Cruise Report of the Japanese Whale Research Program under a Special Permit in the Antarctic (JARPA) Area IV and Eastern Part of Area III in 1997/98

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ABSTRACT

The eleventh year of the Japanese Whale Research Program under Special Permit in the Antarctic (JARPA) was conducted in Area IV and eastern part of Area III (Area IIIE) from 7 December 1997 to 14 March 1998. One sighting vessel (SV), three sighting /sampling vessels (SSVs) and one research base were engaged in the research. The SV covered 5,136.4 n. miles, and made primary sightings of 127 schools/ 243 individuals of minke whales. A total of 30 biopsy samples was obtained from blue, humpback, right and minke whales by the SV. Three SSVs searched a total of 16,462.0 n. miles and sighted 545 schools/ 1,130 individuals of minke whales as primary sightings. Humpback whale was the most dominant species in Area IV, whereas minke whale was the most dominant in Area IIIE. Humpback whales were found in high density between 83 ° E - 108 ° E even at the ice edge and showed clear segregation with minke whales. Yearly change in sightings of humpback whales suggested possible recovery of the stock of this species. A total of 526 minke whales were targeted for sampling resulting in the catch of 438 individuals (110 from Area III and 328 from Area IV). Sexual maturity rate of female samples of minke whales in Area IV was very low at 22.7% and immature females were dominant in the south strata. It was suspected that most of the mature females existed in the ice-free waters which was formed inside of the ice edge where the research vessels could not enter.

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. JARPA is planned by the Japanese Government and conducted by the Institute of Cetacean Research (ICR). After two seasons of feasibility research in 1987/88 and 1988/89, full-scale research started in the 1989/90 season. The program is designed to repeat surveys in the Antarctic Areas Ⅳ and Ⅴ alternatively in each of the sixteen years of the research period. From the 1995/96 season, the survey area was expanded into a part of Areas Ⅲ and Ⅵ to improve the stock structure study (Government of Japan, 1987, 1989, 1995). The original object of the expansion to the eastern part of Area Ⅲ in 1995/96 season was a feasibility study on stock identification to examine the hypothesis of the occurrence of more than one stock in the Areas Ⅳ and Ⅴ (Government of Japan, 1995). Initial study using commercial samples suggested that the core stock (C stock) was widely distributed in the Areas Ⅳ and Ⅴ and a different stock (W stock) occurred in the eastern part of Area Ⅲ (Area ⅢE) and western part of Area Ⅳ (Area ⅣW) in the early period of feeding season (Pastene *et al.*, 1996). However, the result of mitochondrial DNA analyses using the 1995/96 samples was the reverse as the sample from Area ⅢE and Area ⅣW in the early period resembled C stock. Two possible explanations for such differences were given: 1) stocks migrating into Area ⅢE and Area ⅣW did not mix to each other, but the pattern of distribution of a given stock changed both within and between years; 2) two different stocks mixed in the Area ⅢE and Area ⅣW with the mixing proportion changing within and between years (Pastene and Goto, 1997). Further sampling in the expanded area was required to elucidate yearly variation of stock distribution pattern.

The research plan of the 1997/98 JARPA was submitted to 49th Annual Meeting of the International Whaling Commission and the Scientific Committee (IWC/ SC) meeting (Government of Japan, 1997). The objectives of the research are as follows;

1) elucidation of the stock structure of the Southern Hemisphere minke whales to improve the stock management,
2) estimation of biological parameters of the Southern Hemisphere minke whales to improve the stock management,
3) elucidation of the role of whales in the Antarctic marine ecosystem through studies of whale feeding ecology,
4) elucidation of the effect of environmental changes on cetaceans.

Although these objectives were the same as previous research, the research was planned with special reference to elucidation of the W stock distribution pattern.

This paper reports on the eleventh cruise of the JARPA, which was conducted from 7 December 1997 to 14 March 1998 in the Antarctic Area Ⅳ and Area ⅢE.

RESEARCH METHODS

1. Research area

The research area in the present survey was composed of the eastern part of Area Ⅲ (Area ⅢE, 35° E – 70° E) and the entire Area Ⅳ (70° E - 130° E) south of 60° S (Fig. 1). The Area Ⅳ was divided into two sectors, east and west, by the 100° E. They were further divided into two strata, a south stratum

extending from the pack ice edge to a locus 45 n. miles from the ice edge, and a north stratum extending from the northern boundary of the southern stratum to the 60° S. The southern boundary of the North-west stratum was fixed at 65° S (70° E - 80° E) and 64° 15'E (80° E - 100° E) in advance, which were estimated from the results of previous surveys. The survey of each stratum in Area IV was conducted as follows; North-west, South-east, North-east, South-west and Prydz Bay. The order of survey was changed from the previous research in 1995/96 in order to collect samples in the North-west stratum early in the season. Area IIIE was not divided into smaller strata and was surveyed before and after the survey of Area IV.

2. Research vessels

Three vessels, *Kyo Maru No.1* (K01; 812.08 GT), *Toshi Maru No.25* (T25; 739.92 GT) and *Toshi Maru No.18* (T18; 758.33 GT) were engaged in sighting and sampling surveys. *Nisshin Maru* (NM; 7,569GT) served as a research base on which all biological examination of collected samples was conducted. *Kyoshin Maru No.2* (KS2; 361.00 GT) was dedicated to sighting surveys from which all experiments were conducted.

3. Cruise track line and sighting and sampling method

Construction method of the cruise track line was same as the previous research in 1995/96 (Nishiwaki *et al.* 1996). Fig.2 shows the track line of the main course. In Prydz Bay, unexpected ice edge covered the predetermined track line, therefore it was concluded that the survey inside the Bay was impossible even if there were open sea beyond the pack ice. Limited open water remained south of 66° S and two parallel track lines were re-established to cover whole researchable area.

Sighting and sampling procedures were as in the previous JARPA surveys (Nishiwaki *et al.* 1996, 1997b) with some modifications. The sighting survey using the sighting and sampling vessels (SSVs) was conducted under limited closing mode (when a sighting of minke whale was made on the predetermined track line, the vessel approached the whale and species and school size were confirmed). SSVs followed parallel track lines 7 n. miles apart, at a standard speed of 11.5 knots. The sighting survey using the sighting vessel (SV) was conducted under closing mode and passing mode (even if sighting was made on the predetermined track line, the vessel did not approach the whale and searching from the barrel was uninterrupted). The survey was operated under optimal research conditions (when the wind speed was below 25 knot in the south strata or 20 knot in the north strata and visibility was over 2 n. miles). In addition to the sightings of minke whales or whales suspected to be minke whales, the SV approached blue, right, humpback and beaked whales for conducting some experiments. The SSVs approached blue whales for photo-identification experiments. One ordinary form minke whale was sampled randomly from a primary sighted school within 3 n. miles of the track line. The dwarf form minke whale was not target species.

4. Low and middle latitudinal sighting survey

During transit cruises, sighting surveys were conducted in the area between south of 30° S and north of 60° S except for areas within national EEZs. The result of these surveys will be reported separately.

5. Experiments

Sighting distance and angle experiment

This experiment was conducted in order to evaluate the accuracy of the information on sighting distance and sighting angle given by observers of the SV and SSVs.

Photo-identification experiment

The following species were targeted for photographic record of natural markings during the surveys conducted from the SV; blue, humpback and right whales. Photographic records of blue whales and other species were also taken from the SSVs.

Biopsy sampling

The species targeted for photo-identification experiments as well as minke whales were targeted for biopsy skin sampling from the SV.

Observation of behavior patterns of blue whales

This trial was conducted from the SV in order to collect information on natural behavior of blue whales, especially concerning diving time and swimming direction.

Observation of behavior patterns of beaked whales

This trial was conducted from the SV in order to collect information on natural behavior of beaked whales in the Antarctic Sea with special reference to assessment of the possibility of research take of these species.

Satellite tagging experiment

Attempts to attach a satellite tagging device (Nishiwaki *et al.*, 1994) to the body of a minke whale were made in order to elucidate migration routes.

Oceanographic survey

XCTD profiles were obtained from the SV in the research areas. Marine debris was recorded from the SV in the research areas. Also all marine debris found in stomachs of minke whales was recorded and collected.

Acoustics

An acoustic feasibility study was conducted principally on blue whales using a reusable sonobuoy which consisted of a hydro-phone, battery and DAT recorder.

OUTLINE OF THE RESEARCH ACTIVITIES

An outline of the research activities conducted during the 1997 /98 JARPA survey is as follows.

Event	Date	Vessels
Departure from Japan	11 November 1997	NM, SV and SSVs
Sighting survey in transit area.	28 November - 5 December 1997	SSVs*
Sighting and sampling survey in AreaIIIE (first period)	7 December - 31 December 1997	SSVs
	12 December - 30 December 1997	SV*
Sighting and sampling survey in the North-west stratum in Area IV	31 December 1997 - 14 January 1998	SV
	1 January - 15 January 1998	SSVs
Sighting and sampling survey in the South-east stratum in Area IV	15 January - 29 January 1998	SV
	16 January - 30 January 1998	SSVs
Sighting and sampling survey in the North-east stratum in Area IV	30 January - 12 February 1998	SV
	31 January - 13 February 1998	SSVs
Sighting and sampling survey in the South-west stratum in Area IV	13 February - 27 February 1998	SV
	14 February - 1 March 1998	SSVs
Sighting and sampling survey in the Prydz Bay	1 March - 4 March 1998	SV
	2 March - 9 March 1998	SSVs
Sighting and sampling survey in AreaIIIE (second period)	5 March - 14 March 1998	SV and SSVs**
	10 March - 11 March 1998	SSVs
Sighting survey in transit area.	16 March - 23 March 1998	SV and SSVs
Arrival at Japan	7 April	NM, SV and SSVs

*SV was late for arrival at research area.

**SSVs were dedicated to sighting survey after sampling survey.

RESULTS

1. Searching effort

Table 1 shows the searching distances (n. miles) by each stratum. Total searching distance of one SV and three SSVs was 21,598.4 n. miles (Area IIIE; 7,486.1, Area IV; 14,112.3). In spite of short searching distance in Prydz Bay, this value was higher than previous research in 1995/96 and the highest in the past JARPA cruises. This comparatively long distance was achieved because of good weather and adoption of the passing mode by the SV. Relatively good weather held for nearly whole the research period except for the second period of the survey in Area IIIE. The SV conducted passing mode searching basically three hours a day. Searching by passing mode had the advantage of gaining distance from the following SSVs and allowing enough time to perform several experiments. The ratio of passing mode was 27.2% of total searching distance of the SV. In Area IV, owing to favorable weather, there was short distance which was not surveyed. In this part of the course line, it could not be surveyed primarily because the course line was covered with ice.

2. Species sighted

Tables 2a and 2b summarize the sightings made. In Area IV, sightings of humpback whales dominated over those of minke whales except for the East-south stratum and Prydz Bay. Total primary sightings of minke whales in Area IV involved 115 schools (228 individuals) by the SV and 412 schools (887 individuals) by the SSVs, whereas those of humpback whales involved 117 schools (246 individuals) by the SV and 431 schools (819 individuals) by the SSVs. Distribution of humpback whales concentrated between 83° E - 108° E with high density in the West sector than the East sector. In the West sector, humpback whales were distributed not only in off-shore waters but also at the ice edge (Fig. 4). In the West sector, it was observed that the longitudinal ice edge divided neighboring areas with high concentrations of minke whales and humpback whales. Minke whale was the dominant species in the East-south stratum and Prydz Bay in Area IV and in Area IIIE.

Table 3 shows density indices (DI; schools sighted / 100 n. miles searching distance) of minke whale and humpback whale in each stratum. The DI of humpback whale was 3.88 in Area IV and 1.5 –1.8 times higher than minke whale in the East-north, West-north and West-south strata. On the other hand, it was overwhelmed by that of minke whale in Prydz Bay, East-south strata and the first period of Area IIIE.

Right whale was the third dominant species in Area IV with seven schools (eight individuals) primary sightings by the SV and 27 schools (29 individuals) primary sightings by the SSVs. It was noteworthy that a total of 11 schools (19 individuals) of blue whales were observed by the SSVs in a very small area during the first survey day in Area IIIE (7 December, Fig. 5). However, there were fewer sightings of blue whales in Area IV.

For toothed whales, southern bottlenose whale and unidentified ziphiid species (beaked whales) were the dominant species followed by sperm whale in all research areas. Sightings of these species were much higher in Area IIIE and the West sector of Area IV than in the East sector of Area IV.

3. Sightings and sampling of minke whale

Sightings of minke whales in the first period of Area IIIE were concentrated at the southern most part of the track line at the end of December (Fig. 3). In Prydz Bay, minke whales were also highly concentrated in the icy waters but occurred in low density off the ice edge. The DI in Prydz Bay was 19.84 which was the highest during the whole research (Table 3). On the other hand, there were some areas of high concentration of minke whales in south strata of Area IV. The DI was slightly higher in the south strata (3.44 and 3.66) than the north strata (2.21 and 3.39), whereas mean school size (MSS) in the West-north stratum was higher than the south strata.

Out of 545 schools (1,115 individuals) of minke whales sighted by the SSVs, 526 individuals were targeted for sampling. A total of 438 individuals was collected (110 from Area IIIE, 328 from Area IV) (Fig. 6). Technical sampling efficiency (the rate of sampling for targeted individuals) was 0.83. Technical sampling efficiency by stratum was higher in the north strata (0.87-0.91) and lower in the other (0.68-0.87). It was the lowest in Prydz Bay (0.68) and following the second period of Area IIIE (0.76). The most frequent reason for sampling failure in these strata was missing the whale in the pack ice. 44.8% (39 cases) of cause of sampling failure was missing the whale before commencement of chase. Sampling failure because of technical problems occurred five cases.

Special attention to humane killing was given to all targeted and sampled whales. Explosive harpoons were used for all targeted whales as the primary killing method. The rifle was used as the secondary killing method when required.

4. Experiments

A sighting distance and angle experiment was performed on 7 January by the SV and SSVs. The results of this experiment will be used in calculating abundance estimates.

Table 4 summarizes the results of the other experiments. A total of 129 individuals were photographed and 29 skin samples were collected by biopsy from blue, humpback and right whales. The number of biopsy samples was increased from previous years by using a newly introduced air charging system for the biopsy gun on the SV. To assess the possibility of collecting DNA samples of minke whales by non-lethal method, biopsy sampling was performed for minke whales using same sampling approach as for lethal research, i.e. one (or two) target animal was selected from a primary sighted school by using tables of random sampling digits. A total of nine trials (nine individuals from eight schools /20 individuals) was conducted. Only one succeeded. Sampling efficiency was 0.11. Total experiment time (chasing time) was 8 hours and 17 minutes and averaged 62 minutes per school.

Observations of behavior patterns of blue and beaked whales were conducted two and eighteen times, respectively. Out of 18 schools of beaked whales, 12 schools (66.7%) were identified as southern bottlenose whales while confirmation of species was not possible for six schools.

The newly introduced XCTD survey was conducted at 93 locations in the whole research area. Analysis of XCTD data will be used as an element of studies to elucidate the marine ecosystem of Antarctic Ocean. The marine debris survey was carried out concomitant with the sighting survey of the SV in all research areas. A total of three debris (buoy and pieces of styroform) were confirmed. No artificial object was found from the stomachs of sampled minke whales.

A satellite tagging experiment for minke whale was tried on a school of nine individuals on 6 March, however, no chance was obtained to employ the device and the experiment failed.

Acoustic records were obtained for total of eight hours and four minutes. As there were some problems on the equipment, further improvement on the recording system is needed.

5. Biological research

Biological sampling on the research base (NM) was conducted for all whales caught (279 males, 159 females). Table 5 summarizes data and samples collected. In the first period of Area IIIE, a female fetus with body length of 285cm was collected. This is nearly birth length for minke whales (Kato and Miyashita, 1991). In vitro maturation and fertilization of follicular oocytes were performed in the laboratory of NM by Mr. Toshihiro Mogoe, a guest scientist from the Obihiro University of Agriculture and Veterinary Medicine.

6. Products

All the whales collected were processed on the NM after biological sampling was completed, according to the provisions of Convention, Article Ⅷ. A total of 1,704 tons of meat, blubber, viscera, etc. was produced. A total of 36.6 tons of oil was produced.

7. Preliminary analyses of biological information

Sex ratio and reproductive status

Table 6 and Fig. 6 show the reproductive status of all samples by each stratum. Because histological examination has not been done yet, maturity of males was tentatively determined by the testis weight according to Kato (1986), i. e., testis over than 400g was determined to be mature while others were

classified to be immature.

There were a few mature females in all the research areas except for the first period of Area IIIE. On the contrary, immature females were dominant in both East-south and West-south strata in Area IV. Nearly half (49.3%) of collected samples were immature females in the East–south stratum. Mature males were dominant in all the research area except for the south strata where immature female was dominant. Among the females, immature animals far outnumbered mature animals even in Prydz Bay. Maturity rate of females in Area IV was 12.7 % in the south strata, 38.9 % in the north strata and 31.3 % in Prydz Bay. Out of 43 pregnant female, 29 (32.6 %) were lactating. Maturity rate of the males was relatively high in every stratum (59.5 % - 78.1 % in Area IV, 69.2 % - 82.0% in Area IIIE).

Length composition

Fig. 7 shows body length composition of minke whales collected in Areas IIIE and IV. Table 7 shows mean body length of minke whales collected in each stratum. Maximum length of the sample was 9.47m for male and 9.94m for female. Minimum length was 5.02m and 4.82m, respectively. Mean body length in each sexual maturity class was not significantly different among strata except for immature females (ANOVA, $p=0.001$). In the East-south stratum and Prydz Bay, mean body length of immature females was higher than other strata.

DISCUSSION

The most characteristic results of the present survey are summarized as 1) low density of minke whales in the south strata and high density of humpback whales in the western part of Area IV, 2) low proportion of pregnant females in the samples collected in the south strata and Prydz Bay in Area IV. Sightings of humpback whales also outnumbered minke whales in similar latitudinal area (83 ° E-115 ° E) of north strata in the previous survey (Nishiwaki *et al.* 1996), however, it is surprising that they are dominant even in the south strata. When compared with the previous survey (1995/96 JARPA), the DI of minke whale in the present survey is lower in all strata except for the West-north stratum and Prydz bay in Area IV. In the south strata, the DI of minke whale is less than half of the previous survey (East sector; 9.12 in 1995/96→ 3.66 in 1997/98, West sector; 7.09→3.44) and the MSS is also smaller (East sector; 2.78→1.71, West sector; 2.35→1.88). Although the DI in Prydz Bay was very high, minke whales concentrated in the pack ice and sightings decreased off the ice edge. It remains unknown whether a large number of minke whales existed in the pack ice where it was not possible to conduct the survey. However, SV which was dedicated to pack ice survey did not find any large herd of minke whales even in the southernmost icy water of the western part of Prydz Bay (Fig. 2).

It was observed that the minke and humpback whale habitats were segregated (Figs. 3, 4). Minke whales appear to be less concentrated in the area where humpback whales are distributed densely. Nishiwaki *et al.* (1997a, 1997b) suggested latitudinal segregation of minke and humpback whales in the northern area. In the present survey, it is noteworthy that humpback whales were highly concentrated even at the ice edge of south strata. However, it seems that the increase in sightings of humpback whales is unrelated to the decrease in sightings of minke whales since there were not so many sightings of humpback whales in the East-south stratum in spite of low density of minke whales. Areas of high concentration of humpback whales were restricted to the western part of Area IV. Fig. 8 shows biennial change of composition of the species sighted and DI of minke and humpback whales in Area IV. The proportion and DI of minke whales fluctuate

in each year and no trend seems to be observed, whereas those of humpback whales clearly increase from 1995/96 season. The result of the present survey strongly supports the recovery of this species which was suggested in both Areas IV and V based on the JARPA surveys (Nishiwaki *et al.*, 1997a).

It is possible to explain that the low density of minke whales in the south strata results from absence of mature females. Table 8 shows comparison of reproductive status of samples collected in same stratum in the previous survey. Sexual maturity rate of females in Area IV from the present survey is 22.7% and less than half of the previous survey (60.3%). The proportion of immature animals in the south strata, not only female but also male animals, is higher than those of the previous survey. Such results conflict with the theory that the mature females distribute in the high latitudinal ice edge area and immature animals are scattered off the ice edge (for example, Kato *et al.* 1989, 1990, Fujise and Kishino, 1997).

One of the probable reasons for the character of the present survey results is a difference of ice edge shape. Fig. 2 and 9 show the shape of ice during the present and previous (1995/96) surveys respectively. The ice edge line is estimated from the National Ice Center (former Navy/NOAA Joint Ice Center) information and real observation by the research vessels. The difference between the present and the previous surveys is that there are large ice free areas which existed south of the ice edge where the southernmost of track line was fixed for the present survey. This phenomenon was observed especially in the East-south stratum. Because a large number of pregnant females had been collected in the jar-shaped inlet formed by ice edge in the former JARPA surveys, it is strongly suggested that the most of mature females entered into such jar-shaped ice free areas where the predetermined course line did not enter.

Another probable reason for the character of the present survey is a difference of the research period. As the North-west stratum was preferentially surveyed in the early period during the present research, the order of the survey of each stratum in Area IV was changed from former surveys. The survey period of the West-south stratum and Prydz Bay was therefore delayed for 5-7 weeks. In the first period of Area IIIE and West-north stratum which were surveyed in the early period, the proportion of mature females shows little difference from previous survey. While in the West-south stratum and Prydz Bay, it is much lower than previous survey. There is a possibility that the mature females which were distributed inside of Prydz Bay had already moved northward with the advance of the seawater freeze when the survey was made. In the East-south stratum, the survey was conducted about one month earlier than the previous survey. This may be the cause of the irregular shape of the ice edge which formed an ice free area in the pack ice.

It is difficult to enter the ice free waters when the mouth of "jar" is made narrow by ice. Furthermore, as the course line is predetermined randomly, the current survey method does not cope with such a temporary ice-free area. However, if there were numerous matured females concentrated in such areas, sampling should be done to ensure a representative sample from the minke whale stock in the Antarctic. A more advanced survey method is needed in future, which can construct a track line in the sea ice free area temporary formed south of ice edge.

ACKNOWLEDGEMENTS

The project leader was Dr. Seiji Ohsumi, director-general of the Institute of Cetacean Research (ICR). We are indebted to Mr. Nobuyuki Yagi, the Government of Japan for implementation of the research. We thank research technicians, Messrs. Yutaka Eguchi, Hirokazu Shotokuji and Makoto Ginyoshiya, Kyodo Senpaku Kaisha Ltd., for their contribution. Shoji Miyamoto and Hiroo Hidaka, Kyodo Senpaku Co. Ltd., contributed strategy and logistics of the sighting and sampling survey. Mr. Katsuhiko Ueda from the Government of

Japan, inspected and supported research on NM. We are also indebted to all the crew, colleagues of ICR and other related institutions who participated in the research for their contributions. We also thank Dan Goodman of the ICR for critically reviewing the manuscript.

Financial support for this research was provided by the Government of Japan.

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Table 1. Searching distances (n. miles) of one sighting vessel (SV) and three sighting/sampling vessels (SSVs) by each stratum. Numbers in parenthesis represent searching distances in passing mode (see text).

Stratum	SV	SSVs	Combined
Area III East			
First period	1,248.3 (333.7)	5,455.7	6,704.0
Area IV			
East-North	979.4 (276.8)	2,643.3	3,622.7
East-South	825.5 (222.6)	2,370.4	3,195.9
West-North	750.9 (199.4)	2,616.3	3,367.2
West-South	787.1 (256.4)	2,645.4	3,432.5
Prydz Bay	135.1 (46.5)	358.9	494.0
Combined	3,478.0 (1,001.7)	10,634.3	14,112.3
Area III East			
Second period	410.1 (61.4)	372.0	782.1
Grand total	5,136.4 (1,396.8)	16,462.0	21,598.4

Table 2a. Summary of sightings (no. schools / no. individuals) conducted by SV and SSVs in Area IV.

Species	SV				SSVs			
	West sector		East sector		West sector		East sector	
	Primary	Secondary	Primary	Secondary	Primary	Secondary	Primary	Secondary
Northern stratum								
Minke whale	27/77	12/25	12/21	1/1	87/229	22/60	68/114	4/4
Like minke whale	2/2	1/2	1/1		1/1	1/1	1/1	
Dwarf minke whale							2/2	
Blue whale	3/4				1/1			
Fin whale	3/14		1/2		1/5		5/9	
Right whale			2/2		2/2		8/8	1/1
Humpback whale	40/87	22/33	31/69	7/20	169/359	13/23	91/160	9/15
Unidentified baleen whales	11/13	3/14	1/3	18/28	9/13	1/2		1/1
Sperm whale	18/19	1/2			87/89	6/6	2/2	
Arnoux's beaked whale					1/4			
Southern bottlenose whale	23/55	4/9	13/19	4/6	44/80	1/2	25/52	1/1
Unidentified *Mesoplodon.sp*		1/7			1/3			
Unidentified Ziphiidae	12/29	6/12	9/17	2/3	52/108	1/2	29/50	
Killer whale	4/66	1/7	4/95		11/155	1/20	9/104	1/2
Hourglass dolphin			1/20	1/3			6/37	
Long-finned pilot whale					5/300	2/90	2/70	
Unidentified pilot whales					2/85			
Unidentified cetacean	6/14	7/7	7/11		34/36		51/52	
Southern stratum								
Minke whale	22/33	10/34	26/43	1/1	96/189	12/18	91/157	8/12
Like minke whale	2/2	2/3	3/7				6/6	
Blue whale							1/1	
Fin whale	1/3	4/14			4/13			
Right whale	3/4	6/7	2/2		16/18	1/1	1/1	
Humpback whale	40/77	18/32	6/13		149/265	15/31	20/32	1/1
Unidentified baleen whales	14/21	12/13	5/6		12/17	1/2		
Sperm whale	17/17	7/8	9/10	2/2	37/37	2/2	9/9	2/2
Southern bottlenose whale	8/12	1/5	11/20	1/2	16/26		15/27	2/3
Unidentified Ziphiidae	3/3	1/1	11/17	1/1	13/20		13/18	
Killer whale	4/8	2/7	5/75		11/135		18/152	
Unidentified cetacean	3/4	2/4	9/10	1/1	42/42		45/45	
Prydz Bay								
Minke whale	28/54	11/22			70/198	81/256		
Like minke whale	1/1							
Humpback whale					2/3	1/1		
Unidentified baleen whales	2/5				1/1	1/100		
Southern bottlenose whale	1/2							
Unidentified Ziphiidae		1/1			2/4			
Killer whale	3/16	1/21			4/59	1/4		
Unidentified cetacean	2/3				2/2			

Table 2b. Summary of sightings (no. schools / no. individuals) conducted by SV and SSVs in eastern part of Area III.

Species	First period				Second period			
	SV		SSVs		SV		SSVs	
	Primary	Secondary	Primary	Secondary	Primary	Secondary	Primary	Secondary
Minke whale	8/8	2/2	112/179	16/34	4/7	3/11	21/64	3/66
Like minke whale	2/2	8/10	3/3	1/1				
Blue whale		1/1	11/19	1/5				
Fin whale			2/6	1/1	1/5			
Humpback whale	5/11	2/4	23/43	4/7		2/6	1/2	
Unidentified baleen whales	2/2	1/2	7/10	11/13				
Sperm whale	9/11	3/4	107/108	10/10				
Arnoux's beaked whale								1/3
Southern bottlenose whale	6/13	2/3	54/93	3/6	3/6	1/2	3/4	
Strap-toothed whale			1/4					
Gray's beaked whale				1/5				
Unidentified *Mesoplodon.sp*			6/11					
Unidentified Ziphiidae	8/10	2/4	42/58	3/6	2/3		1/1	
Killer whale	1/3		4/23		2/12		2/28	
Hourglass dolphin						1/2		
Unidentified cetacean	7/8		73/73	1/1	3/4		3/3	

Table 3. Density indices (DI) and mean school size (MSS) of minke whale and humpback whale primary sightings by SV and SSVs.

Stratum	Minke whale						Humpback whale					
	SV		SSVs		Combined		SV		SSVs		Combined	
	DI	MSS	DI	MSS	DI	MSS	DI	MSS	DI	MSS	DI	MSS
AreaIII East First period	0.64	1.00	2.05	1.60	1.79	1.56	0.40	2.20	0.42	1.87	0.42	1.93
Area IV												
East-North	1.23	1.75	2.57	1.68	2.21	1.69	3.17	2.23	3.44	1.76	3.37	1.88
East-South	3.15	1.65	3.84	1.73	3.66	1.71	0.73	2.17	0.84	1.60	0.81	1.73
West-North	3.60	2.85	3.33	2.63	3.39	2.68	5.33	2.18	6.46	2.12	6.21	2.13
West-South	2.80	1.50	3.63	1.97	3.44	1.88	5.08	1.93	5.63	1.78	5.51	1.81
Prydz Bay	20.73	1.93	19.50	2.83	19.84	2.57	0	0	0.56	1.50	0.40	1.50
Combined	3.31	1.98	3.87	2.15	3.73	2.12	3.36	2.10	4.05	1.90	3.88	1.94
AreaIII East Second period	0.98	1.75	5.65	3.05	3.20	2.84	0	0	0.27	2.00	0.13	2.00
Grand total	2.47	1.91	3.31	2.07	3.11	2.04	2.38	2.11	2.76	1.90	2.67	1.94

Table 4. Summary of the results of experiments conducted by SV. SSVs also conducted photo-ID experiments on some occasions. Preliminary acoustic experiments were conducted to improve the equipment. The number of marine debris represents the number of sighted objects. B: blue whale, Hp: humpback whale, R: right whale, Mi: minke whale and Zi: beaked whales.

Stratum	Photo I. D..			Biopsy				Behavioral observation		Acoustic record	XCTD	Marine debris
	B	Hp	R	B	Hp	R	Mi	B	Zi	(min.)		
Area III East												
First period	5	9			5				5	73	12	
Area IV												
East-North		23	5		5	2			7		10	3
East-South		9	3		2	2			1		40	
West-North	4	44	2	1	6			2*	2	307	11	
West-South		20	5		6				2		4	
Prydz Bay											6	
Combined	4	96	15	1	19	4			12	307	71	3
Area III East												
Second period							1		1	101	10	
Grand total	9	105	15	1	24	4	1	2	18	481	93	3

*One of two observations was performed for fin whales.

Table.5. Summary of biological data and samples collected. Number with parenthesis represents fetal samples and the total number includes the fetuses of which sex were unidentified.

Samples and data	Number of whales		
	Male	Female	Total
-Data-			
Photographic record of external character	279	159	438
Body length and sex identification	279	159	438
Measurement of external body proportion	279	158	437
Body weight	279	159	438
Body weight by total weight of parts	39	39	78
Skull measurement (length and breadth)	255	150	405
Craniometric study	1	1	2
Standard measurements of blubber thickness (five points)	279	158	437
Detailed measurements of blubber thickness (fourteen points)	39	38	77
Mammary grand; lactation status and measurement	-	156	156
Breadth measurement of uterine horn	-	158	158
Testis and epididymis weight	279	-	279
Weight of stomach content in each compartment	279	155	434
Photographic record of foetus	(15)	(23)	(43)
Foetal length and weight	(14)	(19)	(33)
External measurements of foetus	(14)	(19)	(33)
Number of ribs	279	158	437
-Sample-			
Diatom film record and sampling	279	159	438
Serum sample for physiological study	278	159	437
Earplug for age determination	278	159	437
Earplug for chemical analysis (one of the pair)	13	7	20
Tympanic bulla for age determination	278	159	437
Largest baleen plate for age determination	79	94	173
Baleen plate for morphologic study	277	159	436
Vertebral epiphyses sample	278	159	437
Ovary	-	159	159
Histological sample of endometrium	-	159	159
Histological sample of mammary gland	-	159	159
Milk sample for chemical analysis	-	7	7
Histological sample of testis	279	-	279
Histological sample of epididymis	279	-	279
Testis and epididymis stamp smear for sperm detection	279	-	279
Blubber, muscle, liver, kidney and heart tissues for genetic study	279	159	438
Muscle, liver and kidney tissues for heavy metal analysis	279	159	438
Blubber and liver tissues for organochlorine analysis	279	159	438
Muscle, liver and blubber tissues for lipid analysis	39	39	78
Stomach contents for food and feeding study	183	80	263
External parasites	88	38	126
Internal parasites	32	16	48
Fetus	(1)	(6)	(12)
Blubber, muscle, liver, kidney and heart tissues for genetic study (fetus)	(14)	(17)	(31)
Pituitary gland for reproductive study	84	62	146
Serum for reproductive study	110	82	192
Live sperm for in-vitro fertilization (IVF)	10	-	10
Live oocyte for in-vitro fertilization (IVF)	-	87	87
Tooth buds of fetus for embryological study	(5)	-	(5)
Lung tissues for anatomical study	7	2	9
Whole skeleton	1	-	1

Table 6. Reproductive status of minke whales collected. Numbers in parenthesis represent ratio of samples in each stratum (%). Maturity of males was tentatively defined by testis weight according to Kato (1986) i.e., testis over 400g was determined to be mature and others were classified to be immature.

Stratum	Male			Female						
	Immature	Mature	Total	Immature	Mature					Total
					Pregnant	Resting	Lactating	Preg.+Lact	Unknown	
Area III East										
First period	11	50	61	16	11	-	-	5	1	33
	(11.7)	(53.2)	(64.9)	(17.0)	(11.7)			(5.3)	(1.1)	(35.1)
Area IV										
East-North	15	28	43	12	2	-	-	1	-	15
	(25.9)	(48.3)	(74.1)	(20.7)	(3.4)			(1.7)		(25.9)
East-South	11	24	35	36	2	-	-	-	-	38
	(15.1)	(32.9)	(47.9)	(49.3)	(2.7)					(52.1)
West-North	14	39	53	10	6	-	-	5	-	21
	(18.9)	(52.7)	(71.6)	(13.5)	(8.1)			(6.8)		(28.4)
West-South	17	25	42	26	3	2	1	1	-	33
	(22.7)	(33.3)	(56.0)	(34.7)	(4.0)	(2.7)	(1.3)	(1.3)		(44.0)
Prydz Bay	7	25	32	11	4	-	-	1	-	16
	(14.6)	(52.1)	(66.7)	(22.9)	(8.3)			(2.1)		(33.3)
Combined	64	141	205	95	17	2	1	8	-	123
	(19.5)	(43.0)	(62.5)	(29.0)	(5.2)	(0.6)	(0.3)	(2.4)		(37.5)
Area III East										
Second period	4	9	13	1	1	-	-	1	-	3
	(25.0)	(56.3)	(81.3)	(6.2)	(6.2)			(6.2)		(18.7)
Grand total	79	200	279	112	29	2	1	14	1	159
	(18.0)	(45.7)	(63.7)	(25.6)	(6.6)	(0.5)	(0.2)	(3.2)	(0.2)	(36.3)

Table 7. Mean body length (m) with standard deviation and body length range of minke whales collected in each stratum. Maturity of males was defined as Table 6.

Stratum	Male			Female		
	Immature	Mature	Total	Immature	Mature	Total
Area III East						
First period	6.70±0.95	8.31±0.49	8.02±0.86	6.16±1.04	9.07±0.38	7.66±1.64
	(5.43-7.75)	(7.11-9.30)		(5.13-8.06)	(8.62-9.94)	
Area IV						
East-North	6.22±0.59	8.55±0.22	7.74±1.18	5.97±0.56	9.00±0.59	6.58±1.34
	(5.15-6.98)	(8.01-8.97)		(4.95-6.89)	(8.36-9.79)	
East-South	6.55±0.59	8.43±0.33	7.84±0.97	6.75±0.88	8.93±0.53	6.86±0.99
	(5.35-7.25)	(7.73-9.08)		(5.43-8.35)	(8.40-9.46)	
West-North	6.33±0.81	8.50±0.40	7.93±1.10	6.20±0.84	8.99±0.40	7.66±1.54
	(5.19-8.43)	(7.03-9.47)		(4.91-8.00)	(8.22-9.61)	
West-South	6.97±0.93	8.33±0.30	7.54±1.15	6.16±1.00	8.94±0.33	6.75±1.45
	(5.02-8.56)	(7.86-8.91)		(4.82-8.32)	(8.30-9.36)	
Prydz Bay	6.49±0.55	8.49±0.35	8.06±0.92	7.41±1.08	8.95±0.19	7.89±1.15
	(5.68-7.07)	(7.77-9.13)		(5.88-8.57)	(8.62-9.12)	
Combined	6.37±0.75	8.47±0.34	7.81±1.10	6.51±1.01	8.97±0.40	7.07±1.37
	(5.02-8.56)	(7.03-9.47)		(4.82-8.57)	(8.22-9.79)	
Area III East						
Second period	5.79±0.38	8.57±0.45	7.72±1.36	5.81	9.25±0.02	8.10±1.62
	(5.17-6.22)	(7.71-9.08)		(5.81)	(9.23-9.27)	
Grand total	6.39±0.79	8.43±0.39	7.85±1.07	6.45±1.02	9.02±0.39	7.21±1.46
	(5.02-8.56)	(7.03-9.47)		(4.82-8.57)	(8.22-9.94)	

Table 8. Reproductive status of minke whales collected in 1995/96 JARPA (after Nishiwaki *et al.*, 1996). Numbers in parenthesis represent ratio of samples in each stratum (%).

Stratum	Male			Female						
	Immature	Mature	Total	Immature	Mature					Total*
					Pregnant	Rest.+Ovu.	Lactating	Preg.+Lact.	Unknown	
Area III East										
First period	18	28	46	7	12	-	-	4	1	24
	(25.7)	(40.0)	(65.7)	(10.0)	(17.1)			(5.7)	(1.4)	(34.3)
Area IV										
East-North	10	16	26	7	-	1	-	-	-	8
	(29.4)	(47.1)	(76.5)	(20.6)		(2.9)				(23.5)
East-South	4	14	18	12	5	5	-	-	-	22
	(10.0)	(35.0)	(45.0)	(30.0)	(12.5)	(12.5)				(55.0)
West-North	9	28	37	10	3	-	-	-	-	13
	(18.0)	(56.0)	(74.0)	(20.0)	(6.0)					(26.0)
West-South	17	84	101	12	16	1	-	-	-	29
	(13.1)	(64.6)	(77.7)	(9.2)	(12.3)	(0.8)				(22.3)
Prydz Bay	4	18	22	9	44	1	-	-	-	54
	(5.3)	(23.7)	(28.9)	(11.8)	(57.9)	(1.3)				(71.1)
Combined	44	160	204	50	68	8	-	-	-	126
	(13.3)	(48.5)	(61.8)	(15.2)	(20.6)	(2.4)				(38.2)
Area III East										
Second period*	4	18	22	5	12	-	-	-	-	17
	(10.3)	(46.2)	(56.4)	(12.8)	(30.8)					(43.6)
Grand total*	66	206	272	62	92	8	-	4	1	167
	(15.0)	(46.9)	(62.0)	(14.1)	(21.0)	(1.8)		(0.9)	(0.2)	(38.0)

*: excluding a lost male sample.

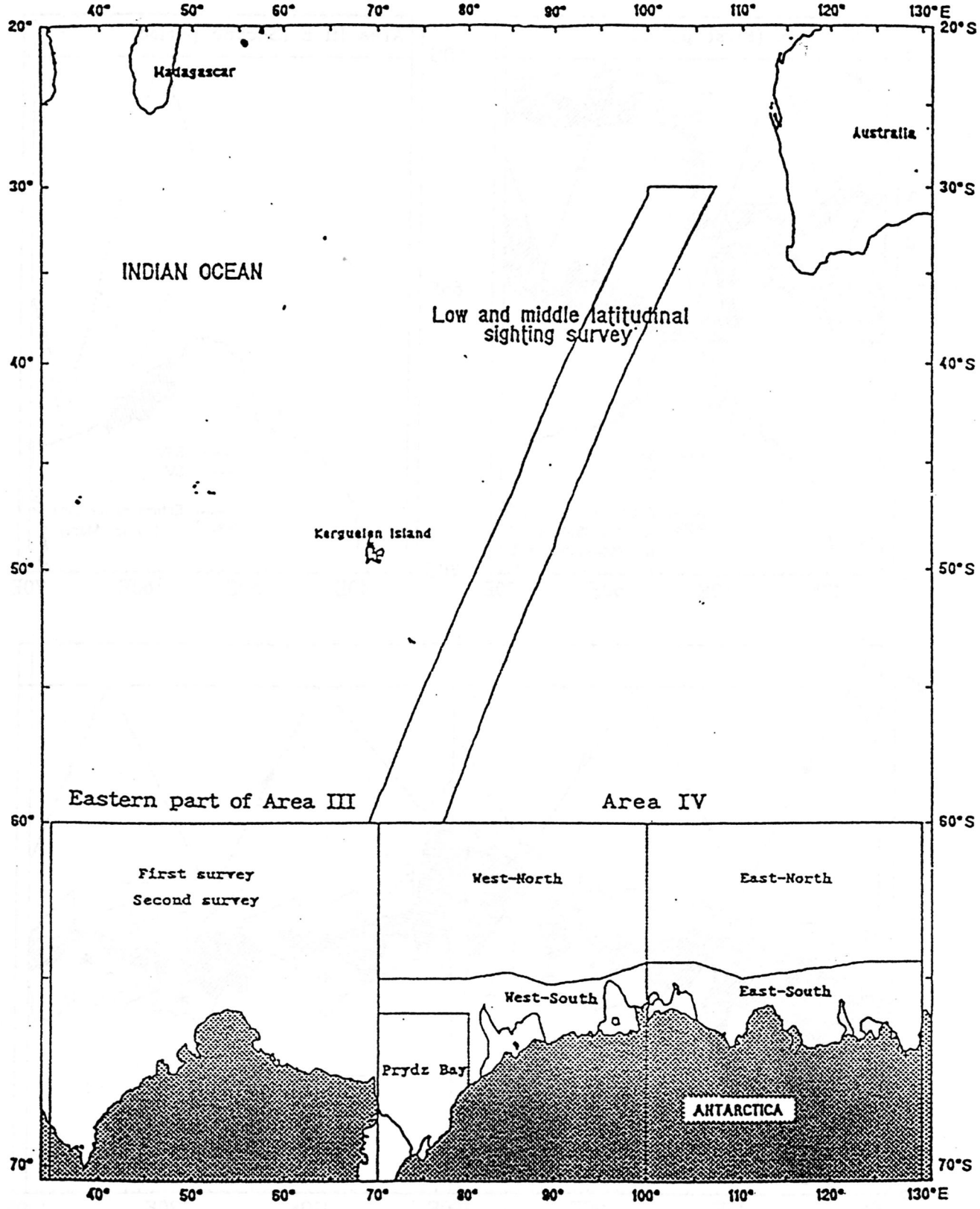

Fig. 1. Geographic location of research area of the 1997 /98 JARPA surveys and cruise tracks of sighting survey between research area and Japan.

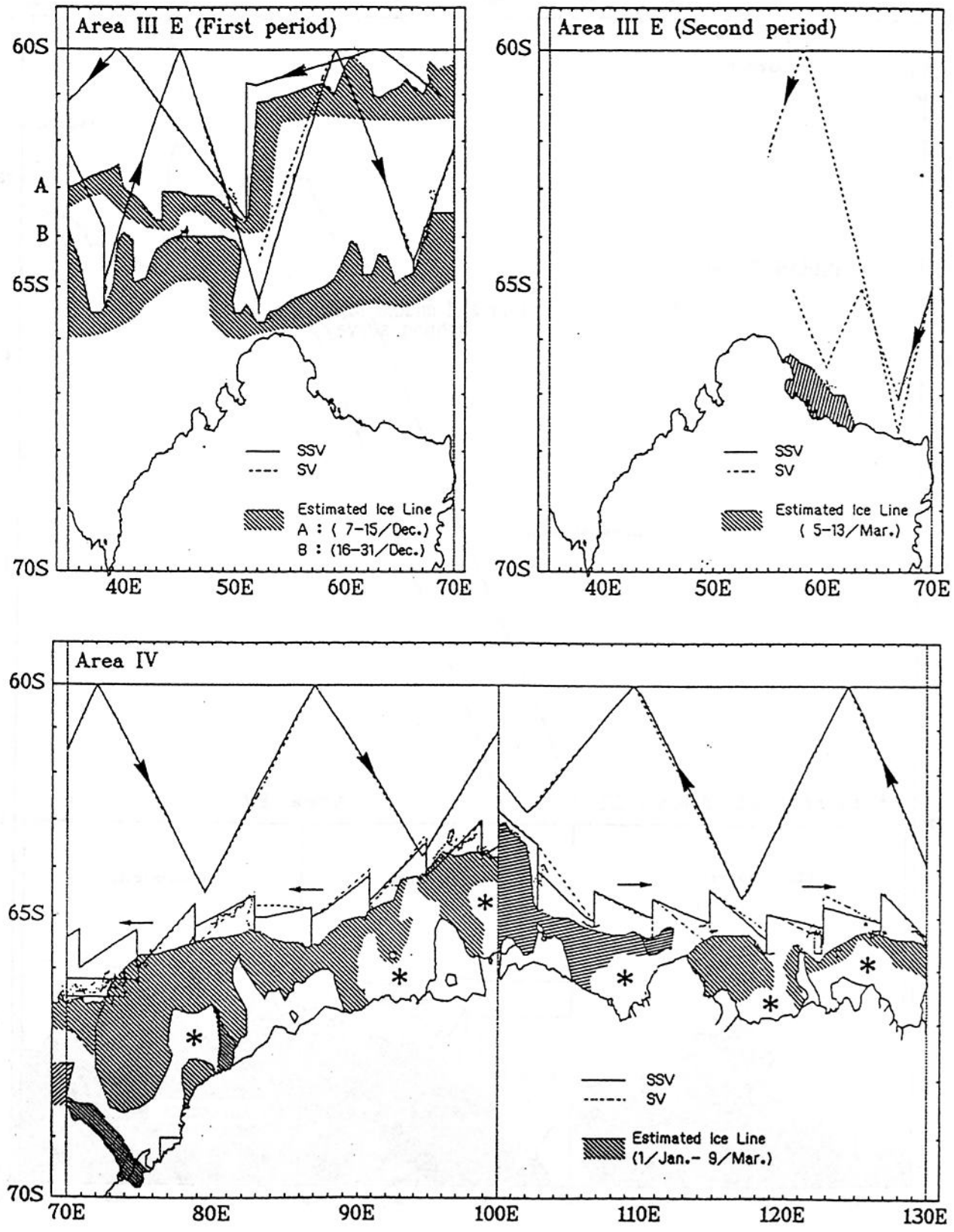

Fig. 2. Cruise track line of sighting vessel (SV, broken line) and sighting/ sampling vessels (SSVs, solid line) in 1997/98 JARPA. Pack ice lines are estimated by observation of research vessels and the information from National Ice Center (NIC). Asterisks represent estimated ice free areas south of the ice edge. Upper; eastern part of Area III (first and second period), lower; Area IV.

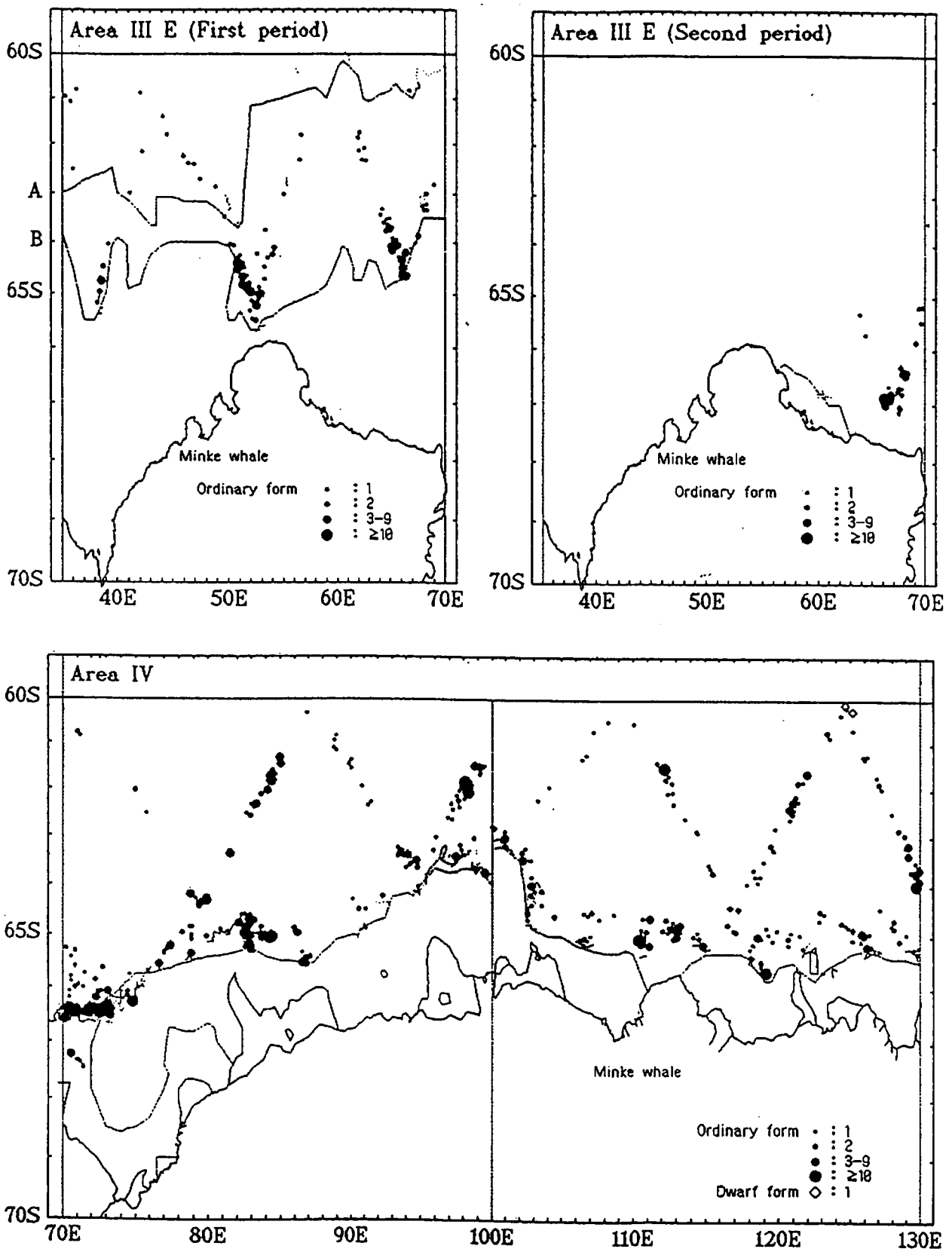

Fig. 3. Distribution of primary sightings of minke whales sighted by SV and SSVs in 1997/98 JARPA. Upper; eastern part of Area III (first and second period), lower; Area IV.

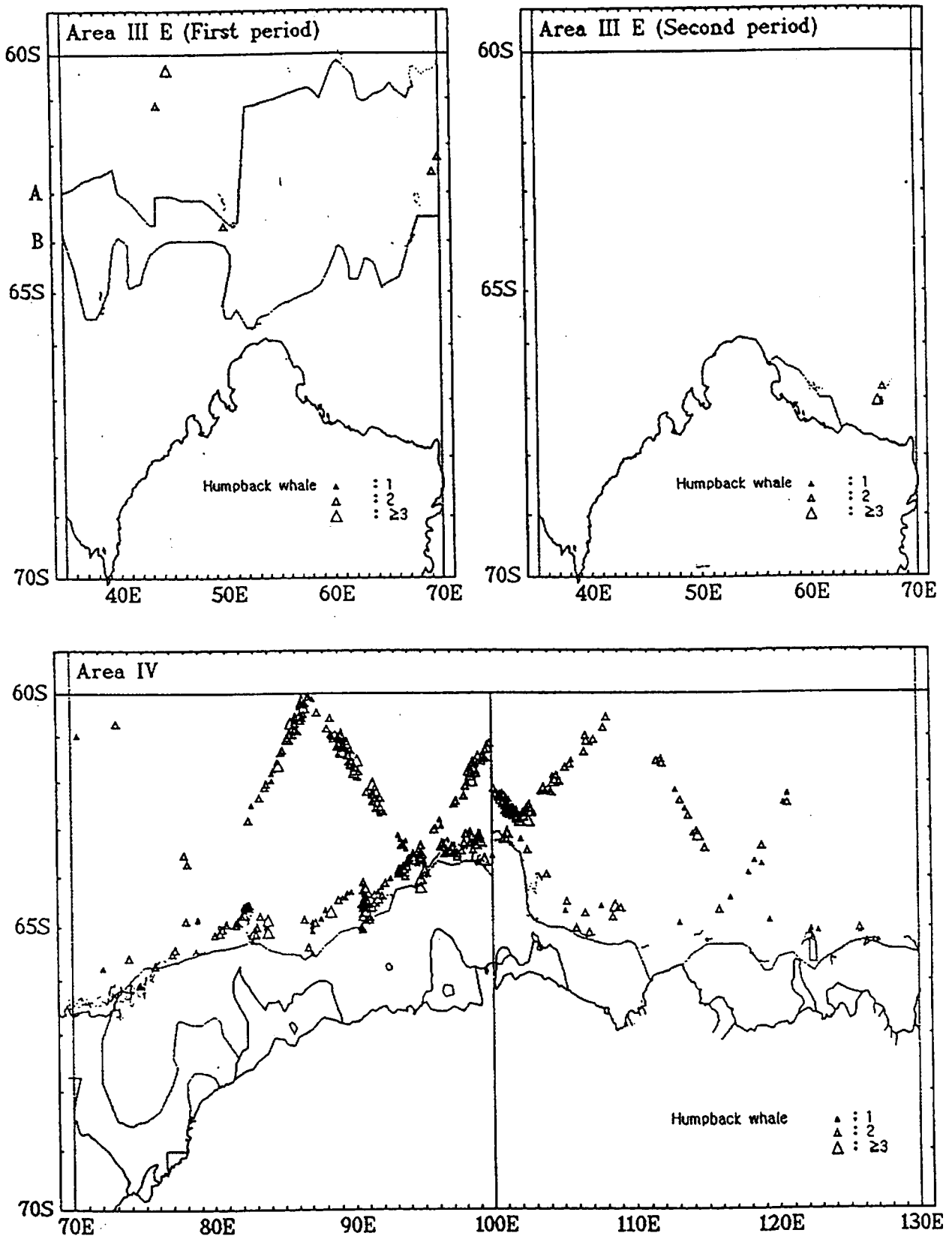

Fig. 4. Distribution of primary sightings of humpback whales sighted by SV and SSVs in 1997/98 JARPA. Upper; eastern part of Area III (first and second period), lower; Area IV.

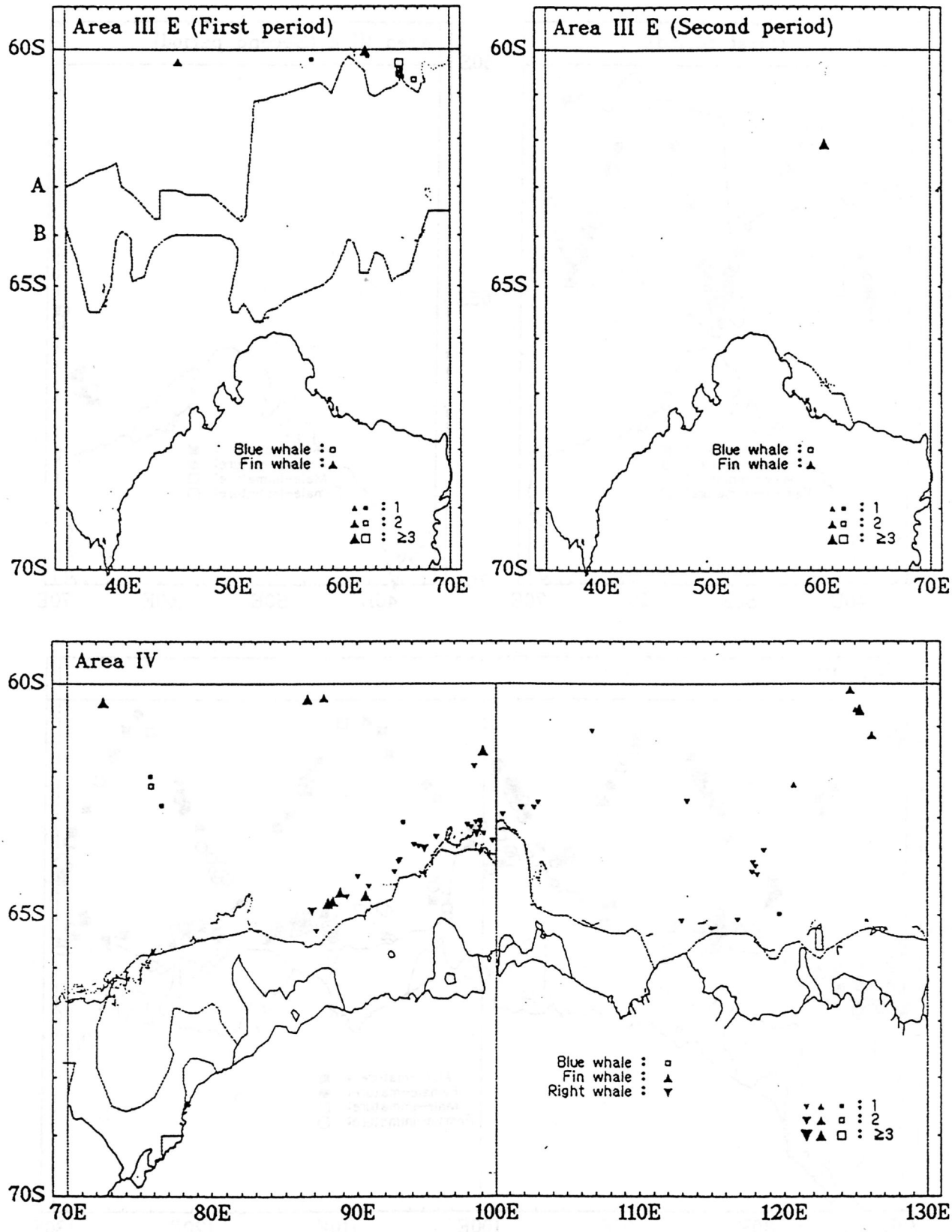

Fig. 5. Distribution of primary sightings of blue, fin and right whales sighted by SV and SSVs in 1997/98 JARPA. Upper; eastern part of Area III (first and second period), lower; Area IV.

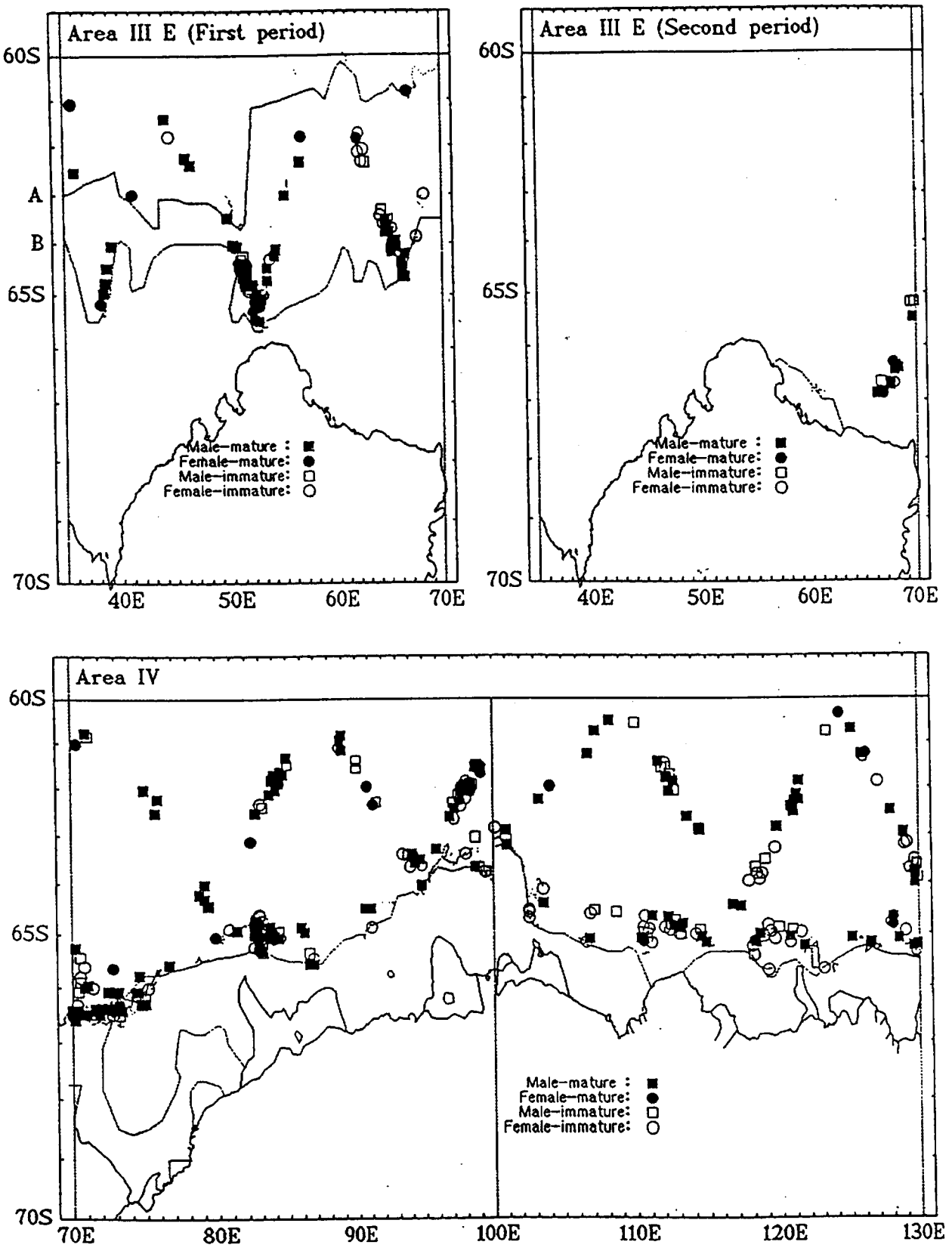

Fig. 6. Sighted position of sampled minke whales by sex and reproductive status in 1997/98 JARPA. Upper; eastern part of Area III (first and second period), lower; Area IV. Maturity of male was tentatively classified by the weight of testis.

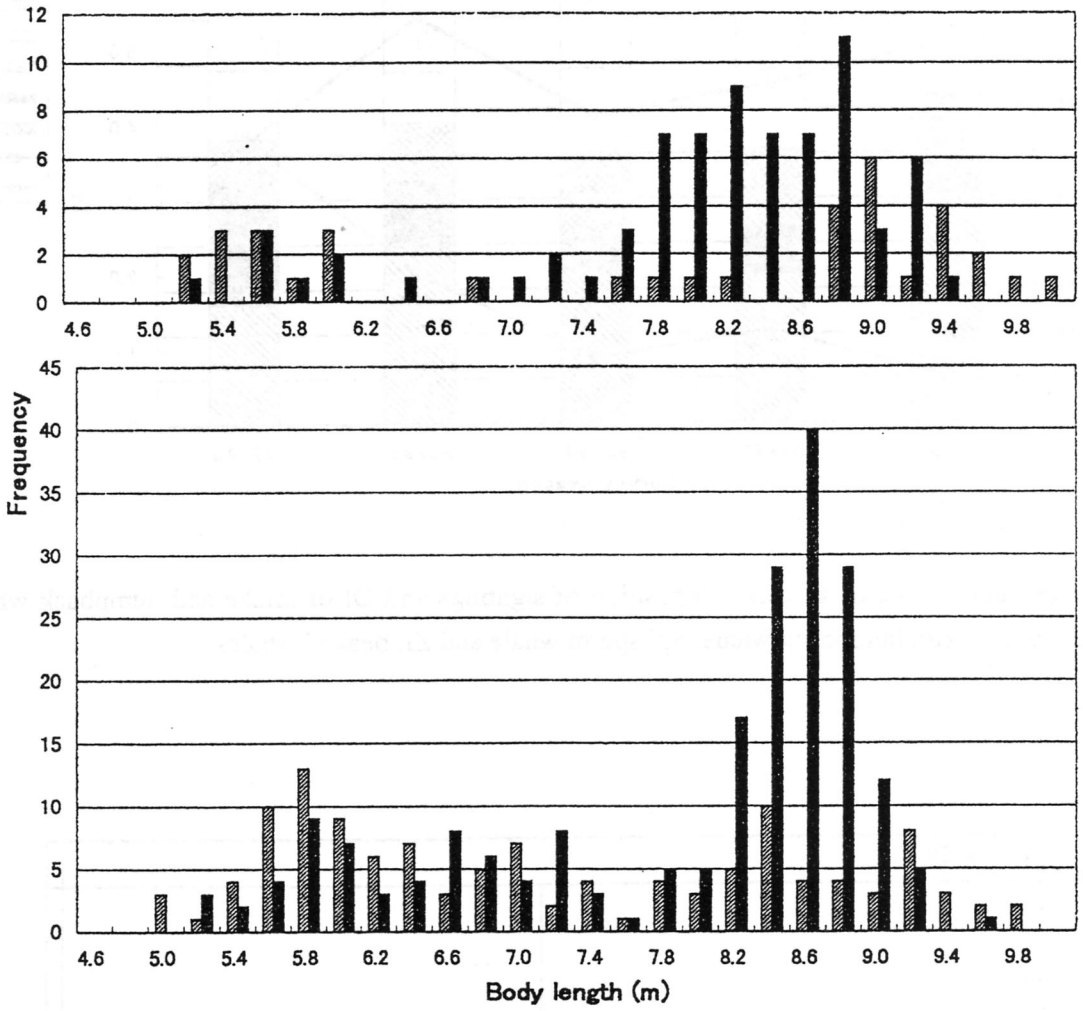

Fig. 7. Body length compositions (20 cm intervals) by sex and Area. Solid and hatched lines represent males and females, respectively. Upper: Area IIIE, lower: Area IV.

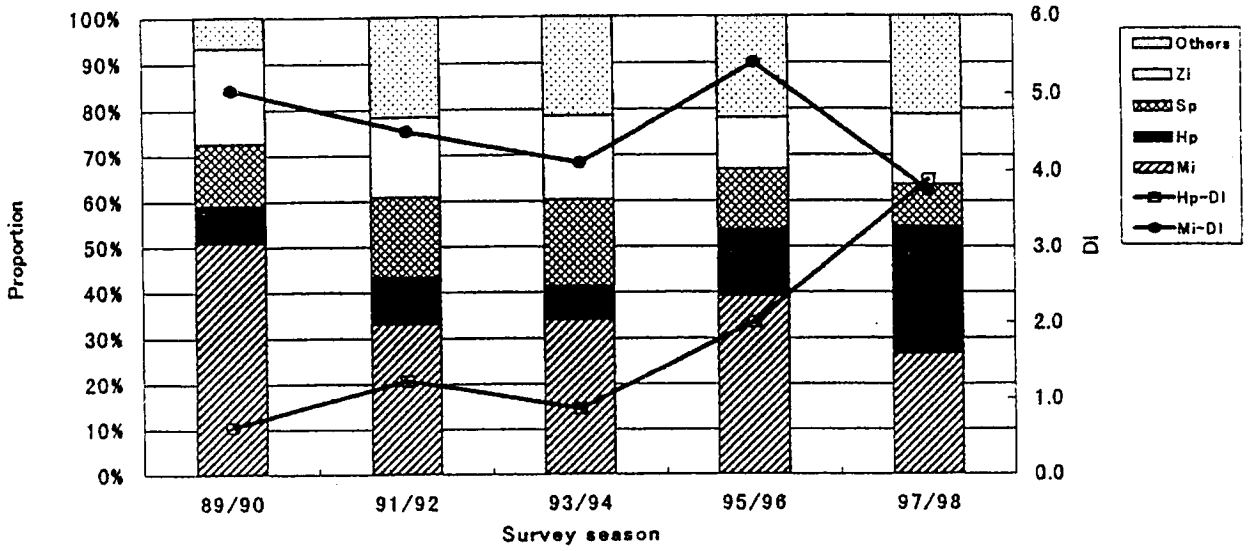

Fig. 8. Seasonal change of species composition of sightings and DI of minke and humpback whales. Mi: minke whale, Hp: humpback whale, Sp: sperm whale and Zi: beaked whales.

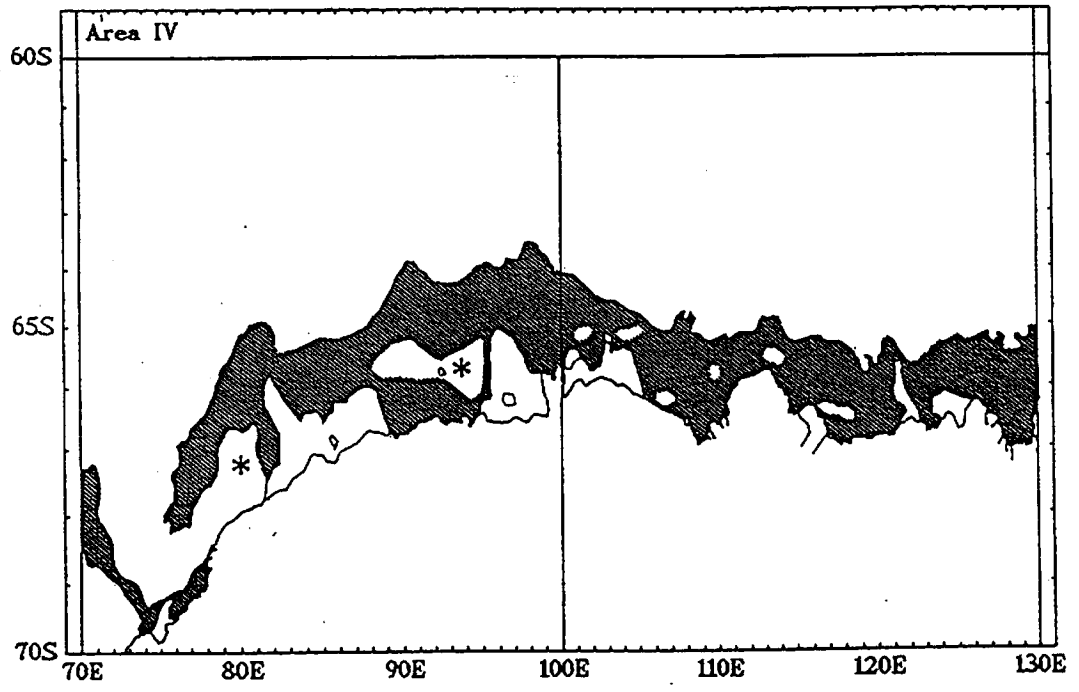

Fig. 9. Ice condition during the survey of the East-south stratum and Prydz Bay in 1995/96 JARPA estimated from the NIC (former JIC) information and the observation of the research vessels. Note the difference of ice free area from 1997/98 survey (Fig. 2, asterisks).