Report of the 1993/94 Cruise of the Japanese Whale Research Programme Under Special Permit in the Antarctic Area IV

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ABSTRACT

The seventh cruise of the Japanese Whale Research Pogramme Under Special Permit in the Antarctic (JARPA) was carried out with one research base and three sighting and sampling vessels in the Antarctic Area IV from 3 December 1993 to 19 March 1994. The research consisted of two different surveys, one conducted in the entire research area and the other in the Special Monitoring Zone (SMZ, 110°E to 130°E). The former was synchronized with the IWC/IDCR survey to concentrate sighting efforts on the peak migration period of minke whales. The survey in the SMZ was conducted twice, before and after the main survey in the entire research area, in order to investigate seasonal changes in the migration of minke whales. The sampling method was the same as in the previous JARPA survey. Dwarf form minke whales were not sampled. One dedicated sighting vessel (SV) which was exclusively engaged in sighting survey covered all the research area along the independent sighting track line. Two sighting/sampling vessels (SSVs) had two track lines for sighting and sampling activities. These three vessels surveyed a total of 17,932.6 n.miles. During the research period, 688 primary (1,619 animals) and 267 secondary (1,200 animals) sightings of ordinary form minke whales were recorded. Out of 433 schools (940 animals) primarily sighted by the SSVs, 330 ordinary form minke whales (200 males and 130 females) were randomly sampled. The distribution pattern of minke whales sighted was not considerably different from those in the previous surveys, with the exception of *Prydz Bay*. The ratio

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of mature males in the sample was higher with the exception of *Prydz Bay* where the ratio of mature females was higher. It should be noted that the ratio of mature female was lower than in the previous research surveys. Several experiments were conducted during the survey. On 15 March 1994, a tow-type satellite telemetry tag was attached to a minke whale. Five schools (9 animals) of the blue whale, 29 schools (48 animals) of the humpback whale and 3 schools (4 animals) of the right whale were photographed for natural markings. Twenty biopsy skin samples were taken from humpback whales, while five samples were taken from right whales.

INTRODUCTION

The proposal on the 1993/94 JARPA survey (Government of Japan, 1993a) was presented to the 45th IWC/SC. Several comments were put forward by members of the Scientific Committee. The Commission recommended a resolution calling for Japan to modify the proposal for improvement. According to the resolution, the 1993/94 research programme was modified as follows (Government of Japan, 1993b).

1) The main sighting activities are implemented along the IWC/IDCR southern minke whale assessment cruises in approximately the same period. SV covered all the research area independent from the other two SSVs. In order to assure the independent nature of the SV, the functions of the three vessels used for the research survey are switched from exclusive sighting to sighting with sampling activity or vice versa not on a daily basis but when the survey shift from one sub-research area to another. The SV always go ahead of the other SSVs to avoid negative influence on sighting results due to the SSVs' sampling activities.

2) Dwarf form minke whales are not be subjected to sampling, as they are recognized at least as a different subspecies (Pastene *et al.*, 1994).

3) Enhanced attention should be paid to the behavior of the blue whales in order to understand their ecology.

4) In light of growing concern within IWC about the environment of the Antarctic Ocean, greater emphasis should be placed on environmental monitoring, that is to detect levels of heavy metals and organochlorine pollutants in minke whales. Stomach contents is to be checked and marine debris is to be monitored.

5) In order to study whether or not sampling activities affect whale schools near the chased animals, a reaction monitoring experiment was carried out in the previous surveys. In this experiment, one vessel chased an animal while the behavior of neighboring schools was observed by another vessel. As no remarkable effect of chasing activity to neighboring schools was detected in the previous surveys, the experiment in this research is newly designed to study the effect of sampling activities in

the behavior of neighboring schools.

This report covers the research cruise in the Antarctic Area IV conducted between 3 December 1993 and 19 March 1994, and presents some preliminary analyses of the biological data obtained.

OUTLINE OF THE CRUISE AND RESEARCH METHODS

Research area

The research area covered the Antarctic Area IV (70°E to 130°E) south of 60°S to the ice edge (Fig. 1). The research consisted of two different surveys, one for the entire research area and the other one for the Special Monitoring Zone (SMZ) designated within the research area. Sighting survey was also conducted in the area between 28°S and 60°S on the way to and from the research area.

Entire research area

The research area was divided into the east and west sectors by longitude of 100°E as a boundary, and then further divided into north (from 60°S to the line 45 n.miles off the ice edge) and south (from the 45 n. mile line to the ice edge) strata. In the area between 70°E and 80°E of the south stratum of the west sector, the southern boundary of the south stratum was drawn at latitude of 66°S. The area south of this boundary was designated as the *Prydz Bay* area. Consequently, the entire research area was divided into five sub-areas (Fig. 1).

Special Monitoring Zone (SMZ)

The area between 110°E and 130°E was designated as the special monitoring zone. The north and south strata division in the SMZ were the same as is applied to the entire research area (Fig. 1).

Research fleet

Three vessels, *Kyomaru No.1 (K01*; 812.08CT), *Toshimaru No.25 (T25*; 739.92GT) and *Toshimaru No.18 (T18*; 758.33GT) engaged in the sighting and sampling surveys of minke whales, photographic experiment of natural markings and collecting biopsy skin samples of blue, right and humpback whales.

In addition, satellite telemetry tag experiment, distance and angle estimation experiment, reaction monitoring experiment and oceanographical surveys were carried out by the fleet, as well.

The research base vessel, *Nisshinmaru (NM*; 7,440GT) supported SV and SSVs. It was also engaged in collecting biological data and samples, and processing the sampled whale carcasses on the deck.

Sighting and sampling methods

Cruise track

In principle, the cruise track in the south stratum was settled according to that used in the 1991/92 research (Fujise *et al.*, 1993). In the north strata, a zigzag line that is used in the IWC/IDCR survey was used both in the SMZ and the entire research area. In the south strata except for the *Prydz Bay*, the track

line was zigzagged from north to south at intervals of four degrees longitude. In the *Prydz Bay*, the pack ice line survey was conducted before the sighting and sampling survey. Then, the area from the mouth to the innermost part of the bay was further divided into the north and south zones, each of which had a latitudinal track line. These two track lines were diagonally connected and formed a Z-shaped track line.

Sighting method

The sighting method was similar to that used in the IWC/IDCR surveys. The detailed information about this method is available in the previous cruise reports (Kato *et al.*, 1989, 1990: Fujise *et al.*, 1990, 1993a, 1993b: Kasamatsu *et al.*, 1993).

The SV is deployed on whole research area. The two SSVs had a main course and sub-course. The main course was the same as the course for the SV. The sub-course was drawn parallel to the main course 12 n.miles apart from it. The SSVs were deployed either a main course or sub-course. The functions of these three vessels were switched from exclusive sighting to sighting/sampling or vice versa not on a daily basis but when the survey shifted from one sub area to another in order to assure the independent nature of the SV. Two SSVs exchanged their courses every day.

Whale schools (minke, blue, humpback and right whales for natural marking) were approached in a closing mode, only when the animals were primarily sighted with the range of 3 n. miles from the track line.

Sampling method

The sampling method was the same as in the 1992/93 research (Fujise *et al.* 1993). One ordinary form minke whale was sampled randomly from a primarily sighted school.

Biological research of sampled whales

Sampled whales were towed by sampling vessels to the research base vessel (*NM*) as quickly as possible to obtain a wide range of biological data and materials, including genetics, morphology, reproductive status, age, food and environmental chemistry. The measurement and collection of specimen were conducted according to the list of biological research items (Table 5).

The trajectory of harpoons fired into the sampled animals were studied, and visual autopsies were carried out to improve the method of human killing.

Experiments

Distance and angle estimation experiment

This experiment was conducted to help adjustment and correction of sighting data for the abundance analysis, by evaluating the accuracy of sighting distance and angle estimates. The method used in the experiment was the same as that of the IWC/IDCR surveys. In the experiment, a buoy was set and then sighting staffs on the moving vessel made an estimation of the distance and angle from the vessel to the buoy. Radar was simultaneously used to detect the position of the buoy.

Reaction monitoring experiment
This experiment was designed to be conducted three times in two days in areas where the density of a minke whale was high.

Experiment for investigating the effect of a sonic device on the behavior of minke whale
A sonic device is expected to be used to estimate the abundance of krill. This experiment was planned in order to assess the effect of the device on the behavior of whales.

Photographic experiments on natural markings
Blue, humpback and right whales were photographed by the SV for natural markings. The SSVs took photographs of blue whales only when they were sighted within 3 n. miles from the track line.

Biopsy sampling
The schools of the blue, humpback and right whales, which were sighted and photographed by the SV were targeted for biopsy skin sampling experiments.

Observation of the behavior of blue whales
The SV engaged in observing various behaviors of blue whales on the feeding grounds. Attention was paid to the diving time.

Observation of the behavior of beaked whales (ZIPHIIDAE)
Beaked whales were specially observed in order to assess the possibility of research take in future. They were observed for the species identification and study of their reactions to approaching vessels.

Satellite telemetry tagging for minke whales
Attachment of a satellite telemetry tag to the whale body was tried on swimming minke whales.

Marine debris
NM engaged in the survey of marine debris in the research area. When the stomach content of minke whale was examined, the presence of artificial materials was checked.

Oceanographical surveys
Oceanographical surveys by XBT were carried out on aboard of *T25* once a day at a discretionary point within the research area. In addition, *NM* was engaged in taking samples of air and sea water during the cruise as part of the Fisheries Agency's (Department of Research, Fishing Ground Environment Conservation Division) Global Environment Monitoring Scheme that utilizes fishing boats.

RESULTS

Sighting surveys

Survey period and main activities
Sighting and sampling activities were carried out in the Antarc-

tic Area IV for 107 days among 3 December 1993 and 19 March 1994. The following is the detailed description of the survey period in each sub-area and main activities of the sighting and sampling vessels.

		K01	T25	T18
First period (SMZ)				
South stratum	3 - 11 Dec. 1993	SSV	SV	SSV
North stratum	12 - 19 Dec. 1993	SSV	SSV	SV
Second period (the entire research area)				
Southeast stratum	21 Dec. 1993 - 4 Jan. 1994	SV	SSV	SSV
Northeast stratum	5 - 20 Jan. 1994	SSV	SV	SSV
Southwest stratum	22 Jan. - 4 Feb. 1994	SSV	SSV	SV
Prydz Bay	6 - 14 Feb. 1994	SSV	SSV	SV
Northwest stratum	15 Feb. - 3 Mar. 1994	SV	SSV	SSV
Third period (SMZ)				
South stratum	5 - 16 Mar. 1994	SSV	SSV*	SV
North stratum	8 - 19 Mar. 1994	SV	-	SV

*:This vessel engaged in the experiments after sampling activity.

Sampling activity was completed on 7 March 1994 in the south stratum during the third period. The number of animals sampled was 330. Following the completion of the sampling activities, *T18* continued the sighting activities in the south stratum of the third period until 16 March, and then moved to the north stratum. *K01* began sighting in the north stratum of the third period from 8 March. *T25* conducted several experiments (attachment of satellite telemetry tag to minke whales, the assessment of the use of a sonic device and a preliminary study of beaked whales, etc.) while it was engaged in sighting activities alongside the ice edge.

Cruise track

The main cruise course in each research area is shown in Fig. 2. The dotted line in the figure shows that the course for the SSVs was altered based on the information provided by the SV ahead. The ice edge within the entire research area was located from 95°E to 120°E and it was further north than in case of the 1991/92 research survey (Fujise *et al.*, 1993a). According to the US Navy-NOAA Joint Ice Center (JIC) information, *Prydz Bay* was opened in early January and the ice edge was located near the edge of the Antarctic Continent, presenting the shape as shown in the figure.

Searching effort

The searching distance (n. miles) of a SV and two SSVs in each research area is shown in Table 1. The total searching distance of the SV and SSVs during the 107-day research period was 17,932.6 n.miles. The searching distance in this cruise was 271.9 n.miles shorter than that in the 1991/92 research survey (Fujise et al., 1993a). This is because three vessels shared the remaining planned track line, after the sampling activities were completed in the south stratum of the third period (SMZ). The SSVs made no searching efforts during the third period after the sampling activities were completed in the south stratum. Mean-

while, the SV made almost the same searching effort throughout the three different periods of research; the first period (30.1%), second period (36.5%) and third period (33.4%). However, the research in the SMZ during the third period took 12 days, which was 50% longer than the planned period. This is because the weather deteriorated considerably in March.

Species sighted

Table 2 shows the species sighted during the research period and the number of animals in the schools. As for minke whales (*Balaenoptera acutorostrata*), 955 schools (2,819 animals) were sighted, including the primary sightings of 688 schools (1,619 animals) and secondary sightings of 267 schools (1,200 animals). Among the minke whales sighted as secondary sightings, 79 schools (765 animals) were sighted by *T25* that conducted a survey in the area from 116° to 127°E during the third period, indicating that the minke whales were concentrated near the ice edge. As for dwarf form minke whales, only 4 schools (4 animals) were primarily sighted in the northwest stratum.

Of the baleen whales, 134 schools (221 animals) of the humpback whale (*Megaptera novaeangliae*) were primarily sighted and 38 schools (70 animals) were secondarily sighted. Humpback whales were the second dominant baleen whales (minke whales were the most dominant). As for blue whales (*B. musculus*), 6 schools (10 animals) were sighted (primary: 5 schools 9 animals, secondary: 1 school 1 animal). Fin whales (*B. physalus*) were 10 schools (28 animals) (primary: 9 schools 26 animals, secondary: 1 school 2 animals). Right whales (*Eubalaena australis*) were 12 schools (16 animals) (primary:11 schools 14 animals, secondary: 1 school 2 animals). The number of right whales sighted was almost the same as that in the 1991/92 survey (Fujise *et al.*, 1993a), and was a larger figure than that in the 1989/90 survey (Fujise et al., 1990).

In the toothed whales, the most dominant species was the sperm whales (*Physeter macrocephalus*). A total of 361 schools (380 animals) were sighted (primary: 321 schools 337 animals, secondary: 40 schools 43 animals). This is followed by 380 schools (649 animals) of beaked whales (primary: 349 schools 576 animals, secondary: 31 schools 73 animals), including 161 schools (276 animals) of southern bottlenose whales (*Hyperoodon planifrons*), 2 schools (2 animals) of the *Mesoplodon spp.* and 2 schools (12 animals) of the Arnoux's beaked whales (*Berardius arnuxii*). In addition, 71 schools (597 animals) of the killer whales, 13 schools (855 animals) of the long-finned pilot whales (*Globicephala melaena*) and 28 schools (150 animals) of the hourglass dolphins (*Lagenorhynchus cruciger*) were sighted.

Minke, humpback, sperm and beaked whales (including southern bottlenose whales) accounted for 70% of the total number of sighted animals. These species were widely distributed within the entire research area.

Distribution of minke whales

The geographical locations of primary sightings of the minke whales are shown in Fig. 3. It is noted that minke whales were widely distributed within the entire research area. Except for

the *Prydz Bay*, the pattern of distribution of minke whales was not considerably different from that observed in the previous surveys. In the *Prydz Bay* area, 233 schools (1,172 animals) of minke whale were sighted in the 1991/92 research survey (Fujise *et al.*, 1993a). However, there were 87 schools (160 animals) in the present research survey. This difference indicates that there may be yearly fluctuations in the pattern of minke whale distribution density, as present research period almost corresponded to that in the 1991/92 survey (Fujise *et al.*, 1993a).

In the SMZ, there were no major difference in distribution between different research periods, except the north stratum of the third period where only 3 schools (4 animals) were sighted as primary sightings by the SV that covered 707 n.miles on effort.

Table 3 shows the Density Indices (DI), which is the number of minke whale schools sighted as primary sightings per 100 n. miles searched and the mean school size (MSS). When the entire research area was examined, it was noted that DI was high in the south strata and *Prydz Bay*. However, considerable difference was not observed between the east and west sector in the research area. In general, DI was higher than that of the past research in area IV, except the *Prydz Bay* (Fujise *et al.*, 1990, 1993a). Mean school size (MSS) ranged from 1.30 to 3.07 in five sub-areas. Solitary schools were dominant in the entire research area and schools of large number of animals were few. In the *Prydz Bay*, DI was 6.98 and MSS was 1.80, and they were similar to those observed in the neighboring southwest stratum (DI: 6.44, MSS: 2.39). In the past surveys, high density was observed in the *Prydz Bay*. It was observed in the east section of the bay in the 1989/90 survey (DI: 31.88) and in the west section of the bay in the 1991/92 survey (DI: 89.46). However, high density was not found in the *Prydz Bay* in the present research, although 1,074.7 n. miles was searched on effort.

DI in the SMZ did not change significantly in all research periods, except the case of the north stratum where DI was as low as 0.42 in the third period. MSS in the SMZ ranged from 1.33 to 2.65, except that of the south stratum in the third period was as large as 5.19.

Distribution of other whales than minke whales

Figs.4 and 5 show the distribution of primary sightings of baleen, sperm and beaked whale species. Humpback whales (Fig. 4) were sighted in every sub-area. Schools of two animals were often observed. Humpback whales were sighted more frequently in the north stratum than in the south stratum. They were found in large numbers particularly in the north stratum between 85°E to 115°E. However, sightings of humpback whales were few in the south stratum.

As for blue whales (Fig. 4), one school (3 animals) was sighted near 120°E in the south stratum of the first research period (SMZ). In addition, there were 2 schools (4 animals) near 94°E in the southwest stratum, 1 school (1 animal) near 85°E in the north west stratum, and 2 schools (2 animals) near 78°E at the entrance of *Prydz Bay*. All the animals except one in the northwest stratum were sighted within 45 n. miles from the ice edge.

Ten schools (28 animals) of the fin whale (Fig. 4) were sight-

ed in the SMZ of the first period and the entire research area. All the schools were sighted in the area between 60°S and 64°S.

In the north stratum of the entire research area, 9 schools (12 animals) of the right whale (Fig. 4) were sighted. There were also 3 schools (4 animals) in the SMZ (118°E to 122°E) of the third period.

As for sperm whales (Fig. 5), the number of sightings was the second largest after minke whales. Most of the schools were composed of one animal. Schools of more than 4 animals were not sighted. Sperm whales were widely distributed south of 60°S within the entire research area. In particular, several spots where sperm whales were densely distributed were identified in the south stratum. None of them were found in the *Prydz Bay*. In the SMZ, the sightings of the sperm whale concentrated in the area between the ice-edge and 100 n. miles off the ice-edge in the first and second periods. The sightings of sperm whales were almost the same as those of minke whales in the second period, while only 1 school (1 animal) was sighted in the third period.

Beaked whales (Fig. 6) were widely distributed in the area south of 60°S. Several spots of highly dense distribution of beaked whales were found in the south stratum in the second period. In the *Prydz Bay* area sightings were few, although some schools were found in the west of the entrance of the bay. The distribution pattern of beaked whales was not necessarily similar to that of minke whales.

In the area where sightings of minke whales were few, humpback, sperm and beaked whales were likely to be found. On the other hand, in the south stratum where minke whales were sighted in large numbers, sightings of the other whales were few. Minke whales were sighted in large numbers in the south strata, but they were also distributed widely in the north strata, while humpback whales were mainly sighted in the north stratum although some were also found in the south stratum. This is indicative that the two species may segregate their habitats. In cases of the sperm and beaked whales, there was a distinctive separation of their distributions in the north stratum. In the areas of the south stratum where the sightings of the two species concentrated, when either of the two was dominant, the other was few or none.

Sampling

Sampling activities and samples

In the present research, samples were taken based on the rule of one animal from one school at primary sighting in order to improve the representation of the population. Two SSVs engaged in taking samples in all the research area except in the north stratum of the third period. It was designed in principle that all minke whale schools which were primarily sighted within 3 n. miles on both sides of the track line were subjected to sampling. However, in order to avoid an excessive burden on the research base vessel and to balance the number of samples among different sub-areas, samples were not taken from total of 18 schools sighted; 1 school in the southeast stratum of the second period, 8 schools in the southwest stratum and 9 schools in the *Prydz Bay*.

Sampling activities were completed in the middle of the third research period. A total of 330 minke whales were sampled. Fig. 7 shows the geographical positions of these whales based on the sighting position. The number of samples in each sub-area is as follows.

Period	Stratum	Males	Females	Total
First (The SMZ)				
	South	15	18	33
	North	11	9	20
Second (The entire research area)				
	East-South	32	27	59
	East-North	36	17	53
	West-South	60	32	92
	Prydz Bay	9	15	24
	West-North	29	11	40
Third (The SMZ)				
	South	8	1	9
	North	-	-	-

Sampling efficiency

The sampling efficiency of minke whales in each sub-area is shown in Table 4. A and B show the total number of schools and individuals which were primarily sighted by the SSVs, respectively. C and D show the number of animals selected for sampling and of samples actually collected, respectively.

The sampling efficiency I (D/B) shows the ratio of samples actually taken from the primary sightings. The value decreases in the south stratum and the *Prydz Bay* areas where the mean school size is large. The sampling efficiency I was 0.35 in average, and this was almost the same as 0.31 in average from 1991/92 survey (Fujise *et al.*, 1993a). The sampling efficiency II (D/C) shows the ratio of samples actually collected from the target animals for sampling. This value is supposed to indicate technical efficiency or success rates of sampling. In the north stratum, the value ranged from 0.70 to 0.82, while it was from 0.79 to 0.88 in the south stratum. It was 0.62 in the *Prydz Bay* area where water color and transparency were not clear enough to chase whales successfully. The sampling efficiency II was 0.79 in average for the entire research area. This was almost the same as that of the third research survey in 1991/92 (Fujise *et al.*, 1993a).

Out of target animals, 87 could not be taken. Sight was lost before identification in case of 26 animals, while sampling was intentionally canceled on 10 animals in order to avoid bad weather, an excessive burden on the base vessel and to balance the number of samples between different sub-areas. 40 animals were missed, because they were swimming too fast or diving too long or too quick to chase. Remaining 11 animals were missed for technical reasons.

Biological survey

Survey items and the number of samples
The number of samples on each items of the biological survey is shown in Table 5. All the whale samples collected were subjected to the biological survey aboard the research base vessel. They were processed after the survey was completed. Among 330 samples 200 were males and 130 females. In addition, 62 fetuses were collected. No twins were observed in this survey. The collection of sperm from the deferent duct was tried on 48 of 149 mature males. It was learned that sperm existed in 35 males and 21 samples of frozen sperm were prepared.

One of the objectives of the present research was to compare the biological data of ordinary form minke whales to the detailed biological data of dwarf form minke whales which were collected in the past. Thus, 3 males and 3 females were subjected to a detailed examination. The skulls of the ordinal form minke whales were taken for measurement.

Experiments

Distance and angle estimation experiment
Three sighting and sampling vessels conducted this experiment during the second research period after a rehearsal. *K01* conducted the experiment on 3 January 1994, *T25* on 8 and 9 January and *T18* on 4 January, respectively. Six top men and seven persons on the upper bridge engaged in the experiment. They estimated distances and angles to the buoy from the positions of eight different combinations of distances and angles. A total of 168 different experiments were conducted by 24 crew members of three vessels who engaged in the sighting activity.

Reaction monitoring experiment
The experiment was planned to be conducted in the *Prydz Bay* where a large number of minke whales were sighted in the 1991/92 research survey (Fujise *et al.*, 1993a). However, the experiment was canceled as it was found that the density of minke whales in the area was much lower than our expectation.

Natural markings
Natural markings of blue, humpback and right whales which were sighted during the research were carried out. Nine blue whales from 5 schools (9 animals), 48 humpback whales from 32 schools (58 animals) and 8 right whales from 6 schools (8 animals) were photographed (Table 6).

Biopsy sampling
The collection of biopsy skin sample was tried for the same whale species targeted for natural markings. Twenty biopsy skin samples were collected from 16 schools (32 animals) of the humpback whale and 5 samples were collected from 3 schools (5 animals) of the right whale.

Observation of the behavior of blue whales
During the research period, 5 schools (9 animals) of the blue whale were sighted. Observation of the behaviors, such as the diving time were not adequately observed because the evasive

behavior of the whales.

Observation of the behavior of beaked whales (Ziphiidae)
Twelve schools (18 animals) of beaked whale species (*Ziphiidae*) were sighted and approached for the observation of their behaviors. Out of these species, 6 schools (9 animals) of the southern bottlenose whale and 1 school (2 animals) of the Arnoux's beaked whale were identified. We were unable to identify species in the remaining 5 schools (7 animal) were unidentified their species (Table 7).

The observation time for beaked whales was 614 minutes in total. One observation session involved 50 - 60 minutes. The sight of 7 schools was lost within 30 minutes of observation. No cue was found after first cue in the case of 2 schools. Six schools were re-sighted once, while four schools were re-sighted twice to four times. The shortest approaching distances to these animals were 0.2 to 0.4 miles except for a case of the southern bottlenose whale (0.02 n. miles). The shortest distance was 0.3 n. miles on the Arnoux's beaked whale and 0.3 to 0.9 n. miles on the other unidentified whales.

The diving time ranged from 13 to 26 minutes and 16.1 minutes in average, excluding a case of short dives from 4 to 6 minutes. The average diving time on 6 schools of the southern bottlenose whale was 13.7 minutes. A surfacing time during which a cue was supplied was 6.5 minutes on the average of all the schools under observation. It was 6.1 minutes in case of the southern bottlenose whale. The traveling distances during one dive were 0.2 to 1.3 n. miles, averaging 0.7 n. miles.

Attachment of a satellite telemetry tag to minke whales
A modified biopsy firing system was used as a device (Fig. 8) to apply a satellite telemetry tag to a swimming minke whale. The satellite telemetry successfully attached to a minke whale, approximately 8 meters in length, which was swimming at a location near the ice edge (65°19'S and 123°54'E) on 15 March. Presently, tracking data is being collected.

Assessment of the effect on behavior of whales by use of sonic device
This experiment was planned to be carried out in addition to the reaction monitoring experiment in the areas where minke whales were expected to be abundant. However, there was no chance to conduct this experiment during the present research. In a preliminary experiment to make sure functions of a sonic device, it was learned that a pulse sound made from the fish finder mounted on the base vessel could be recognized within the coverage of 0.8 n. miles by other vessel when it was working at 24 kHz. As for reactions of minke whales to the omnidirectional sonar or the fish finder of the research base vessel, when the vessel approached minke whales within the distance of 0.5 n. miles, they began splash forward or swimming very fast. However, it was unknown if such reactions were due to the vessel itself or to the sonic device.

Marine debris

A 200 liter drum can was seen floating at 60°46'S and 128°57'E on 5 January. A plastic tank cap was found mixed with contents from the third stomach of a male of minke whale, 9.01 meters in length and 9.01 tons in weight, which was sampled on 31 January.

Oceanographical surveys

The XBT survey was conducted at 97 locations, from 3 December 1993 to 15 March 1994 by the *T25*. Meteorological data such as weather conditions, wind direction, wind power, atmospheric pressure, surface water temperature were also recorded.

Fig. 9 shows the distribution of surface temperatures along with the locations where the XBT survey was made. In the SMZ of the first research period, temperatures were within the range of 0° to -1°C in the area south of 60°S. During the second period, the isothermal line of zero degree temperature moved closer to the ice edge, while temperatures were 1° to 2°C in the north stratum. Temperatures in the south stratum and the peripheral areas of the *Prydz Bay* were 0° to 1°C.

In addition, *NM* was engaged in taking 10 samples of both air and sea water and taking 8 samples of microsubstances in sea water by the use of a filter at discretionary points of the research area.

Products

After the biological survey was completed, whale products were produced according to the provisions of Article VIII of the Convention. All of 330 whales sampled were processed to produce 1,379 tons of frozen products and 25 tons of whale oil (Table 8).

PRELIMINARY ANALYSIS OF SAMPLES

Body length

Table 9 shows the average body length and the range of body length for different sub-areas, by reproductive status. The average body length of the samples were as follows: immature male 6.38m, immature female 6.59m, mature male 8.40m and mature females 8.99m. The range of body length was as follows: immature male 5.01 to 8.57m, immature female 4.90m to 8.59m, mature male 7.30m to 9.32m and mature female 8.13m to 9.84m.

Fig. 10 compares the body length compositions with those from the 1991/92 survey. Although no major difference between the two surveys were observed, the present research survey shows that both males and females smaller than 8m in body length were dominant. As for the average body length, no difference was recognized in males between the two research surveys. In the case of females, the average body length was shorter than in the 1991/92 research survey (Fujise *et al.*, 1993), resulting from a large number of immature whales. There were two peaks in the body length distribution, with the average body length of male being 7.89 meters and female 7.86 meters. It was noted that immature animals were mainly represented by the peak of shorter-than-average body length, while mature animals were mainly observed in the longer-than-average body length distribution (Table 9).

Maturity rates

For females, the existence of corpus luteum or corpus albicans in the ovaries, the width of uterine horn and developmental levels of the mammary glands were examined in order to estimate their maturity status, and then samples were categorized as follows: 1) immature, 2) ovulating (existence of corpus luteum and no existence of fetus), 3)resting (existence of corpus albicans and no existence of corpus luteum), 4) pregnant, 5) lactation, 6) pregnant and lactation, 7) unidentified mature.

For males, determination should be made by the histological observation of the testis and epididymis. However, such observation was not completed and thus samples were categorized as the mature male when they have either of the testis weighing more than 400g (Ohsumi *et al.*, 1970: Kato, 1986). Table 10 shows the maturity status of the sampled whales. The ratio of samples categorized by their maturity status is as follows: mature male 45.2%, immature male 15.5%, pregnant female 18.8% (including simultaneous lactation), mature female without pregnancy (resting and ovulating) 1.8% and immature female 18.5%.

In the entire research area, no major difference was observed in the population structure between the east and west sectors. Excepting the *Prydz Bay*, the ratios of mature males were dominant with the range of 40.0% - 88.9%. In the north strata, the ratios of immature males and females (immature male: 15.0% - 27.5%, immature female: 17.5% - 40.0%) were the second highest, while the ratios of mature females were as low as 5.0% - 10.0%. In the south strata, the ratios of pregnant females were 11.1% - 30.3%, the second highest after mature males. However, the ratio of immature females was also as high as 15.2% - 21.2%, indicating no significant difference between immature and mature females. In the *Prydz Bay*, pregnant females accounted for 62.5%, followed by the mature males (33.3%). In contrast, immature females, which were dominant in the other areas, were infrequent. The fact that mature males were dominant throughout the entire research area, while pregnant females were abundant in the south stratum, especially in the *Prydz Bay*, was consistent with the result of the research surveys in 1989/90 and 1991/92 seasons (Fujise et al., 1990, 1993a). However, it was learned in the present research that the ratio of immature whales was higher than those in the previous surveys in both north and south strata. As for maturity rates, it was 74.5% for males (1989/90: 83.7%, 1991/92: 77.4%) and 53.1% for females (1989/90: 59.9%, 1991/92: 67.8%). Both of them were lower than the previous research surveys. The apparent pregnancy rate (the ratio of pregnant females to the total mature females) was 91.2%.

Table 11 shows the maturity rates of the sampled whales according to the school size. It was learned that the ratio of immature whales was high in solitary school. This tendency was observed more clearly in females. It was 42.4% for male and 75.5% for female. It seems that the larger the school size became, the higher the rates of maturity was. However, as far as females were concerned, the ratio of immature animals increased in the schools of more than 5 animals.

Change in the average thickness of blubber

Fig. 11a shows the average thickness of blubber (the average thickness of blubber measured on three points of the body) of mature whales in relation to the progress of the sampling season. The moving average was also shown in Fig. 11b. As sampling activities were conducted alternately between the north and south strata, it might have been the case that the difference of the strata affected the thickness of blubber. However, it was learned that the average thickness increased as the sampling season progressed. The increase was indicated by $y=0.01x+4.38$. The thickness of blubber increased by 1 centimeter from the start of the sampling activities in early December to the completion in early March. The moving average of blubber increased from 3 centimeters when the sampling activities began to 5 centimeters when sampling was put to an end. These results indicate the physiological relationship between feeding and the accumulation of blubber of minke whale in the Antarctic Ocean. However, it was noted that the average thickness of blubber differs from one individual to another through the entire research period. It was presumed that minke whales migrating to the Antarctic Ocean might not remain there continuously from the beginning to the end of the feeding season. This presumption was supported by the fact that minke whales of which blubber was thin or females which had just finished lactating were sampled even in February.

DISCUSSION

The 1993/94 JARPA survey was carried out as the third research survey in the Antarctic Area IV on a full scale. The major objective of the research was to follow up previous surveys to find out if there are seasonal change and yearly fluctuations of the distribution of minke whales and of their population structure, and levels of such fluctuations. In addition, the present survey was designed to investigate the reason why the abundance estimates presented by the past IWC/IDCR survey was inconsistent with those of the JARPA (Kishino *et al.* 1991).

Thus, unlike the previous JARPA survey, the entire research area was surveyed almost at the same period as the IWC/IDCR survey. In addition, SV was exclusively engaged in sighting and it covered all of the research area independent from SSVs. In order to assure the independent nature of the sighting vessel, the functions of the three vessels used for the research were switched from SV to SSV or vice versa when the survey shifted from one sub-area to another. The SV always went ahead of other two vessels to avoid negative influence on sighting results due to the sampling activities of SSVs.

In the entire research area, the total searching distance of the SV was 5,254.3 n.miles, while two SSVs covered 7,774.0 n.miles. Each searching distances was longer than the 4,439.7 n. miles achieved by the 1988/89 IWC/IDCR survey (Haw, 1990).

The Density Indices (DI) of the entire research area was higher than those found in the 1989/90 and 1991/92 surveys, excepting the *Prydz Bay*. In the past surveys, high density was observed in the *Prydz Bay*. However, such high density was not found in the bay, although 1,074.7 n. miles was searched.

The observation that mature males were dominant throughout the entire research area, while pregnant females were abundant in the south stratum, especially in the *Prydz Bay*, was consistent with the result of the researches in the 1989/90 and 1991/92 research surveys. However, it was learned that the ratio of immature whales was higher than those in the previous research surveys in both north and south strata and that the ratio of mature females were lower in the present survey.

These findings are not related to the timing of the research survey but to the distribution of minke whales. It is presumable that there is a year-on-year difference in DI and MSS values and a population structure. In particular, it was learned that the distribution and DI values fluctuated significantly in the *Prydz Bay* which is susceptible to the influence of the moving ice edge. It is presumable that such fluctuation occurs due to the movement of the ice edge which causes changes in sea state of the Antarctic Circle and the distribution and abundance of krill which constitutes an important food source for minke whales. It is also believed that the distribution of other whale species is deeply involved in such fluctuation.

In addition to the minke whales, it was learned that humpback, sperm and beaked whales (including southern bottlenose whales, etc.) were widely distributed in the research area. Their density was comparable to that of minke whales. As for the distributions of the minke and the humpback whales, it was noted that minke whales were mainly sighted in the south stratum. However, they were also spotted in the north stratum. On the other hand, humpback whales were frequent in the north stratum but they were spotted in the south stratum, too. In case of the sperm and beaked whales there was a distinctive separation of their distributions in the north stratum. In the south stratum where the sightings of the two species were concentrated, when either of the two species was dominant, the other was infrequent or none. This is indicative that the two species may segregate their habitats.

Compared with the 1991/92 survey, the ice edge in the present research was located further north between 95°E and 120°E. The density of the humpback , sperm and beaked whales within this area was high. It is known that the distribution of minke whales is also observed in areas within the ice edge (Leatherwood *et al.*, 1981: Naito, 1982). It is presumable that minke whales go beyond the ice edge to avoid competition with the other species mentioned above. Especially, is likely that the distribution and density of minke whales in the south stratum may be underestimated in the present research survey as regard previous surveys in this area, as the ice edge was located further north than usual. In future, it may be necessary that the location of the ice edge is taken into consideration when research survey is designed. In order to understand the ecosystem of the Antarctic Ocean, it is also necessary to research the distribution and migration of not only the minke whale but other species such as the humpback, sperm and beaked whales as well in addition to research on the abundance and distribution of their prey species.

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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 (*Second period*)			
East-North	1,250.2	1,912.1	3,162.3
East-South	839.3	1,419.8	2,259.1
West-North	1,663.8	2,492.3	4,156.1
West-South	1,023.4	1,352.8	2,376.2
Prydz Bay	477.6	597.1	1,074.7
Total	5,254.3	7,774.1	13,028.4
The SMZ (110°E-130°E)			
First period			
North	635.5	979.9	1,615.4
South	565.1	1,056.5	1,621.6
Combined	1,200.6	2,036.4	3,237.0
*Second period**			
North	915.2	1,383.8	2,299.0
South	537.6	860.4	1,398.0
Combined	1,452.8	2,244.2	3,697.0
Third period			
North	707.0	-	707.0
South	623.9	336.4	960.3
Combined	1,330.9	336.4	1,667.3
Total	3,984.3	4,617.0	8,601.3

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

Table 2a. Summary of sightings (no. schools/no. individuals) 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	26/33		23/40	2/3	57/75	4/4	65/113	6/6
Dwarf minke whale							4/4	
Like minke whale			1/2		5/5	1/1	5/5	
Blue whale					1/1			
Fin whale	1/2		1/2				2/5	
Humpback whale	11/19		11/21	6/13	34/53	1/2	20/40	2/2
Right whale	2/2		1/2		1/1		4/5	1/2
Baleen whales					1/1	1/1	2/5	
Sperm whale	45/50	3/5	15/15		57/59	12/13	6/8	
S. bottlenose whale	12/21		14/23	1/2	16/25	3/5	9/12	
Mesoplodon spp.							2/2	
Ziphiid whales	19/26		9/15		22/34	2/4	22/42	
Killer whale	5/35		2/22		12/64		5/43	
Long-finned pilot whale	2/40	1/5	2/260		1/20	3/380	2/70	
Pilot whales							1/2	
Hourglass dolphin	5/14	2/8	1/1		5/23	9/65		
Unidentified dolphins						1/20		
Unidentified whales	2/2		13/14		28/28		27/32	
South stratum								
Minke whale	42/111	5/11	63/207	51/102	111/255	19/45	72/207	34/64
Dwarf minke whale								
Like minke whale	2/2		1/1	3/4	7/7		6/6	3/6
Blue whale					2/4			
Fin whale					1/1			
Humpback whale	7/12		1/2	2/3	19/25	9/15	6/11	1/1
Right whale								
Baleen whales					1/1	4/7		
Sperm whale	54/55	3/3	18/19	3/3	29/29	7/7	72/77	9/9
S. bottlenose whale	21/36	4/10	6/8	3/4	12/25		27/47	4/9
Mesoplodon spp.								
Ziphiid whales	8/13	1/1	11/14	2/4	40/71	2/6	24/41	3/8
Killer whale	3/25		1/20	1/5	8/54	2/6	3/37	
Long-finned pilot whale					1/20			
Pilot whales								
Hourglass dolphin								
Unidentified dolphins								
Unidentified whales	7/7		4/4		29/30		19/20	

Table 2a. (continued)

Species	SV		SSVs	
	Primary	Secondary	Primary	Secondary
Prydz Bay				
Minke whale	27/42	5/11	48/93	7/14
Dwarf minke whale				
Like minke whale	3/3	2/2	4/4	1/1
Blue whale	1/1			1/1
Fin whale				
Humpback whale	1/2		3/5	2/4
Right whale				
Baleen whales	1/1		1/2	1/1
Sperm whale				
S. bottlenose whale	8/11			
Mesoplodon spp.				
Ziphiid whales	5/11			
Killer whale	4/27	1/3	4/17	2/35
Long-finned pilot whale				
Pilot whales				
Hourglass dolphin				
Unidentified dolphins				
Unidentified whales	4/4		3/9	

Table 2b. Summary of sightings (no. schools/no. individuals) conducted by the sighting vessel (SV) and the two sighting/sampling vessels (SSVs) in each stratum in the SMZ (110°E-130°E) surveys.

Species	SV				SSVs			
	North strata		South strata		North strata		South strata	
	Primary	Secondary	Primary	Secondary	Primary	Secondary	Primary	Secondary
First period								
Minke whale	14/31	2/2	31/75	6/8	27/43	5/6	43/103	13/20
Like minke whale			4/4	3/3	2/2		4/4	1/1
Blue whale			1/3					
Fin whale	2/11				1/3	1/2	1/2	
Humpback whale	3/4		1/1		3/4		7/10	
Baleen whales			1/1					
Sperm whale			7/7				16/16	2/2
S. bottlenose whale	2/2		5/11	1/1	1/1		2/5	1/4
Ziphiid whales	2/3		9/10		5/9		20/37	1/2
Killer whale	2/8		2/9				1/7	
Unidentified whales	5/6		1/1		11/12		9/14	
Second period *								
Minke whale	19/35	1/1	14/38	3/5	45/75	5/5	38/100	15/21
Dwarf minke whale					4/4			
Like minke whale					4/4		5/5	3/6
Fin whale	1/2				1/4			
Humpback whale	3/4	1/2			7/11	1/1	1/1	
Baleen whales					1/3			
Sperm whale	12/12		14/15	3/3	6/8		50/52	9/9
S. bottlenose whale	10/18	1/2	4/5	1/1	4/5		24/44	4/9
Mesoplodon spp.					2/2			
Ziphiid whales	8/13		8/11	1/2	14/29		18/33	3/8
Killer whale	1/16				3/11		1/10	
Long-finned pilot whale					1/50			
Pilot whales					1/2			
Hourglass dolphin	1/1							
Unidentified whales	9/9				20/25		10/10	
Third period **								
Minke whale	3/4	1/1	26/136	5/39			10/51	82/835
Like minke whale			1/2					
Humpback whale	2/3		2/4	1/2			3/5	9/19
Right whale	1/1		2/3					
Baleen whales				4/5				
Sperm whale	1/1							
S. bottlenose whale	3/5		3/4				2/4	1/1
Arnoux's beaked whale								2/12
Ziphiid whales	2/2		1/1				5/5	
Killer whale	1/10		2/7				2/15	7/98
Hourglass dolphin	5/37		1/2					
Unidentified whales			3/3				3/3	2/2

* : This survey was carried out as a part of the East Sector in the entire research area.
** : Include the ice edge 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		Total	
	Primary	Secondary	Primary	Secondary	Primary	Secondary
Minke whale	255/679	176/971	433/940	91/229	688/1619	267/1200
Dwarf minke whale			4/4		4/4	
Like minke whale	13/15	7/8	32/32	8/11	45/47	15/19
Blue whale	2/4		3/5	1/1	5/9	1/1
Fin whale	4/15		5/11	1/2	9/26	1/2
Humpback whale	39/68	23/46	95/153	15/24	134/221	38/70
Right whale	6/8		5/6	1/2	11/14	1/2
Baleen whales	2/2	4/5	5/9	6/9	7/11	10/14
Sperm whale	140/147	11/13	181/190	29/30	321/337	40/43
S. bottlenose whale	74/121	10/18	69/119	8/18	143/240	18/36
Arnoux's beaked whale		2/12				2/12
Mesoplodon spp.			2/2		2/2	
Ziphiid whales	66/95	3/5	138/239	8/20	204/334	11/25
Killer whale	22/163	10/156	35/237	4/41	57/400	14/197
Long-finned pilot	4/300	2/65	4/110	3/380	8/410	5/445
Pilot whales			1/2		1/2	
Hourglass dolphin	12/54	2/8	5/23	9/65	17/77	11/73
Unidentified dolphins				1/20		1/20
Unidentified whales	39/41	2/2	129/148		168/189	2/2

Table 3. Density indices (DI) and mean school size (MSS) of minke whale 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 (*Second period*)												
East-North	23	40	1.84	1.74	65	113	3.40	1.74	88	153	2.78	1.74
East-South	63	207	7.51	3.29	72	207	5.07	2.88	135	414	5.98	3.07
West-North	26	33	1.56	1.27	57	75	2.29	1.32	83	108	2.00	1.30
West-South	42	111	4.10	2.64	111	255	8.21	2.30	153	366	6.44	2.39
Prydz Bay	27	42	5.65	1.56	48	93	8.04	1.94	75	135	6.98	1.80
Total	181	433	3.44	2.39	353	743	4.54	2.10	534	1176	4.10	2.20
The SMZ survey (110°E-130°E)												
First period												
North	14	31	2.20	2.21	27	43	2.76	1.59	41	74	2.54	1.80
South	31	75	5.49	2.42	43	103	4.07	2.40	74	178	4.56	2.41
Combined	45	106	3.75	2.36	70	146	3.44	2.09	115	252	3.55	2.19
*Second period**												
North	19	35	2.08	1.84	45	75	3.25	1.67	64	110	2.78	1.72
South	14	38	2.60	2.71	38	100	4.42	2.63	52	138	3.72	2.65
Combined	33	73	2.27	2.21	83	175	3.70	2.11	116	248	3.14	2.14
Third period												
North	3	4	0.42	1.33	-	-	-	-	3	4	0.42	1.33
South	26	136	4.17	5.23	10	51	2.97	5.10	36	187	3.75	5.19
Combined	29	140	2.18	4.83	10	51	2.97	5.10	39	191	2.34	4.90
Total	107	319	2.69	2.98	163	372	3.53	2.28	270	691	3.14	2.56

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 East Sector in the entire research area.

Table 4. Number of minke whales sighted (schools/individuals, A/B), targeted (C), sampled (D) and efficiencies of sampling. Efficiency I shows the ratio of samples actually taken from the primary sightings and II shows the ratio of samples actually collected from target animals.

Stratum	Sighted* A / B	Targeted** C	Sampled D	Efficiency I(D/B)	Efficiency II(D/C)
The SMZ *(First period)*					
North	27 / 43	28	20	0.47	0.71
South	43 / 103	42	33	0.32	0.79
The entire research area *(Second period)*					
East-North	65 / 113	65	53	0.47	0.82
East-South	72 / 207	71	59	0.29	0.83
West-North	57 / 75	57	40	0.53	0.70
West-South	111 / 255	105	92	0.36	0.88
Prydz Bay	48 / 93	39	24	0.26	0.62
The SMZ *(Third period)*					
North	— / —	—	—	—	—
South	10 / 51	10	9	0.18	0.90
Combined	433 / 940	417	330	0.35	0.79

* : primary sightings of sighting and sampling vessel.
** : including secondary target in the same school.

Table 5. Summary of biological data and samples collected.

Data and samples	Number of whales		
	Male	Female	Total
-Data-			
Photographic record of external character*	200	130	330
Body length	200	130	330
External measurement	200	130	330
Body weight	200	130	330
Body weight by total weight of parts	39	34	73
Skull measurement (length and breadth)	194	124	318
Craniometric study	3	3	6
Standard measurement of blubber thickness (three points)	200	130	330
Detailed measurement of blubber thickness (fourteen points)	39	34	73
Lactation status of mammary grand	—	130	130
Breadth and thickness measurement of mammary grand	—	130	130
Breadth measurement of uterine horn	—	130	130
Testis and epididymis weight	200	—	200
Stomach contents weight	199	128	327
Photographic record of fetus	—		62
Fetal sex (identified by visual observation)	(34)	(27)	(61)**
Fetal length and weight	(34)	(27)	(62)**
External measurement of fetus	(33)	(27)	(60)
-Sample-			
Diatom film	200	130	330
Serum sample for chemical analysis	199	130	329
Earplug for age determination	200	130	330
Tympanic bulla for age determination	194	125	319
Largest baleen plate for age determination	61	60	121
Earplug for chemical analysis (one of the pair)	8	9	17
Vertebral epiphysis sample	197	128	325
Ovary	—	130	130
Histological sample of endometrium	—	130	130
Histological sample of mammary grand	—	130	130
Milk sample for chemical analysis	—	4	4
Histological sample of testis	200	—	200
Histological sample of epididymis	200	—	200
Testis and epididymis smear for sperm detection	200	—	200
Urine sample for sperm detection	101	—	101
Blubber, muscle, liver, kidney and heart tissues for genetic study	200	130	330
Muscle, liver and kidney tissues for heavy metal analysis	75	51	126
Stomach contents for heavy metal analysis	26	14	40
Blubber and liver tissues for organochlorine analysis	200	130	330
Stomach contents for organochlorine analysis	20	8	28
Cerebrum and kidney tissues for organochlorine analysis	8	2	10
Stomach contents for the food and feeding study	104	60	164
Muscle, liver and blubber tissues for lipid analysis	39	33	72
Stomach contents for lipid analysis	18	12	30
External parasites	27	62	89
Internal parasites	4	4	8
Whole skeleton	3	2	5
Larynx for morphological study	2	2	4
Live sperm for reproductive study	21	—	21
Serum sample for reproductive study	22	31	53
Fetus	(2)	(0)	(3)**
Blubber, muscle, liver, kidney and heart tissues for genetic study (fetus)	(32)	(25)	(57)
Jaws of fetus for embryological study	(6)	(6)	(13)**
Blood smear of fetus for embryological study	(6)	(6)	(13)**

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

Table 6. Summary of natural marking and biopsy skin sampling attempt during the survey.

Species	Natural marking			Biopsy sampling		
	Target		Success	Target		Samples
	Sch.	Ind.	Ind.	Sch.	Ind.	Ind.
Blue whale	5	9	9	0	0	0
Right whale	6	8	8	3	5	5
Humpback whale	32	58	48	16	32	20

Sch. : number of schools sighted.
Ind. : number of individuals sighted.

Table 7. Summary of the preliminary survey on the behavior of ziphiid whales.

Species	Sch.	Ind.
S.bottlenose whale	6	9
Arnox's beaked whale	1	2
Ziphiid whales	5	7
Total	12	18

Sch. : number of schools sighted.
Ind. : number of individuals sighted.

Table 8. Products from samples.

Items of products	Weight (kg)	Items of products	Weight (kg)
Freezed products			
Ordinal meat	363,105	Maxillary cartilage	2,075
Premium meat (Oniku)	810	Mandibular ligaments	3,965
Breast meat	448,080	Nasal plug	4,100
Meat pieces	108,465	Tendon	26,054
Meat inside ventral grooves	15,530	Hart	3,836
Blubber of ventral grooves	7,101	Tongue	28,340
Meat/blubber of ventral grooves	86,535	Diaphragm	7,560
Meat/blubber of ventral part	60,950	Stomach	3,380
Ordinal blubber	146,574	Intestine	5,825
Underside part of blubber	15,275	Pancreas	810
Lining of meat	13,425	Kidney	2,814
Tail flukes	19,700	Testes	168
Meat/connective tissue of lower jaw	3,975	Esophagus	286
		Total	1,378,738
Others			
Oil*	25,000		

* : Oil was consumed as fuel of Nisshin-maru.

Table 9. Mean body length(m) by sex and maturity in each stratum.

Male

Stratum	Immature					Mature				
	Mean	SD	Min.	Max.	n	Mean	SD	Min.	Max.	n
The SMZ *(First period)*										
North	5.84	0.47	5.24	6.38	3	8.31	0.43	7.40	8.98	8
South	5.28	——	5.28	5.28	1	8.35	0.45	7.30	9.02	14
The entire research area *(Second period)*										
East-North	5.86	0.75	5.10	7.45	13	8.55	0.37	7.88	9.26	23
East-South	6.48	0.70	5.33	7.17	8	8.31	0.37	7.56	8.88	24
West-North	6.46	1.17	5.36	8.57	11	8.52	0.31	7.90	9.08	18
West-South	6.91	0.91	5.01	8.23	14	8.37	0.34	7.37	9.23	46
Prydz Bay	6.64	——	6.64	6.64	1	8.39	0.42	7.90	9.32	8
The SMZ *(Third period)*										
North	——	——	——	——	—	——	——	——	——	—
South	——	——	——	——	0	8.40	0.40	7.89	9.02	8
Total	6.38	0.97	5.01	8.57	51	8.40	0.38	7.30	9.32	149

Female

Stratum	Immature					Mature				
	Mean	SD	Min.	Max.	n	Mean	SD	Min.	Max.	n
The SMZ *(First period)*										
North	6.63	1.05	5.24	8.25	8	8.82	——	8.82	8.82	1
South	6.64	1.35	4.90	8.43	7	8.84	0.25	8.32	9.20	11
The entire research area *(Second period)*										
East-North	6.15	0.98	5.04	7.90	13	9.33	0.39	8.78	9.84	4
East-South	6.85	1.12	5.21	8.59	12	8.98	0.34	8.38	9.61	15
West-North	6.83	0.87	5.89	8.30	7	9.50	0.37	8.90	9.81	4
West-South	6.61	0.90	5.51	7.95	14	8.81	0.38	8.16	9.34	18
Prydz Bay	——	——	——	——	0	9.07	0.43	8.13	9.77	15
The SMZ *(Third period)*										
North	——	——	——	——	—	——	——	——	——	—
South	——	——	——	——	0	9.44	——	9.44	9.44	1
Total	6.59	1.07	4.90	8.59	61	8.99	0.41	8.13	9.84	69

Table 10. Reproductive status of samples in each stratum.

Stratum	Male		Female							M%*
	Imm.	Mat.	Imm.	Mat.						
				Preg.	Ovu.	Rest.	Lact.	P & L	Unk.	
The SMZ *(First period)*										
North	3	8	8	1	0	0	0	0	0	55.0
	(27.3)	(72.7)	(88.9)	(11.1)						
South	1	14	7	10	1	0	0	0	0	45.5
	(6.7)	(93.3)	(38.9)	(55.6)	(5.6)					
The entire research area *(Second period)*										
East-North	13	23	13	2	0	0	0	1	1	67.9
	(36.1)	(63.9)	(76.5)	(11.8)				(5.9)	(5.9)	
East-South	8	24	12	13	1	1	0	0	0	54.2
	(25.0)	(75.0)	(44.4)	(48.1)	(3.7)	(3.7)				
West-North	11	18	7	2	0	0	0	2	0	72.5
	(37.9)	(62.1)	(63.6)	(18.2)				(18.2)		
West-South	14	46	14	13	1	2	0	2	0	65.2
	(23.3)	(76.7)	(43.8)	(40.6)	(3.1)	(6.3)		(6.3)		
Prydz Bay	1	8	0	15	0	0	0	0	0	37.5
	(11.1)	(88.9)		(100.0)						
The SMZ *(Third period)*										
North	–	–	–	–	–	–	–	–	–	——
South	0	8	0	1	0	0	0	0	0	88.9
		(100.0)		(100.0)						
Total	51	149	61	57	3	3	0	5	1	60.6
	(25.5)	(74.5)	(46.9)	(43.8)	(2.3)	(2.3)		(3.8)	(0.8)	

Explanation of abbreviations.
Imm.: immature, Mat.: mature, Preg.: pregnant, Ovu.: ovulating,
Rest.: resting, Lact.: lactating, P&L: pregnant and lactating,
Unk.: unknown.
* : percentage of males.

Table 11. Reproductive status by school size.

School size	Male			Female		
	Imm.	Mat.	Total	Imm.	Mat.	Total
1	36 (42.4)	49 (57.6)	85	37 (75.5)	12 (24.5)	49
2	7 (11.9)	52 (88.1)	59	9 (27.3)	24 (72.7)	33
3	6 (19.4)	25 (80.6)	31	6 (30.0)	14 (70.0)	20
4	0 (0.0)	13 (100.0)	13	3 (20.0)	12 (80.0)	15
>= 5	2 (16.7)	10 (83.3)	12	6 (46.2)	7 (53.8)	13
Total	51 (25.5)	149 (74.5)	200	61 (46.9)	69 (53.1)	130

Explanation of abbreviations
Imm.: Immature, Mat.:Mature.

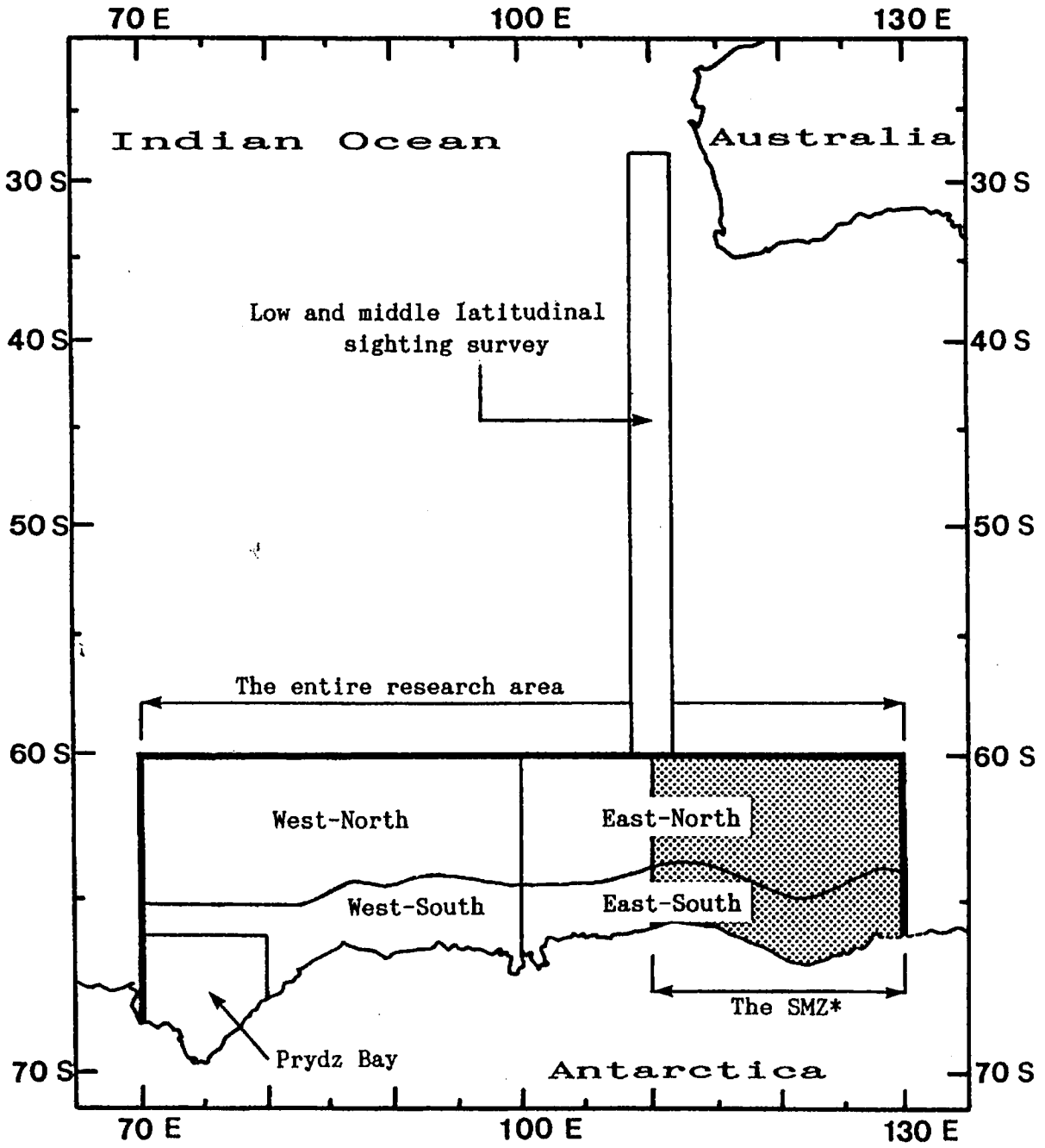

Fig. 1. Geographical location and the stratification of the research area in the JARPA in 1993/94.
* : Special Monitoring Zone (SMZ) to investigate the seasonal changes of the distribution and segregation of minke whales.

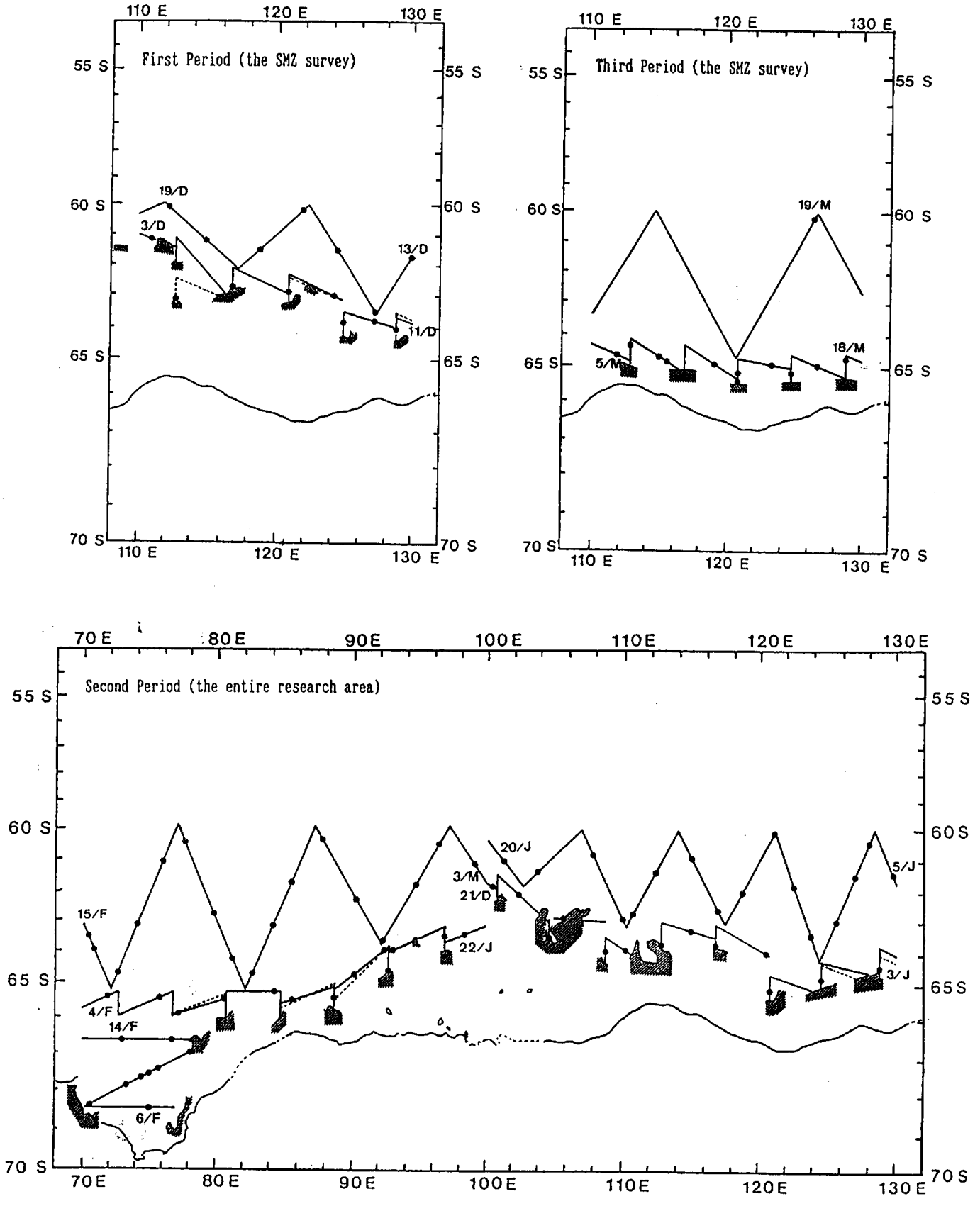

Fig. 2. Cruise tracks and noon positions of the research base (NM) in the JARPA in 1993/94.
Upper: the survey in the SMZ in the First and Third period, lower : the survey in the entire research area in the Second period.

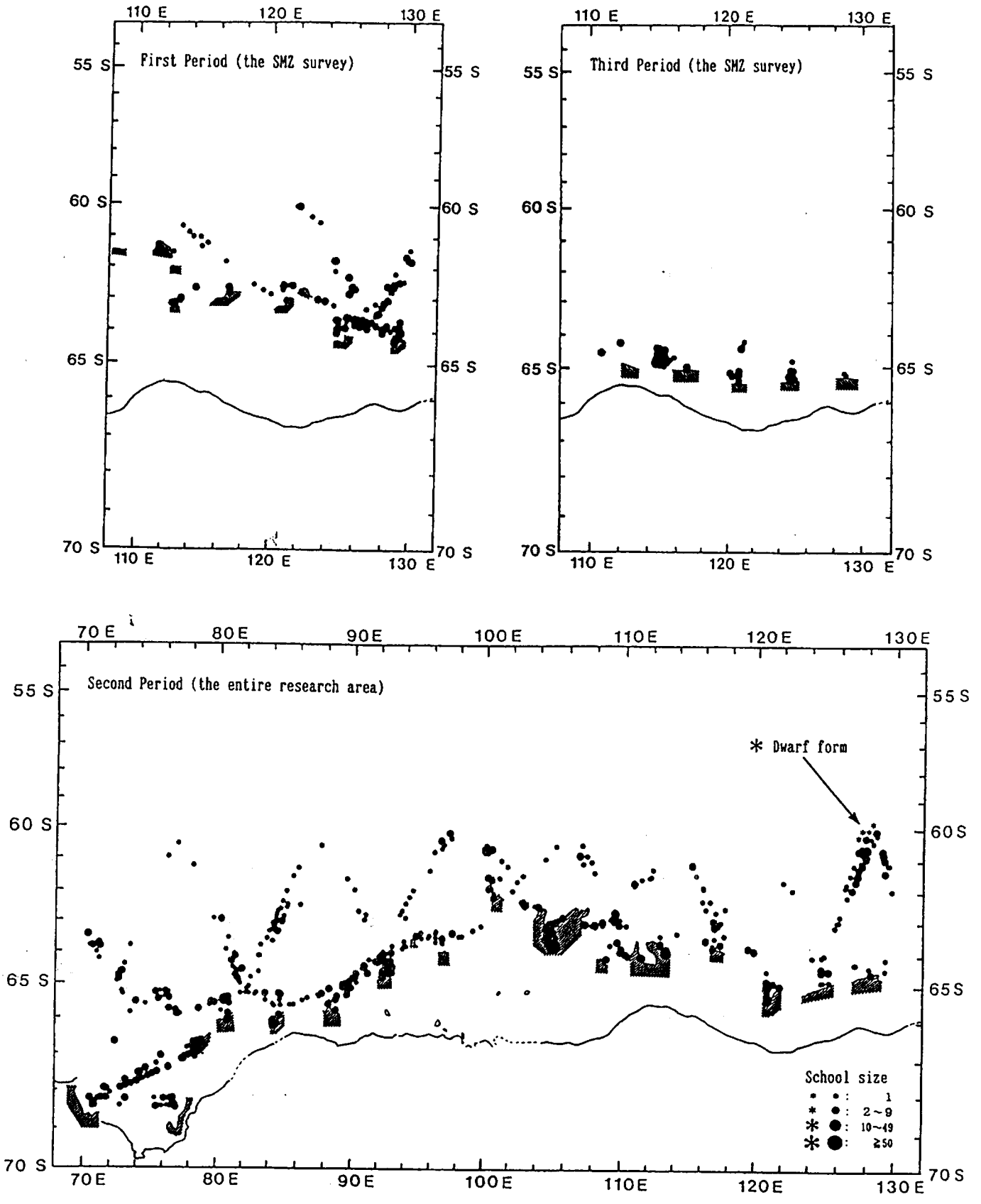

Fig. 3. Distribution of the primary minke whale sightings by three sampling and sighting vessels. Upper : the survey in the SMZ in the First and Third periods, lower : the survey in the entire research area in the Second period.

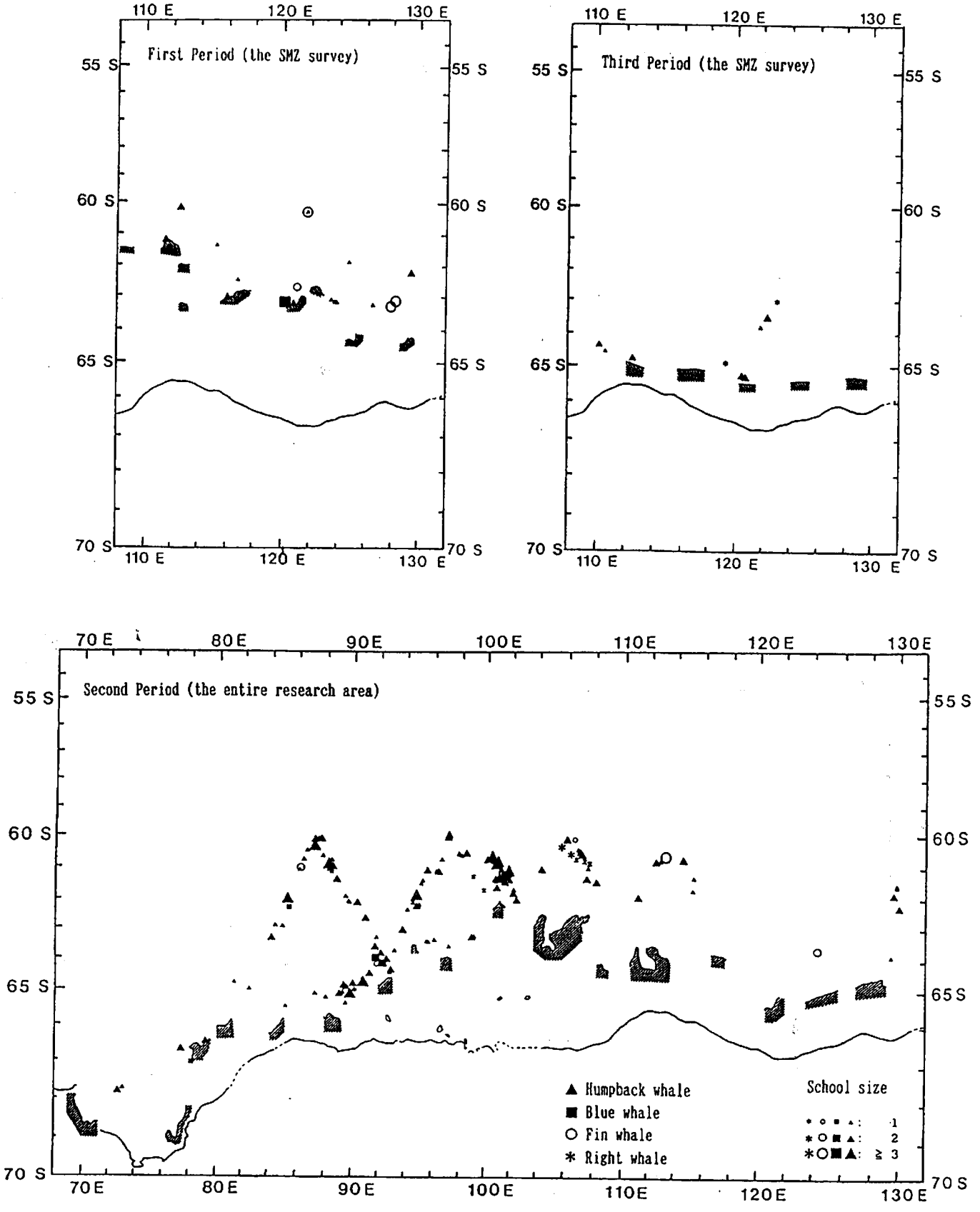

Fig. 4. Distribution of humpback ,blue, fin, right whales sighted by three sighting and sampling vessels. Upper :the survey in the SMZ in the First and Third periods, lower : the survey in the entire research area in the Second period. lower : the survey in the entire research area in the Second period.

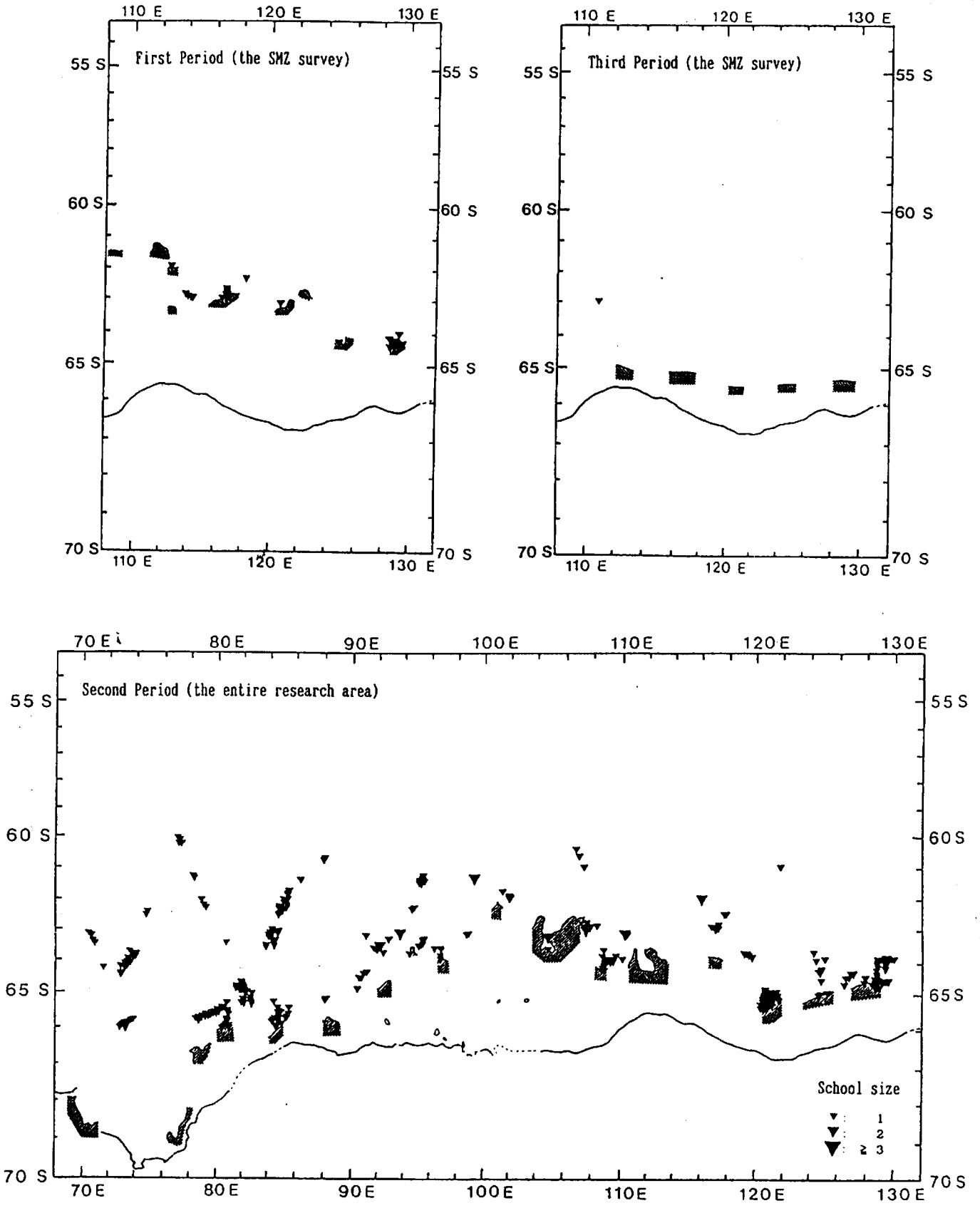

Fig. 5. Distribution of sperm whales sighted by three sighting and sampling vessels. Upper :the survey in the SMZ in the First and Third periods, lower : the survey in the entire research area in the Second period. lower : the survey in the entire research area in the Second period.

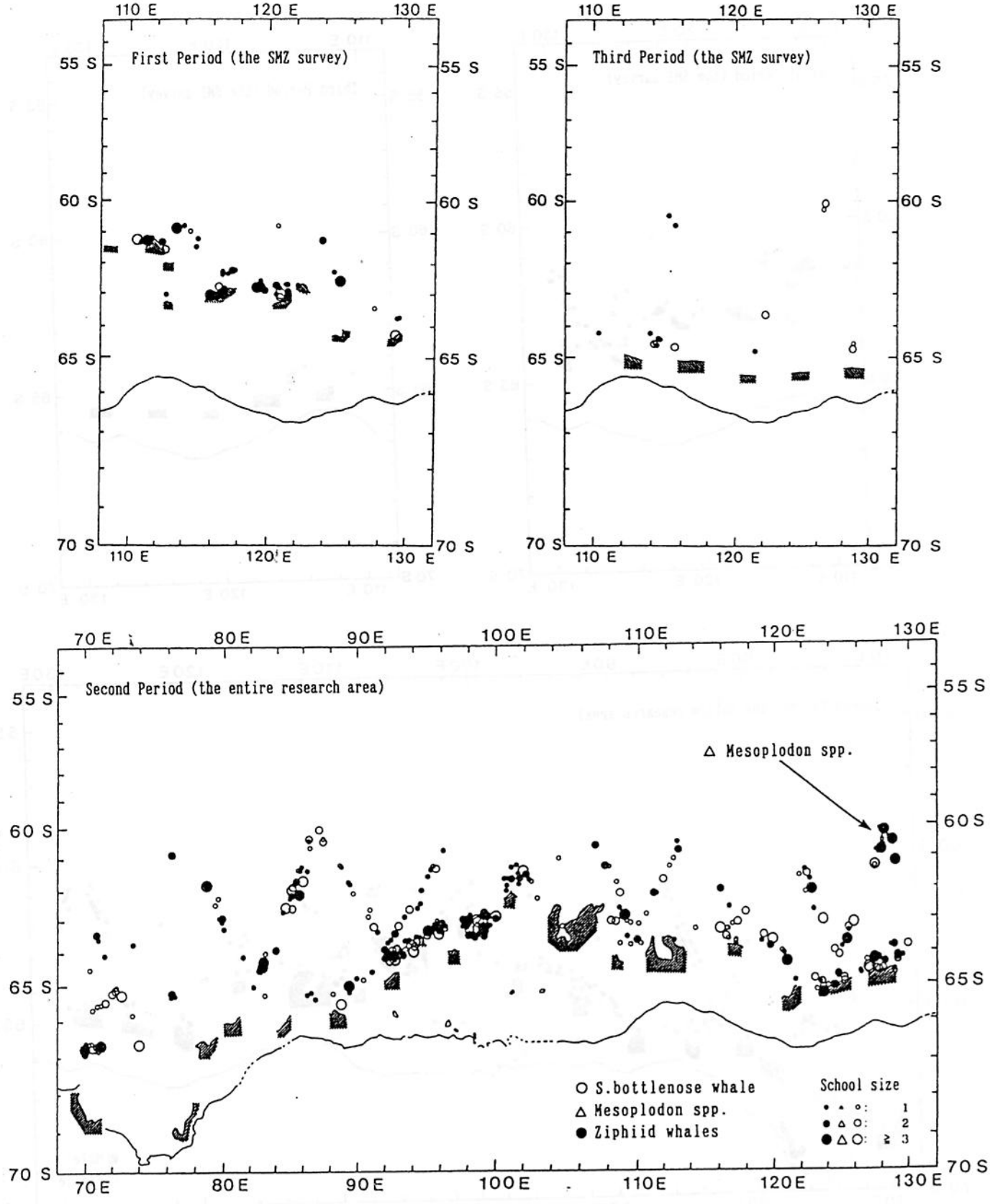

Fig. 6. Distribution of ziphiid whales sighted by three sighting and sampling vessels. Upper :the survey in the SMZ in the First and Third periods, lower : the survey in the entire research area in the Second period. lower : the survey in the entire research area in the Second period.

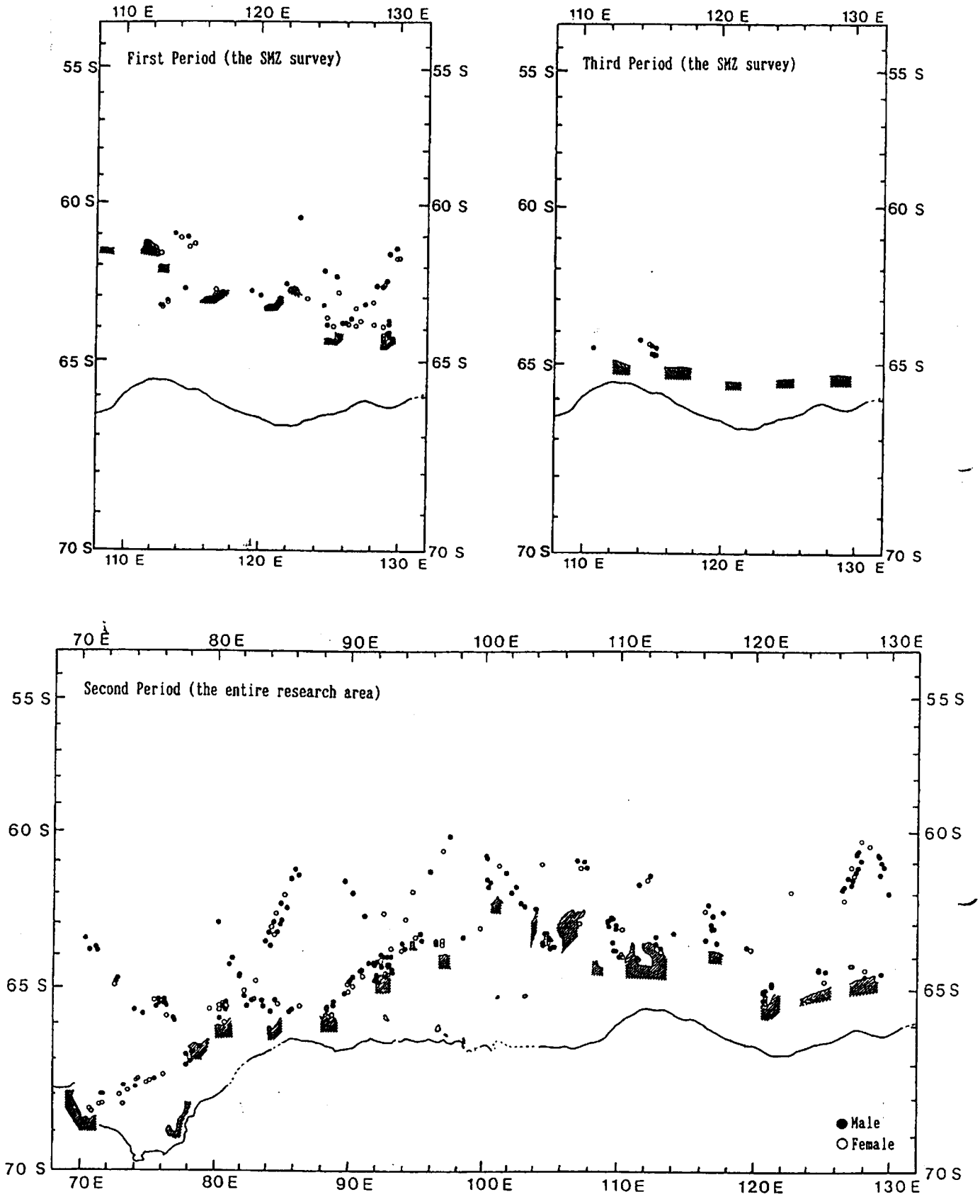

Fig. 7. Distribution of minke whales sampled based on their sighted position. Upper : the survey in the SMZ in the First and Third periods, lower : the survey in the entire research area in the Second period.

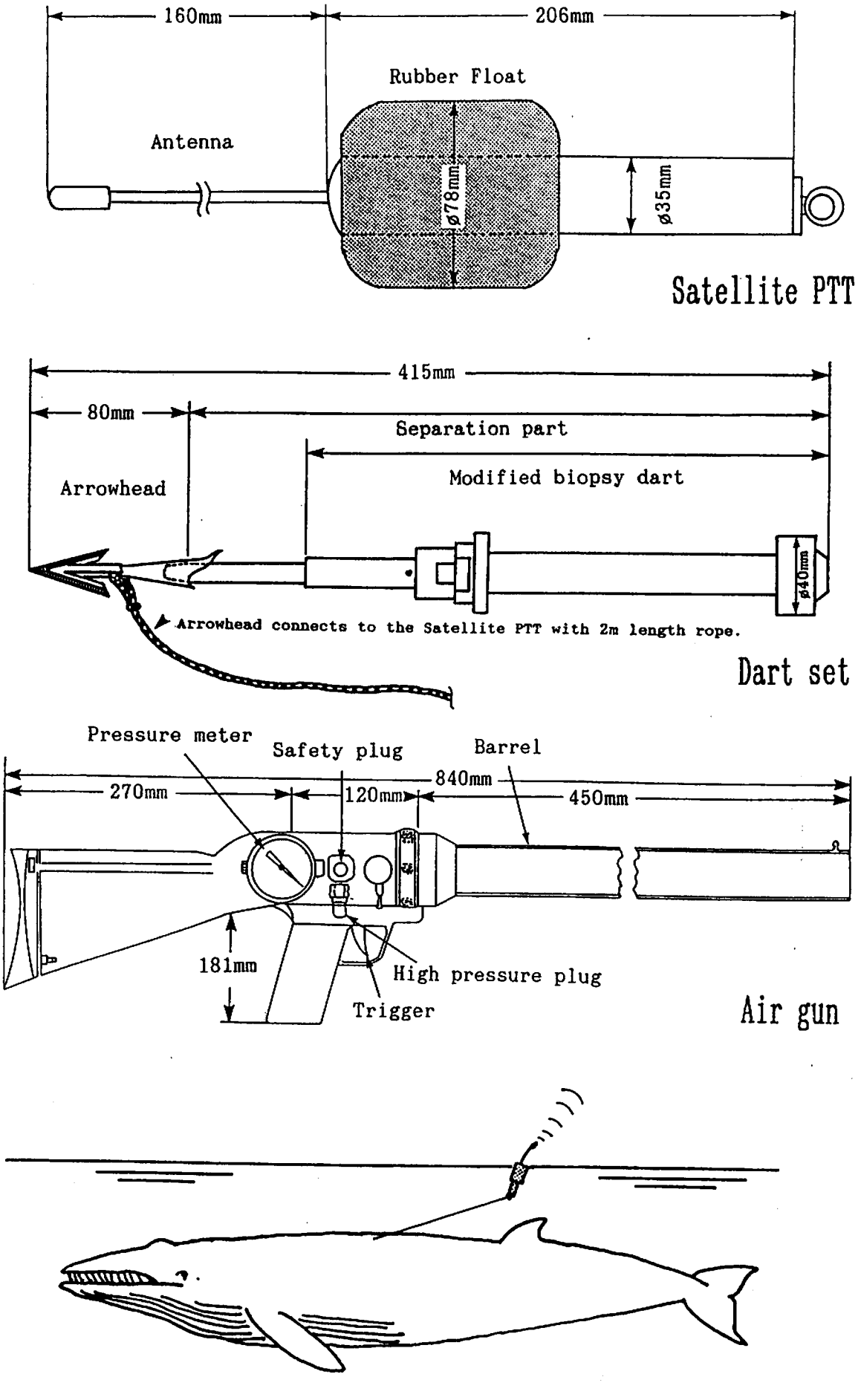

Fig. 8. Newly developed satellite tagging system. Upper : satellite PTT, dart set and air gun, lower : total system after attachment.

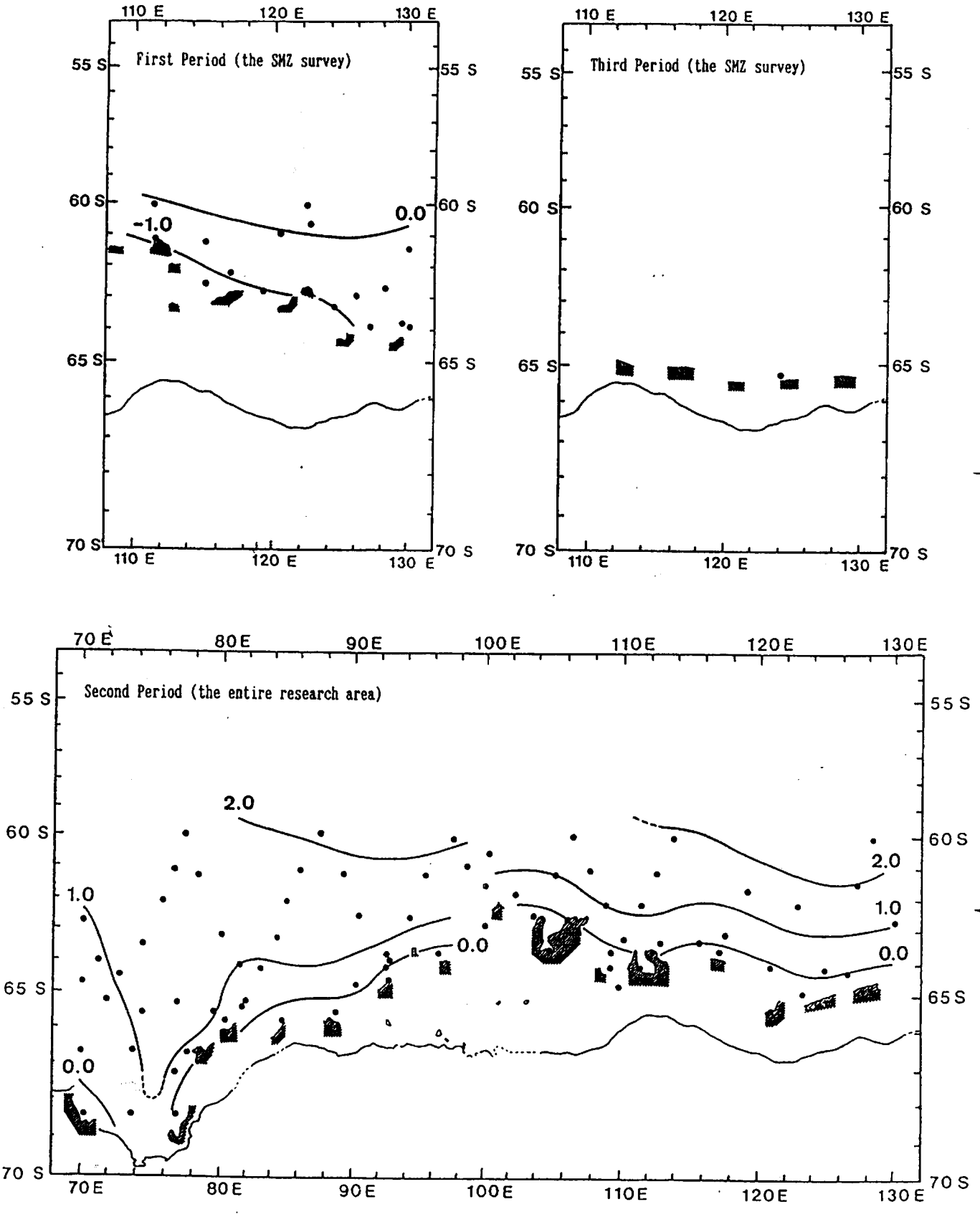

Fig. 9. Surface water isothermal (°C) and positions of the XBT survey. Upper : the survey in the SMZ in the First and Third periods (only one observation in the third period), lower : the survey in the entire research area in the Second period.

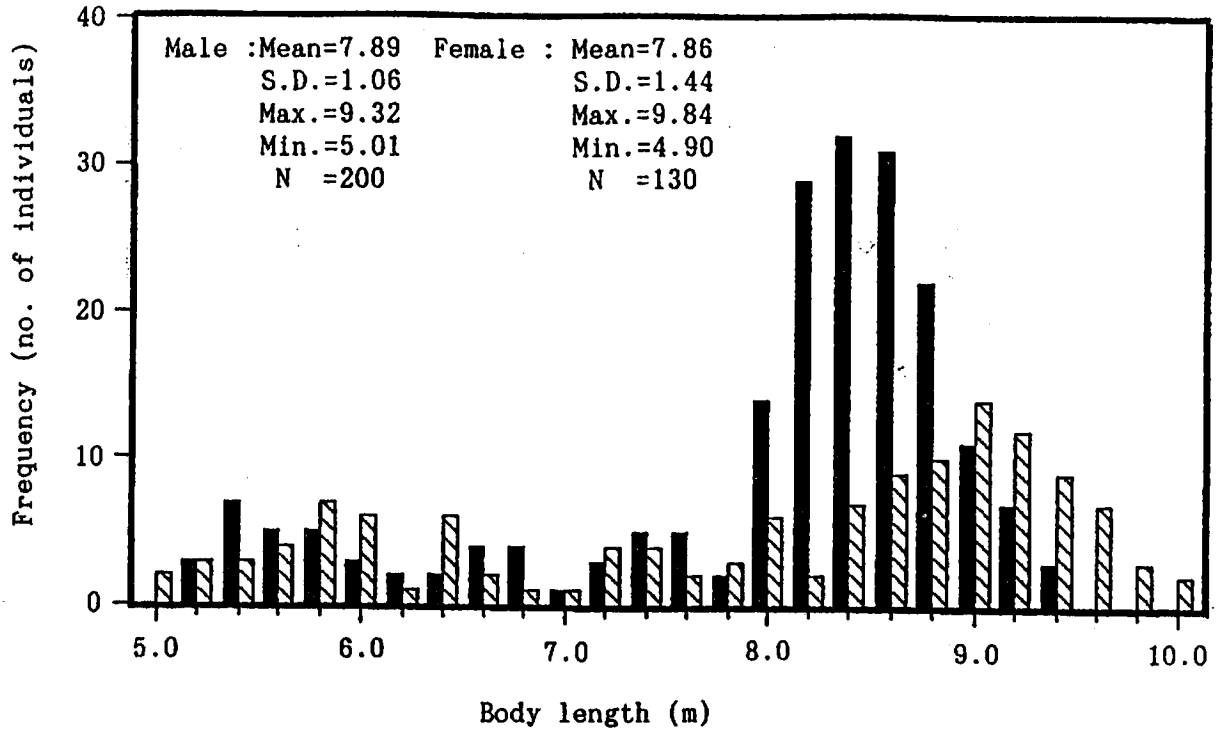

Fig.10a. Body length compositions (20cm intervals) of the samples taken in the whole research area. Solid and striped lines represent males and females, respectively.

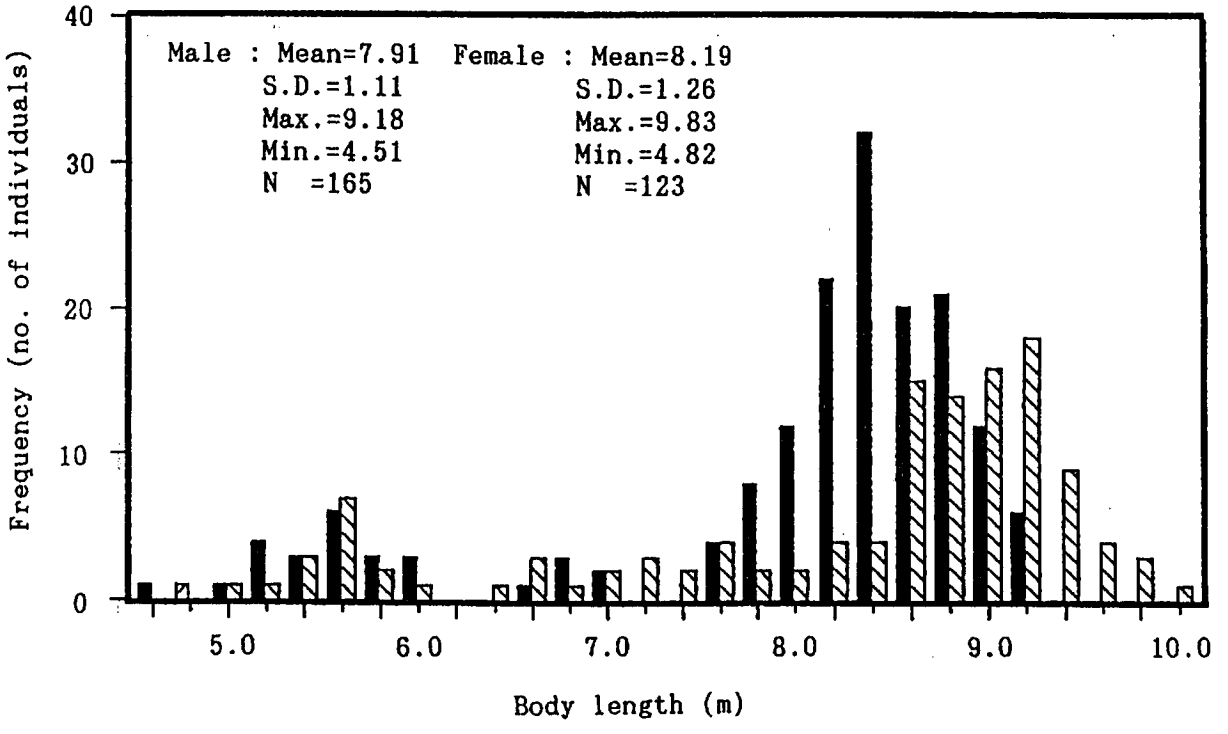

Fig.10b. Body length compositions (20cm intervals) of the samples taken in the 91/92 Japanese research. Solid and striped lines represent males and females, respectively.

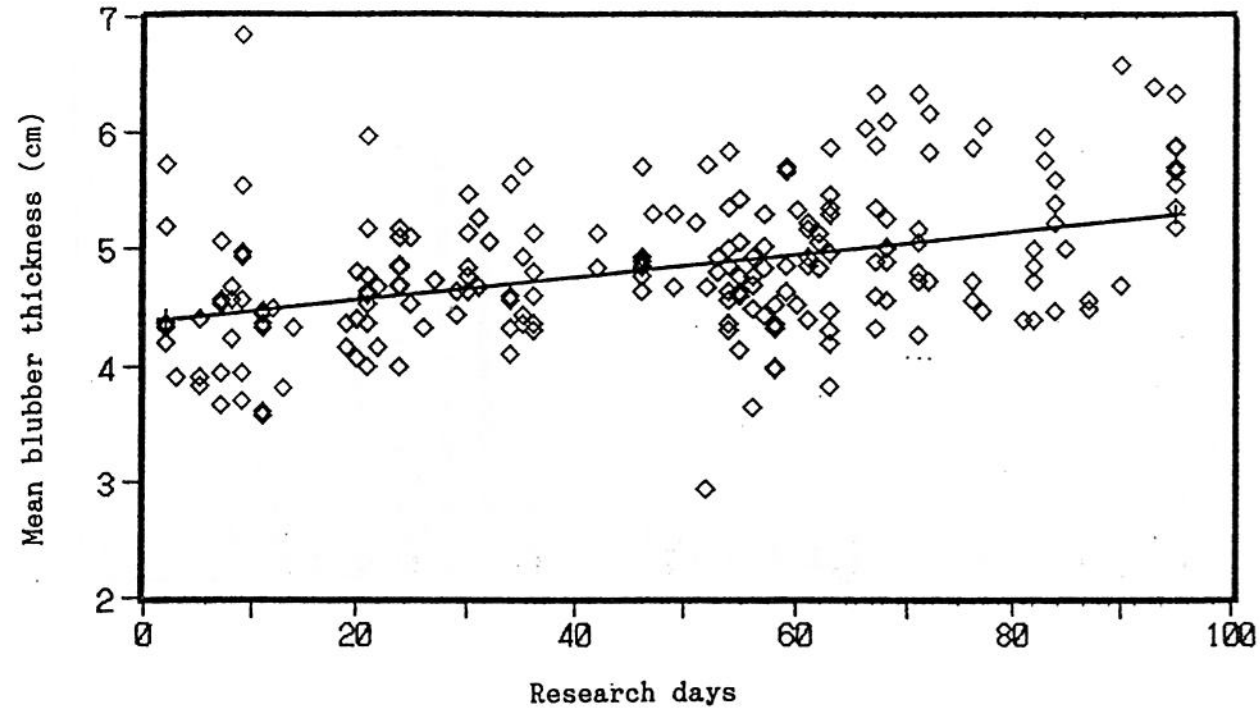

Fig.11a. Relationship between mean blubber thickness (left side points of the body at ear, navel and dorsal fin positions) of matured animals and research days. N=218, y=0.01x + 4.38.

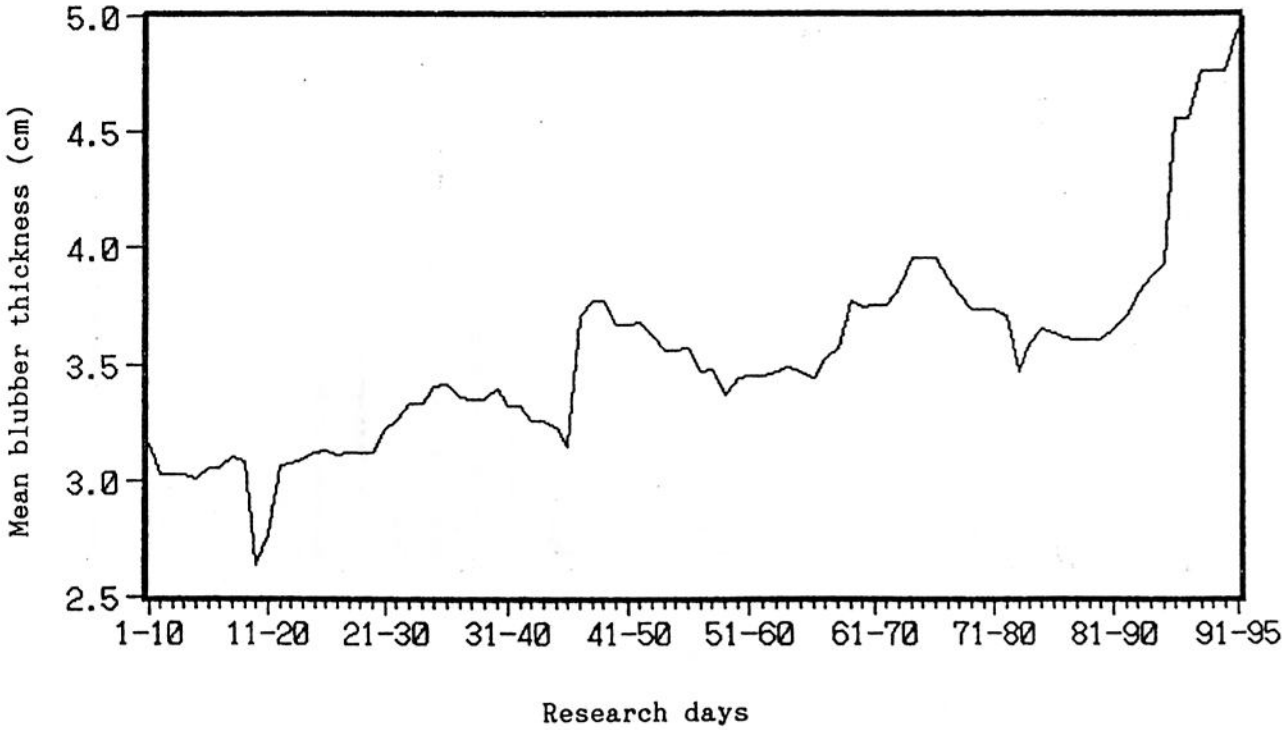

Fig.11b. The moving average of mean blubber thickness (left side points of the body at ear, navel and dorsal fin positions) of matured animals with every 10 research days.