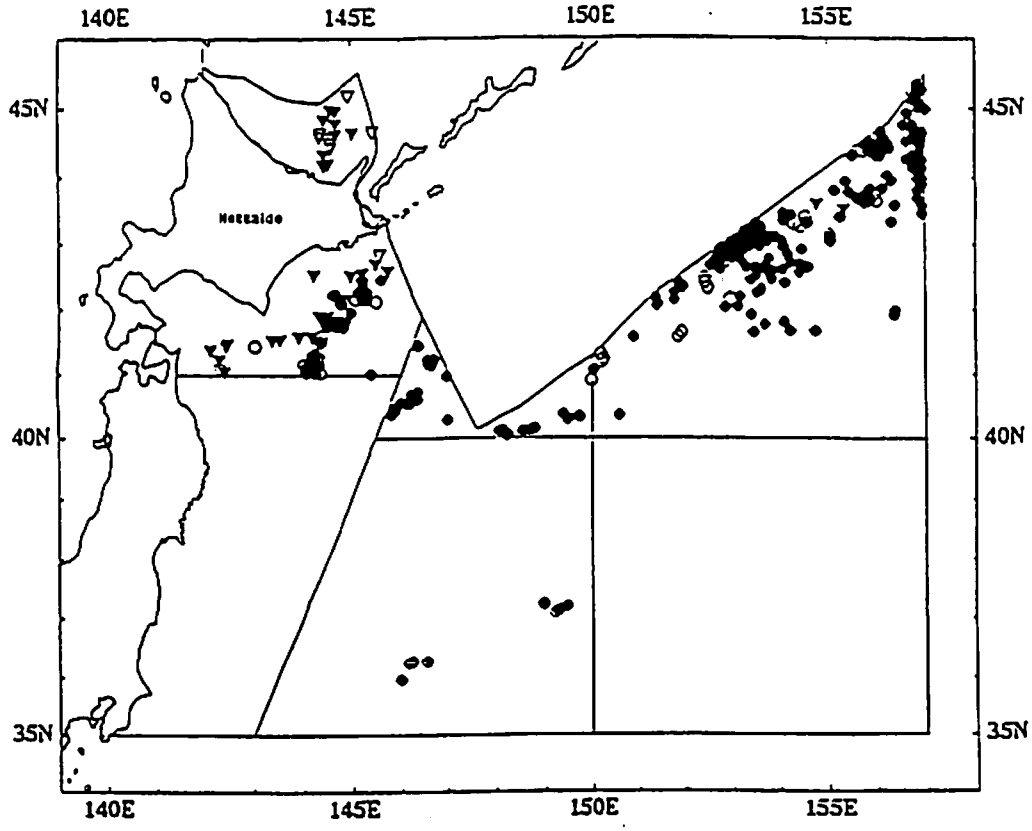


Fig. 7. Distribution of sperm and Baird's beaked whales sighted by three sighting/sampling vessels during the 1996 JARPN survey. Sperm whale : ● primary, ○ secondary; Baird's beaked whale: ▼ primary, ▽ secondary.

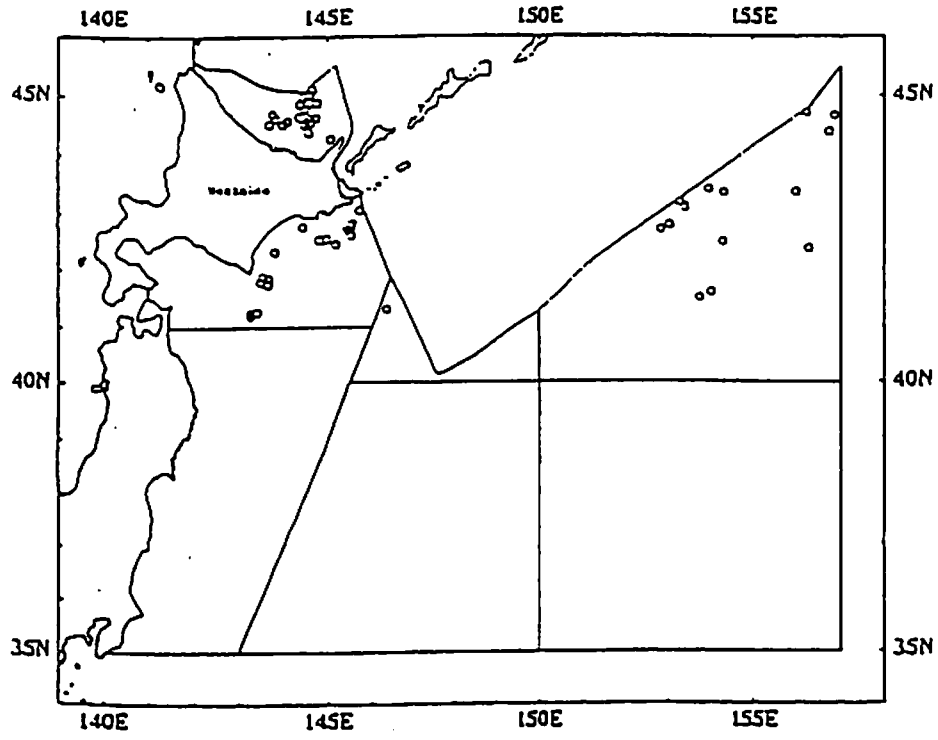


Fig. 8. Distribution of minke whales sampled in the 1996 JARPN survey, based on their sighting position.

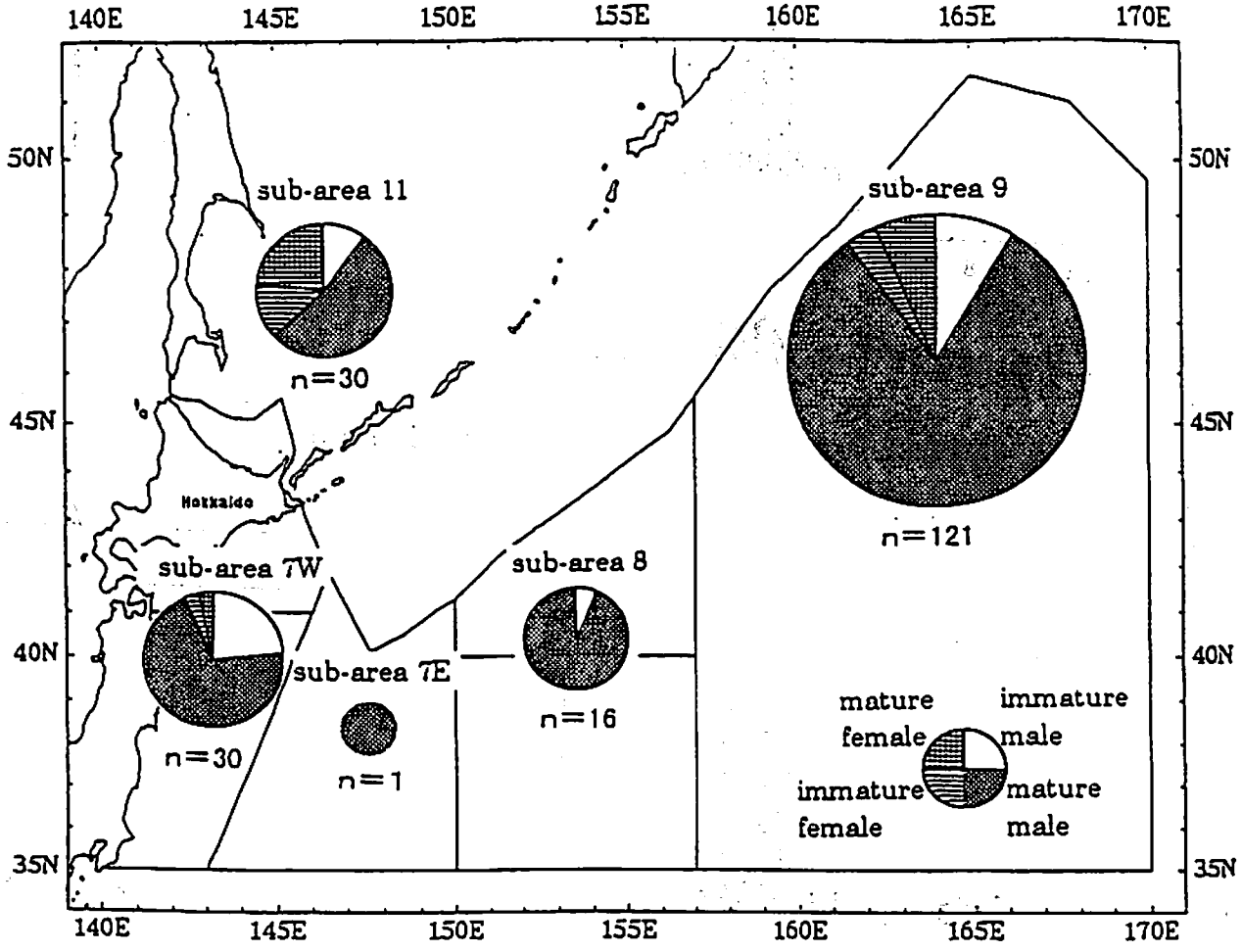


Fig. 9. Reproductive status of minke whales sampled by the 1994-1996 JARPN surveys, by sex and sub-area.

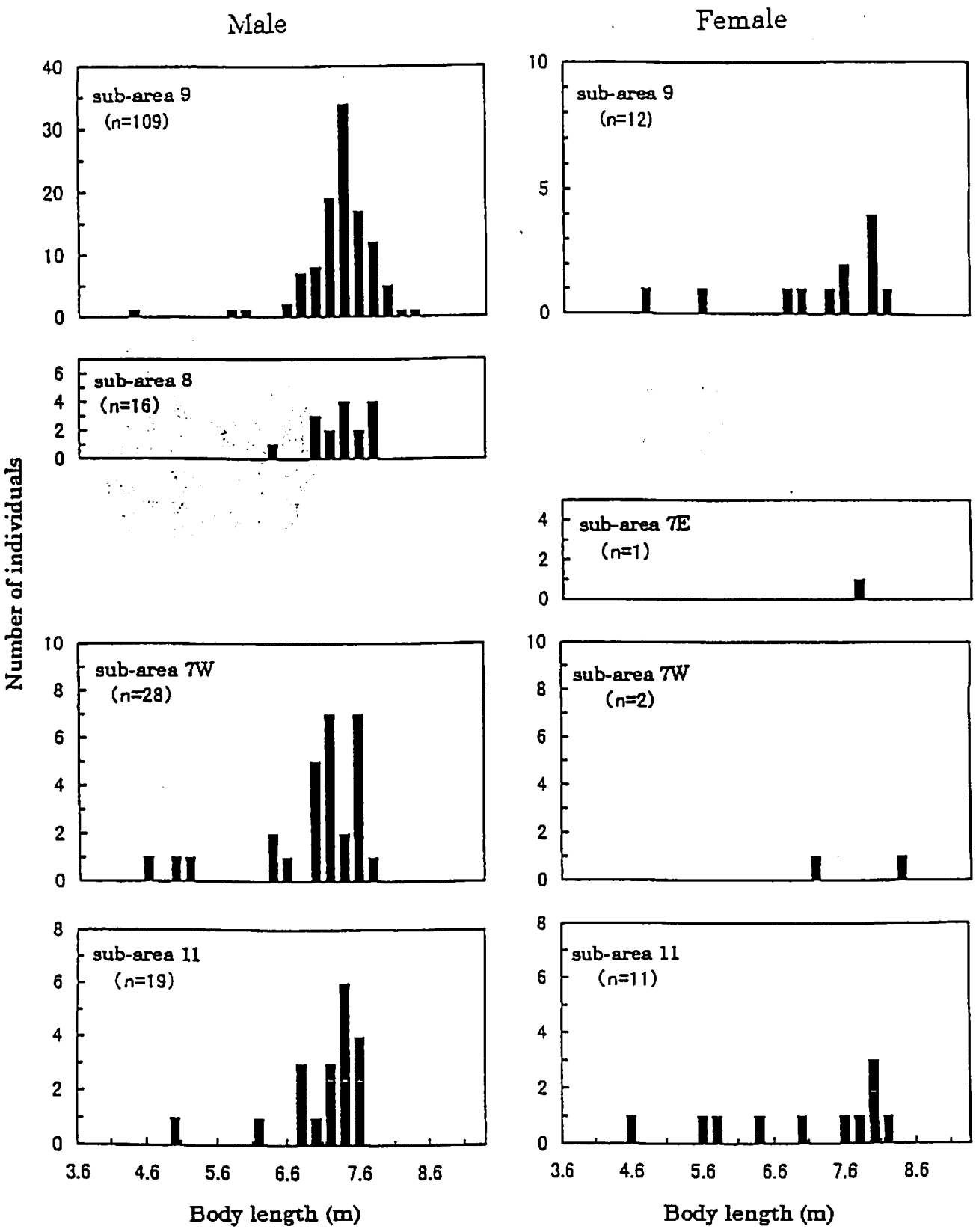


Fig. 10. Body length distribution of minke whales sampled by the 1994-1996 JARPN surveys, by sex and sub-area.

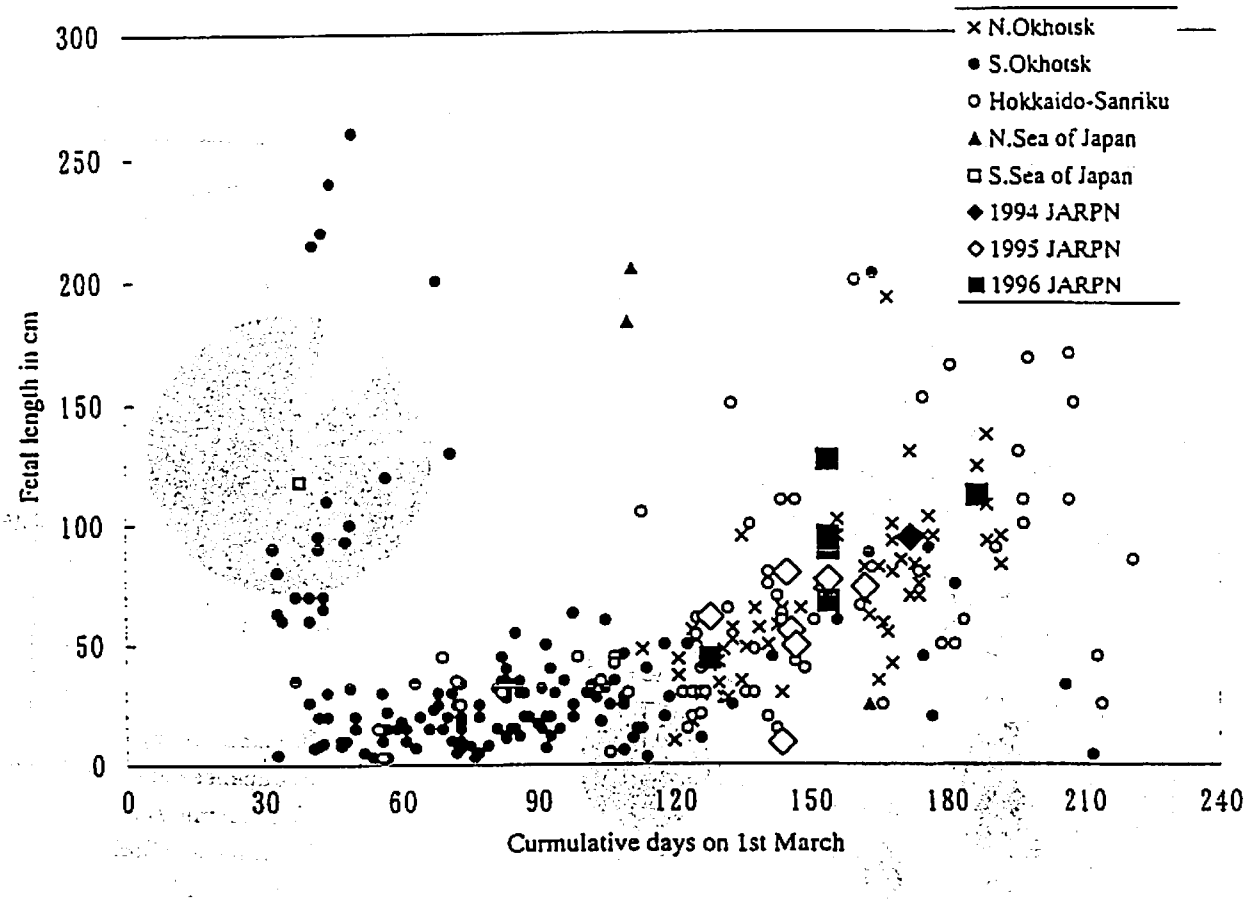


Fig. 11. Relationship between length of foetuses and collection date in minke whales coastal water around Japan (Kato, 1992) and from sub-areas 7, 8, 9 and 11 where conducted the 1994-1996 JARPN surveys.

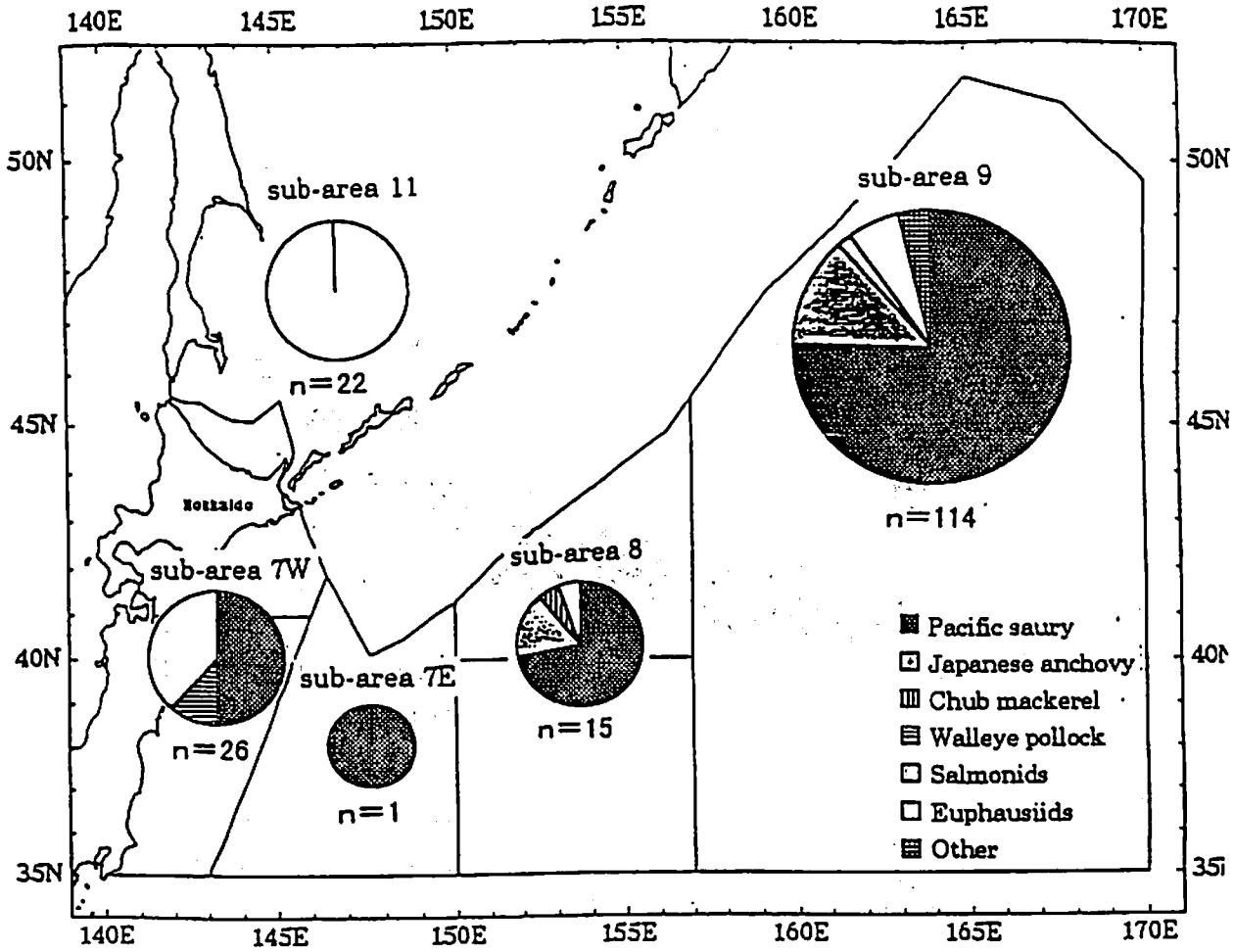


Fig. 12. Food species of minke whales sampled by the 1994-1996 JARPN surveys.

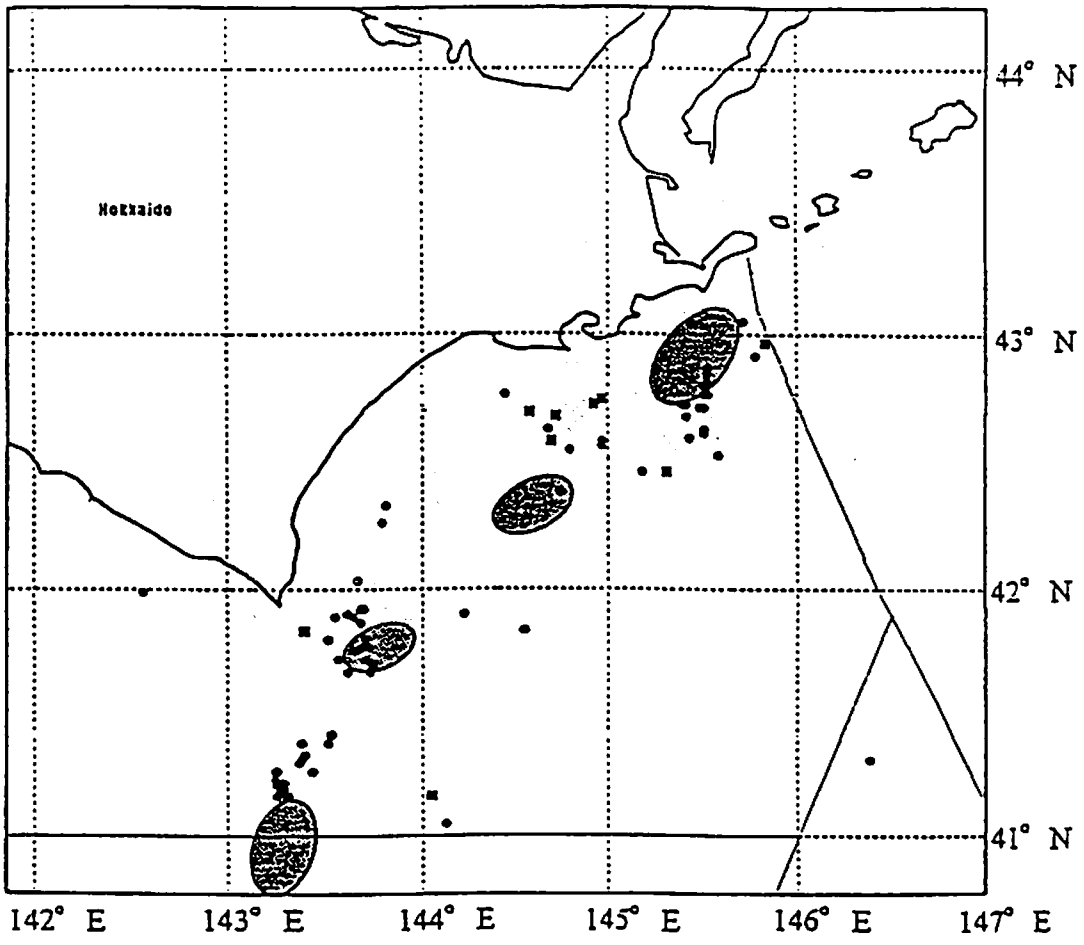
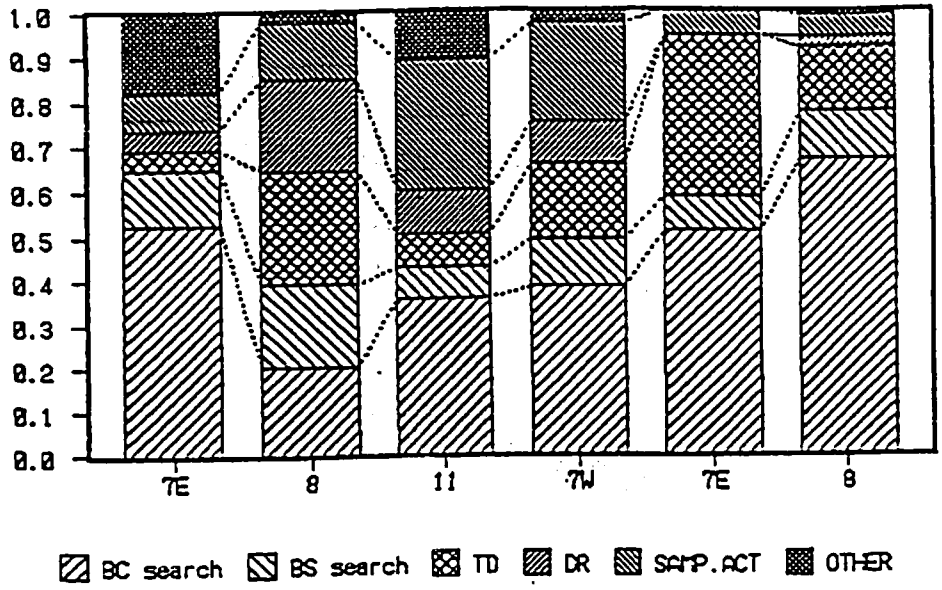


Fig. 13. Relationship between minke whale sightings and the fishing ground of Pacific saury in the sub-area 7W during 22 July and 8 September, 1996. The information of the fishing grounds was obtained from the telex Nos. 27 –33 on fishing grounds off the Pacific coast of eastern Hokkaido by the Fishing Information Service Centre in Japan.



Appendix 1. Proportion of searching mode by sub-area and research period.