Cruise Report of the 1992/93 Japanese Research under the Special Permit for Southern Hemisphere Minke Whales

Yoshihiro Fujise[1], Ryoko Zenitani[1], Shigeo Saino[1], Shunsuke Itoh[1], Masahiro Kawasaki[1], Koji Matsuoka[1], and Tsutomu Tamura[2]

ABSTRACT

The sixth cruise of the Japanese research program conducted under the special permit carried out in Antarctic Area V (south of 60°S, 130°E-170°W including all the regions of the Ross Sea south of 69°S) among 3 December 1992 and 25 March 1993, using one research base and three sightings and sampling vessels. The research consisted of two different surveys, one for the entire research area and one for the special monitoring zone (SMZ). A series of surveys was conducted once during the season, with the survey efforts concentrated on the peak distribution period of minke whales. To investigate seasonal fluctuations of distribution of minke whales in the SMZ, it was surveyed in each case before and after the main research. The sampling methods were changed to taking one whale from a school instead of taking two samples as in the previous season in order to achieve better representation of the whale population using the random sampling procedure. A sighting vessel was allocated in all the research areas for improving the searching effort. The other two vessels were engaged in sampling as well as sighting in all the areas surveyed. The fleet surveyed a total of 13,492.3 n.miles and made 933 primary (3,049 individuals) and 395 secondary (952 animals) sightings of minke whales. In the present season, the highest density area of minke whales was observed in the east part of the Ross Sea. A total of 327 (167 males and 160 females) ordinary forms and three female dwarf form minke whales were caught from

---

[1] Inst. Cetacean Res., 4-18, Toyomi-cho, Chuo-ku, Tokyo 104, Japan.

[2] Facul. Fish., Hokkaido Univ., 3-1-1 Minato-cho, Hakodate 041, Japan.

primary sightings. Reproductive segregations of minke whales were found the Ross Sea and other research areas from the preliminary analyses of the samples: mature females were concentrated in the South strata, especially in the eastern part of the Ross Sea; immature animals occurred in the North strata and mature males were distributed in all the surveyed areas.

INTRODUCTION AND POINTS OF IMPROVEMENT OF RESEARCH

The proposal for the Japanese research program in the Antarctic for the 1992/93 season (SC/44/SHB14) was submitted to the IWC/SC last year (Government of Japan, 1992a), and received some comments by members of the IWC/SC. The resolution to request Japan to improve the program concerning the special permit on Antarctic minke whales (IWC/44/23 Rev), at the Commission Meeting, was adopted (IWC, 1992). In them, the Government of Japan considered the following points; 1) Some differences exist between the estimated stock examining abundance of Antarctic Minke Whales based on the sighting surveys conducted during the Japanese research activities and those obtained from the IDCR cruise, 2) Samples taken at random by the Japanese research may not represent the whole of the population of the Antarctic minke whales. After the reexamination, this program in 1992/93 season was modified as follows: 1) a series of surveys would be conducted once during the season, with the survey efforts concentrated on the peak distribution period of minke whales, so as to match the procedure taken by the IDCR cruise as much as possible, 2) to investigate seasonal fluctuations of distribution of minke whales, the special monitoring zone (SMZ) is set in a part of the research area, and will be surveyed in each before and after the entire research, 3) the methods for the sighting survey will be adopted as closely as possible to those used in the IDCR, and 4) in order to achieve representation of the whale population by the samples, one whale should be randomly sampled out of a school in stead of taking two samples as in the previous season (Government of Japan, 1992b).

This report covers the research cruise in the Antarctic Area V conducted between 3 December 1992 and 25 March 1993, and presents some preliminary analyses of the biological data obtained. The sighting cruises in the lower and middle latitudes which were done under the same research plan will be reported separately.

AN OUTLINE OF THE CRUISE AND RESEARCH METHOD

Research fleet

Three vessels, *Kyomaru No.1* (*K01*; 812.08GT), *Toshimaru No.25* (*T25*; 739.92GT) and *Toshimaru No.18* (*T18*; 758.33GT), were engaged in the sighting and sampling surveys, natural markings, oceanographical surveys and several experiments were conducted. *Nisshinmaru* (*NM*; 7,440GT) acted in general matters such as planning of the daily research strategy, setting cruise course, arrangements for sampling vessels, weather forecasting, refueling for the sampling vessels etc. The measurements, collection of biological materials and processing of the sampled whale carcasses took place on the deck of *NM*.

Research area

The research area covered the Antarctic Area V south of 60°S between 130°E and 170°W, including all regions of the Ross Sea south of 69°S (Fig. 1). The research in this season consisted of two surveys for the entire research area and the special monitoring zone (SMZ) in one part of the research area.

The entire research area

The research area was divided into West and East sub-areas, divided at 165°E. For the West sub-area, the North and South strata were separated by a line 45 n.miles northward from the ice edge line. For the East subarea, the area between 60°S and 69°S was designed as the North stratum, and all the Ross Sea region south of 69°S as the South stratum.

Special Monitoring Zone (SMZ)

A part of the research area is defined as the "Special Monitoring Zone". The North and South strata were treated in the same way as the entire research area. The SMZ was set between 130°E and 155°E, and conducted additionally before and after the other research. Therefore, the SMZ was surveyed three times.

Research period

The research lasted for 112 days from 3 December 1992 to 24 March 1993. The survey in each stratum was conducted in the following period:

First period (SMZ)	
North stratum	15 - 25 Dec. 1992
South stratum	3 - 14 Dec. 1992

Second period (entire research area)

West-North stratum	25 Jan. - 5 Feb. 1993	
West-South (W) stratum	15 Jan. - 24 Jan. 1993	
(E) stratum	8 Feb. - 13 Feb. 1993	
East-North stratum	30 Dec. 1992 - 11 Jan. 1993	
East-South stratum	14 Feb. - 6 Mar. 1993	

Third period (SMZ)

North stratum	19 - 24 Mar. 1993
South stratum	10 - 18 Mar. 1993

In order to investigate the behavior of blue whales in the feeding ground, a preliminary survey was continuously conducted using one vessel during 23-24 March 1993, and three vessels on 25 March 1993.

Cruise track

The cruise track in each stratum was established by the same principle of the 1990/91 research (Kasamatsu *et al.*, 1991), except for the West-South stratum which was designed the same way as the previous research activity (Fujise *et al.*, 1990, 1992). Fig. 2 shows the trackline of the main course of this survey with the noon positions of the research base.

For the West-South stratum, the trackline was determined with longitude randomly selected from lines divided by one n.mile between 151°E and 155°E. This longitude was determined as 151°26'E. Longitudinal parts of the trackline in the strata were determined at intervals of 4 degrees from the determined longitude. The survey was conducted in the following order: (A) from the point of the ice edge on the determined longitude, (B) from the point 45 n.miles north from point A and (C) from the expected point of the ice edge on the next longitude. When the expected point did not coincide with the actual point of the ice edge, the fleet moved from the expected point to the actual point.

In the East-South stratum, the area was further divided into three sub-areas by longitude: west sub-area (165°E-180°), east sub-area (180°-170°W) and eastmost sub-area (170°W-160°W). The tracklines in these sub-areas were randomly selected in each sub-area independently.

In the North strata in both East and West Sectors, the cruise tracks were constructed on zig-zag patterns the same as those used in IWC/IDCR cruises. The survey lines were randomly selected from points that were determined on 60°S which is the northern boundary of the North strata.

SIGHTING AND SAMPLING

Sighting manner

The principal sighting manner was similar to that 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). Some minor changes are explained below.

Three tracklines consisting of the main and two sub-courses, were established. The main course was randomly determined in the same manner as in the previous section. The sub-courses were parallel to the main course nine miles away from either sides. Three vessels which conducted sighting and sampling, were allocated in each of these three tracklines. Allocation arrangement was rotated daily. In the present survey, one vessel out of three sampling vessels, allocated in the main course, was assigned for sightings in all research areas in order to increase the sighting effort and it was referred to as the 'sighting' vessel. Other two vessels on the sub-courses were engaged in both sighting and sampling activities and were referred to as 'sighting/sampling' vessels. The 'sighting' vessel surveyed at least 12 n.miles ahead of the 'sighting/sampling' vessels to avoid any adverse influences resulting from the sampling vessels' activities.

In order to conduct research in the entire Area V within the comparable period as that adopted by the IDCR survey cruise, it was necessary to establish the minimum proceeding distance. The minimum daily proceeding distance was established in order to increase research activities under favorable weather conditions.

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

The sighting survey was principally made at a speed of 11.5 knots during the day time either from 30 minutes after sunrise to 30 minutes before sunset or between 06:00h and 20:00h. The research was suspended when the average wind velocity reached 26 knots or more in the West-South stratum and 21 knots or more in the West-North stratum and East Sector. No research was conducted when the visibility of minke whales was 1.5 miles or less.

Searching effort

Table 1 indicates the searching distances (n.miles) by the 'sighting' vessel and two 'sighting/sampling' vessels in the full research area and the SMZ. The total searching distance was 13,492.3 n.miles, and was 1,265.5 n.miles shorter than that of the 1990/91 research. Searching of 5,961.0 n.miles by the 'sighting' vessel was 1,570.3 n.miles shorter than that of two 'sighting/sampling' vessels. Allocation of the searching effort was almost similar for each stratum, with the exception of the North stratum of the SMZ in the third period.

Species sighted

Table 2 summarizes the sightings effectuated. The ordinary form minke whale was the most common species throughout all strata. Primary sightings involved 933 schools (3,049 individuals) and secondary sightings 395 schools (952 individuals). Five schools (five individuals) of the dwarf form of minke whale were sighted as primary sightings.

A total of seven schools (nine individuals) of the blue whale was recorded as primary sightings and four schools (nine individuals) as secondary sightings. Most of those were sighted in the South strata. Humpback whales were sighted for 28 schools (56 individuals) as the primary sightings and 10 schools (17 individuals) as the secondary sightings, and sighted in all strata except the North stratum of the SMZ in the first and second periods. Seventeen schools (34 individuals) of fin whales (*B. physalus*) were sighted in all the strata. Four right whales and one sei whale (*B. borealis*) were sighted in the South stratum of the SMZ in the first and third periods.

Sperm whales (*Physeter macrocephalus*) and killer whales (*Orcinus orca*) were common through all strata of both sectors. Some Ziphiidae were also sighted in all the strata except in the North strata in the third period. Primary sightings of 212 schools (423 individuals) and secondary sightings of six schools (15 individuals) were observed. These figures include a total of 11 schools (22 individuals) of the southern bottlenose whale (*Hyperoodon planifrons*) and seven schools (50 individuals) of the Arnoux's beaked whale (*Berardius arnuxii*). Most of the hourglass dolphins (*Lagenorhynchus cruciger*) were in the North strata in the second period and the North and South strata in the third period. Pilot whales (*Globicephala melaena*) were sighted in the West-North stratum in the entire research area.

Distribution and density of whales sighted

Fig. 3 shows the spatial distribution of the primary sightings of minke whales. Minke whales were sighted in all the surveyed strata. The total number of minke whales sighted in the South strata was much higher than in the North strata (Table 2). A similar number of minke whales was observed in the South strata of both Sectors.

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 South strata in the entire research area (Table 3). In the SMZ, the DI was higher in the First and Second periods than in the third period. The MSS was also higher in the First period than the later period, and decreased with the close of the season. In the entire research area survey (Fig. 4), the DI and MSS was higher in the Ross Sea, especially in the eastmost sub-area (170°W-160°W) where the values were 95.4 and 7.40, respectively.

Fig. 5 shows the geographical position of the sightings of humpback, blue, right, and fin whales. Humpback, right and blue whales were target species for natural marking and biopsy sampling. Humpback whales were sighted around the ice edge zone and offshore between 160°E and 170°E, but no sighting was made in the Ross Sea. Blue whales were sighted sporadically in the ice edge zone and the Ross Sea. Blue whales were sighted near the ice edge. Fin whales were sighted north of this position. Three right whales were sighted near the ice edge in the western part of the research area.

Sampling of whales

Samples were collected by only two 'sighting/sampling' vessels in all research areas. In order to attach greater importance to the representativeness of the samples, the current sampling method was changed so that only one whale would be caught from a school instead of taking two samples as in the previous season.

Sampling was tried only from primary sightings of minke whales, within 3 n.miles of the trackline. Selection of the target samples was made as in the previous pattern by which one whale was selected randomly according to the random digits tables prepared by different school sizes (Kato *et al.* 1989, 1990; Fujise *et al.*, 1990, 1992a; Kasamatsu *et al.*, 1991). If the selected and targeted whales could not taken for any reason (see below), the reselection of a targeted whale was applied to the school. This reselection was limited once a school. A total of eight schools was applied the reselection.

In the present research, the 'stop-catch' had to be invoked on certain occasions when the maximum biological surveying and processing capacities of the *NM* were reached. This 'stop-catch' was conducted only two days (10 February and 11 March), nine days fewer than those in the last research.

During the sampling activities, one accident occurred involving *KO1* on 3 March 1993 in the survey of the East-South stratum. On that day, *KO1* started the survey at 06:00h, and sighted a minke whale school at 06:12h. After confirmation, this school was recorded as two minke whales. One whale was selected by the sampling method, and struck by the harpoon at 06:31h. The whale, however, was missed because of the harpoon rope breaking during the electrocution. The researcher on board the vessel judged the whale was dead and lost, and made the selection again from the same school using the sampling method. The second whale was targeted and taken at 06:56h. *KO1* resumed the survey at 07:03h, and sighted a whale school at 07:04h, and began to close the school. During the confirmation, the sighted singleton whale was missed thorough the whale diving, it was swapped for the last lost whale (which had been hit by the harpoon). We decided to take this whale as an exception to the normal sampling procedure for the following reasons. First, it was easily accepted that the struck whale which had the harpoon embedded was on the point of death. The struck whale should have been killed as soon as possible from a humane viewpoint. Second, this whale was the first targeted whale in the school. The whale was taken at 08:04h. Finally, both whales were taken from this school. No more exceptions to the normal sampling scheme were applied during the course of the research.

Fig. 6 indicates the spatial distribution of minke whales sampled based on their sighting position. Sampling activities were conducted in all the strata. A total of 327 ordinary forms (including 167 males and 160 females) and 3 female dwarf form minke whales were sampled. The sample size in each survey period was 77, 210 and 43 in the first, second and third period, respectively. The sampling activity ended on 22 March 1993 when the upper limit (330 individuals) of the sample size in this research was achieved.

Sampling efficiencies and causes of failure in sampling

Table 4 indicates the numbers of whales sighted and sampled and the efficiency of sampling. In this table, the numbers of sightings (A and B) were those made only by the 'sighting/sampling' vessels.

Sampling efficiency (I) indicates the proportion of whales sampled to the number of primary sightings. This efficiency was almost similar among strata (0.22-0.33) with the exception of the values obtained in the East-North stratum (0.54).

Efficiency (II) was the same value as the technical efficiency reported in the previous cruise reports in this program. This value was relatively high in the all strata except in the West-North stratum. The efficiency in total was 0.84, which was remarkably higher than those reported in the previous survey in Area V (0.52, Kasamatsu *et al.*, 1991).

A total of 63 individuals were targeted but not sampled. Table 5 shows the reasons for failure, including eight identified causes of failures for taking targeted whales by school size. The major cause of the failure of sampling was the whale's behavior i.e. quick, mobile, long diving and fast swimming. For schools of 2 or more individuals the major cause of failure was also whale behavior.

BIOLOGICAL DATA AND SAMPLE COLLECTION

Whales sampled were towed by research vessels as soon as possible to the research base (*NM*). Detailed surveys, including weighing of the whale, were conducted on board of *NM*. These descriptions are given in a later section.

Biological measurements and sample collections were made on the deck of *NM* on 327 ordinary and three dwarf form minke whales. Those animals comprised 167 males and 163 females including three female dwarf form minke whales. 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, 1992a; Kasamatsu *et al.*, 1991).

Table 6 summarizes 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 RESEARCH

Mark recapture (Discovery tag)

One mark (Discovery tag, No. 44795) was recovered from the body of a whale during the biological survey. The school including the marked whale was sighted and sampled by *T25* on 10 February 1993 (sighted position: 66°20'S 153°16'E). This school was composed of eight animals, and the whales were randomly sampled from those

animals. The marked whale was targeted and sampled at 66°23'S 153°17'E.

The marked whale (specimen No. 171) was a male having testis weight of 1.05 kg. The body length and weight of this whale were 8.4m and 7.5t, respectively. This whale was marked at 70°57'S 174°58'W on 1 February 1981 by *Kyomaru No.27* during the 1980/81 IWC/IDCR cruise. The elapsed time between marking and recovering was 12 years and nine days. Positions of marking and recovery were in the same Area V (Government of Japan, 1993).

Experiments

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 23 February 1993, in order to evaluate the accuracy of the information on sighting distances and sighting angles given by observers of the sighting and sampling vessels. The procedure was the same as that of the previous research (Kasamatsu *et al.*, 1991). All the top men (6 persons) and other personnel 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 involving a total number of 104 persons moving from their normal places at which they engaged in the searching. The result of this experiment will be reported in a future paper.

Reaction monitoring experiment

This experiment, which began in the 1990/91 season 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. The chasing vessel made a normal procedure of sampling but the whales were not taken. If the vessel reached 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).

The experiment was conducted on 2 March 1993 in the eastmost sub-area of the Ross Sea in which high density region of minke whales was observed. Three sets of trials were carried out. During the experiment, the chasing vessel sighted 15 schools (50

individuals) as primary sightings, and chasing was conducted in the same manner as the normal research activity but without any sampling. 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 the whales in 31 schools of minke whales. Total time of the experiment was 9 hours and 15 minutes.

No obvious change of the behavior of the schools was observed by the chasing activities.

Natural marking and biopsy sampling

If blue, humpback and right whales were found, the vessel tried to close to the school and researchers on board took photographs for the natural markings of these whales, and sampling of biopsy was conducted using the air gun system (Kasamatsu *et al.*, 1991)

Attempts were made to photograph the natural markings of 17 schools (34 individuals) of humpback, eight schools (12 individuals) of blue, and three schools (four individuals) of right whales sighted during the present survey. Finally, 25 humpback, 12 blue and four right whales were photographed. The usefulness of these photographs for individual identification study should be examined carefully in future.

Oceanographical survey

In addition to the routine of records of weather and sea conditions every hour, oceanographical surveys including surface temperature and vertical thermal distributions by XBT were carried out on board the *T25* (K. Matsuoka). The XBT survey was conducted in 95 locations from 3 December 1992 to 24 March 1993.

Fig. 7 indicates the distribution of surface water temperature in each research period. The pattern of isothermal line tended to be parallel to the ice edge line. In the Ross Sea, the temperature of the surface water was -1.0°C or lower. The isothermal line also fluctuated by season. In the first period, a line at 0.0°C was almost located at 62°S of latitude. The line shifted to south at about 65°S in the second period, and shifted to north at about 64°S in the third period. Analysis of XBT data will be examined in a future study.

Marine debris

A survey for marine debris during 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 re-

search area, if debris was seen in the stomach contents of a whale caught, it was recorded by photograph and sampled.

The marine debris survey was made on the deck of *NM*. Two debris were recorded from the stomach contents of the whales sampled. One was a piece of wood and the other was the cap of a plastic bottle.

The preliminary survey on the behavior of blue whales

After the sampling activity on 22 March 1993, a preliminary survey on the behavior of the blue whale in the feeding grounds was conducted by one vessel for 2 days and all three vessels for one day. The trackline was temporarily set at the ice edge zone between 145-155°E. Only one day (25 March 1993) was given over to this survey because of the rough sea condition. The sighting method was limited to the closing mode for the blue whales. Although three vessels searched for a total distance of 325.0 n.miles, no blue whales were sighted. During the survey, a total of 50 schools (76 individuals) of minke whales, one school (three individuals) of Sei whales were primarily sighted. Of the toothed whales, six individuals of Ziphiidae, nine killer whales, and eight hourglass dolphins were sighted.

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 1,536t from all of sampled whales (Table 7).

PRELIMINARY ANALYSES OF SAMPLES TAKEN

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

Body length

Fig. 8 shows the body length composition of the samples in the survey of the entire research area. The number of samples collected came to 13, 73, 29 and 93 in the West-North, West-South, East-North and East-South strata, respectively. Larger males and females were collected in all strata in the research areas, but few smaller whales were obtained in the West-North stratum, where most of whales were larger males. It was noted that most of females with a length of 9.0m or more were collected in the East-

South stratum. Comparing the compositions of the samples in this stratum of the present and previous researches (1990/91), a relatively high proportion of smaller and immature whales to the total is observed in the present research. (In the previous one, the northern part of the stratum was not surveyed because of the rough sea condition and surface ice.) The length composition was examined in separate parts of the stratum in the present research: northern (69°S-71°S) and southern (south of 71°S)(Fig. 9). It indicates that segregation was found in this stratum. Most of the smaller whales were collected in the northern part of this stratum. In the southern part, most whales were as large as 8.0m or more and larger females were dominant. These findings are the same as those in the previous research.

Fig. 10 shows the seasonal changes of the body length compositions of the samples in the SMZ. Smaller males tended to be collected in the early part of the season, but a few smaller males were collected in the third period. In contrast, larger males and smaller females tended to be collected throughout the season. Larger females decreased with the progress of time. This may have been caused by the larger females shifting to areas such as the Ross Sea when it opened in early January.

Reproductive status

The reproductive status of a female was determined by examinations of the ovaries, uterus and mammary glands. While the reproductive status of males should be determined by histological examination of testes and epididymes, preparation of testes and epididymides for examination has not been completed yet. We tentatively used the traditional weight of testis for the determination of the sexual maturity. If the whale has a testis 0.4kg or over in weight, this animal is classified as sexually mature (Ohsumi *et al.*, 1970; Kato, 1986).

The reproductive statuses of the samples in the entire research area are shown in Table 8. Mature males are dominant in all the strata and pregnant females follow with the exception of those in the East-South stratum in which pregnant females dominate. Maturity rates for males and females were 92.9% and 76.1%. The male maturity rates are high in all strata (90.6-94.9%). Those for females are relatively low in the East-North stratum (58.3%), and high in the other strata (70.6-100%).

Table 9 shows the seasonal changes of reproductive status in the SMZ. The maturity rate of males is high through the research period. In the north stratum, immature males and females were found in the first period, but none in the second period. Preg-

nant females were fewer in the second period.

The maturity rates were also varied with their school size (Table 10). Immature whales, especially males tended to be singletons. Mature males and females tended to make up a school.

Dwarf form minke whales

A total of five schools of the dwarf form minke whale were sighted in the North strata in the East and West Sectors. Three whales were taken. Their sighted positions are shown in Fig. 3, and the information about those animals is summarized in Table 11. Two of three female dwarf forms were pregnant having one fetus in each body (83.8cm and 169.2cm). The other female was sexually immature.

DISCUSSION

In this section, the focus is on the sighting and sampling activities and the representative sampling method as modified for this research program.

In Table 3, some differences of the density indices (DI) and mean school sizes (MSS) were observed between the 'sighting' (SV) and 'sighting/sampling' vessels (SSVs). The DI was almost higher in the SV than those in the SSVs, except for the East-North stratum in the entire research area. The MSS also tended to be higher in the SV than that in the SSVs. As mentioned above, in the present research, the survey of the SV is expected to be free from the sampling activities of the SSVs, because the SV was surveyed at 12 n.miles or more ahead of the SSVs. It may be that the cause of the lower DI and MSS in the SSVs resulted from the sampling activities themselves. However, no clear effects on the whale schools were observed in the reaction monitoring experiment. It should be examined to make clear the extent of the effects on the whale schools for the sampling activities in the future.

The sampling rate of the targeted whales was examined in the present and previous researches which were conducted in Antarctic Area V. A lower sampling rate at smaller body length group (7.5m or less) was reported in the previous 1990/91 research (Fujise *et al.*, 1992b). It is suggested that this rate might be effected by the lower proportion of the younger animals in the estimated age distribution. In the present research, the technical sampling rate (the rate of whales sampled to targeted) is 0.84 as a total, and remarkably higher than that in the previous research (0.52). Fig. 11 compares the sampling rates in each estimated body length

class. The rate tends to be decreased with decreasing body length recorded in the previous research. In contrast, no trend relating to the body length class is observed in the present research, and the mean of the rate is as high as 88.5%. This suggests the one whale sampling was fairly successful in the present research.

In the sighting activities, because it was difficult to estimate body length for each individual when a school sighted comprised 16 or more individuals, a rough estimation was applied. Small (7.7m or less), middle (7.8-8.4m) and large sizes (8.5m or more) of body length were used. However, it was reported that the estimated body length was matched the measured one at the EBL class of 7.6m or less, but no correlation was observed at the EBL of 7.7m or more. Because the same results for the samples were obtained in this research (Fig. 12), two body length classes are compared here. Table 12 shows the compositions of estimated body lengths (EBL) from sighting data by the SV and SSVs, and those from the whales sampled. Although the composition of the samples differs to those from the whales sighted by the SSVs, the estimated composition is almost similar to those from the sighting data by the SSVs. However, differences were observed between the estimated compositions from the whale samples and the sighting data from the SV. This may be affected by the unsearched part of the trackline of the SSVs or the application of the minimum proceeding distance, or sampling activities of the SSVs. This should be examined in the future.

ACKNOWLEDGMENTS

Financial support for this research cruise was provided by the Government of Japan. We are largely indebted to Dr. Fukuzo Nagasaki, project leader of the cruise (Director of the Institute of Cetacean Research, ICR) and Dr. Seiji Ohsumi (ICR) for their instructions and valuable suggestions for the cruise. We thank Dr. Yasushi Taga (ICR), and Dr. Hirohisa Kishino, Ocean Research Institute, Tokyo University, for their helpful advice during the planning of the research. We are greatly indebted to the following persons: *Nisshinmaru*, Captain Kazunori Numano and his crew and general manager Shigeru Tanifuji and his staff; *Kyomaru No.1*, Captain Shigeo Suzuki and his crew; *Toshimaru No.25*, Captain Toshinori Tsurii and his crew; *Toshimaru No.18*, Captain Katsuji Gomi and his crew. We thank research technicians, Messrs. Shigeo Tabata, Yutaka Eguchi and Akihiro Kawada of the Kyodo Senpaku for their contributions. We thank Mr. Mark H. Votier his helpful advice with the manuscript. We also thank other colleagues of the

ICR for their support.

REFERENCES

Government of Japan, 1992a. The 1992/93 research plan of whale resources in the Antarctic. Paper SC/44/SHB14 presented to the IWC Scientific Committee, June 1992 (unpublished).

Government of Japan, 1992b. Japanese Research Program in the Antarctic for the 1992/93 season (improved following the IWC Resolution), the Government of Japan. IWC circular communication NH/VJH/19539 (unpublished).

Government of Japan, 1993. Japan Progress Report on cetacean research, June 1992 to March 1993, Government of Japan. April, 1993.

Fujise, Y., Yamamura, K., Zenitani, R., Ishikawa, H., Yamamoto, Y., Kimura, K. and Komaba, M. 1990. Cruise report of the research on southern minke whales in 1989/90 under the Japanese proposal to the scientific permit. Paper SC/42/SHMi25 presented to the IWC Scientific Committee, June 1990 (unpublished).

Fujise, Y., Ishikawa, H., Saino, S., Nagano, M., Ishii, K., Kawaguchi, S., Tanifuji, S., Kawashima, S., and Miyakoshi, H. 1992a. Cruise report of the 1991/92 Japanese research under the special permit for southern hemisphere minke whales. Paper SC/44/SHB11 presented to the IWC Scientific Committee, June 1992 (unpublished).

Fujise, Y., Kato, H., Zenitani, R. and Kishino, H. 1992b. Seasonal and areal changes in age distribution and segregation of the Southern minke whales in Antarctic Areas IV and V using data from the Japanese researches. Paper SC/44/SHB10 presented to the IWC Scientific Committee, June 1992 (unpublished).

International Whaling Commission, 1992. Chairman's report of the Forty-Forth meeting, June 1992.

Kasamatsu, F., Yamamoto, Y., Zenitani, R., Ishikawa, H., Ishibashi, T., Sato, H., Takashima, K. and Tanifuji, S. 1991. Report of the 1990/91 southern minke whale research cruise under scientific permit in area V. Paper SC/43/Mi11 presented to the IWC Scientific Committee, May 1991 (unpublished).

Kato, H. 1986. Study on changes in biological parameters and population dynamics of southern minke whales. Doctoral Thesis, Hokkaido University. 145pp. (in Japanese).

Kato, H., Hiroyama, H., Fujise, Y. and Ono, K. 1989. Preliminary report of the 1987/88 Japanese feasibility study of the special permit proposal for Southern Hemisphere minke whales. *Rep. int. Whal. Commn* 39:235-248.

Kato, H., Fujise, Y., Yoshida, H., Nakagawa, S., Ishida, M. and Tanifuji, S. 1990. Cruise report and preliminary analyses of the 1988/89 Japanese feasibility study of the special permit proposal for Southern Hemisphere minke whales. *Rep. int. Whal. Commn* 40:289-300.

Ohsumi, S., Masaki, Y. and Kawamura, A. 1970. Stock of the Antarctic minke whale. *Sci. Rep. Whales Res. Inst.*, Tokyo 22:75-125.

Table 1. Searching distance (n.miles) by the 'sighting' vessel (SV) and 'sighting/sampling' vessels (SSVs) in each stratum of the research area.

	SV	SSVs	Combined
The entire research area			
West-North	923.2	1,377.0	2,300.2
West-South	1,005.3	902.9	1,908.2
East-North	717.3	944.4	1,661.7
East-South	1,024.8	1,127.0	2,151.8
Combined	3,670.6	4,351.3	8,021.9
The SMZ			
First period			
North	682.3	976.9	1,659.2
South	638.9	789.8	1,428.7
Combined	1,321.2	1,766.7	3,087.9
*Second period**			
North	635.8	1,092.4	1,728.2
South	747.5	746.0	1,493.5
Combined	1,383.3	1,838.4	3,221.7
Third period			
North	255.4	460.5	715.9
South	713.8	952.8	1,666.6
Combined	969.2	1,413.3	2,382.5
Total	5,961.0	7,531.3	13,492.3

*: This survey was carried out as a part of the West Sector in the entire research survey.

Table 2a. Summary of sightings (no. individuals/no. schools) conducted by the 'sighting' vessel (SV) and the two 'sighting/sampling' vessels (SSVs) in each stratum of the entire research survey.

Species	SV				SSVs			
	West Sector		East Sector		West Sector		East Sector	
	Primary	Secondary	Primary	Secondary	Primary	Secondary	Primary	Secondary
North stratum								
Minke whale	73/47	15/11	137/17	23/11	59/40	17/15	55/36	21/17
Like minke whale	3/3		4/4	2/1	3/3		3/3	
Dwarf minke whale							2/2	
Blue whale			1/1		1/1			
Fin whale			7/3		3/2		7/4	1/1
Humpback whale			13/6	2/1	9/5	4/2	5/3	6/3
Sperm whale	2/2		2/2		3/3		2/2	1/1
Killer whale	10/1		4/2			15/1	6/2	10/1
S. bottlenose whale	1/1				2/1		2/1	
Arnoux's beaked whale								
Beaked whales	12/7		20/12	6/1	11/8		15/11	1/1
Long-finned pilot whale					84/3			
Pilot whales					20/1			
Hourglass dolphin	14/3	8/2	13/2	3/1	21/3	29/5		
Baleen whales			1/1		1/1		2/1	1/1
Unidentified dolphin	1/1			1/1			5/1	
Species unknown	2/2	1/1	10/10		13/13		16/14	1/1
South stratum								
Minke whale	511/118	44/22	627/168	102/49	313/83	66/36	290/129	114/41
Like minke whale	7/6	23/9	6/5	56/19	7/5	16/3	8/7	2/1
Blue whale		5/2	2/1		1/1			1/1
Fin whale	1/1		2/1		2/1			
Humpback whale	10/4		3/1	1/1	1/1		5/3	2/1
Sperm whale	24/23	2/2	12/11	2/2	3/3		22/22	4/4
Killer whale	167/16		213/10	30/1	160/10	41/3	209/11	20/3
S.bottlenose whale	4/3							
Arnoux's beaked whale	10/1		30/5				10/1	
Beaked whales	30/15	2/2	25/7		24/16		16/9	
Hourglass dolphin		8/1						
Species unknown	7/6	5/3	14/12		54/16		12/12	1/1

Table 2b. Summary of sightings (no. individuals/no. schools) conducted by the sighting vessel (SV) and the two sighting/sampling vessels (SSVs) in each stratum in the SMZ surveys.

Species	SV				SSVs			
	North strata		South strata		North strata		South strata	
	Primary	Secondary	Primary	Secondary	Primary	Secondary	Primary	Secondary
First period								
Minke whale	57/28	30/10	381/76	170/57	58/29	9/5	245/64	101/24
Like minke whale	4/4		4/4	34/13	2/2		1/1	6/1
Dwarf minke whale	1/1							
Blue whale			2/1		1/1			
Fin whale						4/1	3/1	
Humpback whale			3/1		1/1			
Right whale							1/1	
Sperm whale	11/11	2/2	17/16	2/2	4/4		16/16	4/4
Killer whale			111/8	40/2	13/2		52/3	71/4
S. bottlenose whale						3/1	4/2	
Beaked whales	4/2		61/29		9/8		70/39	3/1
Species unknown	2/2		5/3	8/5	4/4		15/12	39/16
Second period*								
Minke whale	38/25	12/8	249/80	25/14	27/21	12/11	189/60	59/33
Like minke whale	2/2		6/5	19/8			3/3	6/2
Blue whale							1/1	
Fin whale					3/2		2/1	
Humpback whale			1/1				1/1	
Sperm whale	2/2		22/22	2/2	2/2		1/1	
Killer whale	10/1		156/14			15/1	150/9	41/3
S. bottlenose whale			4/3		2/1			
Beaked whales	5/3		20/14	2/2	9/7		21/15	
Long-finned pilot whale					80/2			
Pilot whales					20/1			
Hourglass dolphin	9/2	2/1		8/1	11/2	29/5		
Baleen whales					1/1			
Unidentified dolphin	1/1							
Species unknown	2/2	1/1	5/4	2/1	9/9		52/14	
Third period								
Minke whale		1/1	83/36	1/1	2/2		158/60	38/12
Like minke whale			1/1				3/2	10/1
Dwarf minke whale					2/2			
Blue whale							1/1	
Fin whale			2/1					
Sei whale							1/1	
Humpback whale			2/1	1/1			4/2	
Right whale			2/1				1/1	
Sperm whale								1/1
Killer whale	1/1		61/5	30/1			82/8	
S. bottlenose whale							6/2	
Beaked whales	4/3		20/10		2/2		31/17	
Hourglass dolphin	5/1		15/3	6/1	11/3		32/7	3/1
Unidentified dolphin			7/2				11/2	
Species unknown	1/1		5/5		4/4		35/15	

*: This survey was carried out as a part of the West Sector in the entire research survey.

Table 2c. Summary of sightings (no. individuals/no. schools) conducted by the 'sighting' vessel (SV) and the two 'sighting/sampling' vessels (SSVs) in all the research.

Species	SV		SSVs		Combined	
	Primary	Secondary	Primary	Secondary	Primary	Secondary
Minke whale	1869/490	386/162	1180/443	366/150	3049/933	952/395
Like minke whale	29/27	115/42	27/23	34/6	56/50	152/51
Dwarf minke whale	1/1		4/4		5/5	
Blue whale	5/3	5/2	4/4	1/1	9/7	9/4
Fin whale	12/6		15/8	5/2	27/14	7/3
Sei whale			1/1		1/1	
Humpback whale	31/13	4/3	25/15	12/6	56/28	17/10
Right whale	2/1		2/2		4/3	
Sperm whale	68/65	8/8	50/50	10/10	118/115	20/20
Killer whale	567/43	100/4	522/36	157/12	1089/79	314/20
S. bottlenose whale	5/4		14/6	3/1	19/10	3/1
Arnoux's beaked whale	40/6		10/1		50/7	
Beaked whales	176/85	8/3	178/110	4/2	354/195	12/5
Long-finned pilot whale			84/3		84/3	
Pilot whales			20/1		20/1	
Hourglass dolphin	47/9	25/5	64/13	32/6	111/22	85/14
Baleen whales	1/1		3/2	1/1	4/3	1/1
Unidentified dolphin	8/3	1/1	16/3		24/6	12/3
Species unknown	46/41	14/9	153/90	41/18	199/131	62/34

Table 3. Density indices (DI) and mean school size (MSS) of minke whales sighted primarily by the 'sighting' vessel (SV) and 'sighting/sampling' vessels (SSVs).

	SV				SSVs				Combined			
Stratum	Sch	Ind	DI	MSS	Sch	Ind	DI	MSS	Sch	Ind	DI	MSS
The entire research area												
West-North	47	73	5.09	1.55	40	59	2.90	1.48	87	132	3.78	1.52
West-South	118	511	11.74	4.33	83	313	9.19	3.77	201	824	10.53	4.10
East-North	17	137	2.37	8.06	38	57	4.02	1.50	55	194	3.31	3.53
East-South	168	627	16.39	3.73	129	290	11.45	2.25	298	917	13.85	3.08
Combined	350	1,348	9.54	3.84	290	719	6.66	2.48	640	2,067	7.99	3.23
The SMZ survey												
First period												
North	29	58	4.25	2.00	29	58	2.97	2.00	58	116	3.50	2.00
South	76	381	11.90	5.01	64	245	8.10	3.83	140	626	9.80	4.47
Combined	105	439	7.95	4.18	93	303	5.26	3.26	198	742	6.41	3.75
*Second period**												
North	25	38	3.93	1.52	21	27	1.92	1.29	46	65	2.66	1.41
South	80	249	10.70	3.11	60	189	8.04	3.15	140	438	9.37	3.13
Combined	105	287	7.59	2.73	81	216	4.41	2.67	186	503	5.77	2.70
Third period												
North	0	0	0.00	—	4	4	0.87	1.00	4	4	0.56	1.00
South	36	83	5.04	2.31	60	158	6.30	2.63	96	241	5.76	2.51
Combined	36	83	3.71	2.31	64	162	4.53	2.53	100	245	4.20	2.45
Total	491	1,870	8.24	3.80	447	1,184	5.94	2.65	938	3,054	6.95	3.26

Sch: number of minke whale schools sighted, Ind: number of minke whales sighted, DI: density indices (the number of schools per 100 n.miles searching), MSS: mean school size.
*: this survey was carried out as a part of the West Sector in the entire research survey.

Table 4. Numbers of minke whales (schools/individuals) sighted, targeted, sampled and efficiencies of sampling.

Stratum	Sighted*	Targeted	Sampled	Efficiency	
	A / B	C	D	I(D/B)	II(D/C)
The entire research area					
West-North	40 / 59	27	13	0.22	0.48
West-South	83 / 313	77	73	0.23	0.95
East-North	38 / 57	35	31	0.54	0.89
East-South	129 / 290	115	93	0.32	0.81
Combined	290 / 719	254	210	0.29	0.83
The SMZ survey					
First period					
North	29 / 58	22	19	0.33	0.86
South	64 / 245	67	58	0.24	0.87
*Second period***					
North	21 / 27	13	7	0.26	0.54
South	60 / 189	55	51	0.27	0.93
Third period					
North	4 / 4	1	1	0.25	1.00
South	60 / 158	49	42	0.27	0.86
Combined	238 / 681	207	178	0.26	0.86

*: primary sightings.

**: this survey was carried out as a part of the West Sector in the entire research survey.

Table 5. Summary of causes of failure to collect samples targeted by school size.

School size	Cause of failure								Total
	A	B	C	D	E	F	G	H	
1	4	7	5	5	2	3	4	2	32
2	3	9	1	0	1	2	2	0	18
3	0	0	1	2	2	2	0	0	7
4	0	0	0	0	0	3	0	0	3
≥5	0	1	0	0	0	2	0	0	3
Total	7	17	7	7	5	12	6	2	63

A: quick/mobile behavior, B: long diving, C: fast swimming, D: rough sea condition, E: limited time, F: technical problems, G: occurence of pack ice, H: other.

Table 6. Summary of biological data and samples collected.

Samples and data	Number of whales		
	Male	Female	Total
Body length and sex identification	167	163	330
External measurement	167	163	330
Photographic record of external character*	167	163	330
Diatom film record and sampling	167	163	330
Standard measurement of blubber thickness (three points)	167	163	330
Detailed measurement of blubber thickness	33	27	60
Body weight	166	163	329
Body weight by total weight of parts	34	27	61
Earplug for age determination	167	163	330
Tympanic bulla for age determination	167	161	328
Largest baleen plate for age determination	31	46	77
Earplug for chemical analysis (one of the pair)	8	8	16
Vertebral epiphyses sample	167	161	328
Skull measurement (length and breadth)	167	159	326
Mammary grand; lactation status, measurements and histological sample	—	163	163
Milk sample for chemical analysis	—	1	1
Ovary collection	—	163	163
Uterine horn; measurement and endometrium sample	—	163	163
Photographic record of fetus	—		124
Fetal sex (identified by visual observation)	(50)	(60)	(110)**
Fetal length and weight	(50)	(60)	(120)**
External measurement of fetus	(50)	(60)	(110)**
Collection of fetus	(4)	(3)	(21)**
Testis and epididymis; weight and histological sample	167	—	167
Serum sample	153	150	303
Blubber, Muscle, liver, kidney and heart tissues for genetic study	167	163	330
Tissues for genetic study (fetus)	(46)	(57)	(103)
Muscle, liver and kidney tissues for heavy metal analysis	51	45	96
Muscle, liver and kidney tissues for heavy metal analysis (fetus)	1	0	1
Blubber and liver tissues for organochlorine analysis	55	56	111
Stomach content, conventional record	167	163	330
Weight of stomach content in each compartment	165	162	327
Collection of stomach contents for the food and feeding study	67	74	141
Collection of stomach contents for the heavy metal analysis	21	20	41
Tissues for the lipid analysis	33	27	60
Collection of external parasites	45	52	97
Collection of internal parasites	21	16	37
Collection of whole skeleton	0	2	2

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

Table 7. Products from samples collected for research purpose.

Items of products	Weight (kg)	Items of products	Weight (kg)
Red meat	400,245	Underside part of ordinal blubber	13,975
Tail meat	4,065	Meat/connective tissue between meat and blubber	13,825
Breast meat	500,895	Tail flukes	22,175
Meat inside ventral grooves	17,426	Maxillary cartilage	2,175
Mandibular ligaments	4,264	Cartilage	425
Nasal plug	4,200	Hart	4,214
Tendon	18,326	Esophagus	364
Tongue	32,136	Diaphragm	9,150
Meat pieces	118,155	Stomach	1,794
Meat/blubber of ventral part	72,050	Intestine	5,575
Meat/blubber of ventral grooves	107,096	Pancreas	756
Blubber of ventral grooves	8,154	Kidney	2,912
Meat/connective tissue of lower jaw	4,860	Testes	120
Ordinal blubber	166,913		
		Total	1,536,245

Table 8. Reproductive status of samples in the entire research area.

Stratum	Male		Female							M%*
	Imm.	Mat.	Imm.	Mat.						
				Preg.	Ovu.	Rest.	Lact.	P & L	Unk.	
West-North	1 (9.1)	10 (90.9)	0	2 (100.0)	0	0	0	0	0	84.6
West-South	2 (5.1)	37 (94.9)	10 (29.4)	24 (70.6)	0	0	0	0	0	53.4
East-North	1 (5.9)	16 (94.1)	5 (41.7)	6 (50.0)	0	0	0	1 (8.3)	0	58.6
East-South	3 (9.4)	29 (90.6)	11 (18.0)	48 (78.7)	0	1 (1.6)	0	0	1 (1.6)	34.4
Total	7 (7.1)	92 (92.9)	26 (23.9)	80 (73.4)	0	1 (0.9)	0	1 (0.9)	1 (0.9)	47.6

* percentage of males.

Table 9. Seasonal change of reproductive status of samples in the SMZ (130°E-155°E).

Stratum	Male		Female							M%*
	Imm.	Mat.	Imm.	Mat.						
				Preg.	Ovu.	Rest.	Lact.	P & L	Unk.	
First period										
North	3 (25.0)	9 (75.0)	5 (71.4)	2 (28.6)	0	0	0	0	0	63.2
South	4 (16.0)	21 (84.0)	3 (9.1)	29 (87.9)	0	0	0	0	1 (3.0)	43.1
Second period										
North	0	6 (100.0)	0	1 (100.0)	0	0	0	0	0	85.7
South	2 (7.7)	24 (92.3)	7 (28.0)	18 (72.0)	0	0	0	0	0	51.0
Third period										
North	0	0	0	0	0	0	0	0	0	0.0
South	3 (9.7)	28 (90.3)	3 (27.3)	8 (72.7)	0	0	0	0	0	73.8
Total	12 (12.0)	88 (88.0)	18 (23.4)	58 (75.3)	0	0	0	0	1 (1.3)	56.5

* percentage of males

Table 10. Reproductive status by school size.

School size	Male			Female		
	Imm.	Mat.	Total	Imm.	Mat.	Total
1	12 (25.5)	35 (74.5)	47	21 (37.5)	35 (62.5)	56
2	2 (4.5)	42 (95.5)	44	4 (10.3)	35 (89.7)	39
3	1 (3.8)	25 (96.2)	26	5 (16.7)	25 (83.3)	30
4	0 (0.0)	26 (100.0)	26	2 (16.7)	10 (83.3)	12
>= 5	2 (8.3)	22 (91.7)	24	5 (21.7)	18 (78.3)	23
Total	17 (10.2)	150 (89.8)	167	37 (23.1)	123 (76.9)	160

Table 11. Information of dwarf minke whales taken during the present survey.

Sample No.	Date	Position sighted	School size	Position taken	B.L. (m)	Sex	Reproductive information
107	10.Jan.'93	60°51'S 167°42'E	1	60°49'S 167°44'E	7.04	F	Pregnant, Foetus; 83.8cm, Female
108	11.Jan.'93	60°31'S 166°05'E	1	60°39'S 165°59'E	3.54	F	Immature
330	22.Mar.'93	61°49'S 143°16'E	1	61°50'S 143°18'E	7.17	F	Pregnant, Foetus; 169.2cm, Female

Table 12. Number of whales sighted by the 'sighting' vessels (SV) and 'sighting/sampling' vessels (SSVs), and those of whales sampled, by two estimated body length classes, and their estimated body length composition.

		<7.8m		>=7.8m		Unknown	
		Whales (%)	Est.	Whales (%)	Est.	Whales (%)	Est.
SV	singleton	28 (17.9)	17.9	128 (82.1)	82.1		
	2 or more	189 (12.3)	7.4	1322 (86.1)	91.0	24 (1.6)	1.5
SSVs	singleton	36 (25.5)	25.5	105 (74.5)	74.5		
	2 or more	60 (6.1)	3.1	923 (93.1)	96.5	8 (0.8)	0.3
Samples	singleton	28 (26.4)	26.4	78 (73.6)	73.6		
	2 or more	6 (2.7)	2.7	218 (97.3)	97.3		

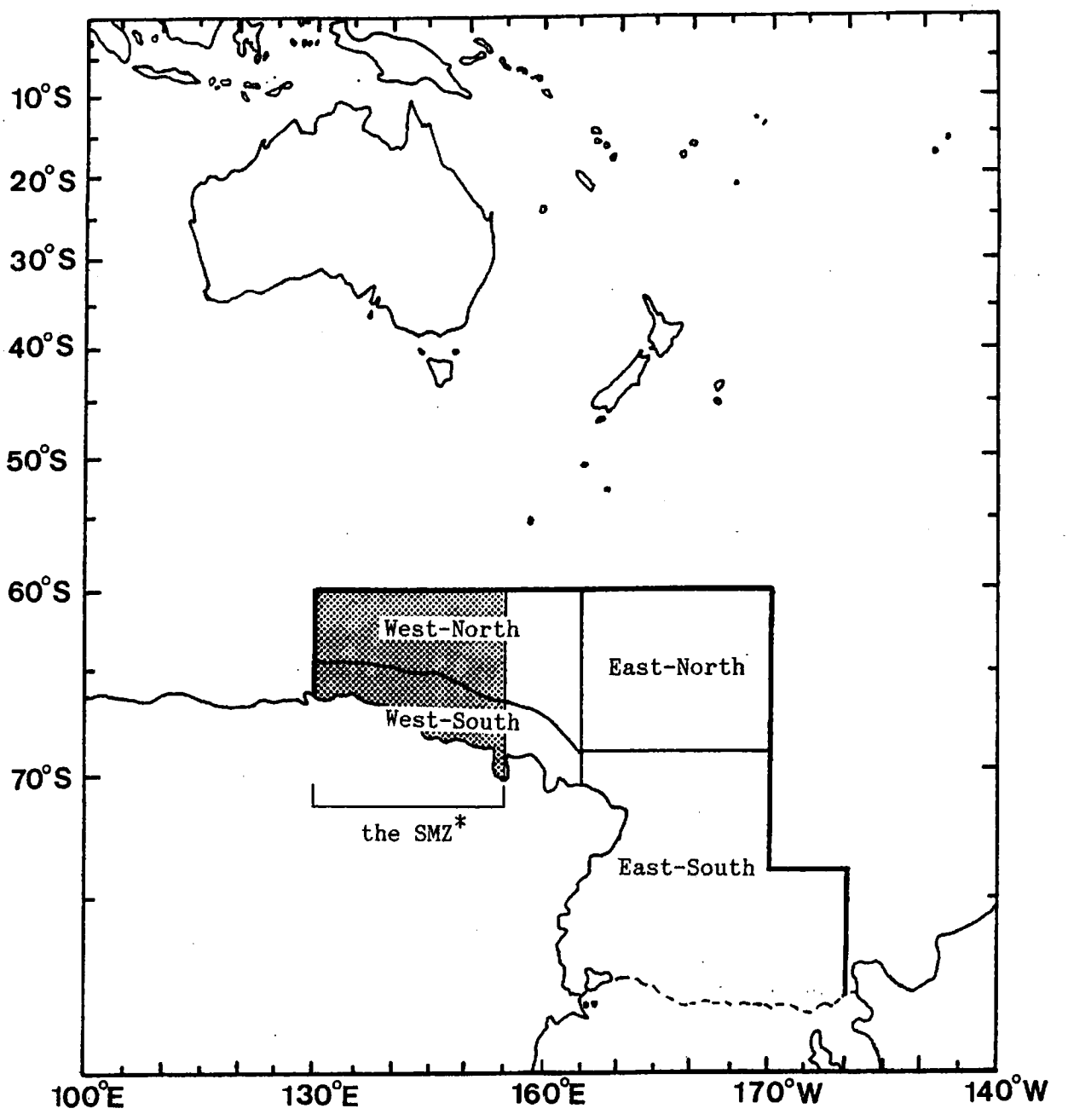


Fig. 1. Geographical location and the stratification of the research area in the Japanese research in 1992/93.
*: Special monitoring zone to investigate the seasonal changes of the distribution and segregation of minke whales.

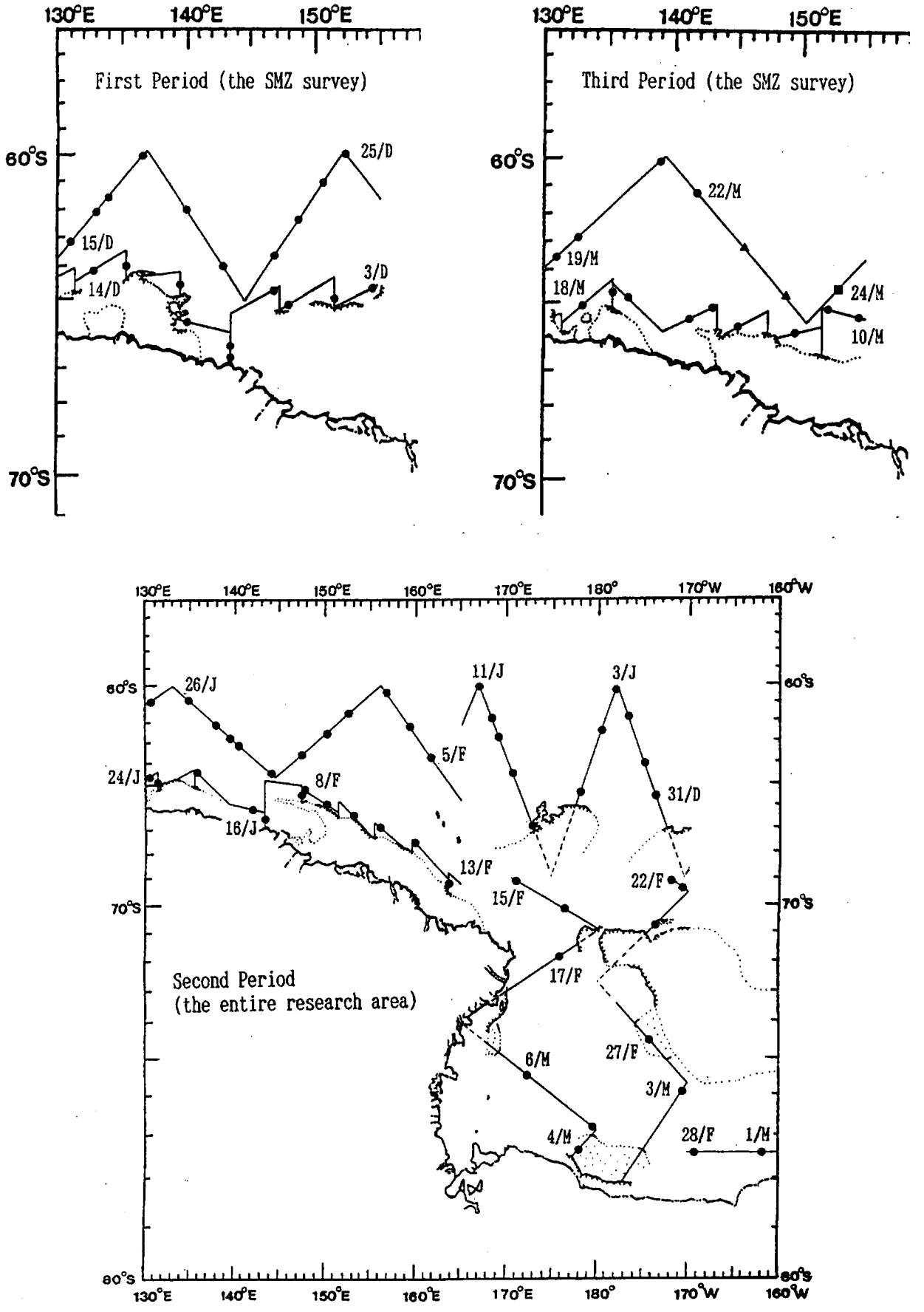


Fig. 2. Cruise tracks and noon positions of the research base (*NM*) in the Japanese research in 1992/93. Upper: the survey in the SMZ in the First and Third periods, lower: the survey in the entire research area in the Second period.

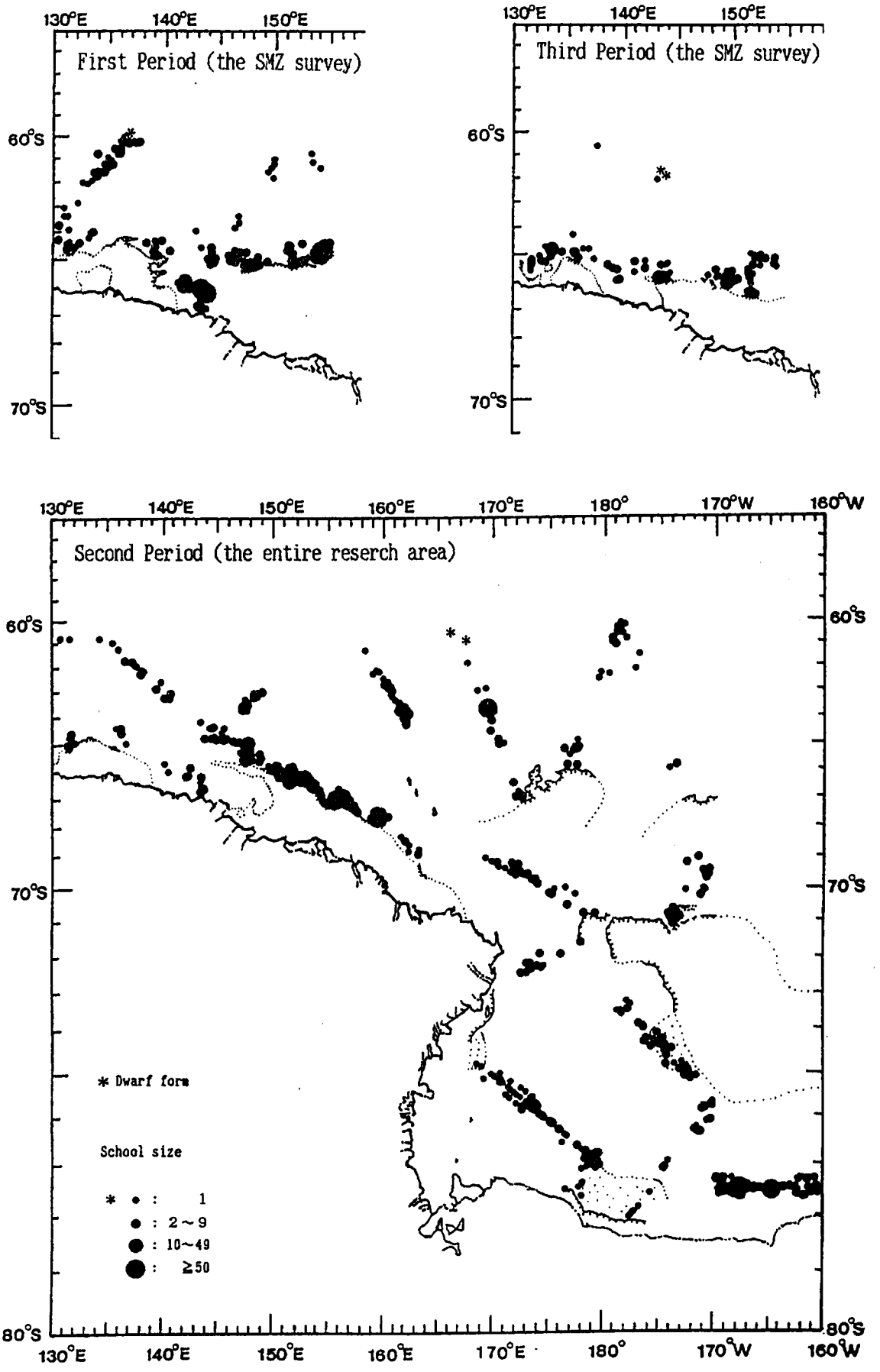


Fig. 3. Distribution of the primary minke whale sightings by three sampling and sighting vessels. Upper: the survey in the SMZ in the First and Third periods, lower: the survey in the entire research area in the Second period.

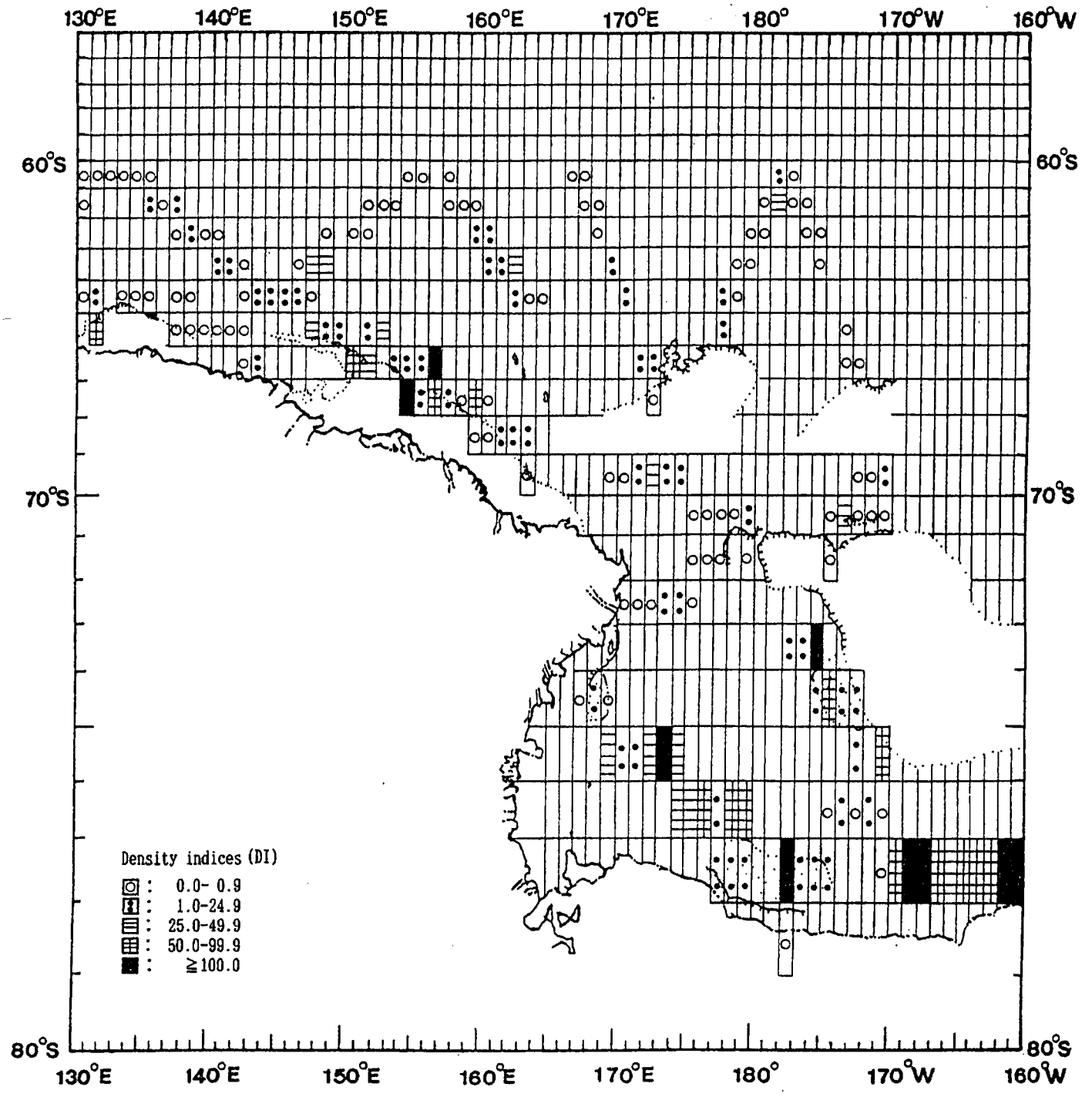


Fig. 4. Distribution of density indices (no. school/100 n.miles searched) of minke whales by the 'sighting' vessel in the entire research area survey.

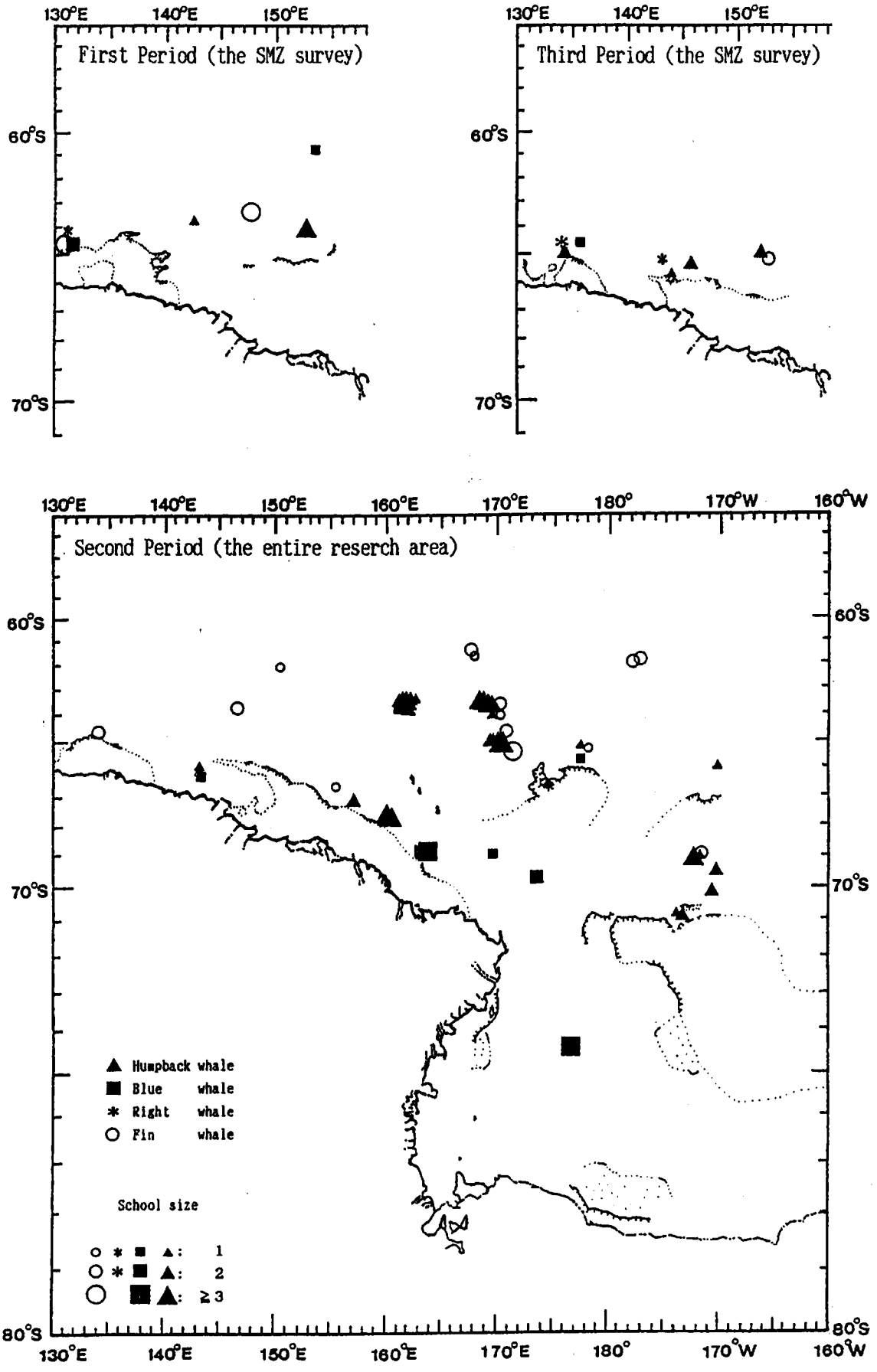


Fig. 5. Distribution of humpback, blue, right and fin whales sighted by three sampling and sighting vessels. Upper: the survey in the SMZ in the First and Third periods, lower: the survey in the entire research area in the Second period.

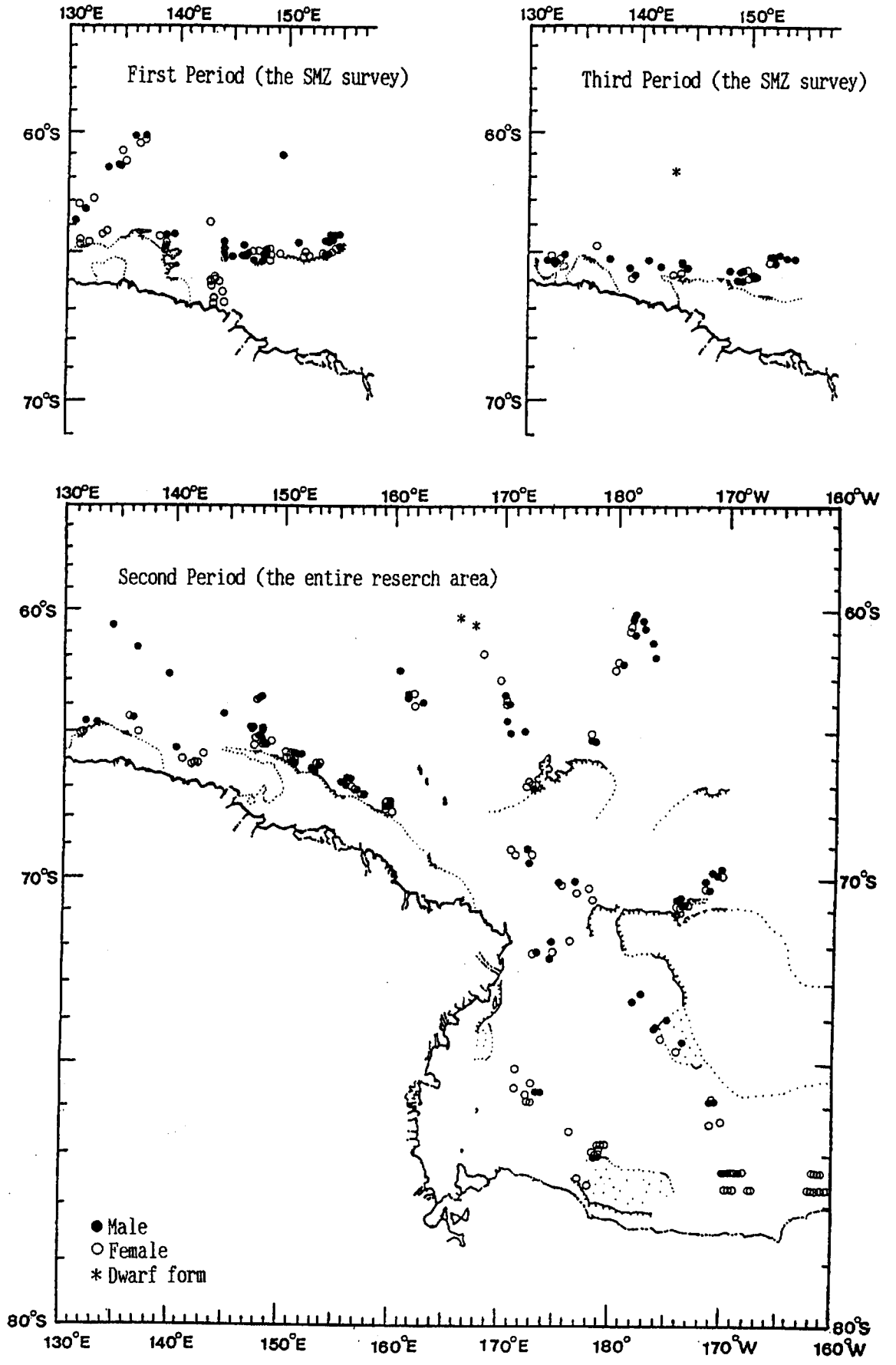


Fig. 6. Distribution of minke whales sampled based on their sighted position. Upper: the survey in the SMZ in the First and Third periods, lower: the survey in the entire research area in the Second period.

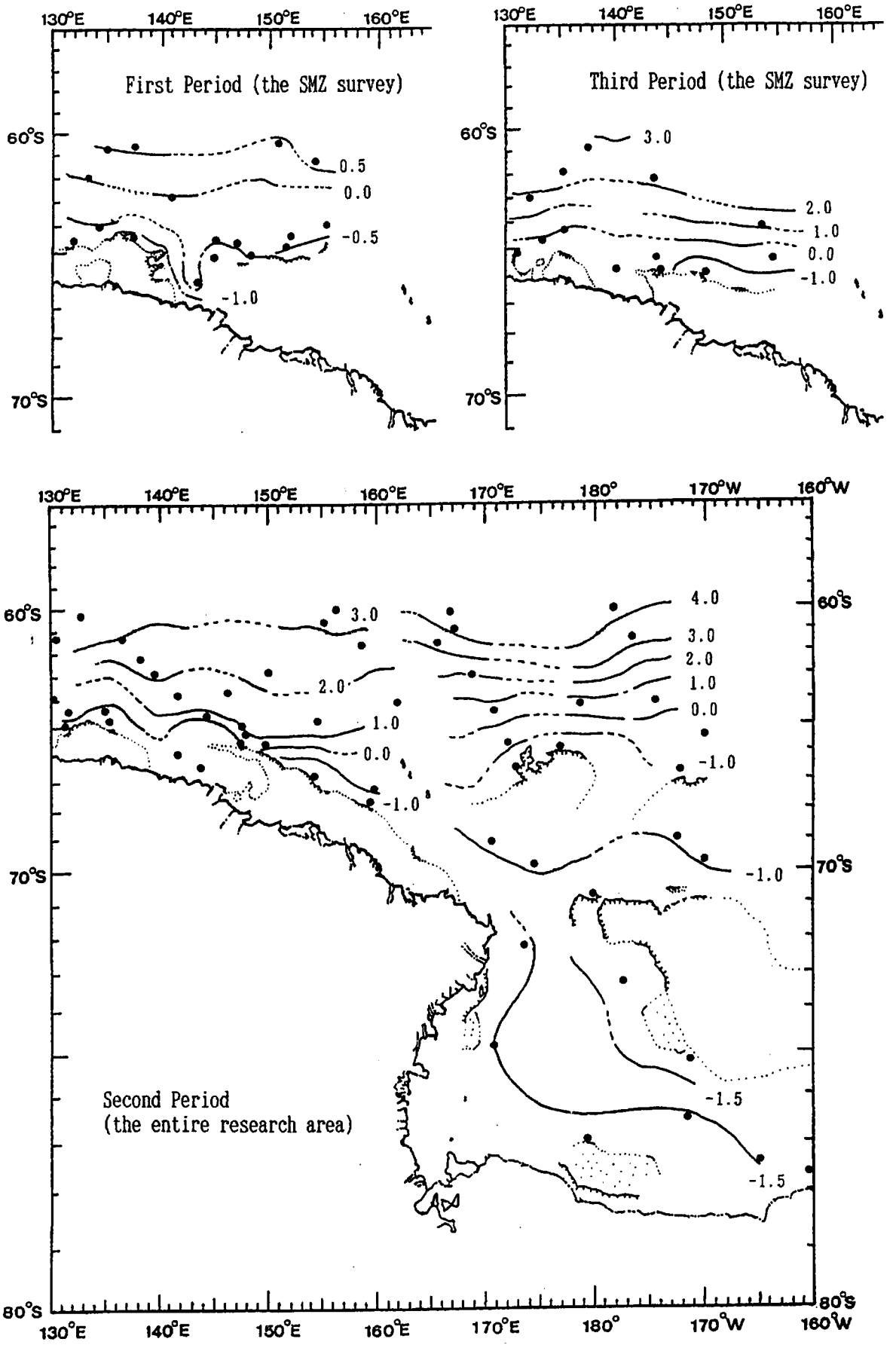
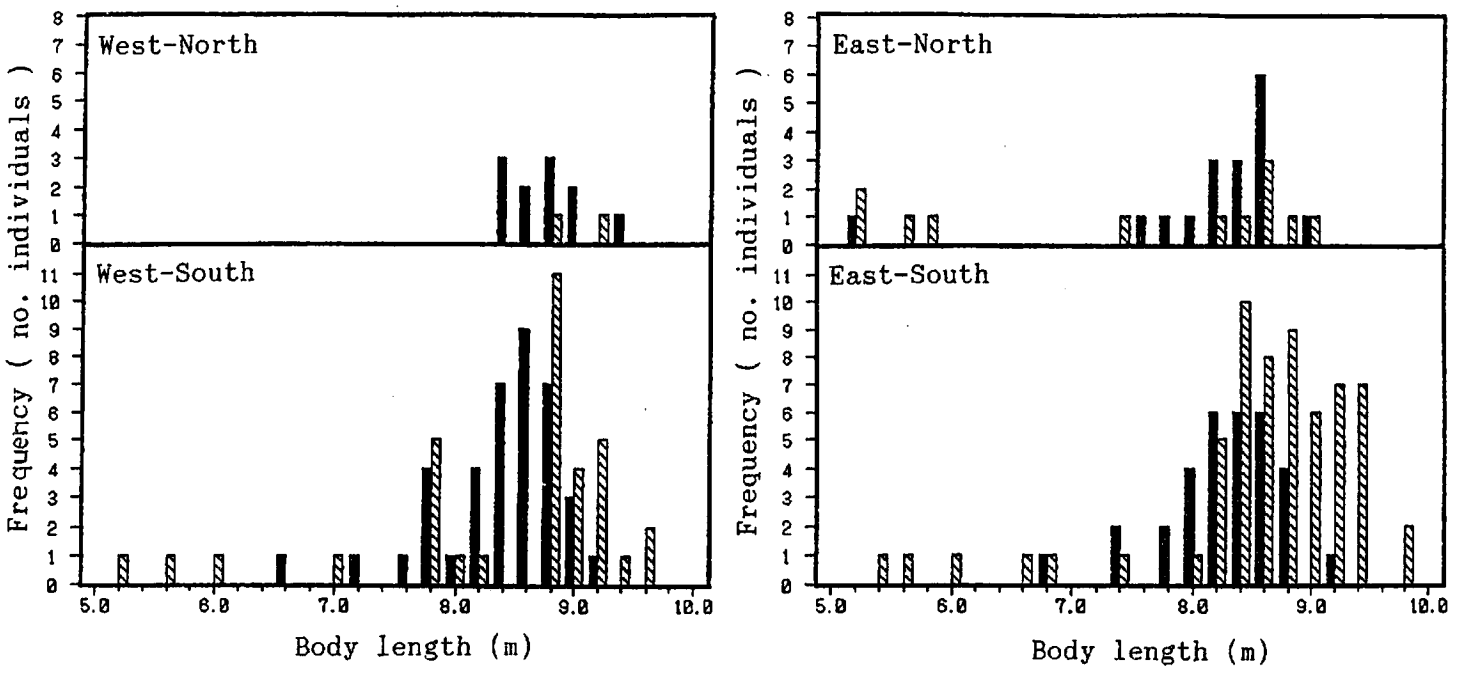


Fig. 7. Surface water isothermal and positions of the XBT survey. Upper: the survey in the SMZ in the First and Third periods, lower: the survey in the entire research area in the Second period.



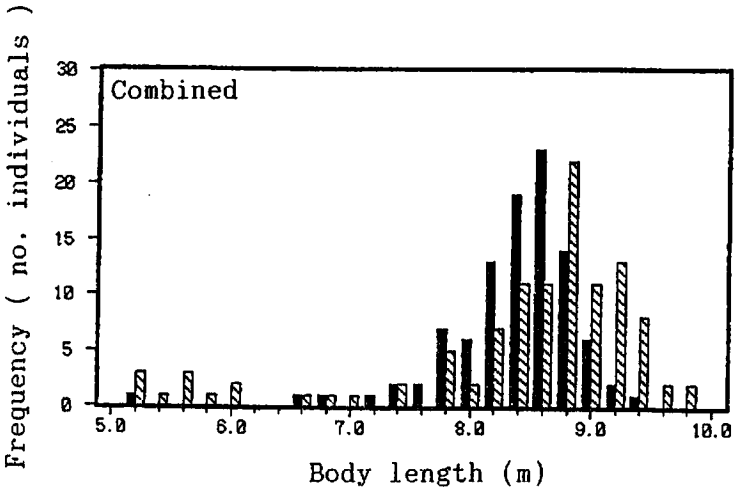


Fig. 8. Body length compositions (20cm intervals) of the samples by each stratum in the survey of the entire research area. Solid and striped lines represent males and females, respectively.

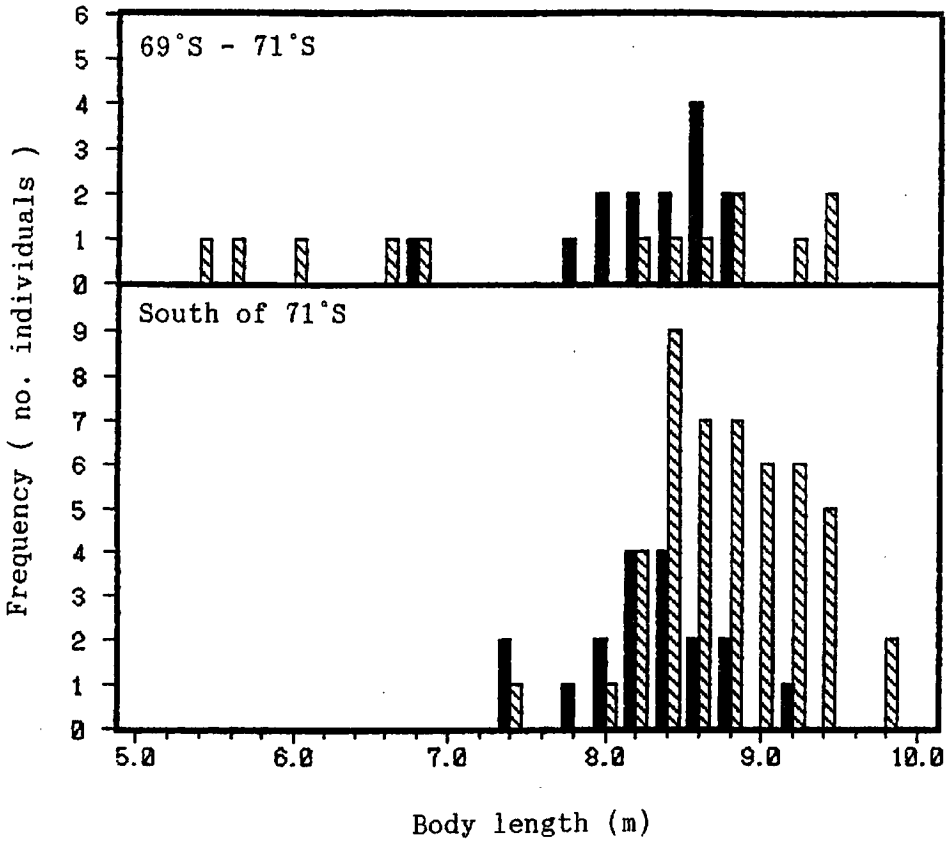


Fig. 9. Comparison of body length compositions on the northern (69°-71°S) and southern (south of 71°S) parts of the East-South stratum of the entire research area. Solid and striped lines represent males and females, respectively.

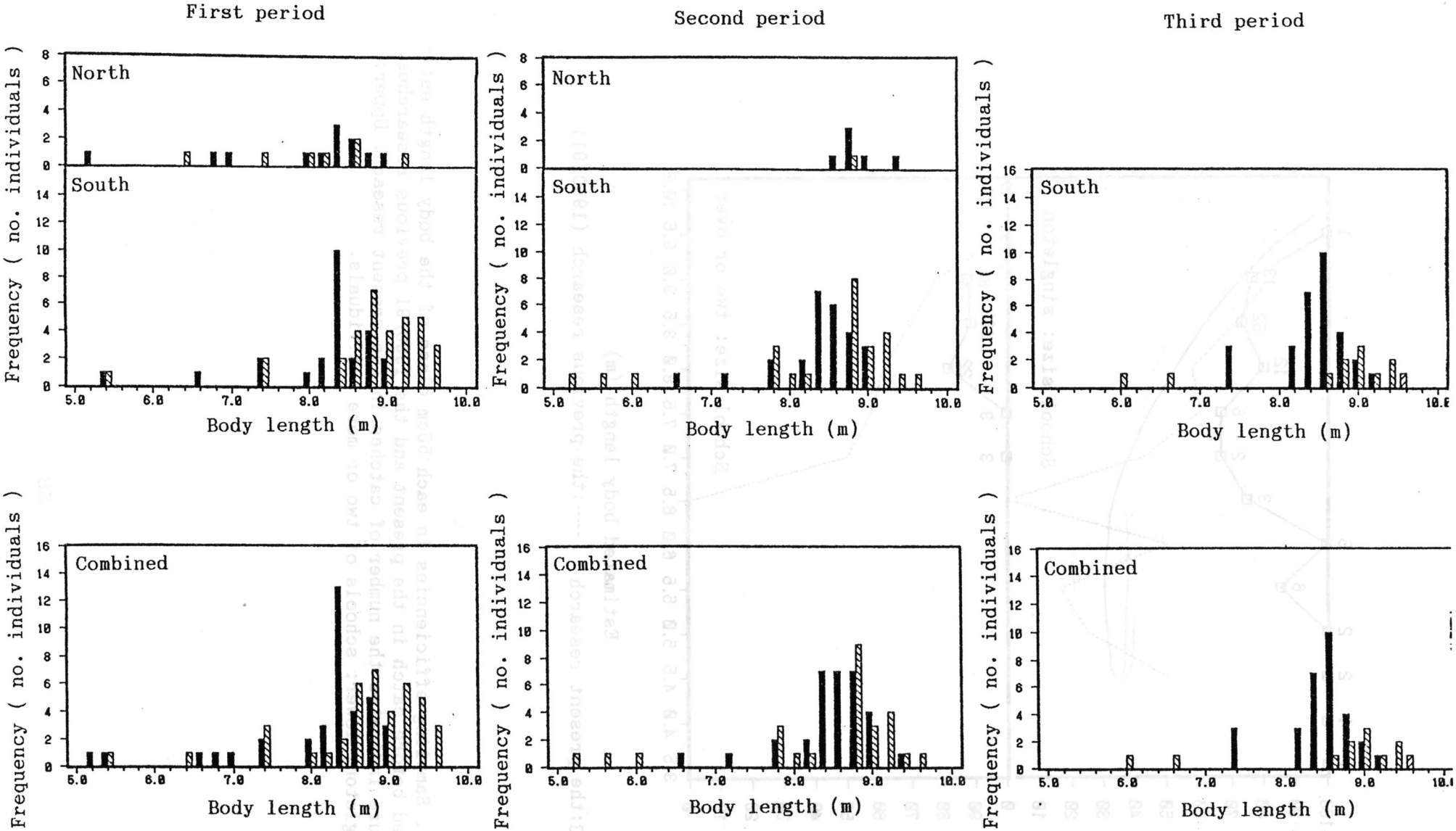


Fig 10. Seasonal changes of body length compositions (20cm intervals) of samples in the Special Monitoring Zone (130°-155°E). Left: the First period (3- 14 Dec. 1992), center: the Second period (15 Jan.- 2 Feb. 1993), right: the Third period (10-24 Mar. 1993). Solid and striped lines represent males and females, respectively.

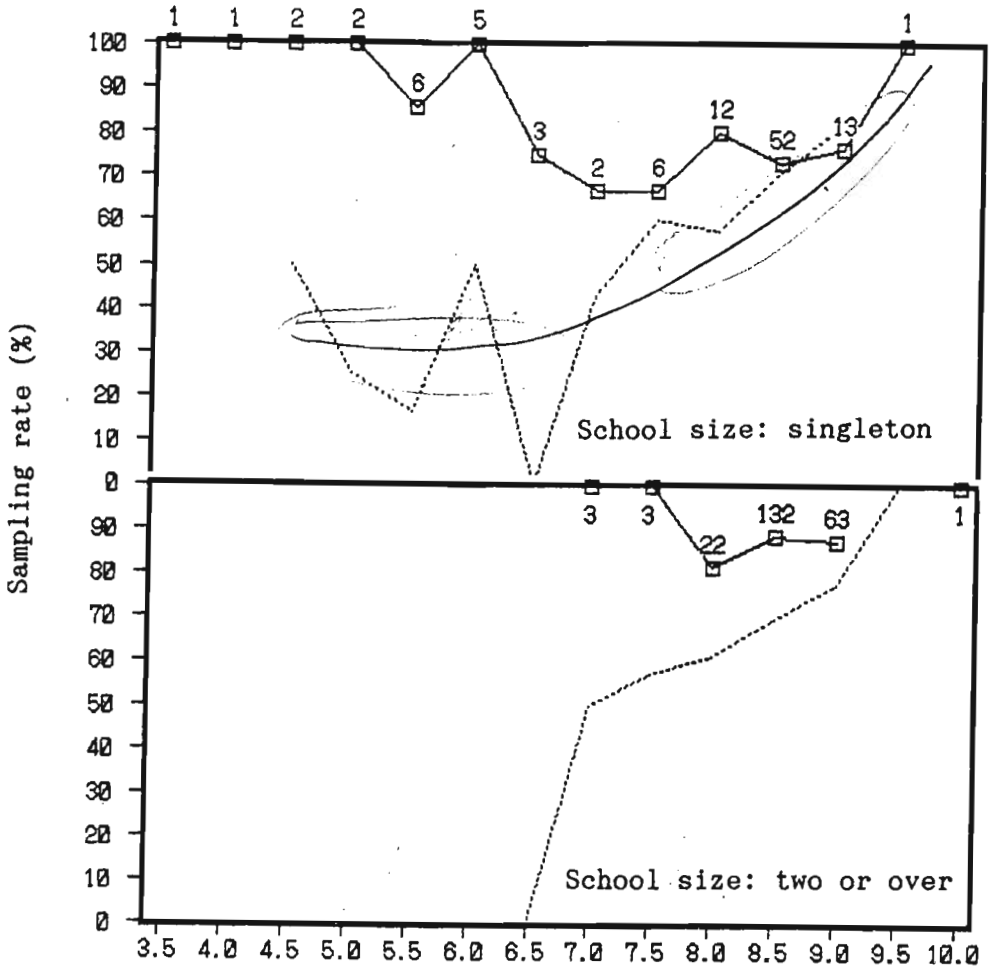


Fig. 11. Sampling efficiencies in each 50cm class of the body length estimated before catch in the present and the 1990/91 previous researches. figure indicates the number of catches in the present reseach. Upper: singleton, lower: schools of two or more individuals.

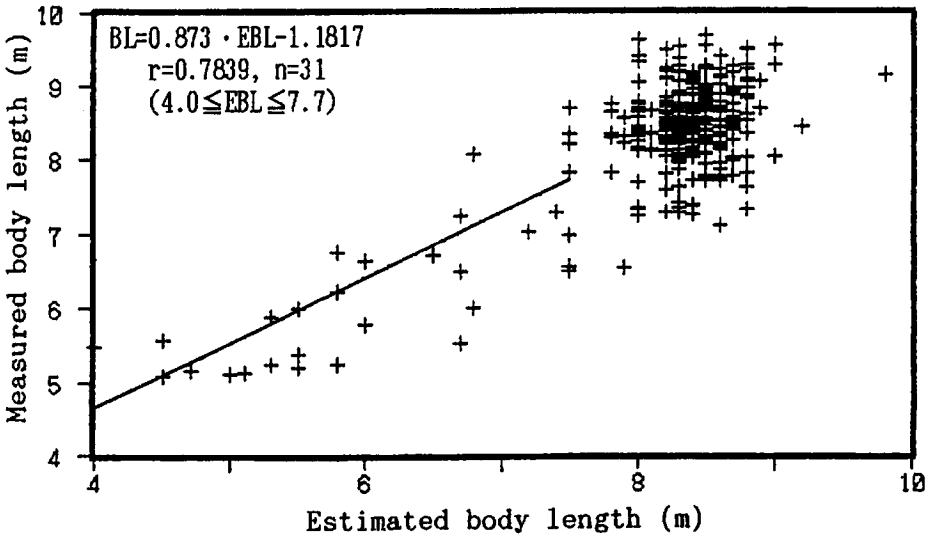


Fig. 12. Relationship between the body lengths estimated before catch (EBL) and measured after catch (BL) in the present research.