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Report of the 1996/97 Japanese Whale Research Program Under Special Permit in the Antarctic (JARPA) in Area V and western part of Area VI

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ABSTRACT

The Tenth survey of the Japanese Whale Research Programme Under Special Permit in the Antarctic (JARPA) was carried out in the Antarctic Area V (south of 60° S between 130°E and 170°W) and western part of Area VI (south of 60° S between 170°W and 145°W). The survey was conducted for 103 days, from 30 November 1996 to 13 March 1997. The research cruise was composed by a research base vessel and four research vessels.The researchbase vessel engaged for the biological survey and processing of the minke whales sampled. Three sighting /sampling vessels (SSVs) engaged in sighting and sampling and one sighting vessel (SV) dedicated exclusively to sighting activities. Survey in the western part of Area VI was conducted before and after the survey in the entire Area V . The survey in Area V was conducted during the period in which the peak migration of minke whales was expected. The western part of Area VI was conducted as a feasibility study on stock identity, and sampling activities were done during an early and late period of the feeding season in order to study intra-seasonal changes. During the sampling, one animal was taken randomly from schools sighted as primary sighting. This was made in order to improve the representation of the population. The SV was exclusively engaged in whale sighting survey in all the research areas, along an independent sighting track line. Sighting and sampling activities were independently conducted by the three SSVs, in parallel track lines to each other. The total searching distance of these four vessels was of 17,755.6 n.miles. During the research period, 852schools (2,608 animals) of the ordinary minke whale were sighted as primary sighting and 113 schools (626 animals) as secondary sightings. Out of 637 schools (1,584 animals) primarily sighted by the SSVs, 440 ordinary form minke whales (206 males and 234 females) were randomly sampled. Concerning the distribution pattern of minke whales in the western part of the Area VI, they were was widely distributed, and no concentrated area was confirmed during the research period. This was consistent with that observed during the eastern part of the Area III in 1995/96 survey. Minke whales were widely distributed

in the Area V and made high density area in the eastern part of South-east stratum (Ross sea). Thus, the distribution pattern of minke whales was not substantially different from that observed during previous JARPA surveys in the same research area. Samples were categorized by their maturity status. It was indicated that the ratio of immature whales was low in the southern stratum for both sexes, and the ratio of pregnant females was high in this stratum.
Fin, humpback, sperm and southernbottlenose whales distributed widely within research areas except the south-east strata (Ross sea) in the area V. The ratio of minke and killer whales were higher in the south-east stratum than the other strata. During the survey, 4 schools (5 animals) of the blue and 23 schools (50 animals) of the humpback whale were photographed for natural markings. Twenty skin biopsy samples were taken from humpback whales and one sample was taken from the blue, respectively.

INTRODUCTION

The Japanese Whale Research Program under Special Permit in the Antarctic (JARPA) has been conducted every year since the 1987/88 season in compliance with Article VIII of the International Convention for the Regulation of Whaling. After two seasons of feasibility research in 1987/88 and 1988/89, full-scale research started in the 1989/90 season (Government of Japan, 1989).

JARPA is designed to repeat surveys in the Antarctic Areas IV and V in every alternative year during the sixteen years research period. "Estimation to biological parameters of minke whale stock" and "elucidation of the role of whales in the Antarctic ecosystem," which are the major objectives of JARPA, reasonably require a long-term continuous survey (Government of Japan, 1987). The statistical performance of the estimation will be improved as research is continued. JARPA was planned by the Japanese government, and the Institute of Cetacean Research (ICR) has been conducting the survey. The research plan in the 1996/97 JARPA was submitted to 48th International Whaling Commission and the Scientific Committee (IWC/SC) meetings by the Japanese Government (Government of Japan, 1996). This research has the following principal Four objectives:

(I) Elucidation of the stock structure of the Southern Hemisphere minke whales to improve the stock management
(II) Estimation of biological parameters of the Southern Hemisphere minke whales to improve the stock management
(III) Elucidation of the role of whales in the Antarctic marine ecosystem through whale feeding ecology
(IV) Elucidation of the effect of environmental changes on cetaceans

The First three objectives are essentially as established by the Government of Japan when JARPA was initially planned (Government of Japan, 1987). The last objective was added from the 1995/96 season in response to the three resolutions below (IWC, 1995, 1996):

Resolution on research on the environment and whale stocks (IWC Resolution1994-13)
Resolution on promotion of research related to conservation of large baleen whales in the Southern Oceans (IWC Resolution 1994-12)
Resolution on research on the environment and whale stocks (IWC Resolution 1995-10)

Detailed discussion on the research needs in the conventional JARPA survey in Areas IV and V has presented in the original research proposal (Government of Japan, 1987), And the main objective of the expansion of area is a feasibility study for stock identity, structure, and distribution of minke whales.

Although IWC has used six areas for management of baleen whales (except Bryde's whale) in the Southern Hemisphere, it has been suggested that different stocks migrate into these areas during the austral summer season (IWC, 1991). A large scale mtDNA survey that used minke whale samples taken by JARPA in Area IV and V, has demonstrated that the stock structure of minke whales in the Antarctic is more complex than was thought initially and that involves both spatial and temporal components. Based on the results of the mtDNA analysis, Pastene *et al.*(1996) hypothesized that a large group ("core stock") migrate into Area V and eastern part of Area IV in most of the years, and that a different group ("western stock") is distributed in the western part of Area IV during the early period of the feeding season.

In 1996/97 JARPA, the regular research in the Antarctic Area V was conducted in peak migration season of minke whales. In order to obtain samples that comparable to the exsting samples, the previous JARPA sampling method will be retained. The number of samples within Area V will be kept unchanged in order to maintain the precision of various estimates. All samples will be collected randomly as in the previous research and no selection will be made in terms of sex and length. In western part of Area VI, a feasibility study was conducted twice before and after the regular research in Area V. The eastward expansion of the "core stock" will be examined. For this purpose, efforts will be expended to sample animals from offshore areas of eastern part of Area V (where past whale sample size still small) and from the western part of Area VI.

RESEARCH METHODS

The pre-cruise meeting was held in Tokyo on 28 October 1996 under the participation of scientists, researchers of the cruise and representatives of the ships' crews. Outline of cruise and research method employed are summarized below.

Research fleet

The research base vessel, *Nisshinmaru* (*NM*; 7,440GT) acted in general matters such as planning of the daily research strategy, setting cruise course and arrangements for SV and SSVs. The measurements, collection of biological samples and processing of the whale carcasses were taken place on the deck of *NM*. A part of humane killing survey was also conducted on the deck.

Three SSVs, *Kyomaru No.1* (*K01*; 812.08GT), *Toshimaru No.18* (*T18*; 758.33GT) and *Toshimaru No.25* (*T25*; 739.92GT) engaged in the whale sightings and sampling of minke whales. During research periods, experiments of the distance and angle estimation were conducted each vessels..

Kyoshinmaru No.2 (*KS2*; 372.00GT) engaged in varous experiments in addition to whale sightings. The distance and angle estimation experiment, the natural markings and collection of skin biopsy samples of blue, right and humpback whales, observations of the behavior of blue and beaked whales and oceanographical surveys were conducted during research periods.

Number of Samples

Present research was planned to collect 300 ordinary minke whales with 10% allowances (+-10%) in Area V and 100 ordinary minke whales with 10% allowances (+-10%) in western part

of Area VI for samples.

Research area divisions

The research area for sampling of minke whales were Antarctic areas V (from 130°E to 170°W) and western part of Area VI (from 170°W to 145°W) in the area between south of 60°S and the ice edge line (Fig. 1). During transit cruises, sighting surveys were also conducted in the area between south of 30°S and north of 60° S to collect information on the distribution of whales on the lower and middle latitudinal areas.

a) Area V (The entire area research)

The research area is divided into the east and west sectors by line of 165°E, and then farther divided into north and south strata. For the west sector, the north and south strata were separated by a line of 45 n.miles northward from the ice edge line. For the east sector, the area between 60°S and 69°S is designed as the north stratum, and all the Ross sea region south of 69°S as the south stratum. Consequently, the entire research area is divided into four strata (Fig. 1).

b) Western part of Area VI (the feasibility research)

Western part of Area VI was not divided to smaller strata. The research conducted twice before and after the research in Area V.

Sighting and sampling methods

a) Cruise track

In principal, the cruise track in the south strata was set according to that used in the 1991/92 JARPA (Fujise *et al.*, 1993). A zigzag line that is used in the IWC/IDCR survey was used both in western part of Area VI and the north strata of the research in Area V except for the west-south stratum. In this stratum, the track line was zigzagged from north to south at intervals of four degrees' longitudes.

b) Sighting method

The sighting method was basically in conformance with that is used in the IWC/IDCR research (Kato *et al.*, 1989,1990: Fujise *et al.*, 1990: Kasamatsu *et al.*, 1993). The limited-closing mode to approach the whale sighted was used, in which the ship should approach only minke whales primarily sighted. Additionally, the SV approached to targeted species for natural markings (blue, right and humpback whales) on the track line. The SV was deployed on whole research area. The SV always preceded SSVs in order to assure the independent sighting activity in the research area. Three SSVs had a main course and two sub-curses of track lines. The main course was the same as the course for the SV, two sub-courses were parallel to the main course 7 n.miles apart from it. Three SSVs exchanged their courses every day in principal.

c) Sampling method

The sampling method was the same as in the 1991/92 research (Fujise *et al.*, 1993). One ordinary form minke whale was sampled randomly from a primarily sighted school. Dwarf form minke whale was not target species.

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 manual of biological re-

search for JARPA.

The survey to improve whale killing method

The whales killing method and times were recorded on SSVs in detail. The trajectory of harpoons fired into the sampled animals are traced, and visual autopsies were carried out on the deck of the *NM*.

Experiments

a) 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 was the same as that of the IWC/IDCR research. A buoy was set and then sighting staff on the moving vessel estimated the distance and angle from the vessel to the buoy. Radar is simultaneously used to detect the position of the buoy.

b) Reaction monitoring experiment

This experiment was planned in order to assess the effects on the behavior of whales by the sampling activity of the SSVs. It is designed to be conducted three times in two days in areas where the density of minke whales was high.

c) Experiment for the assessment of the effect on whales' behavior by the use of a sonic device

A sonic device is expected to be used for the abundance estimation of krill in future. This experiment was planned in order to assess the effects of the sonic device on the behavior of whales.

d) Natural marking

Blue, humpback and right whales within 3 n.miles from the track line were photographed by the SV for natural marking.

e) Skin biopsy sampling

Blue, humpback and right whales that were sighted and photographed by SV were subjected to biopsy skin sampling.

f) Observation of the behavior of blue whales

The SV engaged in observation of behavior of blue whales on feeding grounds. Attention was paid to the diving time.

g) Observation of the behavior of beaked whales

Beaked whales such as Southern bottlenose whale, Arnoux's beaked whale and *Mesoplodon* species were paid close attention in order to assess the possibility of research take of them in future. They had reactions to approaching vessels.

h) Satellite telemetry tagging for minke whales

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

i) Marine debris

The SV was engaged in the survey of marine debris observation in the research area. When the stomach of minke whale was examined on *NM*, the presence of artificial materials were

checked.

j)Oceanographical surveys
Oceanographical surveys with XBT were carried out on board of *KS2* once a day at a discretionary point of the research area.

RESULTS

Sighting surveys
a) Survey period and main activities
Sighting and sampling activities were carried out in the Antarctic Area V and western part of Area VI for 103 days from 30 November 1996 to 13 March 1997. The following is the detailed description of the survey period in each stratum and allotment of duties of three SSVs and one SV.

		KS2	*K01*	*T25*	*T18*
The first survey in eastern part of Area VI					
	30 Nov. -31 Dec. 1996	SV	SSV	SSV	SSV
	1 Jan.1997	SV	Exp.	Exp.	Exp.
	3 Jan.- 4 Jan. 1997		SSV	SSV	SSV
The entire research in Area V					
North-east stratum	3 Jan.- 4 Jan. 1997	SV			
	5 Jan.-20 Jan. 1997	SV	SSV	SSV	SSV
South-west stratum	21 Jan.- 3 Feb. 1997	SV	SSV	SSV	SSV
	4 Feb. 1997		SSV	SSV	SSV
North-west stratum	4 Feb.- 19 Feb. 1997	SV			
	5 Feb.- 20 Feb. 1997		SSV	SSV	SSV
South-east strataum	20 Feb.- 11 Mar.1997	SV			
	21 Feb.- 12 Mar.1997		SSV	SSV	SSV
The second survey in western part of Area VI					
	12Mar.- 13Mar. 1997	SV			
	13Mar. 1997		SSV	SSV	SSV

b) Cruise track
Fig. 2 shows the main cruise tracks in research areas. A broken line in Fig. 2 displays distinction of main cruise tracks between SV and SSVs. Cruise track design of the research area were constructed taking into account NIC (National Ice information center) revised weekly ice information. These ice information was available throughout the research periods. The first survey in western part of area VI consisted of two cruises brcause the degree of change in effeciency of the research activity by fluctuations of packice lines was not clear during the research period. The cruise track in the first survey took the shape of cross. The cruise track in the second survey was composed of four legs in this area.. However, this survey covered only a part of the research area with the few days because of the limted research schdule. In addition, the packice-lines in the second survey advanced southward compared with the first survey. The start point of the second survey was set to southward from 70°S. Therefore, covered range of research area differed between the research period. The pack ice lines in Fig.2 are drawn by the calculated packice line from NIC ice information and its actual positions observed during the research pe-

riod.

c) Searching effort

The searching distance (n.miles) of a SV and three SSVs in each stratum is shown in Table 1. The total searching distance during the 103-day research period was 17,755.6 n.miles. The searching distance in this cruise was 3,717.0 n.miles longer than that in the 1994/95 JARPA (Nishiwaki *et al.*, 1995). This is due to one more research vessel than the previous research. However, searching effort of SV was considerably lower than that in the 1994/95 JARPA. Following cause was considered. *KS2* (Former squid jigging boat), modified sighting vessel was slower in ship speed than ordinary whale catcher boat, and more time was lost by sighting procedure and returning procedure to the track line.

d) The density indices and the mean school size

Table 2 shows the density indices (DI) which is calculated as the number of minke whale schools primarily sighted per 100 n.miles searched and the mean school size (MSS). As for the western part of Area VI, the DI and MSS were similar with the mean value of the northward stratum in the previous JARPA survey. In the area V, it was indicated that the DI and MSS were higher in the southern stratum than in the northern stratum. The MSS in the east-south stratum were remarkably higher than the other stratum.

Compared SV with SSV, it was indicated that the DI was higher in the SSV than in the SV and MSS was higher in the SV than in the SSV. For the MSS, it was also indicated that the SV was remarkably high value in the south strata.

e) Cetacean species sighted

Table 3 shows the number of schools and animals sighted by cetacean species during research period.

As for ordinary form minke whales, 1,137 schools (2,585 animals) were sighted, including the primary sightings of 852 schools (2,608 animals) and secondary sightings of 113 schools (626 animals). Minke whales were the most dominant species throughout research period. As for dwarf form minke whales, the primary sightings of 9 schools (9 animals) and one school (one animal) were sighted.

In the baleen whales othe than minke whales, 115 schools (202 animals) of the humpback whale were primarily sighted and 33 schools (64 animals) were secondarily sighted. Humpback whales were the second dominant baleen whales. As for fin whale sightings of 44 schools (103 animals) and blue whale sightings of 11 schools (15 animals) were confirmed. Sei whale was only primary sighting of one school (one animal) . Right whale was not confirmed. Sighting of baleen whales which were not identified amounted 166 schools 303 animals (primary: 106 schools 172 animals, secondary: 33 schools 64 animals). There was a trend that humpback and fin whales were sighted in same place.

In the toothed whales, 121 schools (128 animals) of the sperm whales were primarily sighted and 8 schools (8 animals) were secondarily sighted. Sperm whales were the most dominant in the toothed whales and density was almost the same as humpback whales. As This is followed by 168 schools (328 animals) of beaked whales, including 80 schools (136 animals) of the Southern bottlenose whales , 6 schools (40 animals) of the Arnoux's beaked whales and one school (3 animals) of the strap-tooth beaked whale . In addition, 63 schools (861 animals) of killer whales, 3 schools (240 animals) of long-finned pilot whales and 44 schools (272 animals) of hourglass dolphins were sighted as identified species.

e) Distribution of whale species

The geographical locations of primary sightings of the minke whales (including dwarf formed minke whales),baleen whales, sperm whales, beaked whales, killer whales and hourglass dolphins were plotted in Fig. 3 to Fig.7.

(1) Minke whales (Fig. 3)

In the western part of Area VI, it is noted that the minke whales were widely distributed. In addition, it was not confirmed that the distribution pattern was partially concentrated during the research period. In the second survey period , research area was expanded by the packice-lines advanced southward remarkably. But the second survey was conducted in a limted small area due to research schedule. This area was covered by packice in the first survey, and the packice line remarkably advanced from 64°S in the first survey to 72°S in second survey. Minke whales were sighted at 45 n.miles off the packice lines.

In the Area V, they were widely distributed in the entire research area similar to previous JARPA surveys. Sightings were uniformly distributed in the north strata. In the west-south stratum, the pattern of distribution of minke whales was differnt from that was obsereved in the 1994/95 survey (*Nishiwaki et al.* 1995). They were sighted more in the eastern part in this stratum than the westhalf. In the east-south stratum, it was obeserved that most of the schools in the west half were composed of one animal while those in the easthalf were 2 animals or more.

Dwarf form minke wahles were observed within north strata in Area V. They were sighted in the north of 64°39'S.

(2)Blue whales (Fig. 4):

In the western part of Area VI, they were sighted sporadically through the research period. In the Area V, they concentrated more west-south stratum than other research area. The patttern of distribution was considerably different from that was observed in the previous surveys.

(3)Fin and humpback whales (Fig. 4):

Fin and humpback whales were widely dispersed on the research areas except the east-south stratum. In the east-south stratum, a few sightings were obtained in the vicinity of nortern boundary. Fin whales were widely distributed more than humpback whales on the research areas. Humpback whales were sighted more in the wesr-north stratum than other research areas. In the Area V, the distribution patterns of them were not considerably different from those were observed in the previous survey.

(4)Sperm Whales (Fig. 5):

Sperm whales were widely sighted in western part of Area VI in the first survey. However, these sightings were concentrated in the area between the ice-edge and 100 n.miles off the edge and near the ice bergs. Such pattern of distribution was consistent with that of the eastern part of Area III in 1995/96 srvey (*Nishiwaki et al.* 1996).

In the entire research in Area V, sperm whales concentrated more in the south strata than the north strata. However, sightings were not obtained in the southern part of the east-south stratum.

(5)Southern bottlenose whales and other beaked whales (Fig. 6):

Southern bottlenose whales were widely distributed in research areas except the east-south stratum. The distribution pattern of them were more dense in the north strata than the south strata. In

the east-south stratum, a few sightings were obtained in the vicinity of northern boundary. They overlaped rarely with minke whales.

Arnoux's beaked whales unevenly distributed along packice line in the inner part of the south-east stratum. In addition, strap-toothed beaked whales and unidentfied mesoplodon species were sighted in the northpart of research areas. The distribution pattern of them were not considerably different from that was obserbed in the previous survey.

(6)Killer whales and hourglass dolphin(Fig.7)

Killer whales were widely sighted in research area and were sighted during research periods. The distribution pattern of them was similar to that of minke wahles.

Hourglass dolphin were observed in the northpart of the Area V. The distribution pattern of them were more dense in the west strata than the east strata. In addition, they were observed in the north of 65°S and the sea temperrature in the vicinity of sightings was more than 1°C.

Sampling

a) Sampling activities and samples

In the present research, samples were taken randomly based on the rule of one animal from one school at primary sighting in order to improve the representation of the population. However, in order to avoid an excessive burden of the research base vessel and to biases that samplings concentration in a particular time of the day, there were some cases in which sample numbers were adjusted, especially in such areas that minke whales were densely distributed. A total of 440 ordinary form minke whales were sampled from 30 November 1996 to 13 March 1997. The number of samples in each stratum is as follows, and Fig. 8 shows the sampling positions based on their sighting position.

Stratum	Male	Female	Total
The western part of Area VI			
First survey	66	31	97
Second survey	8	5	13
The entire research in Area IV			
East-North	61	34	95
East-South	16	92	108
West-North	31	13	44
West-South	24	59	83

b) Sampling efficiency

The efficiency of sampling of minke whales in each stratum is shown in table 4. A and B show the total number of schools and individual minke whales which were primarily sighted by the sighting/sampling vessels, and C and D show the number of target animals for sampling and of samples actually taken. The sampling efficiency I (D/B) shows the ratio of samples actually taken to total primary sightings. The value decreases in the area where the mean school size is large. The sampling efficiency I was 0.33 in average, which was almost the same as the previous research.

The sampling efficiency II (D/C) shows the ratio of samples actually taken to the number of target animals for sampling. This value is supposed to indicate technical efficiency or success rates of sampling. In the western part of Area VI, these were 0.67 in the first survey and 0.93 in the second survey. As for the Area V, the value ranged from 0.72 to 0.86 in the north stratum,

while it was from 0.69 to 0.87 in the south stratum. These values were low compared with previous research.

Out of target animals, 143 could not be taken. Sight was lost before confirmation of target whale in case of 33 animals. 71 animals were missed because they swam too fast or dived too long or too quick to take. Sampling was intentionally canceled on 13 animals in order to time limits for sampling and an excessive burden on the researchbase vessel, 9 animals were abandoned to take because they crossed the border or escaped into the pack ice and 8 animals were missed by technical reasons.

Biological survey

a) Survey items and the number of samples

The number of samples in each items of the biological survey is shown in Table 5. All the samples were subjected to the biological survey on the research base vessel.They were processed after the survey was finished. There were 440 samples in total of which males were 206 and females were 234. In addition, 166 fetuses were collected from 166 pregnant females.

b) Optional biological survey and experiment

A detailed research was conducted to compare the biological data of ordinary form minke whales with those of dwarf form minke whales which were collected in the previous. The skull of four whales were processed and measured in detail.

Experiments

a) Distance and angle estimation experiment

The four sighting and sampling vessels rehearsed the distance and angle estimation experiment after they entered the research area. *K01*, *T25* and *T18* conducted the experiment on 1 January 1997, and *KS2* did it on 20 January.

Six top men and seven persons on the upper bridge who were responsible for searching took part 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 216 experiments were conducted by the four vessels with the participation of 416 persons in total.

b) Reaction monitoring experiment

The experiment was canceled because of restrictions on research schedule from bad weather condition.

c) Photographing of natural markings

Natural markings of blue and humpback whales which were sighted during the research period were photographed by the SV.

Five blue whales from 4 schools (5 animals) and 44 humpback whales from 23 schools (50 animals) were photographed (Table 6).

d) Biopsy sampling of blue, humpback and right whales

The collection of biopsy samples was tried for the whale species whose natural markings were the target of photographing.

Ten biopsy samples were collected from 1 sample from 4 schools (5 animals) of the blue whale and 20 sample of humpback whale from 23 schools (50 animals) (Table 7).

e) Observation of the behavior of blue whales

Observations of the behavior of blue whales were conducted on 2 schools (2 animals) in the western part of Area VI in the first survey and on 1 school (1 animal) in the west-south stratum in Area V. All surfacing cues were counted in these cases.

In the first trial, one blue whale was observed for 42 minutes. Surfacing were confirmed 6 times, cues were counted 25 times. Cues per one surfacing counted from 3 to 6 times and 4 times on the average. The diving time ranged from 6 to 7 minutes and 6.2 minutes in the average. The traveling distance between surfacings ranged from 0.13 to 0.3 n.miles and 0.23 n.miles in the average. The total traveling distance during the observations was 1.13 n.miles.

In the second trial, one blue whale was observed for 35 minutes. Surfacing were confirmed 4 times, cues were counted 33 times. Cues per one surfacing counted from 4 to 9 times and 8 times in the average. The diving time ranged from 5 to 9 minutes and 6.7 minutes in the average. The traveling distance between surfacing ranged from 0.47 to 0.64 n.miles and 0.57 n.miles in the average. The total traveling distance during the observations was 1.7 n.miles.

In the third trial, one blue whale was observed for 10 minutes. Surfacing were confirmed 2 times, cues were counted 10 times. Cues per one surfacing counted 5 times. The diving time ranged 5 minutes. The total traveling distance during the observations was 0.63 n.miles.

f) Observation of the behavior of beaked whales

Twelve schools (28 animals) of species which belongs to the beaked whales were sighted and approached for the observation of their behaviors. Five schools (9 animals) of the southern bottlenose whale and one school (10 animals) of the arnox's beaked whale were identified. The remaining 6 schools (9 animals) were unidentified from the first sighting information and cues during observation (table 7).

Total observation time was 574 minutes. One observation ranged 33 to 75 minutes. The shortest approaching distances to these schools were 0.01 to 0.02 n. miles on the southern bottlenose whale except two cases of available shooting distance below 0.05 n.miles. The shortest distance was 0.1 to 0.6 n. miles on the southernbottlenose whales, 0.3 n.miles on the arnox's beaked whales and 0.2 to 2.0 n.miles on the unidentified beaked whales. A diving time ranged from 9 to 39 minutes on the southern bottlenose whales, 39 minutes on the arnox's beaked whales and 21 to 40 minutes on the unidentified beaked whales. The traveling distances during diving were 0.2 to 0.84 n.miles on the southernbottlenose whale, 1.5 n.miles on the arnox's beaked whales and 0.23 to 1.53 n.miles on the unidentfied beaked whales.

g) Attachment of a satellite telemetry tag to minke whales

A modified biopsy firing system was used and attempted to attach a satellite telemetry tag to a swimming minke whale by the *KS2*. The trial was conducted on one school (10 animals) of minke whales and 2schools (3 animales) of humpback whales. However, there was no chance to attach a satellite telemetry tag because these schools were not reached the firing range.

h) Assessment of the effect on whales' behavior by the use of a sonic device

The experiment was planned to be carried out, in addition to the reaction monitoring experiment in the areas where minke whales were excepted to be abundant. However, the experiment was canceled because of restrictions on research schedule from bad weather condition.

i) Marine debris

Marine debris recording was conducted during the present research (Table 10). No debris was found from the stomach contents of the whales sampled. Pebbles ranged from 5 to 6 cm were found mixed with contents from the stomach of a female of minke whales, 8.73 meters in

length which was sampled on 2 february. In addition, feathers were found mixed with contents from the stomach of seven females of minke whales. These whales were sampled in the east-south stratum in Area V from 6 to 9 March.

j) Oceanographical surveys
The XBT observation was made at 89 locations from 30 November 1996 to 13 March 1997 by *KS2* (Fig. 9). Meteorological data, such as weather conditions, wind direction, wind power, atmospheric pressure, surface water temperature were also recorded.

Products
After the biological survey was completed, all whales were processed according to the provisions of Article VIII of the Convention. All of 440 were processed to produce 1,994.009 tons of frozen products and 66.7 tons of whale oil (table 9).

Results of preliminary analysis
a) Body length
Table 11 shows the average body length and the range of body lengths by strata and by different reproductive status. The average body length of the sampled whales were as follows: immature male 6.58 meters, immature female 7.09 meters, mature male 8.30 meters and mature females 8.84 meters. The present results were not substantially different from those observed in the previous surveys.

Fig.10 shows body length compositions of minke wahles sampled in the western part of Area VI and Area V.

b) Maturity rates
For females, the existence of corpus luteum or corpus albicans in the ovaries, the width of uterine horn and thickness of the mammary glands were examined in order to estimate their matuity status, and then samples were categorized as follows: 1) immature, 2) ovulating (not existent of corpus albicans but existence of corpus luteum), 3) resting (not exstent of corpus luteum but existent of corpus albicans 4) pregnant, 5) lactation, 6) pregnant and lactation, 7) unidentified mature. And for males, determination should be made by the histological observation of the testis and epididymis. However, such analysis was not completed and thus samples were categorized as the mature male when they have the testis weighing more than 400g (Ohsumi *et al.*, 1970: Kato, 1986).

Table 12 shows the maturity status of the sampled whales. The ratios of samples categorized by their maturity status are as follows: mature male 77.7%, immature male 22.30%, pregnant female 70.9% (including simultaneous lactation), mature female without pregnancy (resting and ovulating) 11.6% and immature female 17.5%.

In the western part of Area VI, the maturity status of the sampled whales except non sampled immature female in the second survey were not significantly different through the reseach periods and were consistent with the results of the eastern part of Area III in 1995/96 survey.

In the Area V, difference was obsereved in the east-south stratum compared with other strata. In the east-south stratum, the ratio of pregnant female was more remarkbly higher than other strata and was cositent with the results of previous sureveys. In the distribution of sampled whales, immature females were unevenly distributed in the vicinity of the nortern boundary on the stratum. Pregnant females were dominant between center and inner part in this stratum.

c) Change in the average thickness of blubber

Table 13 shows the average blubber tickness by sex and maturity in each stratum. The average blubber tickness by maturity status of sampled whales were as follows:, immature male 4.13cm, immature female 4.42cm, mature male 4.84cm and mature females 5.39 meters. In the western part of Area VI, the average blubber tickness in the second survey were ticker than the first survy. In the Area V; it was indicated that the average blubber tickness increased with passing of the research periods. In addition, the average blubber tickness in the second half of the research periods were tickker than that of whole sampled whales. Therefore, It was indicated that most of minke whales within research areas have reached the average fattyness about early februay.

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

Stratum	SV	SSVs	Combined
Area VI West			
First period	1,911.4	4,548.8	6,460.2
Area V (the entire research area)			
East-North	805.9	2,325.3	3,131.2
East-South	790.7	1,314.7	2,105.4
West-North	692.4	2,071.9	2,764.3
West-South	692.8	2,430.4	3,123.2
Combined	2,981.8	8,142.3	11,124.1
Area VI West			
Second period	71.1	100.2	171.3

Table 2. Density indices (DI) and mean school size (MSS) of minke whales sighted primarily by a 'sighting' vessel (SV) and three 'sighting/sampling' vessels (SSVs).

	SV				SSVs				Combined			
Stratum	Sch	Ind	DI	MSS	Sch	Ind	DI	MSS	Sch	Ind	DI	MSS
Area VI West												
First period	41	75	2.15	1.83	145	296	3.19	2.04	186	371	2.88	1.99
Area V (the entire research area)												
East-North	16	30	1.99	1.88	115	218	4.95	1.90	131	248	4.18	1.89
East-South	117	704	14.80	6.02	173	529	13.16	3.06	290	1233	13.77	4.25
West-North	16	57	2.31	3.56	61	102	2.94	1.67	77	159	2.79	2.06
West-South	24	156	3.46	6.50	130	410	5.35	3.15	154	566	4.93	3.68
Combined	173	947	5.80	5.47	479	1259	5.88	2.63	652	2206	5.86	3.38
Area VI West												
Second period	1	2	1.41	2.00	13	29	12.97	2.23	14	31	8.17	2.21

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.

Table 3a. Summary of sightings (no. schools/no. individuals) conducted by a 'sighting' vessel (SV) and three 'sighting/sampling' vessels (SSVs) in Area V (the entire research area).

Species	SV				SSVs			
	West sector		East sector		West sector		East sector	
	Primary	Secondary	Primary	Secondary	Primary	Secondary	Primary	Secondary
Northern stratum								
Minke whale	16/ 57	3/ 5	16/ 30	8/ 15	61/102	4/ 5	115/218	6/ 8
Dwarf minke whale					6/ 6		3/ 3	
Like minke whale	2/ 3	1/ 1	4/ 4		4/ 4		4/ 4	2/ 2
Fin whale	1/ 2		5/ 7		2/ 3		2/ 3	4/ 16
Humpback whale		1/ 1	1/ 1		1/ 2	1/ 1	15/ 25	7/ 15
Sei whale							1/ 1	
Baleen whales		2/ 5	3/ 3	3/ 5	2/ 4		11/ 25	1/ 2
Sperm whale	2/ 3		2/ 2		2/ 2		12/ 13	2/ 2
S. bottlenose whale	1/ 1				12/ 22	1/ 1	10/ 17	1/ 1
Strap-toothed whale					1/ 3			
Mesoplodon spp.							1/ 1	
Ziphiid whales	1/ 1	1/ 3	1/ 2		13/ 15		8/ 11	
Killer whale	1/ 8		1/ 7		7/ 52	1/ 1	2/ 8	
Long finned pilot whale		1/ 20			2/220			
Globicephala whales					4/160			
Pilot whales						1/ 10		
Hourglass dolphin	5/ 80	2/ 3			14/ 60	5/ 22	5/ 18	2/ 15
Unidentified dolphins	2/ 53	1/ 6				1/ 3		
Unidentified whales	3/ 3	3/ 3	5/ 5	1/ 1	25/ 26		29/ 29	
Southern stratum								
Minke whale	24/156	18/143	117/704	21/ 48	130/410	8/ 12	173/529	25/365
Like minke whale				5/ 19	6/ 6	5/ 8	7/ 7	6/108
Blue whale	1/ 1					1/ 1		
Fin whale	2/ 4		1/ 2		2/ 3			
Humpback whale	9/ 15			1/ 2	10/ 16	5/ 10	6/ 11	4/ 8
Baleen whales	1/ 1	2/ 5	4/ 4	4/ 9	16/ 23	2/ 4		
Sperm whale	21/ 23	2/ 2	2/ 2		44/ 45			2/ 2
S. bottlenose whale	4/ 6				15/ 27			1/ 1
Arnoux's beaked whale			1/ 10					5/ 30
Ziphiid whales			3/ 26		13/ 28			
Killer whale	4/ 53		5/200	3/155	14/ 83	3/ 24	7/ 37	4/125
Hourglass dolphin	1/ 20				8/ 46	1/ 3		
Unidentified dolphins	1/ 2							
Unidentified whales	3/ 3		9/ 11	2/ 2	28/ 28	1/ 1	26/ 26	

Table 3b. Summary of sightings (no. schools /no. individuals) conducted by a 'sighting' vessel (SV) and three 'sighting/sampling' vessels (SSVs) in Area VI West.

Species	SV		SSVs	
	Primary	Secondary	Primary	Secondary
First period				
Minke whale	41/ 75	5/ 9	145/296	13/ 13
Dwarf minke whale		1/ 1		
Like minke whale	11/ 11	1/ 2	9/ 11	2/ 2
Blue whale	3/ 3		2/ 3	1/ 2
Fin whale	9/ 31		12/ 25	3/ 4
Humpback whale	17/ 38	7/ 14	49/ 83	7/ 13
Baleen whales	20/ 38	2/ 4	50/ 75	15/ 24
Sperm whale	12/ 12	1/ 1	22/ 24	3/ 3
S. bottlenose whale	5/ 10		27/ 44	3/ 6
Mesoplodon spp.			1/ 1	
Ziphiid whales	4/ 5		34/ 56	
Killer whale	2/ 38	2/ 17	6/ 33	
Hourglass dolphin				1/ 5
Unidentified whales	8/ 11	1/ 1	80/ 81	
Second period				
Minke whale	1/ 2		13/ 29	1/ 2
Blue whale	1/ 2	2/ 3		
Fin whale	1/ 2			
Humpback whale	3/ 5		4/ 6	
Killer whale			1/ 20	
Unidentified whales	1/ 1		1/ 1	

Table 3c. Summary of sightings (no. schools /no. individuals) conducted by a 'sighting' vessel (SV) and three 'sighting/sampling' vessels (SSVs) in the whole research.

Species	SV		SSVs		Total	
	Primary	Secondary	Primary	Secondary	Primary	Secondary *
Minke whale	215/1024	56/ 221	637/1584	57/ 405	852/2608	113/ 626
Dwarf minke whale		1/ 1	9/ 9		9/ 9	1/ 1
Like minke whale	17/ 18	7/ 21	30/ 32	15/ 120	47/ 50	22/ 141
Blue whale	5/ 6	2/ 3	2/ 3	2/ 3	7/ 9	4/ 6
Fin whale	19/ 48		18/ 34	7/ 20	37/ 82	7/ 20
Humpback whale	30/ 59	9/ 17	85/ 143	24/ 47	115/ 202	33/ 64
Sei whale			1/ 1		1/ 1	
Baleen whales	28/ 46	13/ 28	79/ 127	18/ 30	107/ 173	31/ 58
Sperm whale	39/ 42	3/ 3	82/ 86	5/ 5	121/ 128	8/ 8
S. bottlenose whale	10/ 17		65/ 111	5/ 8	75/ 128	5/ 8
Arnoux's beaked whale	1/ 10		5/ 30		6/ 40	
Strap-toothed whale			1/ 3		1/ 3	
Mesoplodon spp.			2/ 2		2/ 2	
Ziphiid whales	9/ 34	1/ 3	69/ 110		78/ 144	1/ 3
Killer whale	13/ 306	5/ 172	37/ 233	8/ 150	50/ 539	13/ 322
Long finned pilot whale		1/ 20	2/ 220		2/ 220	1/ 20
Globicephala whales			4/ 160		4/ 160	
Pilot whales				1/ 10		1/ 10
Hourglass dolphin	6/ 100	2/ 3	27/ 124	9/ 45	33/ 224	11/ 48
Unidentified dolphins	3/ 55	1/ 6		1/ 3	3/ 55	2/ 9
Unidentified whales	29/ 34	7/ 7	189/ 191	1/ 1	218/ 225	8/ 8

* : including secondary sightings during transit between strata and experiments.

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 taken from the targeted animals.

Stratum	Sighted *	Targeted **	Sampled	Efficiency	
	A / B	C	D	I(D/B)	II(D/C)
Area VI West					
First period	145/ 296	145	97	0.33	0.67
Area V (the entire research area)					
East-North	111/ 208	111	95	0.46	0.86
East-South	157/ 457	157	108	0.24	0.69
West-North	61/ 102	61	44	0.43	0.72
West-South	95/ 240	95	83	0.35	0.87
Area VI West					
Second period	13/ 29	14	13	0.45	0.93
Combined	582/1332	583	440	0.33	0.75

* : primary sightings of three 'sighting/sampling' vessels.

** : including the second 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[1)]	206	234	440
Body length	206	234	440
External measurement	206	234	440
Body weight	206	234	440
Body weight by total weight of parts	42	36	78
Skull measurement (length and breadth)	198	231	429
Craniometric study	2	2	4
Standard measurement of blubber thickness (three points)	206	234	440
Detailed measurement of blubber thickness (fourteen points)	42	36	78
Measurement of mammary grand and observation of lactation status	—	234	234
Breadth measurement of uterine horn	—	213	213
Testis and epididymis weight	206	—	206
Stomach contents weight	203	232	435
Photographic record of fetus	(77)	(86)[2)]	(166)[3)]
Fetal length and weight	(77)	(86)[2)]	(166)[3)]
External measurement of fetus	(77)	(86)[2)]	(164)[3)]
Number of ribs	206	234	440
-Sample-			
Diatom film	206	234	440
Serum sample for chemical analysis	204	234	438
Earplug for age determination	206	234	440
Earplug for chemical analysis (one of the pair)	5	3	8
Tympanic bulla for age determination	205	233	438
Largest baleen plate for age determination	48	32	80
Baleen plate for morphologic study	205	232	437
Vertebral epiphysis sample	206	234	440
Ovary	—	234	234
Histological sample of endometrium	—	234	234
Histological sample of mammary gland	—	234	234
Milk sample for chemical analysis	—	2	2
Histological sample of testis	206	—	206
Histological sample of epididymis	206	—	206
Testis and epididymis smear for sperm detection	206	—	206
Urine sample for sperm detection	153	—	153
Blubber, muscle, liver, kidney and heart tissues for genetic study	206	234	440
Muscle, liver and kidney tissues for heavy metal analysis	206	234	440[4)]
Blubber and liver tissues for organochlorine analysis	206	234	440[5)]
Muscle, liver and blubber tissues for lipid analysis	42	36	78[6)]
Stomach contents for the food and feeding study	130	125	255
External parasites	48	60	108
Internal parasites	23	20	43
Fetus	(0)	(0)	3[3)]
Blubber, muscle, liver, kidney and heart tissues for genetic study (fetus)	77	86[2)]	163[7)]
Hypophysis for reproductive physiology	—	69	69
Serum sample for reproductive physiology	—	51	51
Salivary glands for histological study	8	9	29[8)]

1) : photos including (1) color pattern of dorsal side, (2) dorsal fin, and (3) pectoral fin (left or right).
2) : including a fetus of the twin.
3) : including fetuses of sex unidentified.
4) : including 27 samples of stomach contents.
5) : including 32 samples of stomach contents.
6) : including 32 samples of stomach contents.
7) : some organ samples are incomplete.
8) : including 5 samples of male fetuses and 7 sample of female fetuses.

Table 6. Records of photo ID for natural marking and biopsy sampling.

Vessel	Date	Sight No.	Position	Species	School size	Whale No.	Target	Opportunity	Biopsy
KS2	5/Dec.	1	63.295 S 159.289 W	Humpback	2	1	Left dorsal	Good	
KS2	5/Dec.	1	63.295 S 159.289 W	Humpback	2	1	Right dorsal	Good	
KS2	5/Dec.	1	63.295 S 159.289 W	Humpback	2	1	Right side	Good	
KS2	9/Dec.	3	61.517 S 154.360 W	Blue	1	1	Back	Unidentified	
KS2	9/Dec.	3	61.517 S 154.360 W	Blue	1	1	Right side	Poor	
KS2	16/Dec.	5	61.064 S 149.492 W	Humpback	2	2	Left dorsal	Poor	
KS2	16/Dec.	5	61.064 S 149.492 W	Humpback	2	1	Left dorsal	Poor	Y
KS2	18/Dec.	11	63.161 S 152.450 W	Humpback	4	1	Left dorsal	Unidentified	
KS2	18/Dec.	11	63.161 S 152.450 W	Humpback	4	2	Left dorsal	Unidentified	
KS2	18/Dec.	11	63.161 S 152.450 W	Humpback	4	3	Left dorsal	Good	
KS2	23/Dec.	2	62.139 S 162.357 W	Humpback	2	1	Flukes	Poor	Y
KS2	23/Dec.	2	62.139 S 162.357 W	Humpback	2	1	Left dorsal	Poor	
KS2	23/Dec.	2	62.139 S 162.357 W	Humpback	2	2	Left dorsal	Poor	
KS2	24/Dec.	6	63.297 S 163.439 W	Humpback	2	1	Flukes	Poor	
KS2	24/Dec.	6	63.297 S 163.439 W	Humpback	2	1	Right dorsal	Poor	
KS2	24/Dec.	6	63.297 S 163.439 W	Humpback	2	1	Left dorsal	Poor	
KS2	24/Dec.	8	63.423 S 163.569 W	Blue	1	1	Left dorsal	Unidentified	
KS2	27/Dec.	3	65.434 S 167.280 W	Humpback	4	1	Right dorsal	Good	Y
KS2	27/Dec.	3	65.434 S 167.280 W	Humpback	4	2	Right dorsal	Good	
KS2	27/Dec.	6	65.400 S 167.362 W	Humpback	3	1	Dorsal fin	Unidentified	
KS2	27/Dec.	6	65.400 S 167.362 W	Humpback	3	2	Dorsal fin	Unidentified	Y
KS2	27/Dec.	6	65.400 S 167.362 W	Humpback	3	3	Dorsal fin	Unidentified	Y
KS2	27/Dec.	6	65.400 S 167.362 W	Humpback	3	2	Dorsal fin	Unidentified	
KS2	28/Dec.	4	64.277 S 168.425 W	Humpback	2	1	Right dorsal	Mechanical missed	
KS2	28/Dec.	4	64.277 S 168.425 W	Humpback	2	2	Right dorsal	Mechanical missed	
KS2	28/Dec.	4	64.277 S 168.425 W	Humpback	2	1	Flukes	Mechanical missed	
KS2	28/Dec.	9	64.180 S 168.543 W	Humpback	2	1	Right dorsal	Good	
KS2	28/Dec.	9	64.180 S 168.543 W	Humpback	2	2	Right dorsal	Good	
KS2	28/Dec.	9	64.180 S 168.543 W	Humpback	2	1	Left dorsal	Good	
KS2	29/Dec.	1	65.498 S 168.515 W	Humpback	2	1	Right dorsal	Poor	
KS2	29/Dec.	1	65.498 S 168.515 W	Humpback	2	2	Right dorsal	Poor	
KS2	29/Dec.	1	65.498 S 168.515 W	Humpback	2	1	Left dorsal	Poor	
KS2	29/Dec.	1	65.498 S 168.515 W	Humpback	2	2	Dorsal fin	Unidentified	
KS2	30/Dec.	8	65.402 S 167.189 W	Humpback	1	1	Right dorsal	Poor	
KS2	30/Dec.	9	65.407 S 167.228 W	Humpback	1	1	Right dorsal	Poor	Y
KS2	31/Dec.	1	65.185 S 166.545 W	Humpback	2	1	Right dorsal	Poor	
KS2	31/Dec.	1	65.185 S 166.545 W	Humpback	2	2	Right dorsal	Poor	
KS2	31/Dec.	3	65.155 S 166.545 W	Humpback	2	1	Right dorsal	Poor	
KS2	31/Dec.	3	65.155 S 166.545 W	Humpback	2	2	Right dorsal	Poor	
KS2	1/Jan.	4	65.296 S 167.252 W	Humpback	3	1	Right dorsal	Poor	Y
KS2	1/Jan.	4	65.296 S 167.252 W	Humpback	3	2	Right dorsal	Poor	Y
KS2	1/Jan.	4	65.296 S 167.252 W	Humpback	3	3	Right dorsal	Poor	Y
KS2	1/Jan.	6	65.362 S 167.301 W	Humpback	3	1	Right dorsal	Poor	Y

Table 6. (continued)

Vessel	Date	Sight No.	Position	Species	School size	Whale No.	Target	Opportunity	Biopsy
KS2	1/Jan.	6	65.362 S 167.301 W	Humpback	3	2	Right dorsal	Poor	Y
KS2	1/Jan.	6	65.362 S 167.301 W	Humpback	3	3	Right dorsal	Poor	Y
KS2	1/Jan.	6	65.362 S 167.301 W	Humpback	3	1	Left dorsal	Poor	
KS2	1/Jan.	6	65.362 S 167.301 W	Humpback	3	2	Left dorsal	Poor	
KS2	1/Jan.	6	65.362 S 167.301 W	Humpback	3	1	Lateral	Unidentified	
KS2	1/Jan.	6	65.362 S 167.301 W	Humpback	3	2	Lateral	Unidentified	
KS2	1/Jan.	6	65.362 S 167.301 W	Humpback	3	3	Lateral	Unidentified	
KS2	21/Jan.	9	66.026 S 162.077 E	Humpback	3	1	Right dorsal	Good	
KS2	21/Jan.	9	66.026 S 162.077 E	Humpback	3	1	Flukes	Good	
KS2	21/Jan.	9	66.026 S 162.077 E	Humpback	3	1	Left dorsal	Good	
KS2	21/Jan.	9	66.026 S 162.077 E	Humpback	3	1	Dorsal fin	Unidentified	Y
KS2	21/Jan.	9	66.026 S 162.077 E	Humpback	3	2	Dorsal fin	Unidentified	Y
KS2	21/Jan.	9	66.026 S 162.077 E	Humpback	3	3	Dorsal fin	Unidentified	Y
KS2	21/Jan.	9	66.026 S 162.077 E	Humpback	3	?	Flukes	Unidentified	
KS2	21/Jan.	9	66.026 S 162.077 E	Humpback	3	3	Right dorsal	Good	
KS2	21/Jan.	21	66.159 S 161.351 E	Humpback	2	1	Right dorsal	Good	
KS2	21/Jan.	21	66.159 S 161.351 E	Humpback	2	1	Flukes	Good	
KS2	21/Jan.	21	66.159 S 161.351 E	Humpback	2	2	Right dorsal	Good	
KS2	21/Jan.	21	66.159 S 161.351 E	Humpback	2	2	Flukes	Good	
KS2	25/Jan.	13	64.444 S 151.415 E	Humpback	2	1	Right dorsal	Good	
KS2	25/Jan.	13	64.444 S 151.415 E	Humpback	2	2	Right dorsal	Good	Y
KS2	25/Jan.	13	64.444 S 151.415 E	Humpback	2	2	Left dorsal	Good	
KS2	25/Jan.	13	64.444 S 151.415 E	Humpback	2	1	Left dorsal	Good	
KS2	26/Jan.	7	64.364 S 150.363 E	Blue	1	1	Right dorsal	Poor	
KS2	26/Jan.	7	64.364 S 150.363 E	Blue	1	1	Left dorsal	Poor	
KS2	26/Jan.	7	64.364 S 150.363 E	Blue	1	1	Left side	Poor	
KS2	26/Jan.	7	64.364 S 150.363 E	Blue	1	1	Left side	Poor	
KS2	27/Jan.	1	65.132 S 149.393 E	Humpback	1	1	Right dorsal	Good	Y
KS2	13/Mar.	3	71.190 S 169.076 W	Humpback	2	1	Left dorsal	Good	
KS2	13/Mar.	3	71.190 S 169.076 W	Humpback	2	1	Head	Good	Y
KS2	13/Mar.	3	71.190 S 169.076 W	Humpback	2	2	Left dorsal	Good	Y
KS2	13/Mar.	6	71.580 S 168.395 W	Humpback	2	1	Flukes	Good	
KS2	13/Mar.	6	71.580 S 168.395 W	Humpback	2	2	Flukes	Good	
KS2	13/Mar.	6	71.580 S 168.395 W	Humpback	2	2	Left dorsal	Good	
KS2	13/Mar.	7	72.049 S 168.420 W	Blue	2	1	Left side	Good	Y
KS2	13/Mar.	7	72.049 S 168.420 W	Blue	2	2	Left side	Good	
KS2	13/Mar.	7	72.049 S 168.420 W	Blue	2	1	Head	Good	

Table 7. Result of the biopsy skin sampling. "Position struck" refers to the position where the biopsy dart struck the whale.

Vessel	Date	Species	Sight No.	School size	Whale No.	Position struck	Sample No.	Position			
KS2	16/Dec.	Humpback	5	2	1	LC1	J96KS2H001	61.064	S	149.492	W
KS2	23/Dec.	Humpback	2	2	1	C3	J96KS2H002	62.139	S	162.357	W
KS2	27/Dec.	Humpback	4	3	1	RC3	J96KS2H003	65.432	S	167.298	W
KS2	27/Dec.	Humpback	6	3	2	D3	J96KS2H004	65.400	S	167.362	W
KS2	27/Dec.	Humpback	6	3	3	RC3	J96KS2H005	65.400	S	167.362	W
KS2	30/Dec.	Humpback	9	1	1	RC3	J96KS2H006	65.407	S	167.228	W
KS2	31/Dec.	Humpback	3	2	1	RC2	J96KS2H007	65.155	S	166.545	W
KS2	1/Jan.	Humpback	4	3	1	RC3	J96KS2H008	65.296	S	167.252	W
KS2	1/Jan.	Humpback	4	3	2	RC3	J96KS2H009	65.296	S	167.252	W
KS2	1/Jan.	Humpback	4	3	3	RD3	J96KS2H010	65.296	S	167.252	W
KS2	1/Jan.	Humpback	6	3	1	Bla	J96KS2H011	65.362	S	167.301	W
KS2	1/Jan.	Humpback	6	3	2	C1	J96KS2H012	65.362	S	167.301	W
KS2	1/Jan.	Humpback	6	3	3	RC2	J96KS2H013	65.362	S	167.301	W
KS2	21/Jan.	Humpback	9	3	1	RC3	J96KS2H014	66.026	S	162.077	E
KS2	21/Jan.	Humpback	9	3	2	RC1	J96KS2H015	66.026	S	162.077	E
KS2	25/Jan.	Humpback	1	1	1	A	J96KS2H016	65.195	S	153.356	E
KS2	25/Jan.	Humpback	13	2	2	C2	J96KS2H017	64.444	S	151.415	E
KS2	27/Jan.	Humpback	1	1	1	RC1	J96KS2H018	65.132	S	149.393	E
KS2	13/Mar.	Humpback	3	2	1	RD2	J96KS2H019	71.190	S	169.076	W
KS2	13/Mar.	Humpback	3	2	2	RD3	J96KS2H020	71.190	S	169.076	W
KS2	13/Mar.	Blue	7	2	1	RC1	J96KS2B001	72.049	S	168.420	W

Table 8. Number of sightings of ziphiid whales in their behavioral observation.

Species	Schools	Individuals
S.bottlenose whale	5	9
Arnoux's beaked whale	1	10
Ziphiid whales	6	9
Combined	12	28

Table 9. Products from samples.

Items of products	Weight (kg)	Items of products	Weight (kg)
Frozen products			
Ordinal meat	497,010.0	Maxillary cartilage	3,750.0
Premium meat (Oniku)	4,230.0	Mandibular ligaments	5,798.0
Breast meat	617,325.0	Nasal plug	5,375.0
Meat pieces	165,885.0	Tendon	41,762.0
Meat inside ventral grooves	24,328.5	Hart	5,726.0
Blubber of ventral grooves	11,205.0	Tongue	43,992.0
Meat/blubber of ventral grooves	142,033.5	Diaphragm	10,920.0
Meat/blubber of ventral part	93,975.0	Stomach	6,032.0
Ordinal blubber	211,527.0	Intestine	10,400.0
Underside part of blubber	24,812.5	Pancreas	1,269.0
Lining of meat	16,687.5	Kidney	5,012.0
Tail flukes	30,575.0	Testes	192.0
Meat/connective tissue of lower jaw	6,615.0	Esophagus	572.0
		Boiled meat	7,000.0
		Total	1,994,009.0
Others			
Oil*	66,700.0		

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

Table 10. Observations of marine debris during the survey.

Vessel	Object	Date	Position	Size
KS2	Rubber Buoy	5/Jan.	60.01 S 174.22 W	¢ 40cm
KS2	Rubber Buoy	1/Feb.	64.35 S 135.53 E	¢ 100cm
KS2	Rubber Buoy	1/Feb.	64.35 S 135.06 E	¢ 70cm
KS2	Rubber fender	10/Feb.	64.28 S 148.24 E	¢ 100cm×250cm
KS2	Rubber Buoy	10/Feb.	63.55 S 149.46 E	¢ 50cm

Table 11. Mean body length (m) by sex and maturity in each stratum.

Male

	Immature					Mature				
	Mean	S.D.	Min.	Max.	n	Mean	S.D.	Min.	Max.	n
Area VI West										
First period	6.76	1.08	4.79	8.54	13	8.27	0.37	7.03	9.02	53
Second period	6.05	1.11	4.94	7.15	2	8.21	0.30	7.64	8.56	6
Combined	6.66	1.11	4.79	8.54	15	8.26	0.36	7.03	9.02	59
Area V (the entire research area)										
East-North	6.65	0.98	5.29	8.02	14	8.32	0.33	7.78	9.08	47
East-South	-	-	-	-	0	8.31	0.28	7.95	8.89	16
West-North	6.53	0.65	5.66	7.62	8	8.39	0.28	7.69	8.85	23
West-South	6.37	0.98	5.08	8.41	9	8.27	0.37	7.78	9.38	15
Combined	6.53	0.92	5.08	8.41	31	8.33	0.32	7.69	9.38	101
Total	6.58	0.99	4.79	8.54	46	8.30	0.34	7.03	9.38	160

Female

	Immature					Mature				
	Mean	S.D.	Min.	Max.	n	Mean	S.D.	Min.	Max.	n
Area VI West										
First period	7.35	1.04	5.32	8.20	9	8.74	0.34	7.90	9.48	22
Second period	-	-	-	-	0	8.79	0.09	8.65	8.90	5
Combined	7.35	1.04	5.32	8.20	9	8.75	0.31	7.90	9.48	27
Area V (the entire research area)										
East-North	6.73	1.01	5.38	8.12	13	8.85	0.30	8.29	9.57	21
East-South	8.01	0.60	6.86	8.57	5	8.78	0.38	7.92	10.09	87
West-North	7.54	0.28	7.16	7.91	4	8.98	0.13	8.74	9.18	9
West-South	6.69	1.12	4.96	8.61	10	8.96	0.40	8.22	10.02	49
Combined	7.02	1.06	4.96	8.61	32	8.85	0.38	7.92	10.09	166
Total	7.09	1.06	4.96	8.61	41	8.84	0.37	7.90	10.09	193

Table 12. Reproductive status of samples in each stratum.

	Male			Female							M% *
	Imm.	Mat.	Unk.	Imm.	Mat.						
					Preg.	Ovu.	Rest.	Lact.	P&L	Unk.	
Area VI West											
First period	13	53	0	9	17	0	3	0	0	2	68.0
	(19.7)	(80.3)	(0.0)	(29.0)	(54.8)	(0.0)	(9.7)	(0.0)	(0.0)	(6.5)	
Second period	2	6	0	0	5	0	0	0	0	0	61.5
	(25.0)	(75.0)	(0.0)	(0.0)	(100.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	
Combined	15	59	0	9	22	0	3	0	0	2	67.3
	(20.3)	(79.7)	(0.0)	(25.0)	(61.1)	(0.0)	(8.3)	(0.0)	(0.0)	(5.6)	
Area V (the entire research area)											
East-North	14	47	0	13	18	0	3	0	0	0	64.2
	(23.0)	(77.0)	(0.0)	(38.2)	(52.9)	(0.0)	(8.8)	(0.0)	(0.0)	(0.0)	
East-South	0	16	0	5	72	1	10	0	0	4	14.8
	(0.0)	(100.0)	(0.0)	(5.4)	(78.3)	(1.1)	(10.9)	(0.0)	(0.0)	(4.3)	
West-North	8	23	0	4	9	0	0	0	0	0	70.5
	(25.8)	(74.2)	(0.0)	(30.8)	(69.2)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	
West-South	9	15	0	10	44	1	2	0	1	1	28.9
	(37.5)	(62.5)	(0.0)	(16.9)	(74.6)	(1.7)	(3.4)	(0.0)	(1.7)	(1.7)	
Combined	31	101	0	32	143	2	15	0	1	5	40.0
	(23.5)	(76.5)	(0.0)	(16.2)	(72.2)	(1.0)	(7.6)	(0.0)	(0.5)	(2.5)	
Total	46	160	0	41	165	2	18	0	1	7	46.8
	(22.3)	(77.7)	(0.0)	(17.5)	(70.5)	(0.9)	(7.7)	(0.0)	(0.4)	(3.0)	

Esplanation of abbreviations.
Imm. : immature, Mat. : mature, Preg. : pregnant, Ovu. : ovulating,
Rest. : resting, Lact. : lactating, P&L : pregnant and lactating,
Unk. : unknown.
* : percentage of males.
( ): parcentage of reproductive status of samples.

Table13. Average blubber thickness (cm) by sex and maturity in each stratum.

Male

	Immature					Mature				
	Mean	S.D.	Min.	Max.	n	Mean	S.D.	Min.	Max.	n
Area VI West										
First period	3.95	0.34	3.20	4.40	13	4.39	0.38	3.40	5.27	53
Second perio	5.43	0.27	5.17	5.70	2	5.77	0.50	5.20	6.60	6
Combined	4.14	0.60	3.20	5.70	15	4.53	0.57	3.40	6.60	59
Area V (the entire research area)										
East-North	4.10	0.37	3.27	4.73	14	4.81	0.44	3.90	5.73	47
East-South	-	-	-	-	0	5.47	0.30	4.90	5.93	16
West-North	4.43	0.70	2.70	5.10	8	5.21	0.61	4.10	6.23	23
West-South	3.91	0.43	3.03	4.67	9	4.94	0.59	3.67	5.90	15
Combined	4.13	0.53	2.70	5.10	31	5.02	0.55	3.67	6.23	101
Total	4.13	0.55	2.70	5.70	46	4.84	0.61	3.40	6.60	160

Female

	Immature					Mature				
	Mean	S.D.	Min.	Max.	n	Mean	S.D.	Min.	Max.	n
Area VI West										
First period	3.87	0.37	2.97	4.33	9	4.79	0.41	3.93	5.67	22
Second perio	-	-	-	-	0	6.00	0.55	5.00	6.63	5
Combined	3.87	0.37	2.97	4.33	9	5.01	0.65	3.93	6.63	27
Area V (the entire research area)										
East-North	4.46	0.55	3.63	5.27	13	5.21	0.59	4.37	6.73	21
East-South	5.47	0.40	4.93	6.00	5	5.63	0.57	3.73	7.07	87
West-North	4.53	0.48	3.97	5.20	4	5.54	0.85	4.17	6.90	9
West-South	4.32	0.31	3.80	4.80	10	5.20	0.55	3.87	6.60	49
Combined	4.58	0.60	3.63	6.00	32	5.45	0.62	3.73	7.07	166
Total	4.42	0.63	2.97	6.00	41	5.39	0.64	3.73	7.07	193

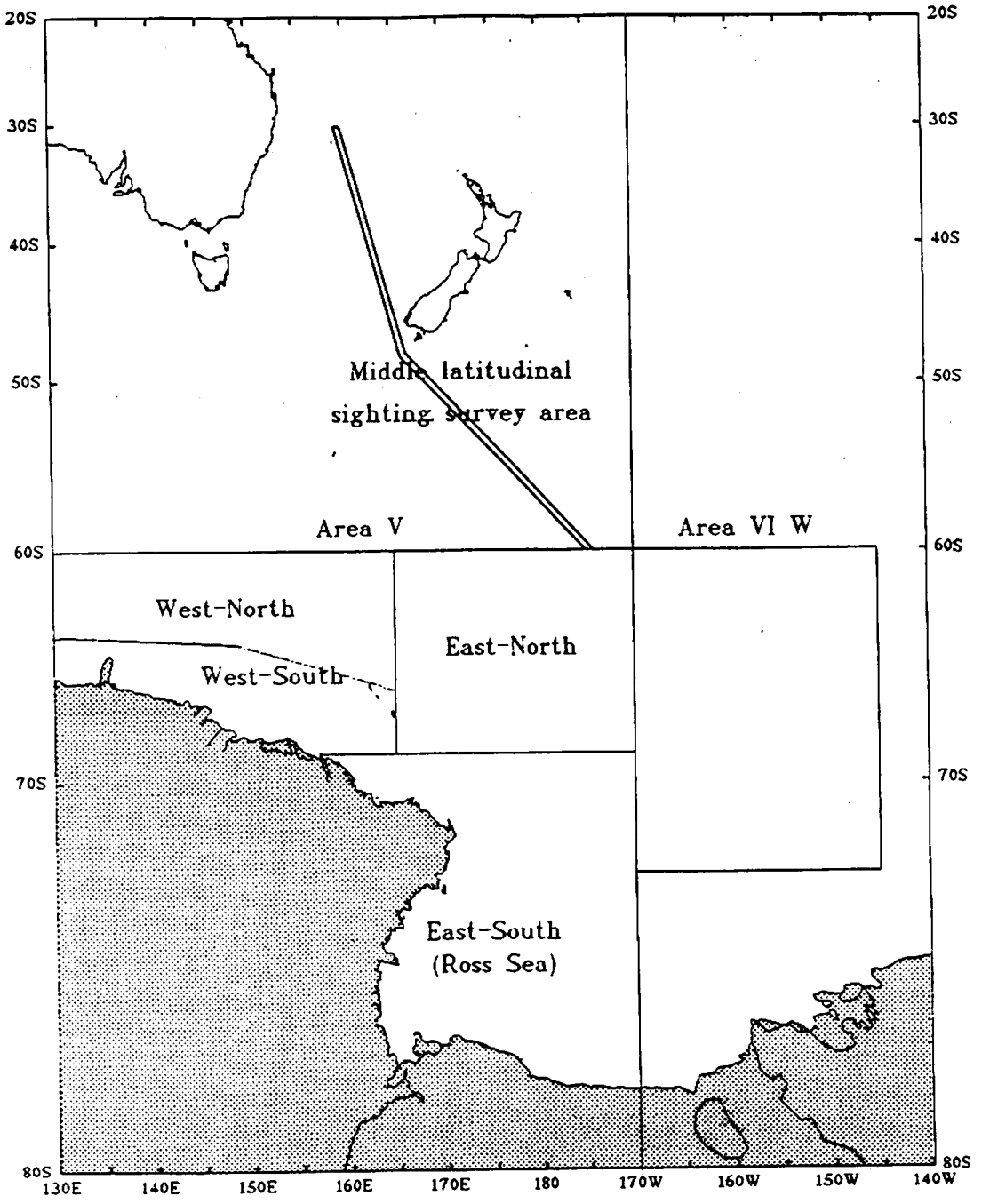

Fig. 1. Geographical location and the stratification of the research area in JARPA in 1996/97.

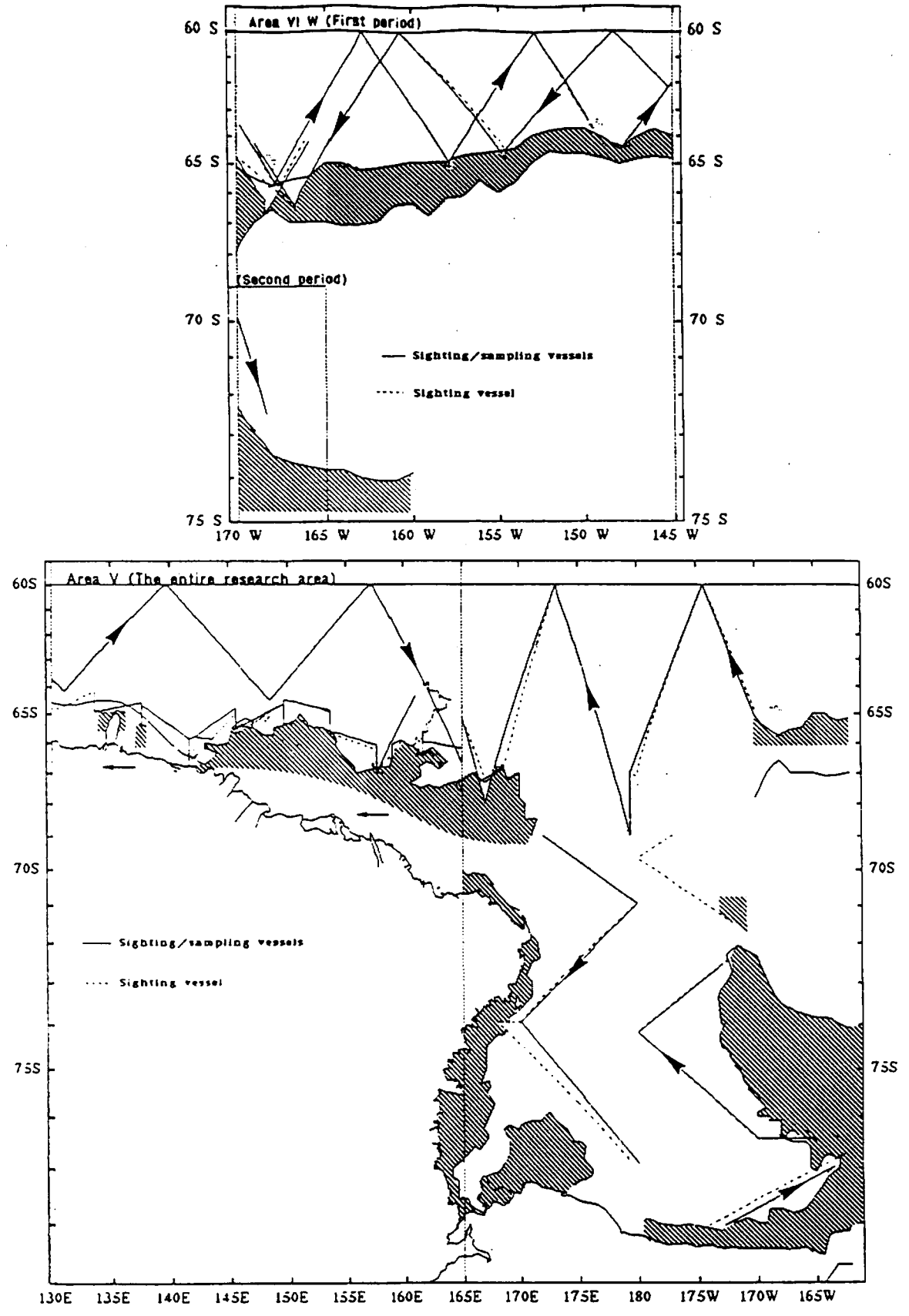

Fig. 2. Cruise tracks of the research vessels in JARPA in 1996/97.

Upper ; Area VI West (first and second period),

lower ; Area V (the entire research area).

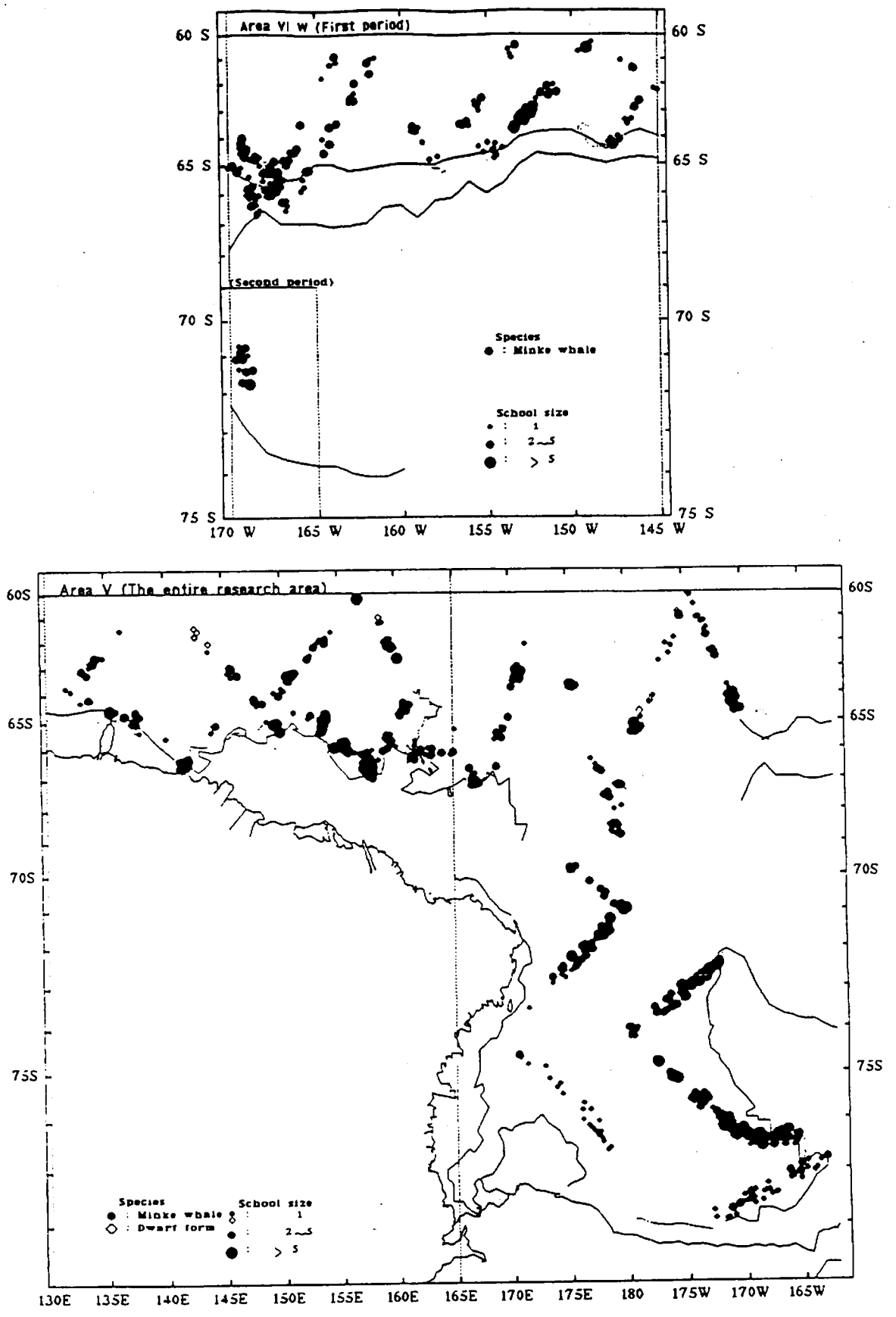

Fig. 3. Distribution of the primary minke whale sightings by a sighting vessel and three sighting/sampling vessels.

Upper ; Area Ⅵ West (first and second period),

lower ; Area Ⅴ (the entire research area).

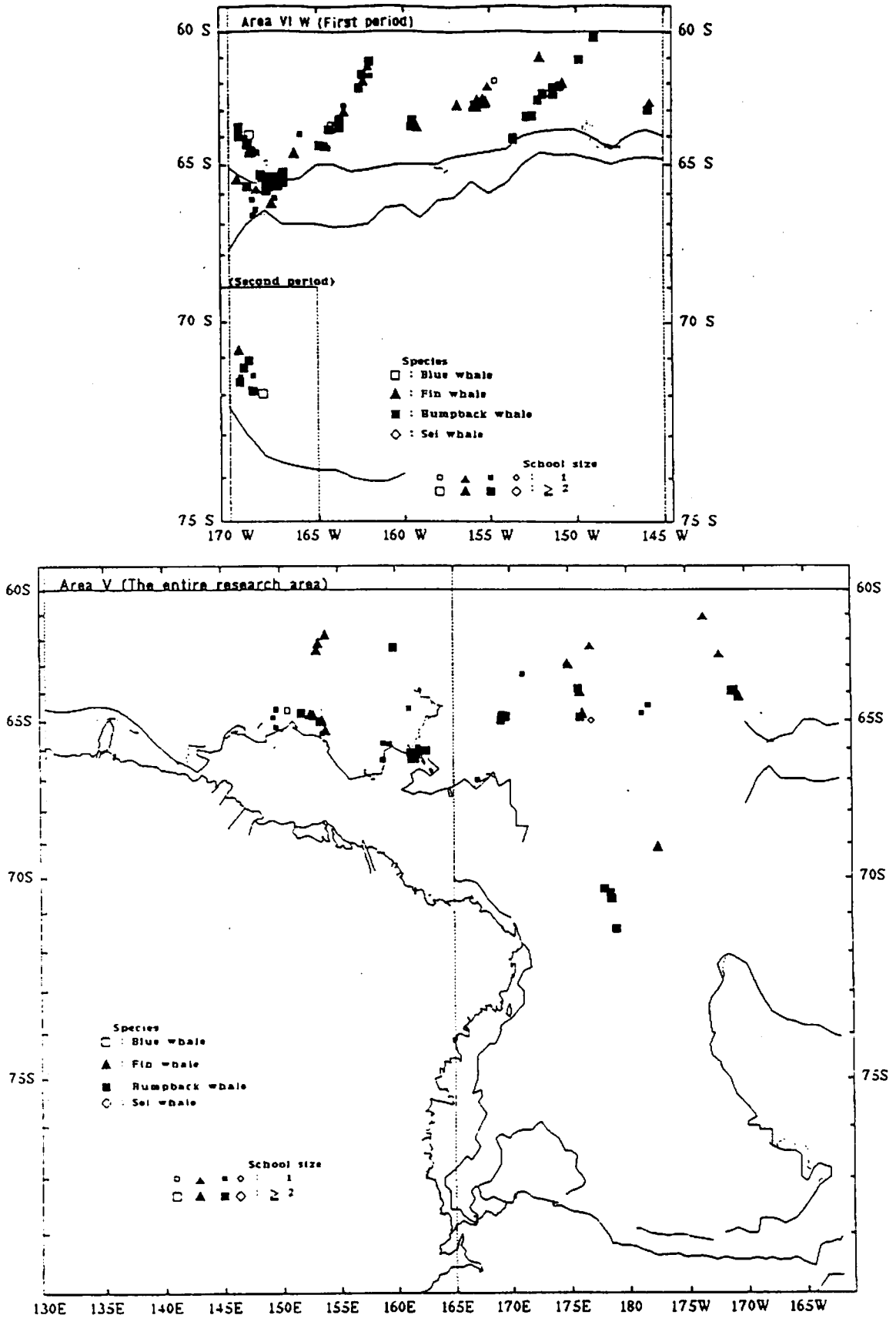

Fig. 4. Distribution of the primary sightings of blue, fin, humpback and sei whales by a sighting vessel and three sighting/sampling vessels.

Upper ; Area VI West (first and second period),

lower ; Area V (the entire research area).

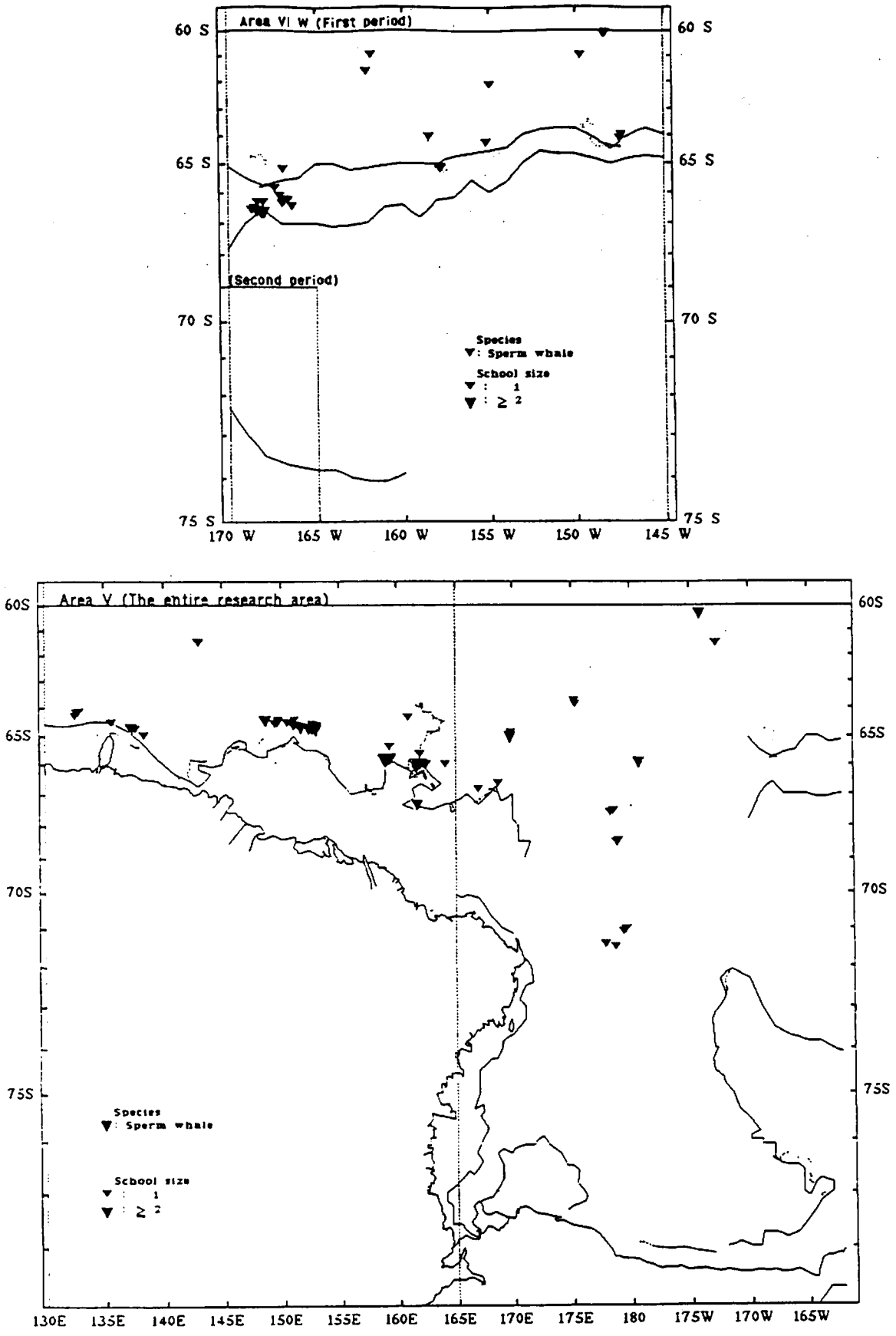

Fig. 5. Distribution of the primary sperm whale sightings by a sighting vessel and three sighting/sampling vessels.

Upper ; Area VI West (first and second period),

lower ; Area V (the entire research area).

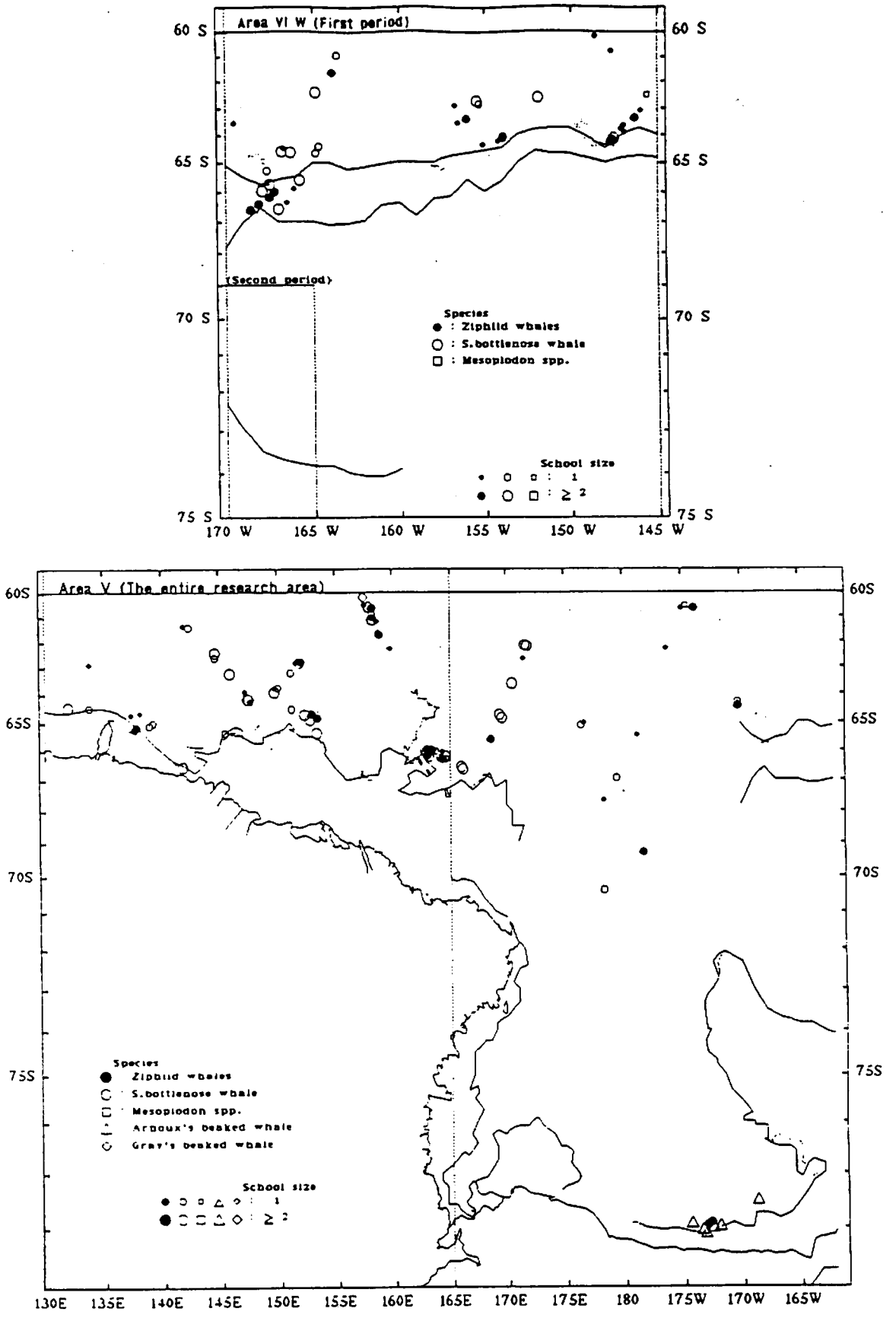

Fig. 6. Distribution of the primary ziphiid whales sightings by a sighting vessel and three sighting/sampling vessels.

Upper ; Area VI West (first and second period),

lower ; Area V (the entire research area).

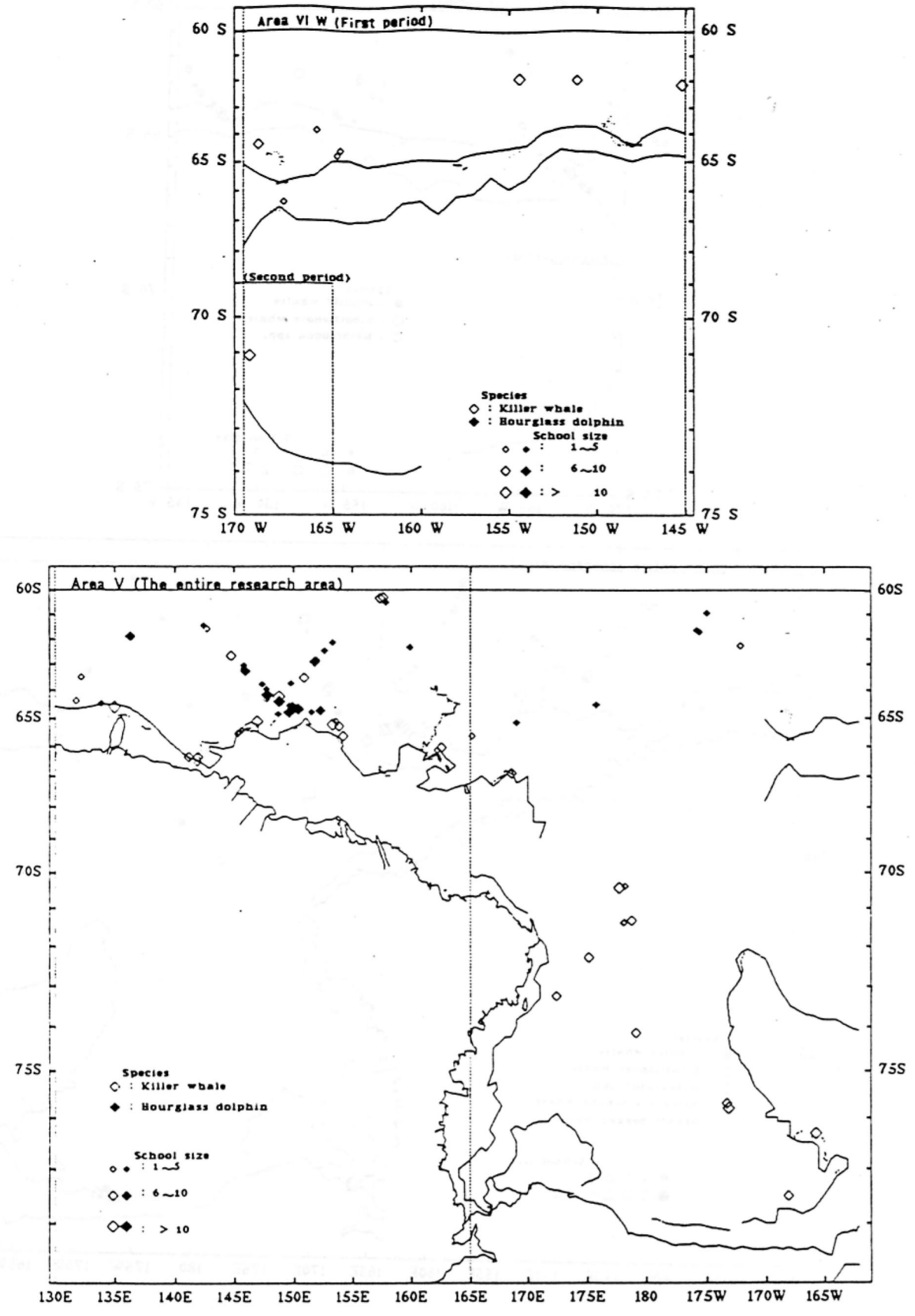

Fig. 7. Distribution of the primary sightings of killer whales and hourglass dolphins by a sighting vessel and three sighting/sampling vessels.

Upper ; Area Ⅵ West (first and second period),

lower ; Area Ⅴ (the entire research area).

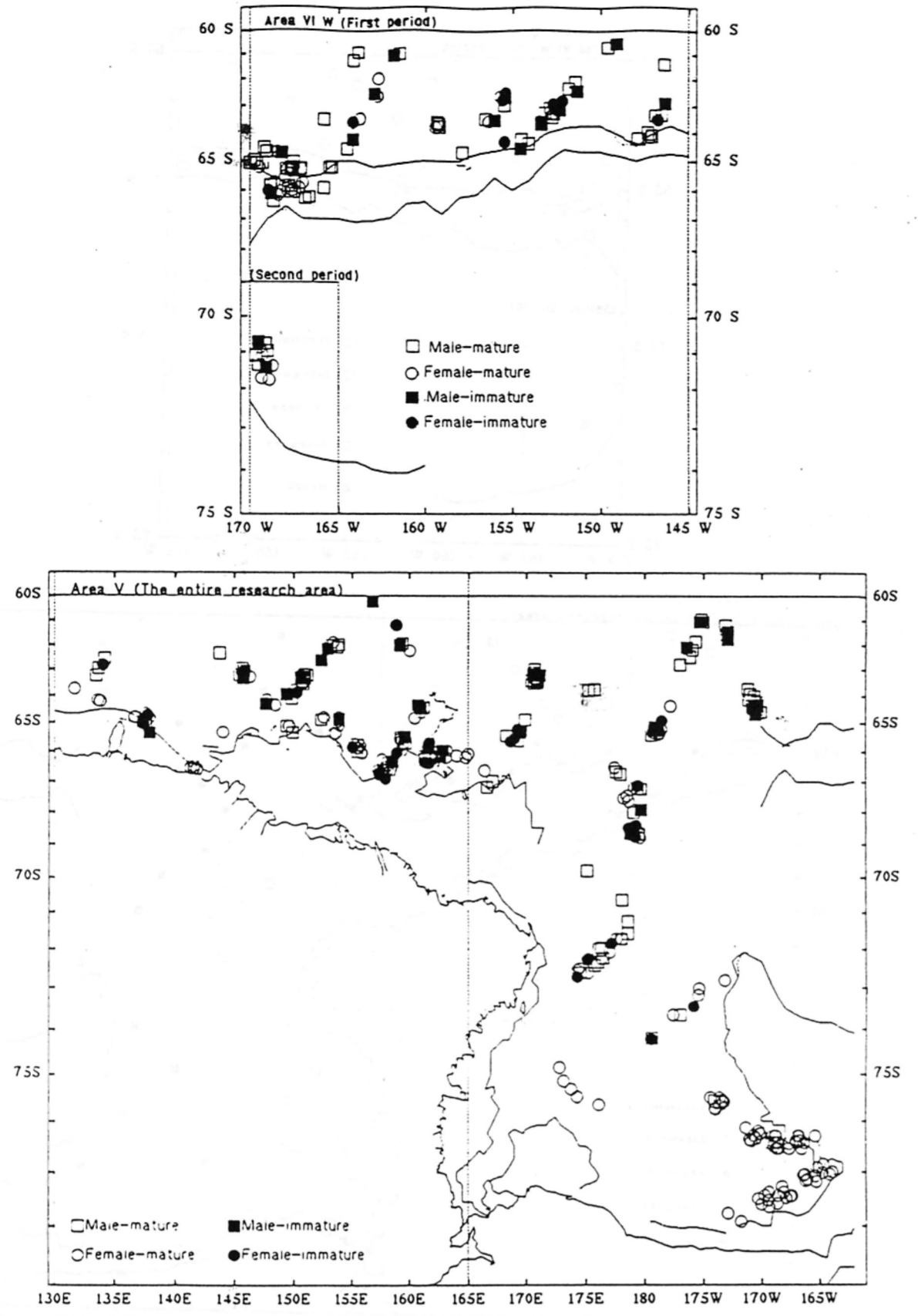

Fig. 8. Distribution of minke whales which were sampled based on their sighted positions.
Upper ; Area VI West (first and second period),
lower ; Area V (the entire research area).

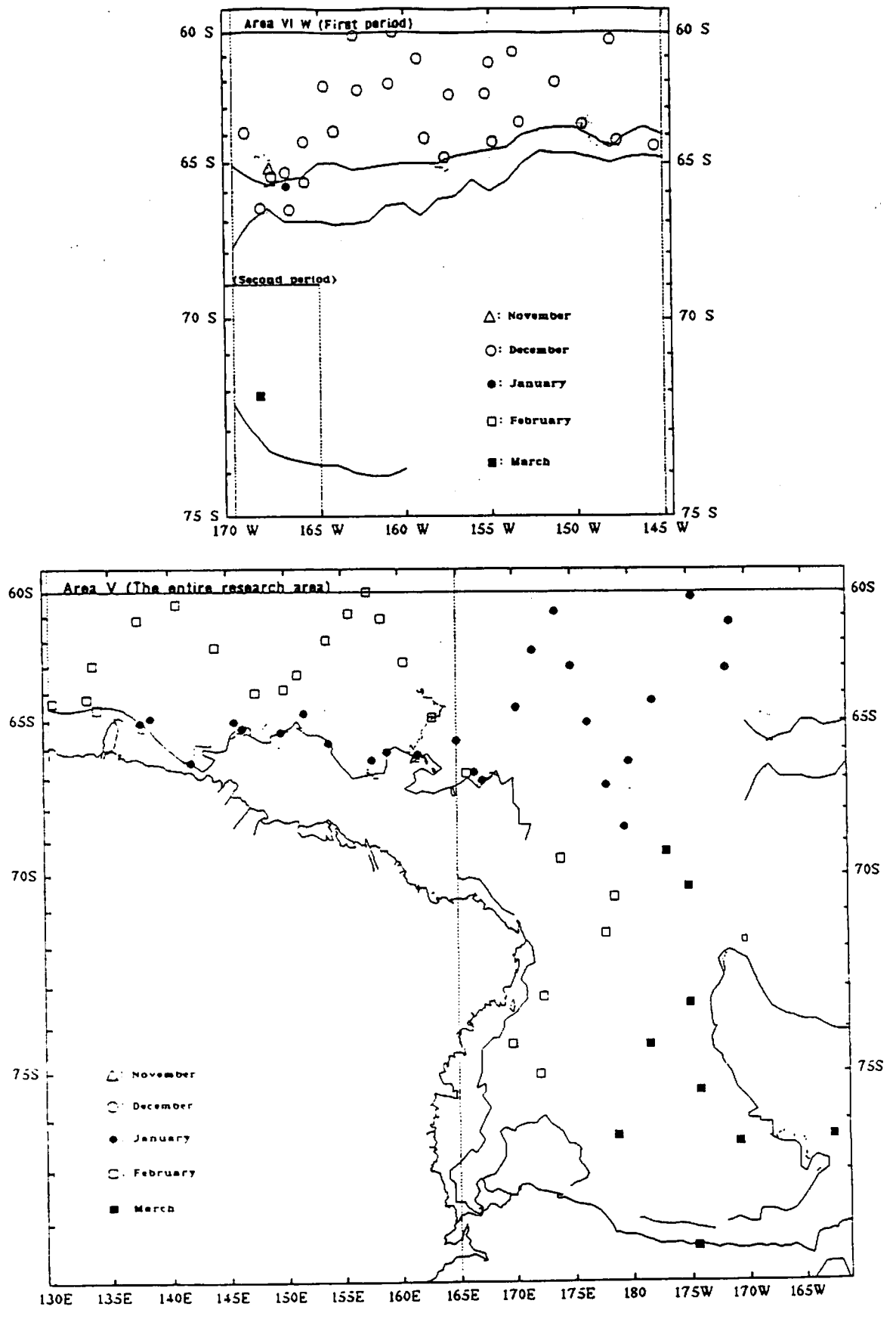

Fig. 9. Positions of the XBT castings.

Upper ; Area Ⅵ West (first and second period),

lower ; Area Ⅴ (the entire research area).

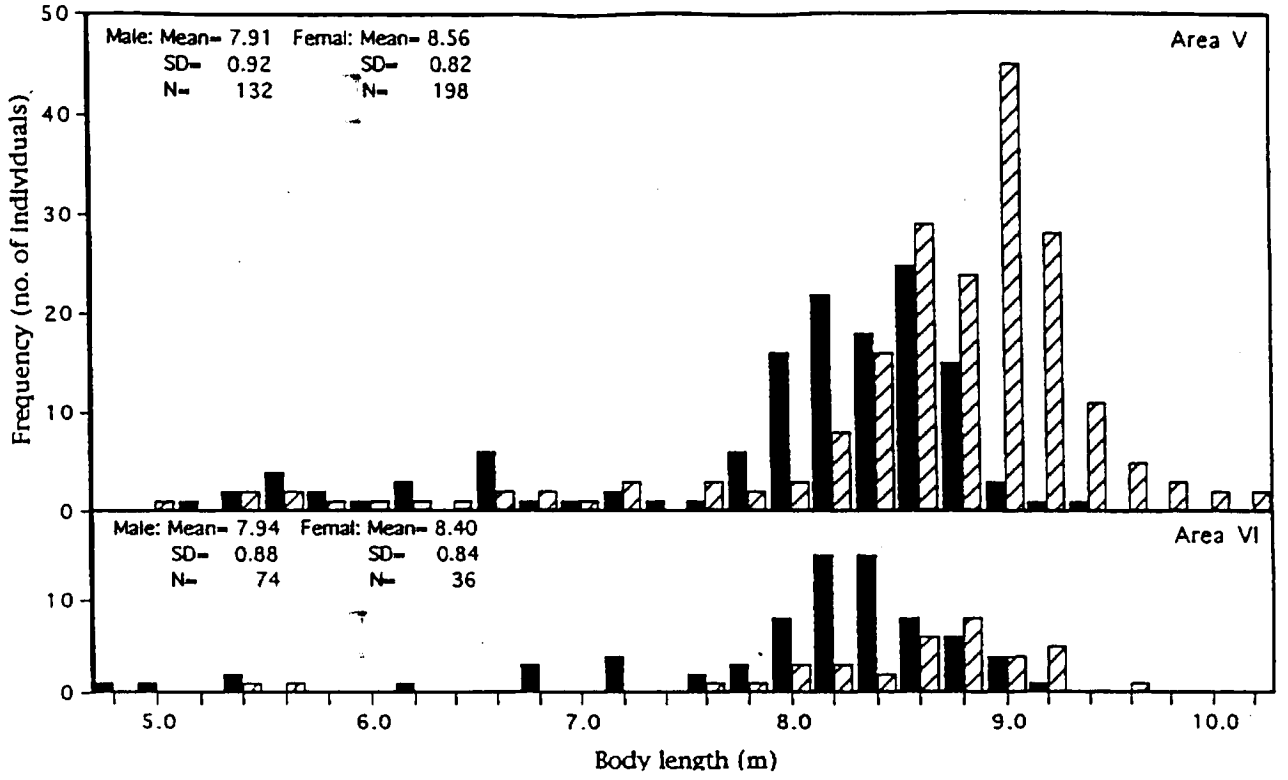

Fig. 10a. Body length compositions (20cm intervals) of minke whales sampled in Area V (upper) and western part of Area VI (lower). Solid and striped lines represent males and females, respectively.

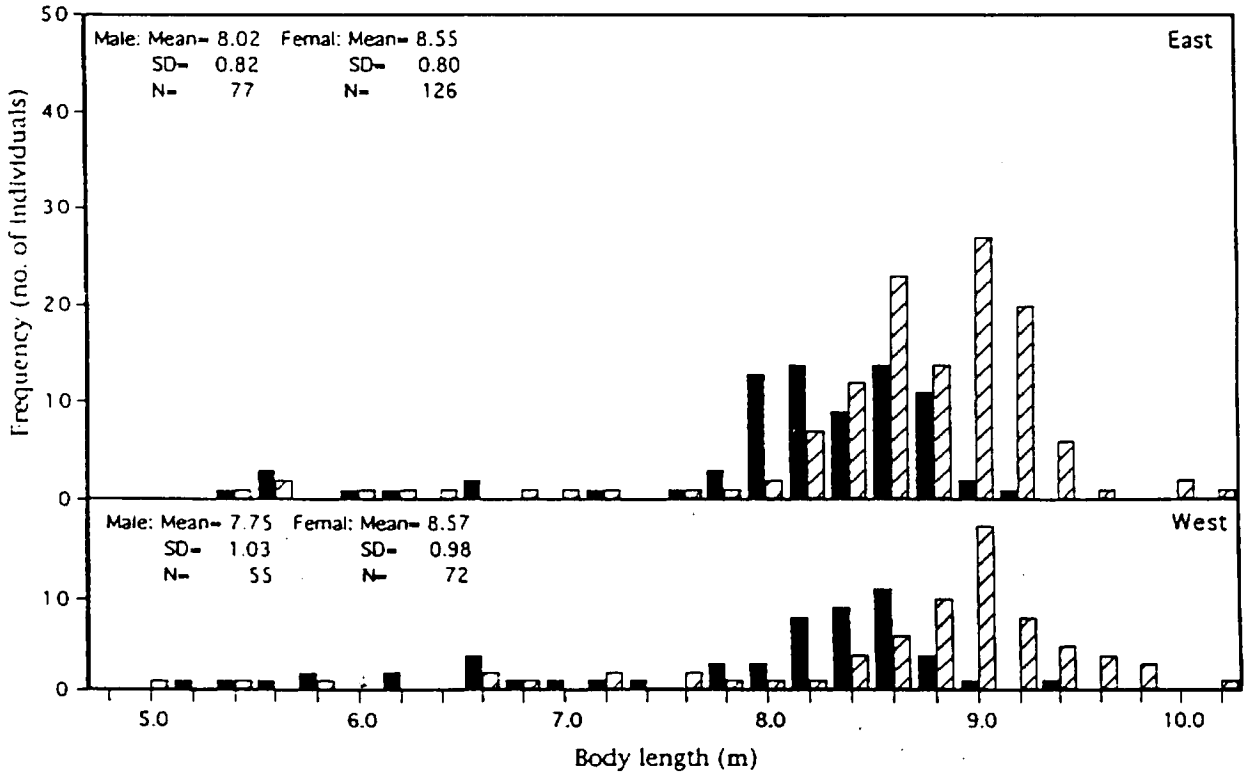

Fig. 10b. Body length compositions (20cm intervals) of minke whales sampled in the eastern strata (upper) and the western strata (lower) of Area V. Solid and striped lines represent males and females, respectively.