Cruise Report of the 1991/92 Japanese Research under the Special Permit for Southern Hemisphere Minke Whales

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ABSTRACT

The cruise for the 1991/92 Japanese research under the special permit took place from December 1991 to March 1992 in the Antarctic Area IV (south of 55°S, 70-130°E) using one research base and three sighting and sampling vessels. The research area was divided into two sectors: West and East which were further divided in latitudinal strata. All of the strata, except the North, were surveyed in two periods. In this cruise, a dedicated sighting vessel was allocated in the south sub-areas for improving the searching effort. Other two vessels were engaged in sighting and sampling activities in all the areas surveyed.

The three sighting and sampling vessels surveyed 18,204.5 n.miles and made 616 primary (2,061 animals) and 478 secondary (1,668 animals) sightings of minke whales. In the present season, the distribution of minke whales was biased westerly and the highest density was observed in the Prydz Bay. On the other hand, no whale was observed in the East-Middle stratum in the Second period. Particularly notable phenomenon was the occurrence of twenty-six schools of right whales which were observed by primarily sighting in the Middle and South strata in the Second period.

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A total of 288 (165 male and 123 female) ordinary forms of minke whales were caught from the primary sightings. Preliminary analyses of the catch indicated that patterns of reproductive segregation of minke whales were similar to those observed in the 1989/90 research carried out on the same Area IV: mature females were concentrated in the South strata, especially in the Prydz Bay, immature animals occurred in the Middle strata and mature males were distributed in all the surveyed areas.

INTRODUCTION

A research plan for Southern Hemisphere minke whale (*Balaenoptera acutorostrata* Lacépède, 1807) was proposed to the IWC Scientific Committee (IWC/SC) by the Government of Japan in 1987 (Anon, 1987). The major objectives of this plan were: (1) to estimate biological parameters of the stock, especially natural mortality and (2) to collect information which permit elucidate the role of whales in the Antarctic Ecosystem.

Two feasibility studies were conducted prior to the plan in the 1987/88 and 1988/89 seasons by the Institute of Cetacean Research under the special permit (Kato *et al.*, 1989, 1990b). Based upon the results of these studies (Kato, Kishino and Fujise, 1990a; Fujise, Kato and Kishino, 1990; Kishino *et al.*, 1991a; Kato, Fujise and Kishino, 1991), Japan decided to conduct the research with some modifications (Anon, 1989). This research which permitted the take of 300 minke whales (with 10% of allowance), commenced in Area IV in the 1989/90 season (Fujise *et al.*, 1990). During the 1990/91 season another research cruise was carried out on Area V (Kasamatsu *et al.*, 1991). The cruise reported here is the second research carried out in Area IV.

Major purposes of this cruise were: (1) to compare the results with those obtained during the first cruise conducted on the same Area IV in 1989/90 (Kishino *et al.*, 1991b, Fujise, Kato and Kishino, 1991) and (2) to examine yearly changes in abundance and biological aspects (e.g. distribution, migration pattern, sexual composition and age distribution of minke whale), by accumulating of the data for the long-term objectives of the plan.

The survey design in this cruise was similar to that of the 1989/90 cruise with the following improvements by the reconsideration (Anon, 1991): (1) allocation of one of the three sampling vessels to sighting activities in the southern part of the research area in order to increase the sighting effort, and (2) to set the sampling interval in each stratum for the spacial sampling of whales.

During the period between 7 December 1991 and 31 January 1992, the research activities were disturbed by the interferences

of the GREENPEACE vessel "*Greenpeace*". Then, the research procedures such as the survey order for the stratum and the allocation of surveying effort, had to be changed partly.

This report covers the research cruise in the Antarctic Area IV conducted between 5 December 1991 and 25 March 1992, and presents some preliminary analyses of the biological data obtained during this cruise. The sighting cruises in lower and middle latitudes which were done under the same research plan, will be reported separately in future.

RESEARCH METHOD

Research area

The research area covered the whole Antarctic Area IV, i.e. the waters between 55°S and the ice edge and between 70°E and 130°E. Fig. 1 shows the research area including the sighting cruises in lower latitudes. The research area was divided into two sectors: West (70°E-100°E) and East (100°E-130°E). These sectors were further divided into three strata: North, Middle and South. The Middle and South strata were separated by the line of the 45 n.miles northward from the ice edge line. The southern boundary of the South stratum between 70°E and 80°E was set at 66°S. Survey in the Prydz Bay was conducted when the open sea expanded southward from this boundary. The surveys in the Middle and South strata of both sectors were conducted in two periods in the following order: West-South, West-Middle, East-South and East-Middle. However, the survey order in the East Sector in the First period had to be conducted by swapping the South and Middle strata due to the interferences by a Greenpeace group indicated above. Surveys in the North stratum was conducted in only one period.

Trackline

The tracklines in each stratum were designed as those of the 1989/90 research (Fujise *et al.*, 1990).

In the South strata, a starting longitude between 96°E and 100°E, was randomly selected from lines divided by one n.mile. This longitude was determined as 99°22'E in the present cruise. The following longitudes were determined automatically at intervals of 4 degree taking as reference the above longitude: 71°22'E, 75°22'E, 79°22'E, 83°22'E, 87°22'E, 91°22'E, 95°22'E and 99°22'E in the West Sector, and 103°22'E, 107°22'E, 111°22'E, 115°22'E, 119°22'E, 123°22'E and 127°22'E in the East Sector. These lines were not changed throughout the research period. The survey in this strata was conducted in the following order: (A) the point of ice edge on the longitude, (B) the point of 45

n.miles north from the point A, and (C) the point of the ice edge on the next longitude.

The Middle strata were located between the northern boundary of the South strata and the southern boundary of the North strata (60°S). If the mean of the latitudinal distances between these two boundaries was shorter than 240 n.miles, the northern boundary of the Middle stratum was shifted from 60°S to 58°S.This shift was done in the West Sector during the First period. The survey line was randomly selected from points that were determined dividing by one n.mile between 70°E and 85°E on the northern boundary of the Middle strata. This selection was done for both periods.

In the North strata, the research line was randomly chosen at 94°58'E from the longitudinal range of 85°E-100°E in the First period. In the Second period, it was selected at 102°09'E from the longitudinal range of 100°-115°E.

Research fleet

Three vessels, *Kyomaru No.1* (*K01*; 812.08GT), *Toshimaru No.25* (*T25*; 739.92GT) and *Toshimaru No.18* (*T18*; 758.33GT), performed sighting and sampling surveys, natural marking, oceanographical survey and conducted several experiments. *Nisshinmaru* (*NM*; 7,198GT) acted as a new research base in which general matters such as planning of daily research strategy, setting cruising course, arrangement for sampling vessels, weather forecasting, refueling for the sampling vessel and others were dealt with. The measurements, collection of biological materials and processing of sample whale carcasses took place on the deck of *NM*.

Sighting manner

The principal sighting manner was adopted from those of the current IWC/IDCR southern minke whale assessment cruises with the exception that three men were engaged in sighting on the barrel. Details of the sighting manner were presented in the previous cruise report of the 1989/90 Japanese research take (Fujise *et al.*, 1990). Minor changes as explained in the paragraph below.

Three tracklines consisting of the main and two sub-courses, were established. The main course was randomly determined as it was indicated above. The sub-courses were conducted nine miles away from either sides of the main course. Three vessels, which conducted sighting and sampling activities, were allocated in each of these tracklines. This arrangement was rotated daily. In the present survey, one of the vessels, which was allocated in the main course, was delicately assigned to sightings in the South and Prydz Bay strata for increasing of the sighting effort, and it was named as the 'sighting' vessel. Other two vessels on

the sub-courses were engaged in both sighting and sampling activities and were named as 'sighting/sampling' vessels.

Because the need to cover the designed trackline, the previous research adopted the procedure of steaming of the certain distance per day. In this cruise these steaming were not adopted in the South and the Prydz Bay strata in order to increase the searching efforts. However, the survey had to be changed due to the interferences: one 'sighting' vessel (*T18*) was engaged to the survey in a part (99°22'E-100°E) of the West-South stratum in the First period, and one 'sighting' and one 'sighting/sampling' vessels were engaged in the rest of the West-South stratum. Two 'sighting/sampling' vessels conducted the survey in the West-Middle and in a part (100-103°E) of the East-Middle stratum in the First period.

Closing of vessel for confirmation of whales was conducted for primary sightings of minke whales only when those sightings were within 3 n.miles from the trackline. In addition to this manner, closing was conducted regardless of the distance, in order to take photographs for natural markings of blue (*Balaenoptera musculus*), humpback (*Megaptera novaeangliae*) and right whales (*Eubalaena glacialis*).

The sighting survey was principally made at 12 knot in speed during the day time either between 06:00 and 20:00 or from 30 minutes after sunrise to 30 minutes before sunset.

Sampling of whales

The sampling manner was the same as that of the 1989/90 survey, with the exception of setting of the sampling interval as described below. Sampling were tried only from primary sightings of minke whales, within 3 n.miles away from the trackline. The sampling interval adopted in the present survey was calculated from the data of the 1989/90 survey by the following procedure: (1) the sample size was calculated in each stratum from the estimated abundance data (Kishino *et al.*, 1990) and from the reproductive structure information of the whales sampled in the previous survey (Fujise *et al.*, 1990), and (2) the sampling interval was estimated from the expected sighting data and their technical sampling efficiencies (Fujise *et al.*, 1990). Sampling of the maximum of two individuals from each school (school size of 2 and over) was carried out using tables of random sampling digits prepared by different school sizes (Kato *et al.* 1989, 1990; Fujise *et al.*, 1990; Kasamatsu *et al.*, 1991).

Biological survey

Whales sampled were towed by research vessels shifted as soon as possible to the research base (*NM*). Detailed surveys, including

weighting of a whale, were conducted on board of NM. These descriptions are given in a later section.

Experiments

Estimated distance and angle experiment

This trial was conducted in order to evaluate the accuracy of the information on sighting distance and sighting angle given by observers of the sighting and sampling vessels. The procedure was the same as that of the last research (Kasamatsu *et al.*, 1991).

Reaction monitoring experiment

This experiment, which began in the 1990/91 season (Kasamatsu *et al.*, 1991) was conducted in order to assess the effects on the whales of the chasing activity of the 'sighting/sampling' vessels. One vessel commenced navigation along a trackline while other two monitoring vessels drifted at a distance of 10 n.miles ahead from the chasing vessel and 6 n.miles apart from each other at the start of each trial (See Fig. 7 of Kasamatsu *et al.*, 1991). The chasing vessel made a normal procedure of sampling but the whale were not taken. If the vessel reached to a point of 11 n.miles ahead of the starting point, the trial was terminated. During this steaming, two monitoring vessels observed the reaction of other minke whales around the vessels. Details of the procedure were presented by Kasamatsu *et al.* (1991).

Natural marking

If blue, humpback and right whales were found, the vessel tried to close to the school and researchers on board took photograph for the natural marking of these whales.

Biopsy sampling

If a school of hourglass dolphins (*Lagenorhynchus cruciger*) was sighted, the vessel closed and tried to take a skin sample using a biopsy dart (Kato *et al.*, 1989, 1990). This sampling was carried out on board of *KOI*.

Oceanographical survey

In addition to the routine of records of weather and sea condition every one hour, oceanographical surveys including the surface temperature and vertical thermal distribution by XBT were carried out on board of *T25*.

Marine debris

A survey for marine debris diring navigations between the research area and the adjacent waters to Japan was made from the wheel house of *NM* (average height from sea level; 12m) based on the sighting manner of the Japan Fisheries Agency. In the research area, if a debris was seen in stomach contents of a whale caught, it was recorded by photograph and sampled.

RESULTS

Research period

The research lasted for 112 days from 5 December 1991 to 25 March 1992. The survey in each stratum was conducted in the following period:

First period	
North	5 - 6 Dec. 1991
West-South	10 - 21 Dec. 1991. → 10～15, 21,
West-Middle	18 - 31 Dec. 1991. (21 と ダブル)
East-Middle	1 - 9 Jan. 1992
East-South	14 - 26 Jan. 1992
Second period	
West-South	26 Jan. - 6 Feb. 1992
Prydz Bay	9 - 14 Feb. 1992
West-Middle	15 - 25 Feb. 1992
East-South	26 Feb. - 11 Mar. 1992
East-Middle	12 - 23 Mar. 1992
North	24 - 25 Mar. 1992

Trackline

Fig. 2 shows the trackline of the main course of the survey. The shapes of pack ice line in this season was relatively simple throughout the research period in comparison to that observed in the 1989/90 survey. The exception was in the First period in which the pack ice line was complex in the west part (70°E-80°E) of the West Sector. The surveys on longitudes of 75°22'E and 79°22'E had to be started from the bottom of an inlet made by the pack ice.

In the Second period, the survey in the Prydz Bay stratum was conducted. Previously it was determined that the bottom of the Bay was located at 69°45'S. Using this information, the trackline was randomly selected at 68°31'S and 66°39'S.

Differences between the expected ice edge (EIE) and true ice edge (IE) for each trackline are shown in Table 1. The EIE was estimated by available information such as the information on weather conditions and ice edges, derived from past and present surveys. The difference was large in the West Sector where a

range from -58 to 37 n.miles and relatively small in the East, -37 to 14. Mean position of the ice edges surveyed in the First period was 63°44'S and 65°09'S in the West and East Sectors, respectively. The means in the Second period were 64°46'S and 65°17'S. In the West Sector, the ice edge was shifted 62 n.miles south in 52 days, and 8 n.miles in 44 days in the East Sectors. The location of the ice edge in the present season was similar to that observed in the 1989/90 survey with exception of the West Sector in the First period of that survey in which the location of the ice edge was 77 n.miles north from that observed in the present season.

Sighting

Searching effort

Table 2 indicates the searching distances (n.miles) and the number of primary sighting of minkes whale in each stratum. Total searching distance by the three sighting and sampling vessels was 18,204.5 n.miles. This value was higher than that of the 1989/90 research. Allocation of the searching effort was almost the same for each stratum (49.4% in the Middle and 46.7% in the South) with exception of the North strata. Searching efforts between two periods were also similar, 45.7% and 54.3% in the First and Second periods, respectively.

Species found

Table 3 summarizes the sightings results. The ordinary form of minke whale was the most common species throughout all strata, being 616 schools (2,061 individuals) as primary sightings and 478 schools (1,668 individuals) as secondary sightings. Only two schools (two individuals) of the dwarf form of minke whales were sighted as secondary sightings.

A total of 194 schools (351 individuals) of the humpback whales were recorded as primary sightings and 33 schools (61 individuals) as secondary sightings. Five blue whales were sighted in the West Sector. A total of 17 schools (70 individuals) of fin whales (*B. physalus*) were sighted, and most of those were in the Middle and South strata. Two schools (two individuals) of sei whales (*B. borealis*) were sighted in the East-Middle stratum in the Second period.

It should be noted as a characteristic of the present cruise, that right whales were sighted in the Middle and South strata during the Second period. A total of 26 schools (30 individuals) and four schools (four individuals) were recorded as primary and secondary sightings, respectively.

Sperm whale (*Physeter macrocephalus*) was common in the Middle and South strata. Killer whale (*Orcinus orca*) was common through the two sectors. Some kinds of beaked whales were also

sighted in all the strata except in the Prydz Bay and North strata in the Second period. Primary sightings of 330 schools (539 individuals) and secondary sightings of 18 schools (31 individuals) were observed. These beaked whales include 52 schools (89 individuals) of southern bottlenose whales (*Hyperoodon planifrons*), two schools (three individuals) of *Mesoplodon* spp., and one school (five individuals) of Arnoux's beaked whales (*Berardius arnuxii*). Most of hourglass dolphins and pilot whales (*Globicephala melaena*) were sighted in the Middle and South strata.

Distribution and density of minke whale

Fig. 3 shows the spatial distribution of the minke whales sighted as primary sightings. Minke whales were sighted in all the surveyed strata but in the East-Middle stratum no minke whales were sighted despite large amount of searching effort (2,262 n.miles) in the Second period. The total number of minke whales sighted in the Second period was 5.3 times higher than that in the First period (Table 2). Of the whales sighted in the Second period, 67.7% were from the Prydz Bay and west part (70°E-80°E) of the West-South stratum which was located in the north of the Prydz Bay (233 schools and 1,172 individuals).

Density indices (DI) indicating the number of schools observed per 100 n.miles searched and the mean school size (MSS) were also higher in the Second period. These values were 2.16 and 1.83 in the First period and 4.41 and 3.97 in the Second period, respectively. The largest DI and MSS values were obtained in the Prydz Bay (DI:27.94, MSS:5.77).

Distribution and density of other whale species

Figs 4 and 5 show the spatial distribution of the humpback, right and blue whales sighted which were target species of the natural marking. Location of fin and sei whales sighted are also shown in the figures.

Most of humpback whales were sighted in the Middle and South strata (Fig. 4). Number of these whales was almost the same as that of the minke whales in the West Sector in the First period. The number of humpback whales was higher in the area between 80°E-120°E. Most of right whales were sighted between 90°E-115°E during the Second period and within about 150 n.miles away from the ice edge (Fig. 5). Four of five blue whales were sighted in an area between 76°E and 80°E within 100 n.miles away from ice edge (Fig. 5). During the First period, fin whales were sighted in two areas. One was on the north-central part of the research area, between 58°S-61°S and 94°E-103°E, where five schools (seven individuals) were sighted. The other was found around 105°E in the East-South stratum where three schools, including nine individuals, were sighted. In the Second period, most of fin whale

were sighted in a small area located between 61°S-62°S and 95°E-97°E (four schools and 48 individuals). Two schools including two individuals of sei whales were sighted in the East-Middle stratum between 60°S-61°S and 108°E-112°E in the Second period.

Sampling

Sampling activities

Sampling of whales was conducted on the schools which were determined by the sampling interval. Table 4 indicates the interval and the adopted period by stratum. Because the differences in density and distribution pattern of the whales were observed from those of the present and 1989/90 seasons, and the decreasing trend of searching effort in the First period was also observed, the scheduled sampling intervals had to be changed and most of the intervals were set to one (every primary school was targeted). Two and more of the interval values were set for 8 days in the East-South (interval = 2) in the First period; 4 days in the Prydz Bay (3), 4 days in the East-South (2) in the Second period.

Although the proportion of samples to schools targeted would be unchanged, 'stop-catch' had to be invoked on certain occasions for 11 days when the maximum biological surveying and processing capacities of *NM*. This 'stop-catch' was conducted in the West-South (one day) in the First period; the West-South (3), the Prydz Bay (2), the West-Middle (3), and the East-South strata (2) in the Second period.

Distribution of whales sampled

Fig. 6 indicates the spatial distribution of minke whales sampled based on their sighted position. Total of samples was 288 animals including 165 males and 123 females. Sampling activities were conducted in all the strata. Although two schools of minke whales were sighted in the North stratum in the First period, no whale could be taken because of the behavior of the whales such as quick and mobile. In the West-South stratum in the First period, only 21 minke whales were taken (between 70°E and 91°22'E) because of interferences mentioned above. Densities of whales in the First period were relatively low in the Middle strata of the East and West Sectors and the South stratum of the West Sector. The number of samples was 14, 26 and 21, respectively. In the Second period, no sample was collected in the East-Middle stratum, because no whale was sighted. In the North stratum in the Second period, one whale was taken.

Sampling efficiencies

Table 5 indicates the numbers of whales sighted and sampled and the efficiency of sampling. In this table, the numbers of sight-

ings (A and B) were used on those conducted only by the 'sighting/sampling' vessels.

Sampling efficiency (I) indicates the proportion of schools sampled to the number of primary sightings. This efficiency was almost similar among strata with the exception of the values obtained in the North stratum in the First period, and Prydz Bay in the Second period. The total sampling efficiency was 0.57.

Efficiency (II) indicates the proportion of whales sampled to the number of primary sightings. This efficiency was low in the Prydz Bay stratum (0.13) where density and mean school size was high. The efficiency in total was 0.31.

Efficiency (III) was the same value as the technical efficiency reported by Kato *et al.* (1990). This value was relatively high in the First and Second periods except in the North stratum. The efficiency in total was 0.75, which was higher than those (0.69) reported in the 1989/90 survey (Fujise *et al.*, 1990).

Table 6 shows the efficiency (III) and the successful rate of two-whale sampling by school size. The efficiencies and the two-whale sampling increased with school size. Minimum values were observed in schools including two individuals.

Cause of failure in sampling

A total of 98 individuals were targeted but not sampled. Table 7 shows the distribution of nine identified causes of failures by school size. The major causes of the failure of sampling in solitary individuals were the whale behavior such as quick, mobile, long diving and fast swimming. In the schools of 2 individuals and over, the cause of no sampling of individuals primarily targeted was also the whale behavior, and those of the second targeted whale were the lost sight of the whale during the chasing of the first targeted whale.

Biological survey

Biological measurements and sample collections were made on the deck of *NM* on 288 ordinary minke whales. Those animals comprised 165 males and 123 females. The techniques or methods for the present biological survey were principally the same as those in the previous seasons (Kato *et al.*, 1989, 1990; Fujise *et al.*, 1990; Kasamatsu *et al.*, 1991), with exception of minor changes because of the limited space on deck of the new research base.

Table 8 summarized research items of the biological measurements and sample collections and shows the numbers of whales surveyed in each item. Details of the analyses of those will be reported in future.

Other surveys

Mark recapture (Discovery tag)

One mark (Discovery tag, No. 26236) was recovered from the body of a whale during the biological survey. The school including the marked whale was sighted and sampled by *KOI* on 3 February 1992 (sighted position: 65°36'S, 79°E). This school was composed of four animals, and two whales were randomly sampled from those animals. The marked whale was targeted and sampled as the second whale in this school at 65°35'S, 79°13'E.

The marked whale (specimen No. 115) was a pregnant female having a fetus of 72.4cm. Body length and weight of this whale were 9.0m and 10.4t, respectively. The other whale caught in the school (specimen No. 114) was a male having testis weight of 0.6 kg, and its body length and weight were 8.0m and 5.1t, respectively.

This whale was marked at 63°11'S, 100°05'E on 29 December 1978 by *Toshimaru No.16* during the 1978/79 IWC/IDCR cruise. The elapsed time between marking and recovering was 14 years and one month. Positions of marking and recovery were in the same Area IV.

Experiments

1. Distance and angle estimation experiment

The experiment of the distance and angle estimations was carried out in each of three sighting and sampling vessels on 19 January 1992. All the top men (6 persons) and other personnels involved in searching activities on the upper bridge (7 persons) participated in this experiment.

A total of 56 experiments in each of the sighting and sampling vessel was made in the total number of 105 persons from their normal places at which they engaged in the searching. The result of this experiment will be reported on a future paper.

2. Reaction monitoring experiment

This experiment was conducted on 12 February 1992 in the central part of the Prydz Bay. Four sets of trials were carried out. During the experiment, the chasing vessel sighted for 11 schools (47 individuals) as primary sightings, and chasing was conducted as the same manner as the normal research activity but without sampling of whale. The chasing was conducted within 30 minutes or after the finish of two chances for firing of the harpoon (but not fired). Two other vessels observed the reaction of whales in 15 schools of minke whales. Total time of the experiment was 6 hours and 56 minutes.

Most of the schools were not effected by the chasing operation. One school, however, was recorded as effected. The movements of this school was recorded for 91 minutes. Although no changes were observed in the movements of the school until 7.9

n.miles from the chasing vessels, this school begun to swim fast and to escape the chasing vessel at the distance of 1.5 n.miles and less.

Natural marking

Photographic records were conducted for natural marking of blue, humpback and right whales.

Of 227 schools (412 individuals) of humpback whales sighted during the present survey, 61 schools were closed for recording the natural marking of the whales. Finally, 111 individuals corresponding to 61 schools were photographed. A total of 30 schools (34 individuals) of right whales was sighted and was photographed for 17 individuals (16 schools). One blue whale was photographed.

The use of these photographs for individual identification study will be examined in future.

Biopsy sampling

Attempts for taking biopsy samples from schools of hourglass dolphins were made by *KOI*. Of seven schools sighted, three schools were targeted. A biopsy dart was shot in the first school, but a miss was recorded. No chance for shooting a dart was obtained on the second school. The third school came a bow during 19 minutes and a dart was shot but was miss because of rough sea condition.

After the above trials, the reaction of all the hourglass dolphin schools to the vessel was recorded. Table 9 indicates these reactions by wind speed. No dolphin came a bow of vessel at larger than 5 knots of the wind speed and in the rough sea condition (25 knots and more of wind speed) these dolphins trend to come a bow.

Oceanographical survey

The XBT survey was conducted for 86 points from 4 December 1991 to 24 March 1992. At the same time, weather, wind direction and speed, atmospheric pressure and sea surface temperature were recorded.

Fig. 7 indicates the distribution of surface water temperature in each research period. The pattern of the temperature decreased from easterly to westerly, which was similar to the pattern observed in the previous 1989/90 research. However, the temperature was relatively lower in the present survey, especially in the First period in which lower temperatures such as 0°C to 1°C were recorded in the Middle strata. In the previous research, water temperature of 1°C covered most of the research area in the First period. Analysis of XBT data will be examined in a future study.

Marine debris survey

The marine debris survey was made on the deck of *NM*. The total observation time was 430.5 hours.

Two debris were recorded from the stomach contents of the whales sampled. One was a piece of wood work and another one was a piece of plastic bottle.

Products

After the biological survey was completed, all the whales sampled were processed according to the provisions of Convention Article VIII. Total of the products was 1,259 t from all of sampled whales (Table 10).

Preliminary analysis of samples taken

Preliminary analyses of minke whale samples were made during the return of the vessels from the Antarctic. Detailed analyses of samples taken and population estimate will be done in future studies.

The reproductive status of a female was determined by examinations of ovary, uterus and mammary gland. While the reproductive status of male should be determined by the histological examination of testis and epididymis, preparation of testes and epididymides has not been completed by this time. We tentatively used the traditional weight of testis for the determination of the sexual maturity. If whale has a testis 0.4kg or over in weight, this animal was classified as a sexually mature (Ohsumi, Masaki and Kawamura, 1970; Kato, 1986)

Table 11 indicates the reproductive structure in each stratum on 165 males and 123 females obtained in the present survey. The proportion of males was 57.3%. Mature males were dominant (44.4%). Pregnant females (25.0%), immature females (13.5%) and immature males (12.8%) followed in occurrence. Three lactating females were sampled and two of these animals were pregnant. Apparent pregnancy rate of whales sampled was calculated as 87.8%. Similar structure was observed in both the West and East-South strata during the First period. In the Second period, mature females (resting, lactating and ovulating females) were observed. In the Prydz Bay, pregnant females were dominant.

Table 12 indicates the reproductive structure by school size. It was obvious that immature animals dominated in the singleton (males: 45.0%, females: 60.5%), and mature animals in two and more schools (males: 80.0-91.8%, females: 80.0-90.0%).

DISCUSSION

Table 13 compares the searching distances and the number of schools sighted in the previous and present researches, by stratum. As mentioned in the above section, the research methods adopted in the present cruise were almost similar to those in the previous ones. Although the surveys in the East Sector had to be conducted by swapping of the Middle and South strata in the First period, the surveyed period in each stratum of the present cruise was almost similar to that in the previous research. Difference between the survey dates was only 10-15 days. The searching distances in the Middle strata during the present research were almost similar to those in the previous ones. Those in the south strata were 1.5 times longer in this cruise, because the searching effort was increased by the allocation of a 'sighting' vessel in the South and Prydz Bay strata. No differences in the distribution of searching efforts between cruises were observed.

Difference was observed in the distribution of the density indices (DI) between the present and previous researches. The DI in the previous research was higher in the East Sectors (DI: 10.87-11.97) than in the West, regardless of research period. On the other hand, the DI value in the present survey was higher in the West than in the East and the highest value was recorded in the Prydz Bay (DI: 27.94).

The mean school size (MSS) of minke whale in the previous research (1989/90) was 1.00-2.69 with the exception of those in the East-South stratum (5.04) in the Second period. The MSS was not related with the research periods. However, in the present research the MSS increased with the time.

The distribution of body length and reproductive structure of the samples are also compared between these two researches. Both surveys show similar pattern in these parameters: larger and matured females were dominant in the South and Prydz Bay strata and smaller and immature animals were distributed in the Middle strata. Larger and mature males occurred in all the strata (Fig. 8). Differences were observed between the West-South stratum in the First period of both researches. Those in the previous research were different from those in the other South strata, the proportion of males was relatively high (76.9% of animals), and immature females were dominant as 72.2% of females (Fujise *et al.*, 1990). In contrast, those in the present research were almost similar to those in the other South strata.

The differences between both surveys may be reflected partly by condition of pack ice. The mean position of ice edge was 62°27'S in the West in the First period in the 1989/90 research, which is located 77 n.miles northward from that in the present research. The ice edge was defined as a position where the vessel

could not gained forward by the ice, but it was not true for the edge of hard pack. It was expected that an open sea area was inside of the pack ice edge. It was known that minke whales were distributed inside of the ice edge (Naito, 1982; Leatherwood *et al.*, 1981). Furthermore, in the present survey, three whales were run into this area, and could not be taken. This case was recorded in the past researches (e.g. ten whales were recorded in the 1989/90 research, Fujise *et al.*, 1990).

The differences of the distribution pattern of minke whale by year should be examined further in a future study.

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Table 1. Latitudinal differences (LD) between expected (EIE) and true ice edge (IE) on the longitudinal track line in each period.

West-South stratum

Longitude	First period (10 Dec.'91 - 21 Dec.'91)			Second period (26 Jan.'92 - 6 Feb.'92)			LD
	EIE (E)	IE (T)	LD (T-E)	EIE (E')	IE (T')	LD (T'- E')	(n.mile) (E - E')
71°22'E	---	63° 7'S		66° 0'S	---		> 7
75°22'E	64°30'S	64°15'S	-15	66° 0'S	---		> 75
79°22'E	64°20'S	63°39'S	-41	65°50'S	65°33'S	-17	114
83°22'E	64° 0'S	64°10'S	10	65°10'S	65°44'S	34	94
87°22'E	64°40'S	64°18'S	-22	65° 0'S	65°15'S	15	57
91°22'E	63°35'S	63°35'S	0	64° 0'S	64°37'S	37	62
95°22'E	63°20'S	63°21'S	1	64°30'S	63°32'S	-58	11
99°22'E	63°09'S	63°23'S	14	---	63°54'S		31
Average	64°12'S	63°44'S	-28	64°51'S	64°46'S	-8	> 62

East-South stratum

Longitude	First period (14 Jan.'92 - 26 Jan.'92)			Second period (26 Feb.'92 - 11 Mar.'92)			LD
	EIE (E)	IE (T)	LD (T-E)	EIE (E')	IE (T')	LD (T'- E')	(n.mile) (E - E')
103°22'E	64°21'S	64°30'S	9	---	64°52'S		22
107°22'E	65°20'S	65°12'S	-8	65°30'S	65°26'S	-4	14
111°22'E	65°00'S	65°14'S	14	65°45'S	65°16'S	-29	2
115°22'E	65°00'S	65°06'S	6	65°30'S	64°53'S	-37	-13
119°22'E	65°30'S	65°35'S	5	65°40'S	65°47'S	7	12
123°22'E	65°14'S	65°20'S	6	65°30'S	65°31'S	1	11
127°22'E	64°59'S	65°04'S	5	65°20'S	65°13'S	-7	9
Average	65°03'S	65°09'S	6	65°33'S	65°17'S	-16	8

Table 2. Searching distances (n.mile) and numbers of primary sightings of minke whale in each stratum. Dist: searching distance, Sch: number of schools sighted, Ind: number of individuals sighted, DI: density indices*, MSS: mean school size.

	'Sighting' vessel					'Sighting/sampling' vessel					Combined				
Stratum	Dist	Sch	Ind	DI	MSS	Dist	Sch	Ind	DI	MSS	Dist	Sch	Ind	DI	MSS
First period															
West-North	-	-	-	-	-	421.2	2	2	0.47	1.00	421.2	2	2	0.47	1.00
West															
Middle	-	-	-	-	-	2090.3	32	59	1.53	1.84	2090.3	32	59	1.53	1.84
South	887.0	27	46	3.04	1.70	464.4	23	40	4.95	1.74	1351.4	50	86	3.70	1.72
East															
Middle	-	-	-	-	-	2160.2	26	33	1.20	1.27	2160.2	26	33	1.20	1.27
South	926.6	30	76	3.24	2.53	1364.4	40	73	2.93	1.83	2291.0	70	149	3.06	2.13
Second period															
East-North	-	-	-	-	-	290.2	2	8	0.69	4.00	290.2	2	8	0.69	4.00
West															
Middle	-	-	-	-	-	2472.3	77	129	3.11	1.68	2472.3	77	129	3.11	1.68
South	1034.8	52	171	5.03	3.29	1163.1	61	137	5.24	2.25	2197.9	113	308	5.14	2.73
Prydz Bay	212.2	84	665	39.59	7.92	364.1	77	264	21.15	3.43	576.3	161	929	27.94	5.77
East															
Middle	-	-	-	-	-	2262.0	0	0	0.00		2262.0	0	0	0.00	
South	844.2	36	176	4.26	4.89	1247.5	47	182	3.77	3.87	2091.7	83	358	3.97	4.31
Total	3904.8	229	1134	5.86	4.95	14299.7	387	927	2.71	2.40	18204.5	616	2061	3.38	3.35

*Density indices : the number of schools per 100 n.miles searching.

Table 3. Summary of the sightings conducted by the three sighting and sampling vessels in each stratum. Sch: number of schools, Ind: number of individuals.

West-North stratum in the First period

Species	Primary		Secondary	
	Sch	Ind	Sch	Ind
Minke whale	2	2	-	-
Like minke whale	1	1	-	-
Fin whale	1	2	-	-
Humpback whale	6	10	1	2
Killer whale	2	2	1	3
Beaked whales	5	6	1	2
Species unknown	9	34	1	2

West and East Sectors in the First period

Species	West Sector								East Sector							
	Middle				South				Middle				South			
	Primary		Secondary		Primary		Secondary		Primary		Secondary		Primary		Secondary	
	Sch	Ind	Sch	Ind	Sch	Ind	Sch	Ind	Sch	Ind	Sch	Ind	Sch	Ind	Sch	Ind
Minke whale	32	59	2	2	50	86	27	35	26	33	7	8	70	149	23	36
Like minke whale	5	5	-	-	7	7	1	2	2	2	-	-	5	5	4	7
Dwarf minke whale	-	-	-	-	-	-	-	-	-	-	2	2	-	-	-	-
Blue whale	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fin whale	3	4	-	-	-	-	-	-	1	1	-	-	3	9	1	2
Humpback whale	31	53	5	9	4	7	-	-	16	27	-	-	18	34	3	5
Sperm whale	9	9	2	2	79	80	16	16	12	12	1	1	52	53	7	7
Killer whale	4	29	-	-	8	29	-	-	2	21	-	-	31	491	11	120
S.bottlenose whale	4	5	-	-	8	15	-	-	-	-	1	3	17	29	-	-
Mesoplodon spp.	1	2	-	-	-	-	-	-	-	-	-	-	-	-	1	1
Beaked whales	28	43	-	-	54	83	3	3	17	25	1	2	57	97	6	12
Pilot whale	4	198	-	-	-	-	1	10	1	60	1	8	-	-	-	-
Species unknown	33	55	5	9	10	19	-	-	18	29	-	-	21	37	4	7

Table 3. (continued)

West and East Sectors in the Second period

Species	West Sector								East Sector							
	Middle				South				Middle				South			
	Primary		Secondary		Primary		Secondary		Primary		Secondary		Primary		Secondary	
	Sch	Ind	Sch	Ind	Sch	Ind	Sch	Ind	Sch	Ind	Sch	Ind	Sch	Ind	Sch	Ind
Minke whale	77	129	12	14	113	308	50	130	-	-	-	-	83	358	28	100
Like minke whale	4	4	-	-	5	5	1	1	-	-	-	-	1	1	-	-
Blue whale	-	-	-	-	2	2	1	1	-	-	-	-	-	-	-	-
Fin whale	4	42	2	6	-	-	-	-	1	2	-	-	-	-	-	-
Sei whale	-	-	-	-	-	-	-	-	2	2	-	-	-	-	-	-
Humpback whale	42	81	9	11	20	33	7	13	19	34	1	2	37	70	7	19
Right whale	6	8	1	1	-	-	-	-	-	-	1	1	20	22	2	2
Sperm whale	67	71	4	4	87	87	9	9	3	3	-	-	8	8	-	-
Killer whale	6	46	2	10	12	121	11	174	2	17	-	-	15	210	2	6
S.bottlenose whale	3	5	-	-	9	19	2	3	3	4	-	-	3	3	1	2
Arnoux's beaked whale	-	-	-	-	-	-	-	-	-	-	-	-	1	5	-	-
Beaked whales	43	69	2	3	35	53	-	-	14	22	-	-	27	53	-	-
Pilot whale	1	5	-	-	1	15	-	-	-	-	-	-	-	-	-	-
Hourglass dolphin	7	61	4	39	-	-	-	-	4	17	6	51	6	20	4	28
Species unknown	45	105	10	13	20	33	7	13	21	47	2	4	39	73	10	24

Pridz Bay stratum in the Second period

Species	Primary		Secondary	
	Sch	Ind	Sch	Ind
Minke whale	161	929	329	1,343
Like minke whale	4	13	2	21
Humpback whale	1	2	-	-
Sperm whale	5	9	8	8
Killer whale	6	130	4	34
Species unknown	2	3	-	-

East-North stratum in the Second period

Species	Primary		Secondary	
	Sch	Ind	Sch	Ind
Minke whale	2	8	-	-
Fin whale	1	2	-	-
Killer whale	1	2	-	-
S.bottlenose whale	1	1	-	-
Hourglass dolphin	1	2	-	-

Table 3. (continued)

Combined

Species	Primary		Secondary	
	Sch	Ind	Sch	Ind
Minke whale	616	2,061	478	1,668
Like minke whale	34	43	11*	34*
Dwarf minke whale	-	-	2	2
Blue whale	3	3	2*	2*
Fin whale	14	62	3	8
Sei whale	2	2	-	-
Humpback whale	194	351	33	61
Right whale	26	30	4	4
Sperm whale	322	332	47	47
Killer whale	89	1,098	31	347
S.bottlenose whale	48	81	4	8
Mesoplodon spp.	1	2	1	1
Arnoux's beaked whale	1	5	-	-
Beaked whales	280	451	13	22
Pilot whale	7	278	2	18
Hourglass dolphin	18	100	15*	120*
Species unknown	218	435	39	72

*Include the sighting during the pack ice survey and movement between strata.

Table 4. Sampling intervals and the days of the limited sampling in each stratum.

Stratum	Sampling interval		Limited sampling (day)	Stratum	Sampling interval		Limited sampling (day)
	Interval	Days			Interval	Days	
Fist period				*Second period*			
West-North	1	2	0	East-North	1	2	0
West				West			
Middle	1	13	0	Middle	1	11	3
South	1	7	1	South	1	12	3
East				Pridz Bay	1	2	2
Middle	1	9	0		3	4	0
South	2	8	0	East			
	1	5	0	Middle	1	12	0
				South	2	4	0
					1	11	2
Total		44	1	Total		58	8

Table 5. Numbers of animals sighted and sampled by sampling vessels and their sampling efficiencies.

Stratum	Sighted		Targeted		Sampled		Sampling efficiencies		
	Sch (A)	Ind (B)	Sch (C)	Ind (D)	Sch (E)	Ind (F)	I(E/A)	II(F/B)	III(F/D)
First period									
West-North	2	2	2	2	0	0	0.00	0.00	0.00
West									
Middle	32	59	29	41	22	26	0.69	0.44	0.63
South	23	40	16	22	16	21	0.70	0.53	0.95
East									
Middle	26	33	18	22	14	14	0.54	0.42	0.64
South	40	73	23	33	17	21	0.43	0.29	0.64
Second period									
East-North	2	8	2	4	1	1	0.50	0.13	0.25
West									
Middle	77	129	55	77	51	64	0.66	0.50	0.83
South	61	137	54	86	46	66	0.75	0.48	0.77
Pridz Bay	77	264	28	44	25	35	0.32	0.13	0.80
East									
Middle	0	0	0	0	0	0			
South	47	182	33	55	28	40	0.60	0.22	0.73
Total	387	927	260	386	220	288	0.57	0.31	0.75

Table 6. Numbers of schools targeted and sampled and their sampling efficiencies by school size.

School size	No. of schools targeted (A)	No. of schools sampled			Two whales sampled (D/A)	Efficiency III*
		none (B)	one (C)	two (D)		
1	134	32	102	-		0.76
2	59	4	30	25	0.42	0.68
3	34	3	11	20	0.59	0.75
4	12	0	5	7	0.58	0.79
5	10	1	2	7	0.70	0.80
6	5	0	1	4	0.80	0.90
7	3	0	1	2	0.67	0.83
8	2	0	0	2	1.00	1.00
10	1	0	0	1	1.00	1.00
Total	260	40	152	68	0.26	0.85

* See Table 5.

Table 7. Causes of failure to collect samples by school size.

School size	Reasons why whales could not be sampled									Total
	A	B	C	D	E	F	G	H	I	
1	10	7	4	1	0	5	2	-	3	32
2	3	2	2	0	0	0	1	29	1	38
3	1	1	0	2	0	0	0	13	0	17
4	0	0	1	0	0	0	0	4	0	5
5	0	0	1	0	0	0	0	2	1	4
6	0	0	0	0	0	0	0	1	0	1
7	0	0	1	0	0	0	0	0	0	1
Total	14	10	9	3	0	5	3	49	5	98
(%)	14.3	10.2	9.2	3.1	0.0	5.1	3.1	50.0	5.1	100

A= quick/mobile; B= long diving; C= fast swimming; D= sea condition; E= limited time; F= technical problems; G= pack ice; H= missing of the targeted animal before chasing; I= other.

Table 8. Summary of biological data and samples collected.

Samples and data	Number of whales		
	Male	Female	Total
Body length and sex identification	165	123	288
External measurement	165	123	288
Photographic record of external character*	165	123	288
Diatom film record and sampling	165	123	288
Standard measurement of blubber thickness (three points)	165	123	288
Detailed measurement of blubber thickness	39	21	60
Body weight	159	116	275
Body weight by total weight of parts	42	21	63
Earplug for age determination	165	123	288
Tympanic bulla for age determination	165	121	286
Largest baleen plate for age determination	41	40	81
Earplug for chemical analysis (one of the pair)	5	5	10
Vertebral epiphyses sample	165	122	287
Skull measurement (length and breadth)	164	121	285
Mammary grand; lactation status, measurements and histological sample	—	123	123
Milk sample for chemical analysis	—	2	2
Ovary collection	—	123	123
Uterine horn; measurement and endometrium sample	—	123	123
Uterine mucus for sperm detection	—	123	123
Photographic record of fetus	—	73	73
Fetal sex (identified by visual observation)	(29)	(32)	(61)
Fetal length and weight	(29)	(32)	(61)
External measurement of fetus	(21)	(19)	(40)**
Collection of fetus	(3)	(5)	(19)**
Testis and epididymis; weight and histological sample	165	—	165
Smear samples from testis and epididymis tissues	165	—	165
Urine sample for sperm detection	51	—	51
Serum sample for gonadal hormone assay	156	118	274
Muscle tissue for gonadal hormone assay	63	63	126
Muscle, liver and heart tissues for isozyme analysis	165	123	288
Tissues for isozyme analysis (fetus)	(26)	(27)	(53)
Blubber, muscle and kidney tissues for DNA study	165	123	288
Tissues for DNA study (fetus)	(26)	(27)	(53)
Muscle, liver and kidney tissues for heavy metal analysis	59	46	105
Blubber and liver tissues for organochlorine analys	57	41	98
Stomach content, conventional record	165	123	288
Weight of stomach content in each compartment	163	123	286
Collection of stomach contents for the food and feeding study	31	14	45
Tissues for the lipid analysis	39	21	60
Collection of external parasites	45	33	78
Collection of internal parasites	1	1	2
Collection of whole skeleton	0	1	1

* photos include 1) color pattern of dorsal side, 2) dorsal fin, and 3)flipper (left or right).
** including fetuses of sex unidentified.

Table 9. Relation between activity of hourglass dolphin to vessel* and the velocity of the wind.

Velocity	Not associate		Associate	
Kt	Sch.	%	Sch.	%
0	0	-	0	-
5	2	100	0	0.0
10	6	85.7	1	14.3
15	12	85.7	2	14.3
20	3	75.0	1	25.0
25	1	25.0	3	75.0

* Activity was judged whether dolphins associated with vessel or not.

Table 10. Products amassed at research base.

Name of product	Amount (kg)	Name of product	Amount (kg)
O-niku* (premium)	1,365.0	Ventral blubber	13,804.0
O-niku* (regular)	1,035.0	Bacon (grade 1)	62,788.5
Ventral blubber(neck)	780.0	Bacon (grade 2)	2,254.5
Jaw skin (mottled)	2,595.0	Bacon (small pieces)	19,494.0
Jaw skin (regular)	1,005.0	Ventral grooves	6,615.0
Red meat (premium)	2,490.0	Blubber (premium)	6,110.0
Red meat (grade 1)	296,325.0	Blubber (grade 1)	73,216.0
Red meat (grade 2)	40,365.0	Kidney	2,184.0
Red meat (regular)	12,270.0	Heart	3,276.0
Small pieces (grade 1)	26,025.0	Pancreas	567.0
Small pieces (grade 2)	28,995.0	Esophagus	286.0
Small pieces (regular)	34,800.0	Mandibular ligaments (hard)	2,067.0
Breast meat (grade 1)	53,280.0	Mandibular ligaments (soft)	1,092.0
Breast meat (grade 2)	98,115.0	Tongue (mottled)	1,937.0
Breast meat (grade 3)	255,225.0	Tongue	22,009.0
Breast meat (regular)	1,200.0	Tongue (regular)	1,729.0
Diaphragm	7,155.0	Stomach lining	1,482.0
Blubber (regular)	57,275.0	Intestine	5,087.5
Posterior ventral blubber	57,825.0	Underside of blubber	12,750.0
Nasal passage lining	3,400.0	Lining of meat	9,525.0
Tale flukes (premium)	15,675.0	Testis	96.0
Tale flukes (regular)	2,975.0	Brain	0.0
Maxillary cartilage	1,800.0	Caudal tendon	2,786.0
Cartilage	350.0	Tendon	5,040.0
		Total	1,258,520.5

*: muscles associated with caudal vertebra.

Table 11. Reproductive status and male sex ratio (%) of samples in each stratum.

Stratum	Male		Female							Total (% M)*
	Imm.	Mat.	Imm.	Mat.						
				Ovu.	Rest.	Preg.	Lact.	P & L	Unk.	
First period										
West-North	-	-	-	-	-	-	-	-	-	-
West										
Middle	3 (11.5)	16 (61.5)	5 (19.2)	-	1 (3.8)	1 (3.8)	-	-	-	26 (73.1)
South	3 (14.3)	9 (42.9)	3 (14.3)	-	-	6 (28.6)	-	-	-	21 (57.1)
East										
Middle	8 (57.1)	3 (21.4)	1 (7.1)	-	-	2 (14.3)	-	-	-	14 (78.6)
South	2 (9.5)	9 (42.9)	3 (14.3)	-	-	7 (33.3)	-	-	-	21 (52.4)
Second period										
East-North	-	1 (100)	-	-	-	-	-	-	-	1 (100)
West										
Middle	13 (20.3)	35 (54.7)	8 (12.5)	-	-	6 (9.4)	-	2 (3.1)	-	64 (75.0)
South	5 (7.6)	27 (40.9)	10 (15.2)	1 (1.5)	3 (4.5)	18 (27.3)	1 (1.5)	-	1 (1.5)	66 (48.5)
Pridz Bay	-	9 (25.7)	5 (14.3)	2 (5.7)	-	19 (54.3)	-	-	-	35 (25.7)
East										
Middle	-	-	-	-	-	-	-	-	-	-
South	3 (7.5)	19 (47.5)	4 (10.0)	-	2 (5.0)	11 (27.5)	-	-	1 (2.5)	40 (55.0)
Total	37 (12.8)	128 (44.4)	39 (13.5)	3 (1.0)	6 (2.1)	70 (24.3)	1 (0.3)	2 (0.7)	2 (0.7)	288 (57.3)

* percentage of males.

Table 12. Reproductive status by school size.

School size	Male			Female		
	Imm.	Mat.	Total	Imm.	Mat.	Total
1	27 (45.0)	33 (55.0)	60	26 (60.5)	17 (39.5)	43
2	4 (8.2)	45 (91.8)	49	3 (10.0)	27 (90.0)	30
3	2 (6.7)	28 (93.3)	30	5 (23.8)	16 (76.2)	21
4	2 (20.0)	8 (80.0)	10	1 (11.1)	8 (88.9)	9
>= 5	2 (12.5)	14 (87.5)	16	4 (20.0)	16 (80.0)	20
Total	37 (22.4)	128 (77.6)	165	39 (31.7)	84 (68.3)	123

Table 13. Comparison of searching distances (n.miles), number of primary sightings, density indices (DI) and mean school sizes (MSS) for the present research in 1991/92 with those for the research in 1989/90.

Stratum	Research in 1989/90					Research in 1991/92				
	Distance	Sighting Sch	Sighting Ind	DI	MSS	Distance	Sighting Sch	Sighting Ind	DI	MSS
First period										
West-North West	522.9	3	3	0.57	1.00	421.2	2	2	0.47	1.00
Middle	1976.0	51	77	2.58	1.51	2090.3	32	59	1.53	1.84
South	2876.7	88	140	3.06	1.59	1351.4	50	86	3.70	1.72
East										
Middle	1963.5	49	109	2.50	2.22	2160.2	26	33	1.20	1.27
South	1328.1	159	428	11.97	2.69	2291.0	70	149	3.06	2.13
Second period										
East-North West	206.0	1	1	0.49	1.00	290.2	2	8	0.69	4.00
Middle	1978.5	57	75	2.88	1.32	2472.3	77	129	3.11	1.68
South	2497.7	90	175	3.60	1.94	2197.9	113	308	5.14	2.73
Pridz Bay	837.5	44	77	5.25	1.75	576.3	161	929	27.94	5.77
East										
Middle	1489.0	75	137	5.04	1.83	2262.0	0	0	0.00	
South	1380.0	150	756	10.87	5.04	2091.7	83	358	3.97	4.31
Total	17055.9	767	1978	4.50	2.58	18204.5	616	2061	3.38	3.35

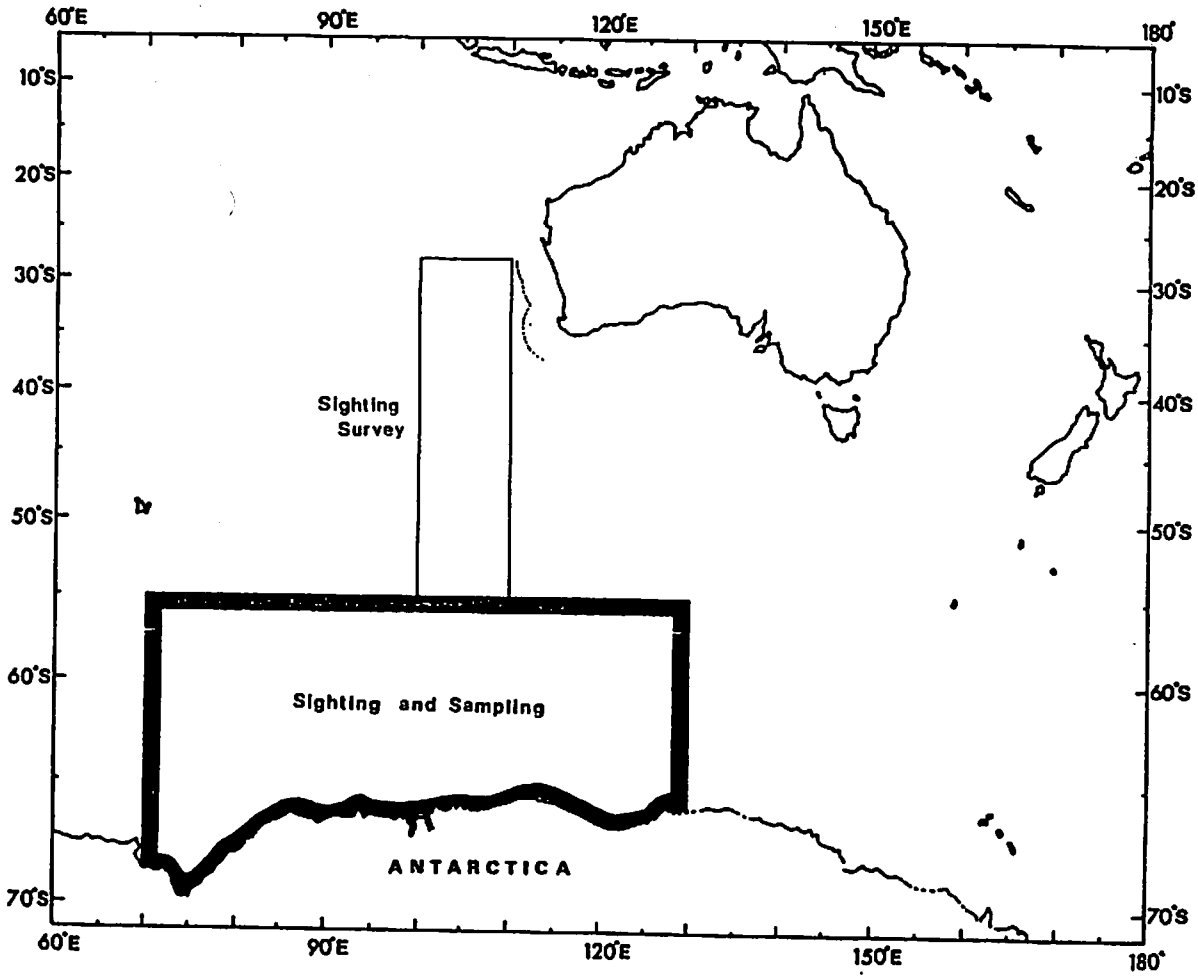

Fig. 1. Research area covered in the Japanese research in 1991/92.

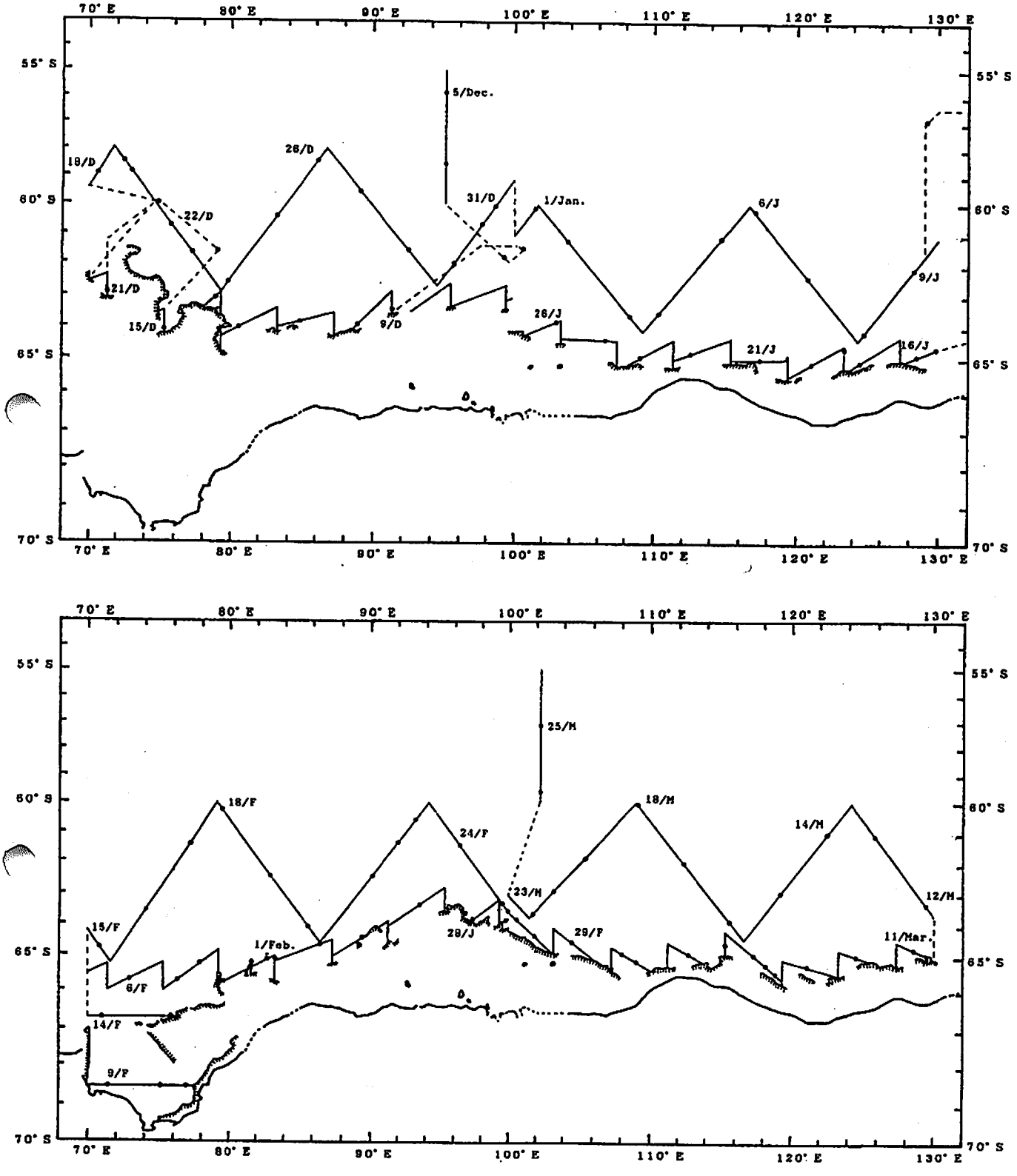

Fig. 2. Cruise tracks and noon positions of the research base (*NM*) in the Japanese research in 1991/92. Solid and broken lines represent track and movement lines in research area, respectively. Upper: First period, lower: Second period.

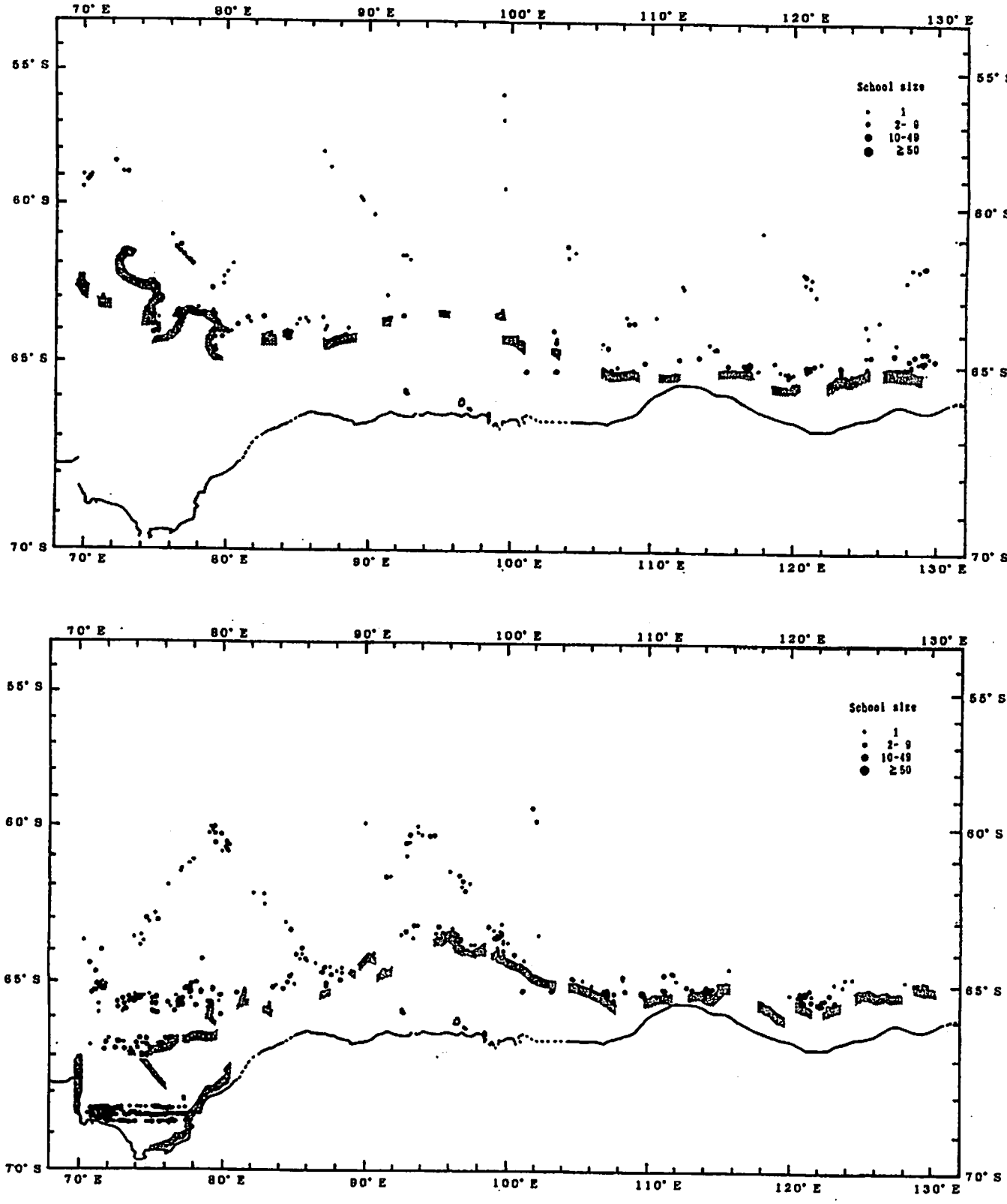

Fig. 3. Distribution of the primary minke whale sightings by three sampling and sighting vessels. Upper: First period, lower: Second period.

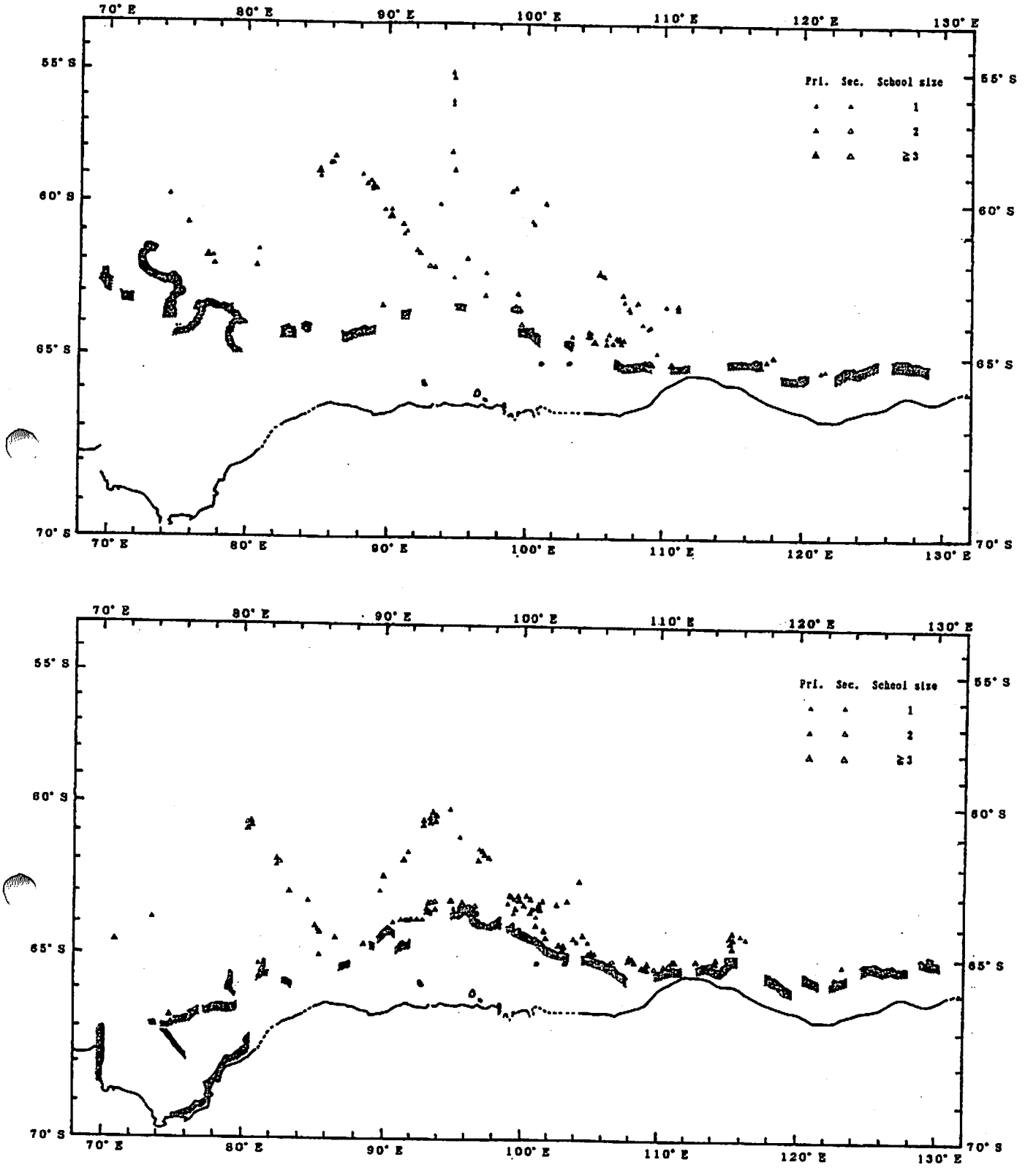

Fig. 4. Distribution of humpback whales sighted by three sampling and sighting vessels. Closed and open triangles indicate primary (pri.) and secondary (sec.) sightings, respectively.

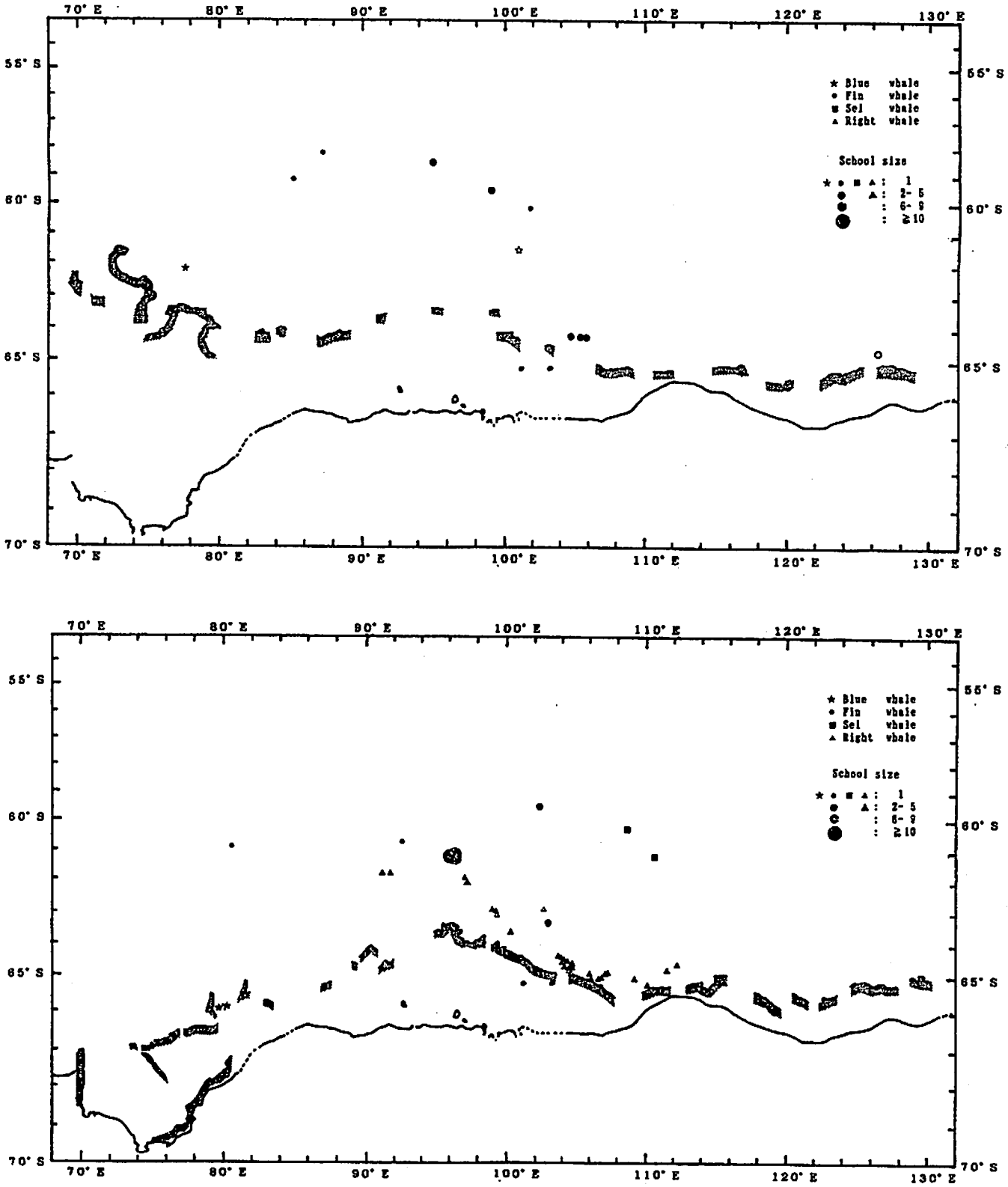

Fig. 5. Distribution of blue, fin, sei, and right whales sighted by three sampling and sighting vessels. Closed and open marks represent primary (pri.) and secondary (sec.) sightings, respectively. Upper: First period, lower: Second period.

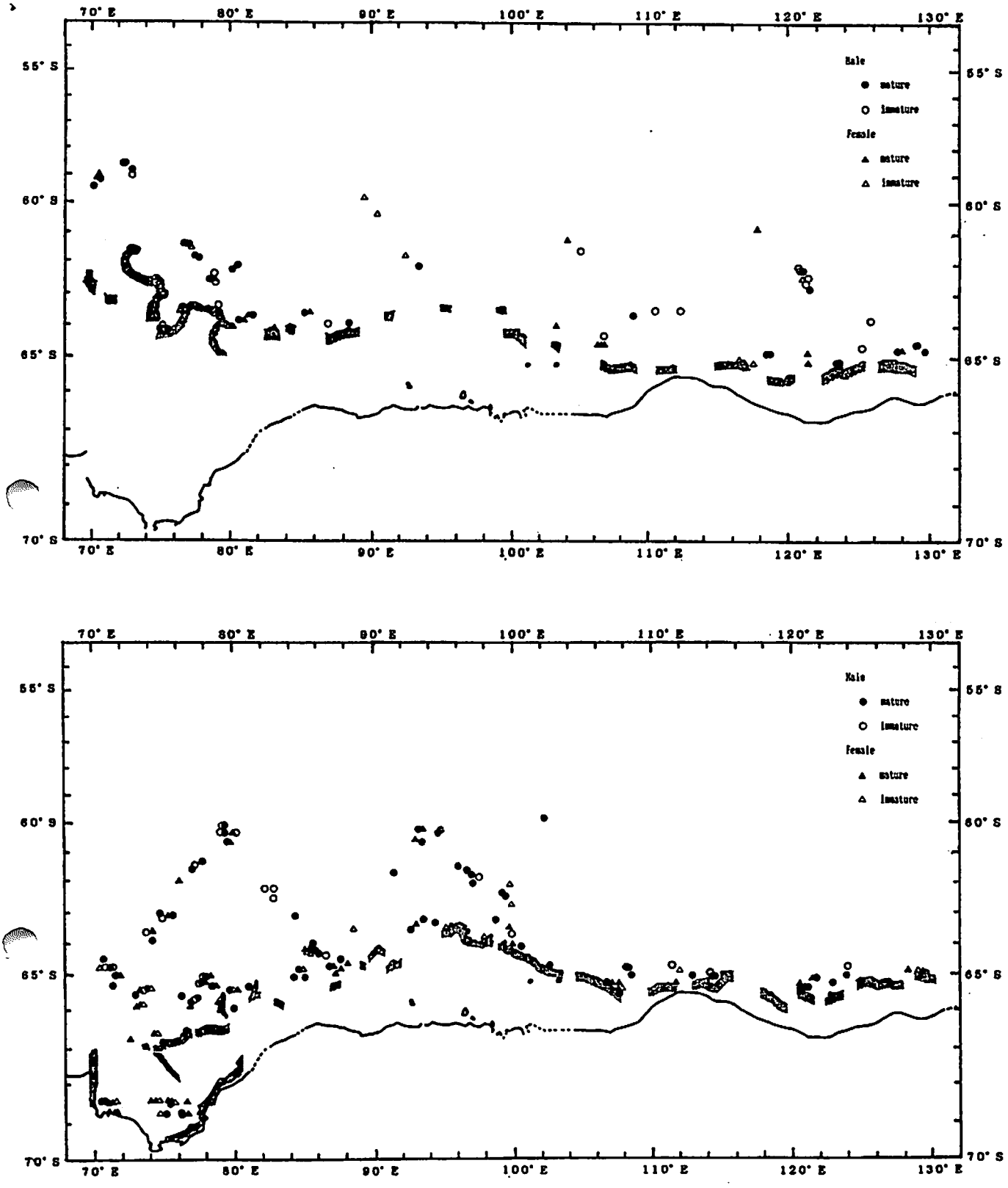

Fig. 6. Distribution of minke whale sampled based on their sighted position. Upper: First period, lower: Second period.

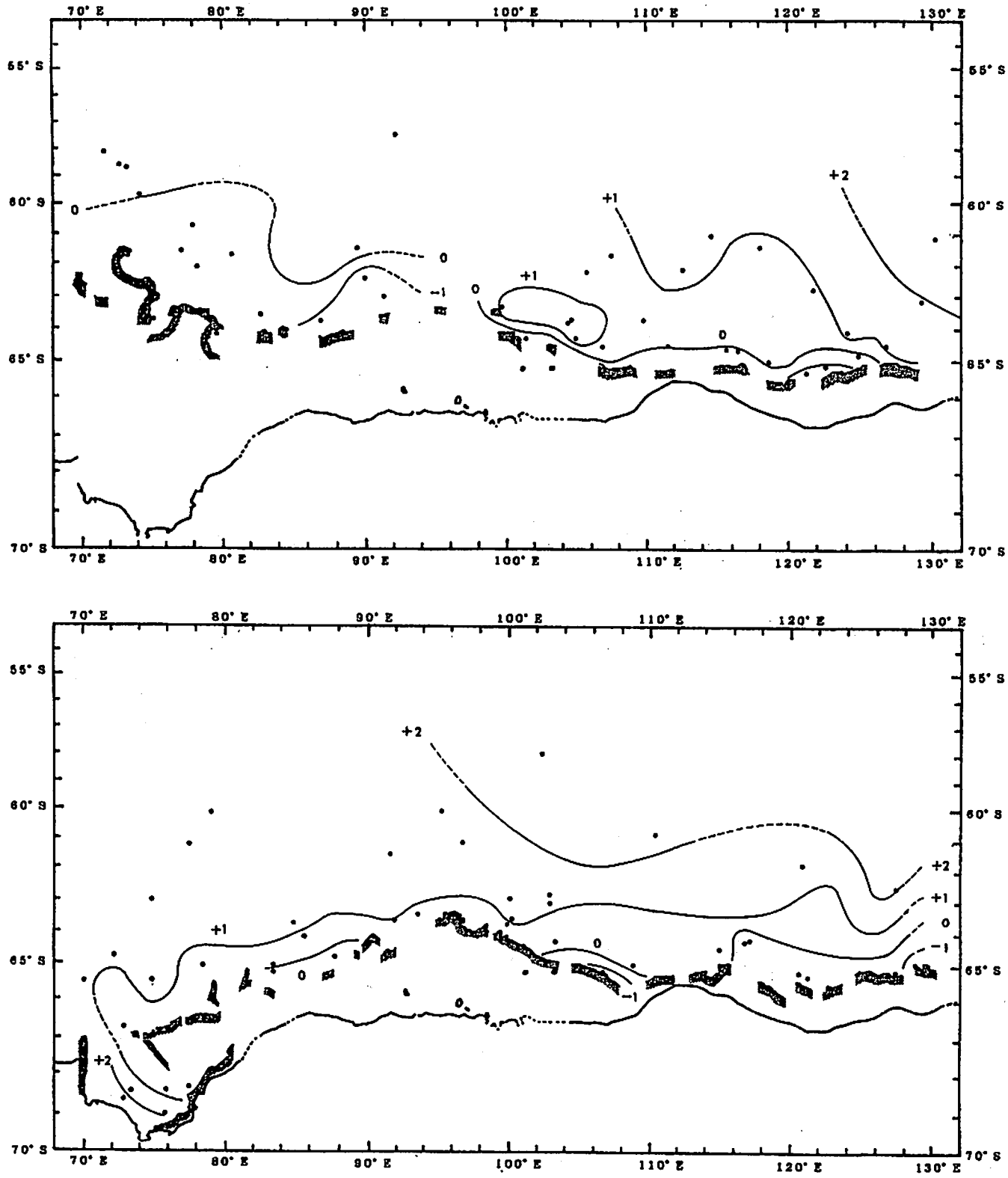

Fig. 7. Surface water isothermals and positions of the XBT survey.

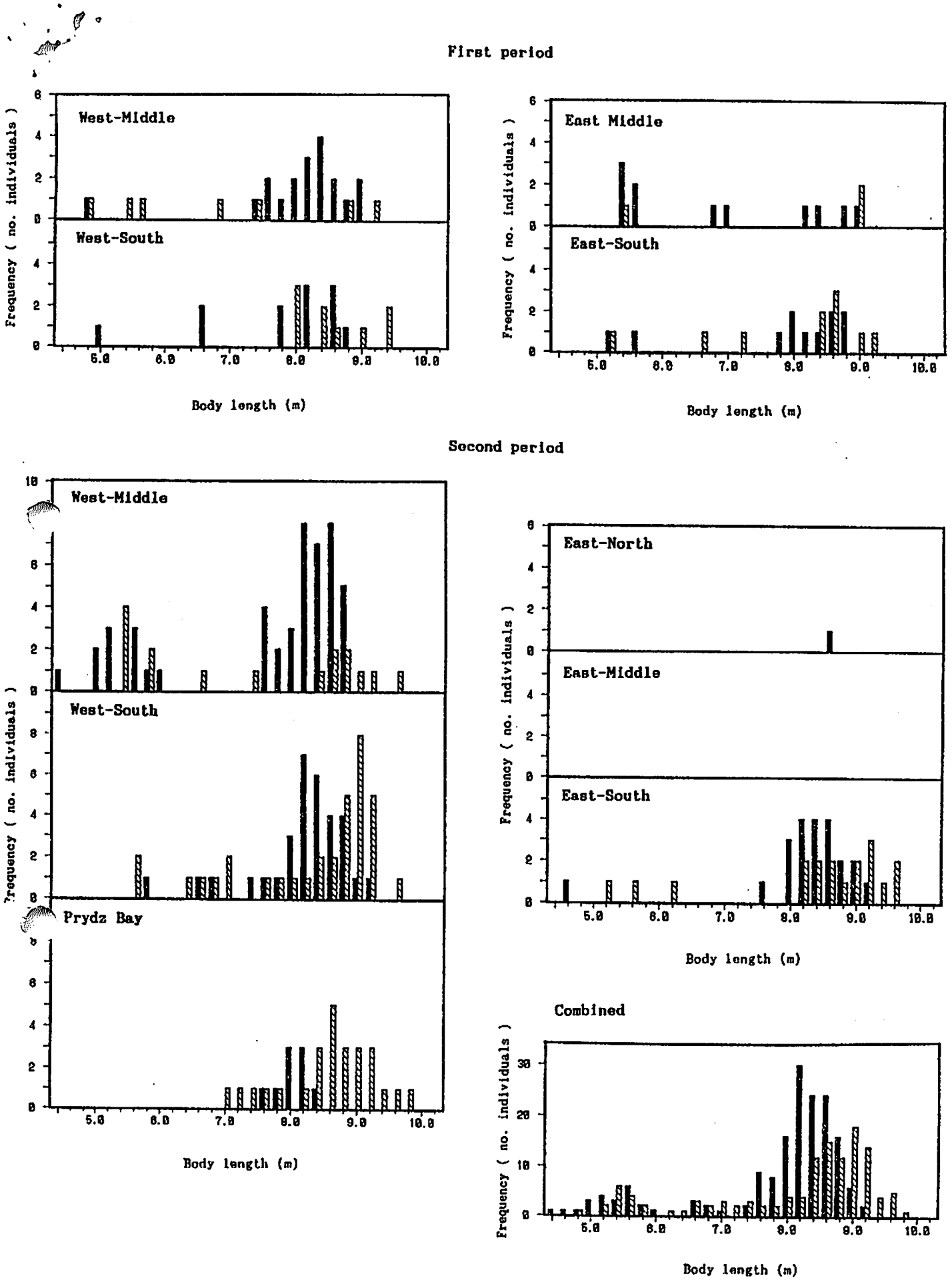

Fig. 8. Body length compositions (20cm intervals) by each stratum. Solid and hatched lines represent males and females, respectively.