Cruise Report of the Japanese Whale Research Program under Special Permit in the Antarctic (JARPA) Area IV and Eastern Part of Area III in 2001/2002

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ABSTRACT

The fifteenth 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 29 November 2001 to 9 March 2002. One sighting vessel (SV), three sighting and sampling vessels (SSVs) and one research base ship were engaged in the research. The SV covered 5,970.2 nautical miles of searching distance and made primary sightings of 745 schools / 1,751 individual of Antarctic minke whales *Balaenoptera bonaerensis*. Three SSVs searched a total of 13,797.2 n. miles and sighted 1,122 schools / 2,623 individual of Antarctic minke whales as primary sightings. Antarctic minke whale was the most dominant species and followed by humpback whale *Megaptera novaeangliae*. Antarctic minke whale occurred in extremely high density in the East-south stratum and the Prydz Bay in Area IV. Sightings of humpback whales were much higher than those of Antarctic minke whales in the north strata and the West-south stratum in Area IV. Distribution of humpback whales showed clear segregation from Antarctic minke whales except for some areas near the ice edge where both species were highly concentrated. The sighting number for Antarctic minke whale was a match with the highest record observed in the previous research in Areas IIIE and IV. The sighting number for both humpback whale and fin whale was higher than the past JARPA survey records. The recent increase of humpback whales may result in inter species competition with Antarctic minke whale. A total of 493 Antarctic minke whales was targeted for sampling resulting in the catch of 440 individuals (110 from Area IIIE and 330 from Area IV). A total of 52 biopsy samples was obtained from humpback, blue, fin and right whales by the SV and SSVs. The SV conducted an oceanographic survey using a passive acoustic system, Electric Particle Counting and Sizing System (EPCS), CTD and XCTD. One of the SSVs also conducted an oceanographic survey using EPCS.

KEYWORDS: JARPA, CRUISE REPORT, ANTARCTIC MINKE WHALE, HUMPBACK WHALE

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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 authorized by the Government of Japan and planned 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, 1987a, 1987b, 1989, 1995). The original objective of the expansion to the eastern part of Area III (Area IIIE) in 1995/96 season was a feasibility study on stock identification to examine the hypothesis of the occurrence of more than one stock in Areas IV and V (Government of Japan, 1995). Initial study of mitochondrial DNA (mtDNA) analyses suggested that the core stock (C stock) widely distributed in Areas IV and V and a different stock (W stock) occurred in 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 mtDNA analyses using the sample from recent JARPA was the reverse to what was anticipated, as the samples from Area IIIE and Area IVW in the early period were not W stock (Pastene and Goto, 1997, 1999, Pastene *et al.*, 2001). Although these results are consistent with the view that different stocks interact in the western part of Area IV, it seems their distribution pattern could change both within and between years. Further sampling in the expanded area was required to elucidate yearly variation of the stock distribution pattern.

The research plan for the 2001/2002 JARPA was submitted to the 53rd Annual Meeting of the International Whaling Commission and the Scientific Committee (IWC/ SC) meeting (Government of Japan, 2001). As in the past, the objectives of the research were as follows; 1) estimation of biological parameters of minke whale stock, 2) elucidation of the role of whales in the Antarctic ecosystem, 3) elucidation of the effect of environmental changes on cetaceans, and 4) elucidation of the stock structure of the Southern Hemisphere minke whales to improve the stock management.

This paper reports on the fifteenth cruise of the JARPA, which was conducted from 29 November 2001 to 9 March 2002 in the Antarctic Area IV and Area IIIE.

RESEARCH METHODS

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 northern boundary of Area IIIE in the first period was expanded to 58°S to increase the number of samples apart from the ice edge in the early period of feeding season. 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 ice edge to a locus 45 n. miles, and a north stratum extending from the northern boundary of the south stratum to the 60°S. As the north strata were surveyed prior to the south strata, the southern boundary of the north strata was set at estimated latitude expecting a retreat of the ice edge at the time of the survey of the south strata. The southern boundary of the West-south stratum between 70°E and 80°E was fixed at 66°S and Prydz Bay was defined as the southern area of this boundary. The survey of each stratum in Area IV was conducted in the order of West-north, East-north, East-south, West-south and Prydz Bay. Area IIIE was surveyed twice, before and after the survey of Area IV to compare seasonal change of whale distribution. Area IIIE in the first period was divided northern and southern strata at the 60°S to collect Antarctic minke whale migrating off shore in the early feeding season. Area IIIE in the

second period was also divided into two strata with boundary from the pack ice edge to a locus 60 n. miles.

Research vessels

Three vessels, *Kyo Maru No.1* (K01; 812.08 GT), *Toshi Maru No.25* (T25; 739.92 GT) and *Yushin Maru* (YS1; 720 GT) were engaged in sighting and sampling surveys (the sighting and sampling vessels; SSVs). *Nisshin Maru* (NM; 7,575GT) served as a research base on which all biological examinations of collected samples were conducted. *Kyoshin Maru No.2* (KS2; 368 GT) was dedicated to sighting survey from which most of the experiments were conducted (the sighting vessel; SV).

Cruise track line and sighting and sampling method

Fig. 2 shows the track line of the SV and SSVs. The method for establishment of the cruise track line in Area IV was the same as for previous surveys (Nishiwaki *et al.* 1996, Ishikawa *et al.* 1998, Ishikawa *et al.* 2000). In Area IIIE, two longitudinal zigzag lines were set in each stratum.

Sighting and sampling procedures were as in the previous JARPA surveys (Ishikawa *et al.* 1998, Ishikawa *et al.* 2000). The sighting survey using SSVs was conducted under limited closing mode (when a sighting of Antarctic minke whale was made on the predetermined track line, the vessel approached it 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 SV was conducted under limited closing mode and passing mode, i.e. even if sighting was made on the predetermined track line, the vessel did not approach the whale directly 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 Antarctic minke whales or whales suspected to be Antarctic minke whales, the SV approached blue whale *Balaenoptera musculus*, right whale *Eubalaena glacialis* and humpback whale for conducting some experiments. The SSVs also occasionally approached these whales for conducting experiments. One Antarctic minke whale was sampled randomly from each primary sighted school within 3 n. miles of the track line. The dwarf form minke whale was not a target species for sampling.

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 exclusive economic zones (Fig. 1). The results of these surveys are not included in this report.

Experiments

Following experiments were conducted.

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 in this cruise. Observers on each vessel were required to assess eight sets of angles and distance from two platforms (barrel and upper bridge). All trials were conducted under good sighting condition.

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 these species were also taken from the SSVs occasionally.

Biopsy sampling

The species targeted for photo-identification experiments and fin whale *Balaenoptera physalus* were also targeted for biopsy skin sampling using a crossbow or an air gun developed by ICR (Kasamatsu *et al*, 1991). All collected sample were preserved at – 80°C

Acoustics

SV conducted acoustic monitoring of baleen whale species using a retrievable sonobuoy system (Matsuoka *et al.*, 2000).

Oceanographic survey

SV conducted the following oceanographic survey; 1) hydro-acoustic survey using a passive acoustic system (EK500 38kHz, 120kHz, 200kHz, SIMRAD, Norway) to elucidate distribution and abundance of prey species of Antarctic whales, 2) consecutive measuring of surface water temperature, conductivity, surface chlorophyll, dissolved oxygen, surface particle and surface flow by Electric Particle Counting and Sizing System (EPCS), 3) XCTD and CTD survey and 4) marine debris recording in the research area. YS1 also conducted EPCS survey. All marine debris found in the stomach of Antarctic minke whales was recorded and collected on NM.

Biological research

Biological research on all sampled whales was conducted on NM.

OUTLINE OF THE RESEARCH ACTIVITIES

An outline of the research activities conducted during the 2001 /2002 JARPA survey is as follows.

Event	Date	Vessels
Departure from Japan	6 November 2001	NM, SV and SSVs
Sighting survey in transit area.	21 November - 27 November 2001	SV and SSVs
Sighting and sampling survey in Area IIIE (First period)	29 November - 24 December 2001 29 November - 25 December 2001	SV SSVs
Sighting and sampling survey in the West-north stratum in Area IV	25 December 2001 - 8 January 2002 26 December 2001 -10 January 2002	SV SSVs
Sighting and sampling survey in the East-north stratum in Area IV	9 January - 25 January 2002 11 January - 26 January 2002	SV SSVs
Sighting and sampling survey in the East-south stratum in Area IV	26 January - 8 February 2002 27 January - 11 February 2002	SV SSVs
Sighting and sampling survey in the West-south stratum in Area IV	10 February - 21 February 2002 27 February 2002 12 February - 22 February 2002	SV SV* SSVs
Sighting and sampling survey in the Prydz Bay	22 February - 27 February 2002 23 February - 27 February 2002	SV* SSVs
Sighting and sampling survey in Area IIIE (Second period)	28 February - 8 March 2002 28 February - 8 March 2002	SV* SSVs
Sighting survey in transit area.	9 March - 18 March 2002	SV and SSVs
Arrival at Japan	4 April	NM, SV and SSVs

*One SSV was allocated SV position after completion of sampling survey in each Area IV and Area IIIE.

RESULTS

Searching effort

Table 1 shows the searching distances (n. miles) by each stratum. The SV covered 5,970.2 n. miles and the three SSVs covered an average of 4,599.1 n. miles each. Total searching distance of one SV and three SSVs was 19,767.4 n. miles (Area IIIE; 7,211.5, Area IV; 12,555.9). As some SSVs were allocated to the sighting survey of un-surveyed area after the sampling survey in each Area was completed, data obtained in such case was regarded as SV activity. Total searching distance in Area IIIE increased in comparison with previous research as the second survey of Area IIIE was canceled in that time. The SV conducted passing mode searching (NSP) for eight hours a day. The ratio of NSP was 66.7 % of total searching distance of the SV. The searching distance of SSVs was divided into searching survey with sampling operation (NSC/ NSH) and that without sampling operation (ASP). The ratio of ASP was 25.9 % of total searching distance of the SSVs.

Species sighted

Tables 2a and 2b summarize the sightings made. Antarctic minke whale was the most dominant species followed by humpback whale in both Areas IIIE and IV. No dwarf minke whale was sighted in the whole research area. Total primary sightings of Antarctic minke whales involved 1,867 schools / 4,374 individuals, whereas those of humpback whales involved 1,219 schools / 2,387 individuals. In Area IV, Antarctic minke whale was abundant in southern area, especially in the East-south stratum and Prydz Bay (Fig. 3). Most of the primary sightings in Prydz Bay were Antarctic minke whales (96.7%). Distribution of Antarctic minke whales in Area IIIE was concentrated near pack ice and sightings of Antarctic minke whales in the northern stratum were few (Fig. 3). On the other hand, humpback whale was highly abundant in northern area in both Areas IIIE and IV (Fig. 4). Sightings of humpback whales overwhelmed those of Antarctic minke whales in the north strata and even in the West-south stratum in Area IV. They were concentrated especially in the middle of Area IV between 90°E – 110°E. Distribution of humpback whales in Area IIIE and the north strata of Area IV showed clear separation from Antarctic minke whales. However, it was also observed that both species were highly concentrated in the same area when humpback whales distributed near the pack ice. No humpback whale was seen in the Prydz Bay (Fig. 5, color page).

Table 3 shows density indices (DI: schools sighted / 100 n. miles searching distance) and mean school size (MSS) of Antarctic minke whale and humpback whale in each stratum. Although the DI of Antarctic minke whale was relatively low in the north strata, it increased dramatically in the south strata to a level 2-10 times higher than in the north strata. The DI in the Prydz Bay marked the highest value among all strata. The MSS of Antarctic minke whale was relatively low in southern strata and Prydz Bay in spite of high value of DI. The DI of humpback whale was the highest in the West-south stratum where DI of Antarctic minke whale was also high. In Area IIIE, the DI of both minke and humpback whales in southern stratum increased in the second period compared with the first period, while DI of both species showed a little difference in northern stratum between the two periods.

A total of 17 schools / 26 individual blue whales, 143 schools / 983 individual fin whales and 15 schools / 22 individual right whales were primarily sighted. Sightings of blue whales occurred mainly in northern area between 55°E - 80°E. Fin whales occasionally formed large groups in western part of the West-south stratum and Area IIIE in the second period. Such groups of fin whale were observed in some limited waters and there were few other baleen whales. Most of sightings of right whales occurred in eastern part of the West-south stratum where both minke and humpback whales were also abundant (Fig. 6).

Sperm whale and beaked whales were the most abundant toothed whales. Many sightings of sperm whales were made off eastern mouth of the Prydz Bay in Area IV (62°30'S-65°30'S, 79°E-84°E). Killer whales were frequently observed

where sightings of Antarctic minke whales were concentrated (no figure).

Sampling of Antarctic minke whale

Out of 1,122 schools / 2,623 individual Antarctic minke whales sighted by the SSVs, 493 individuals were targeted for sampling. A total of 440 individuals was collected (110 from Area IIIE, 330 from Area IV, see Fig. 7). Technical sampling efficiency (the rate of sampling for targeted individuals) was 0.89. Out of 53 cases of sampling failure, the most frequent reason was an escape of targeted whale into pack ice (12 cases). Struck and lost also occurred in 12 cases.

Special attention to reduce the time to death was given to all targeted and sampled whales. Explosive harpoons were used for all targeted whales as the primary killing method. A large caliber rifle was used as the secondary killing method when required.

Experiments

A sighting distance and angle experiment was performed on 2 January by the SV and SSVs. The results of this experiment will be used in calculating abundance estimates.

Table 4a summarizes the results of photo-ID, biopsy sampling and acoustic monitoring. A total of 118 individuals from humpback, blue, and right whales were photographed and 52 biopsy samples were collected from those whales and fin whales. Acoustic record was obtained for a total of 175 minutes from a school of six humpback whales.

Table 4b summarizes the results of the oceanographic and hydro-acoustic surveys. XCTD and CTD surveys were conducted at 138 and 52 locations respectively in all research areas. EPCS surveys and hydro-acoustic surveys were also conducted in the all research areas.

The marine debris survey was carried out concomitant with the sighting survey of the SV in all research areas. A plastic buoy and a steel oil drum were confirmed. A small stone and a feather of a seabird were also found in the third compartment of the stomach of Antarctic minke whales sampled near the Antarctic continent during the biological research.

Biological research

Table 5 summarizes data and samples collected. These data and samples will be analyzed for the purposes of JARPA and some will be used for collaborative study in various fields such as histology, physiology, embryology, pharmacology, pathology and reproductive physiology.

A severe pneumonia case was found during the biological research. The whale (sample number 431) was an immature female with body length of 8.37 m and body weight of 5.55 t. A gross anatomy revealed a purulent pneumonia and pleuritis, while a sepsis was not observed. According to the sighting record of the whale, it was found as a solitary school and no abnormal behavior was observed but it was very easy to take. Though this whale was the largest immature female in this research (Table 7), it was unclear whether this was related to the disease or not.

Mark recapture (Discovery tag)

Two discovery tags (No. 43924 and No. 39415) were recovered from a whale during the biological research on 31 January 2002. The whale was sighted as a solitary school at 66°37'S, 120°47'E (East-south stratum in Area IV). This whale (sample number 250) was a pregnant female with body length of 8.94 m and body weight of 7.70 t. Fetal body length was 46.3cm. Two tags were found in right dorsal muscles and in left caudal muscles, respectively. The former was enveloped by tight connective tissue. According to the National Research Institute of Far Seas Fisheries, Shimizu, Japan, these two tags were marked at the same occasion on a whale estimated 27 feet in length. They were marked from a sighting vessel *Vdumchivyi No. 34* that was dedicated to IDCR. The marking date was 7 January 1981 and position

was 65°15'S, 134°24'E. Although the time from marking to recapture was 21 years, the distance between marking and recapture was only 344 n. miles.

Products

All the whales collected were processed on NM after biological sampling was completed according to the provisions of Article VIII of the Convention. A total of 1,937 tons of meat, blubber, viscera, etc. was produced.

Preliminary analyses of biological information

Sex ratio and reproductive status

Table 6 and Fig. 7 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 as immature. Maturity of females was determined by existence of corpus luteum or albicans on ovaries.

Mature females were dominant in the East-south stratum (50.9 %) and Prydz Bay (76.0 %), whereas mature males were dominant in the East-north stratum (41.3 %), West-south stratum (44.3 %) in Area IV and the second period of Area IIIE (64.3 %). In the West-north stratum in Area IV, maturity ratio of both male and female was low (63.6 % in male and 41.7 % in female). No mature female was collected in the second period of Area IIIE. All immature animals were weaned.

Length composition

Fig. 8 shows body length composition of Antarctic minke whales collected in Areas IIIE and IV. Table 7 shows mean body length of Antarctic minke whales collected in each stratum. Maximum length of the sample was 9.33 m for male and 10.22 m for female. Minimum length was 4.87 m and 4.95 m, respectively. Mean body length of females was significantly larger than males in each sexual maturity class (immature; $P=0.098$, mature; $P<0.001$). Mean body length in each sexual maturity class was not significantly different among strata except for immature females (ANOVA). Mean body length of immature females in the East-south stratum was larger than other strata in Area IV and Area IIIE in the second period ($P=0.012$ - 0.0597).

DISCUSSION

The most characteristic result of the present survey is a large number of sightings of Antarctic minke whales and humpback whales. Total sighting number of Antarctic minke whales in the present survey was higher in school number but lower in individual number than those in previous survey in Areas IV and IIIE, 1999/2000 JARPA (1,507 schools and 6,581 individuals). Meanwhile, total sighting number of humpback whales was nearly twice the number of 1999/2000 JARPA (661 schools and 1,269 individuals) and marked the largest record in the history of JARPA (see Ishikawa *et al.* 2000).

Distribution patterns of sightings of these two species were similar to the previous survey in Areas IV and IIIE. Sightings of Antarctic minke whales in the Area IIIE concentrated near ice edge and a large number of Antarctic minke whales were observed in the East-south stratum and in the Prydz Bay in Area IV. Maturity rate of female was high in those strata. On the other hand, most of sightings of humpback whales concentrated off the ice edge or the Antarctic continent, and showed clear separation from where sightings of Antarctic minke whales were abundant (Fig. 5). However, when humpback whales were also abundant near the ice edge, many schools of the two species were found together. As large number of fin whales was also sighted in some restricted small waters (Fig. 6), it seems these rorqual

schools tend to gather by same species.

Fig. 9 shows yearly change of species composition of sightings and DI of Antarctic minke and humpback whales in Area IV. The composition ratio and DI of humpback whale have been increasing especially from 1995/96 JARPA, while those of Antarctic minke whales did not change until 1999/2000 JARPA. The DI of humpback whale increased from 0.63 (1989/90 JARPA) to 7.70 (present survey) during 12 years. Matsuoka *et al.* (2001) estimated population and annual rate for increase humpback whales in Area IV using the latest JARPA sighting data and showed 12,093 (CV=0.29) and 17.2 % (CV=0.29), respectively. The estimated population was 3.5 times higher than that obtained from 1988/89 IWC/IDCR sighting data (Brown and Butterworth, 1999). These data therefore confirm an increase of humpback whales.

It appears that large number of sightings of Antarctic minke whales in recent two surveys in Area IV is due to fast retreat of the ice edge and relatively good weather during the research period (Ishikawa *et al.* 2000). As we surveyed the south strata in Area IV after the retreat of the ice edge, the possible existence of a large number of Antarctic minke whales beyond the pack ice where sighting vessels could not go inside may have decreased. Therefore recent increases of sightings have occurred near the ice edge.

In the West-south strata in Area IV and Area IIIE in the second period, it was often observed that Antarctic minke whales concentrated along the ice edge (or the continent) were separated from a large number of humpback whales just a short distance away from the ice edge (Fig. 5). As both minke whales and humpback whales tend to gather by the same species and separate from the other species, it seems that the recent increase of humpback whales might force Antarctic minke whales to concentrate near the ice edge.

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

Stratum	SV			SSVs			Grand Total
	Passing mode (NSP)	Closing mode (ASP)	Total	Sampling survey (NSC,NSH)	Sighting survey (ASP)	Total	
Area IIIE	**1,040.3**	**1,061.2**	**2,101.5**	**3,717.6**	**1,392.4**	**5,110.0**	**7,211.5**
First Period	665.6	421.5	1,087.1	3,492.1	243.7	3,735.8	4,822.9
Northern stratum	239.4	163.6	403.0	1,533.0	0.0	1,533.0	1,936.0
Southern stratum	426.2	257.9	684.1	1,959.1	243.7	2,202.8	2,886.9
Second Period	374.7	639.7	1,014.4	225.5	1,148.7	1,374.2	2,388.6
Northern stratum	0.0	551.1	551.1				551.1
Southern stratum	374.7	88.6	463.3	225.5	1,148.7	1,374.2	1,837.5
Area IV	**2,938.9**	**929.8**	**3,868.7**	**6,500.7**	**2,186.5**	**8,687.2**	**12,555.9**
East-North	810.5	211.0	1,021.5	2,062.1	188.0	2,250.1	3,271.6
East-South	636.5	197.1	833.6	1,123.9	927.7	2,051.6	2,885.2
West-North	507.2	189.5	696.7	2,333.1	13.8	2,346.9	3,043.6
West-South	652.8	198.5	851.3	897.8	572.7	1,470.5	2,321.8
Prydz Bay	331.9	133.7	465.6	83.8	484.3	568.1	1,033.7
Grand Total	**3,979.2**	**1,991.0**	**5,970.2**	**10,218.3**	**3,578.9**	**13,797.2**	**19,767.4**

Table 2a. Summary of sightings (no. schools / no. individual) conducted by SV and SSVs in Area IV. Secondary sightings during transit between areas (18 schools/ 32 individual of minke whales, 1 school / 1 individual of humpback whale and 3 schools / 21 individual of killer whales) were excluded.

	SV				SSV			
	West Sector		East Sector		West Sector		East Sector	
Species	Primary Sch. / Ind.	Secondary Sch. / Ind.	Primary Sch. / Ind.	Secondary Sch. / Ind.	Primary Sch. / Ind.	Secondary Sch. / Ind.	Primary Sch. / Ind.	Secondary Sch. / Ind.
Northern Stratum								
Antarctic minke whale	16 / 29	5 / 7	44 / 79	51 / 150	87 / 119	6 / 8	149 / 302	26 / 51
Like Antarctic minke whale	2 / 2	-	1 / 1	-	1 / 2		2 / 2	-
Blue whale	4 / 8	-	-	-	2 / 4	1 / 2	1 / 1	-
Fin whale	10 / 25	2 / 6	3 / 7	-	14 / 36	3 / 7	12 / 44	3 / 20
Sei whale	-	-	-	-	-	-	1 / 2	-
Right whale	-	-	-	-	-	-	1 / 2	-
Humpback whale	57 / 100	14 / 29	58 / 84	18 / 32	202 / 403	18 / 35	189 / 349	16 / 34
Unidentified baleen whales	17 / 28	3 / 4	15 / 16	2 / 2	6 / 11	4 / 8	3 / 4	1 / 3
Sperm whale	13 / 13	5 / 5	6 / 6	-	43 / 43	4 / 4	35 / 35	1 / 1
Southern bottlenose whale	13 / 17	1 / 2	7 / 10	1 / 2	18 / 28	-	17 / 29	-
Mesoplodon spp.	-	-	-	-	-	-	3 / 6	-
Unidentified beaked whales	4 / 6	-	5 / 6	-	14 / 17	-	28 / 40	1 / 1
Killer whale	4 / 35	-	1 / 6	-	5 / 49	-	9 / 120	-
Long-finned pilot whale	2 / 50	3 / 93	-	-	-	-	4 / 103	-
Unidentified pilot whales	-	-	-	-	2 / 55	-	2 / 110	-
Hourglass dolphin	1 / 13	-	-	-	-	-	-	1 / 3
Unidentified whales	3 / 3	-	6 / 6	-	31 / 31	-	29 / 29	-
Southern Stratum								
Antarctic minke whale	126 / 256	51 / 80	192 / 412	60 / 171	103 / 176	8 / 11	282 / 573	30 / 61
Like Antarctic minke whale	5 / 7	-	2 / 3	1 / 1	1 / 1	-	2 / 2	-
Blue whale	-	-	1 / 1	-	2 / 2	-	-	-
Fin whale	36 / 439	3 / 24	1 / 1	-	23 / 155	8 / 38	1 / 1	-
Right whale	1 / 1	/	-	-	11 / 17	4 / 5	-	1 / 1
Humpback whale	127 / 290	22 / 39	11 / 16	4 / 6	270 / 520	7 / 16	53 / 91	6 / 10
Unidentified baleen whales	17 / 26	-	1 / 1	1 / 2	-	2 / 13	1 / 1	-
Sperm whale	27 / 27	6 / 6	3 / 3	-	48 / 50	3 / 3	29 / 29	1 / 2
Arnoux's beaked whale	-	1 / 4	-	-	-	-	-	-
Southern bottlenose whale	2 / 3	1 / 3	1 / 2	-	6 / 13	-	4 / 10	-
Unidentified beaked whales	-	-	-	-	7 / 12	-	9 / 14	-
Killer whale	7 / 41	1 / 30	7 / 100	6 / 61	13 / 132	-	15 / 184	2 / 35
Unidentified whales	9 / 10	1 / 1	1 / 1	-	13 / 13	-	29 / 29	-
Prydz Bay								
Antarctic minke whale	230 / 603	44 / 94	-	-	209 / 643	5 / 18	-	-
Like Antarctic minke whale	-	-	-	-	2 / 2	-	-	-
Unidentified baleen whales	1 / 4	2 / 2	-	-	-	-	-	-
Killer whale	7 / 111	1 / 10	-	-	5 / 67	-	-	-
Unidentified whales	-	1 / 1	-	-	-	-	-	-

Table 2b. Summary of sightings (no. schools / no. individual) conducted by SV and SSVs in Area IIIE.

	SV				SSV			
	Northern Stratum		Southern Stratum		Northern Stratum		Southern Stratum	
Species	Primary Sch. / Ind.	Secondary Sch. / Ind.	Primary Sch. / Ind.	Secondary Sch. / Ind.	Primary Sch. / Ind.	Secondary Sch. / Ind.	Primary Sch. / Ind.	Secondary Sch. / Ind.
First Period								
Antarctic minke whale	2 / 3	1 / 1	41 / 112	30 / 50	7 / 9	-	141 / 403	21 / 104
Like Antarctic minke whale	2 / 2	-	4 / 4	3 / 3	1 / 1	-	2 / 2	1 / 8
Blue whale	1 / 1	1 / 1	-	-	1 / 1	-	-	1 / 1
Fin whale	2 / 5	3 / 16	10 / 18	7 / 12	6 / 12	3 / 13	7 / 16	1 / 2
Right whale	-	-	-	-	1 / 1	-	-	-
Humpback whale	18 / 36	4 / 7	3 / 5	6 / 10	50 / 101	7 / 16	31 / 51	5 / 8
Unidentified baleen whales	9 / 13	4 / 5	9 / 18	3 / 3	1 / 1	5 / 12	1 / 1	-
Sperm whale	-	-	6 / 6	3 / 3	6 / 6	-	51 / 52	6 / 6
Southern bottlenose whale	3 / 5	-	12 / 16	-	12 / 29	-	24 / 45	1 / 2
Mesoplodon spp.	1 / 1	-	-	-	-	-	2 / 3	-
Unidentified beaked whales	9 / 12	1 / 1	7 / 8	1 / 1	20 / 29	-	23 / 44	-
Killer whale	-	1 / 3	-	-	3 / 66	-	1 / 12	-
Strap-toothed whale	-	-	-	-	-	-	1 / 3	-
Unidentified whales	7 / 7	-	-	4 / 4	19 / 22	-	29 / 30	-
Second Period								
Antarctic minke whale	3 / 3	-	91 / 254	60 / 237	-	-	144 / 398	6 / 11
Like Antarctic minke whale	-	-	1 / 4	-	-	-	1 / 1	-
Blue whale	3 / 3	1 / 1	-	-	-	-	2 / 5	-
Fin whale	6 / 34	-	7 / 168	-	-	-	5 / 22	1 / 1
Right whale	-	-	-	-	-	-	1 / 1	-
Humpback whale	17 / 31	4 / 10	38 / 107	1 / 6	-	-	95 / 203	4 / 10
Unidentified baleen whales	1 / 1	-	13 / 17	2 / 4	-	-	-	-
Sperm whale	-	-	-	-	-	-	2 / 2	-
Arnoux's beaked whale	-	-	2 / 9	-	-	-	1 / 30	-
Southern bottlenose whale	5 / 12	-	1 / 5	-	-	-	1 / 2	-
Unidentified beaked whales	3 / 6	-	1 / 4	-	-	-	4 / 7	1 / 2
Killer whale	1 / 8	-	-	-	-	-	1 / 8	-
Hourglass dolphin	2 / 40	-	-	-	-	-	-	-
Unidentified whales	-	-	2 / 4	-	-	-	3 / 3	-

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

	Minke Whale						Humpback Whale					
	SV		SSV		Combined		SV		SSV		Combined	
Stratum	DI	MSS	DI	MSS	DI	MSS	DI	MSS	DI	MSS	DI	MSS
Area IIIE	**6.52**	**2.72**	**5.71**	**2.77**	**5.95**	**2.76**	**3.62**	**2.36**	**3.44**	**2.02**	**3.49**	**2.12**
First Period	3.96	2.67	3.96	2.78	3.96	2.76	1.93	1.95	2.17	1.88	2.11	1.89
Northern stratum	0.50	1.50	0.46	1.29	0.46	1.33	4.47	2.00	3.26	2.02	3.51	2.01
Southern stratum	5.99	2.73	6.40	2.86	6.30	2.83	0.44	1.67	1.41	1.65	1.18	1.65
Second Period	9.27	2.73	10.48	2.76	9.96	2.75	5.42	2.51	6.91	2.14	6.28	2.27
Northern stratum	0.54	1.00	—	—	0.54	1.00	3.08	1.82	—	—	3.08	1.82
Southern stratum	19.64	2.79	10.48	2.76	12.79	2.77	8.20	2.82	6.91	2.14	7.24	2.33
Area IV	**15.72**	**2.27**	**9.55**	**2.18**	**11.45**	**2.22**	**6.54**	**1.94**	**8.22**	**1.91**	**7.70**	**1.92**
East-North	4.31	1.80	6.62	2.03	5.90	1.97	5.68	1.45	8.40	1.85	7.55	1.75
East-South	23.03	2.15	13.75	2.03	16.43	2.08	1.32	1.45	2.58	1.72	2.22	1.67
West-North	2.30	1.81	3.71	1.37	3.38	1.44	8.18	1.75	8.61	2.00	8.51	1.94
West-South	14.80	2.03	7.00	1.71	9.86	1.89	14.92	2.28	18.36	1.93	17.10	2.04
Prydz Bay	49.40	2.62	36.79	3.08	42.47	2.84	0.00	0.00	0.00	0.00	0.00	0.00
Combined	**12.48**	**2.35**	**8.13**	**2.34**	**9.44**	**2.34**	**5.51**	**2.03**	**6.45**	**1.93**	**6.17**	**1.96**

Table 4a. Summary of photo-ID, biopsy sampling and acoustic monitoring. B, HP, R, F represent blue, humpback, right, fin whales respectively.

Stratum	SV							SSV						
	Photo-ID			Biopsy			Acoustic Monitoring	Photo-ID			Biopsy			
	number of individuals			number of samples			minutes	number of individuals			number of samples			
	B	HP	R	F	HP	R	HP	B	HP	R	B	F	HP	R
Area IIIE	**3**	**20**	**0**	**0**	**9**	**0**	**175**	**4**	**8**	**2**	**0**	**0**	**3**	**2**
First Period	2	11			2			1		1				1
Second Period	1	9			7		175	3	8	1			3	1
Northern stratum	1													
Southern stratum		9			7		175	3	8	1			3	1
Area IV	**12**	**22**	**1**	**1**	**10**	**1**	**0**	**5**	**23**	**18**	**1**	**3**	**9**	**13**
East-North	4	3			1			1	4	2			1	1
East-South	1	1			1									
West-North	7	5			1			2						
West-South		13	1	1	7	1		2	19	16	1	3	8	12
Prydz Bay														
Grand Total	**15**	**42**	**1**	**1**	**19**	**1**	**175**	**9**	**31**	**20**	**1**	**3**	**12**	**15**

Table 4b. Summary of oceanographic and hydro-acoustic surveys.

Stratum	CTD	XCTD	EPCS		Scientific Echosounder
	number of stations	number of stations	running days		
			KS2	YS1	logging n.miles
Area IIIE	**26**	**19**	**35**	**35**	**4,296**
First Period	22	18	27	26	3,505
Second Period	4	1	8	9	791
Northern stratum				6	
Southern stratum	4	1	8	3	791
Area IV	**26**	**119**	**61**	**64**	**7,568**
East-North	5	21	17	16	1,972
East-South	4	33	13	16	1,775
West-North	7	24	14	16	1,746
West-South	8	25	11	11	1,443
Prydz Bay	2	16	6	5	632
Grand Total	**52**	**138**	**96**	**99**	**11,864**

Table 5. Summary of biological data and samples collected.

Samples and data	Number of whales		
	Male	Female	Total
-Data-			
Photographic record of external character	201	239	440
Body length and sex identification	201	239	440
Measurement of external body proportion	201	239	440
Body weight	201	238	439
Body weight by total weight of parts	26	43	69
Skull measurement (length and breadth)	199	230	429
Standard measurement of blubber thickness (five points)	175	196	371
Detailed measurement of blubber thickness (fourteen points)	26	43	69
Mammary gland; lactation status and measurement	-	239	239
Breadth measurement of uterine horn	-	239	239
Testis and epididymis weight	201	-	201
Weight of stomach content in each compartment	201	239	440
Photographic record of fetus	68	57	143*
Fetal length and weight	67	57	142*
External measurements of fetus	68**	57	125
Number of ribs	201	239	440
-Sample-			
Diatom film record and sampling	200	239	439
Serum sample for physiological study	199	239	438
Earplug for age determination	201	239	440
Eyeballs for age determination	30	27	57
Tympanic bone for age determination	199	239	438
Largest baleen plate for age determination	47	59	106
Largest baleen plate for morphological study	197	237	434
Vertebral epiphyses sample	201	239	440
Ovary	-	239	239
Histological sample of endometrium	-	239	239
Histological sample of mammary gland	-	239	239
Milk sample for chemical analysis	-	3	3
Histological sample of testis	201	-	201
Histological sample of epididymis	201	-	201
Testis and epididymis stamp smear for sperm detection	201	-	201
Skin, blubber, muscle, liver, kidney and heart tissues for genetic study	201	239	440
Muscle, liver and kidney tissues for heavy metal analysis	201	239	440
Blubber and liver tissues for organochlorine analysis	201	239	440
Muscle, liver and blubber tissues for lipid analysis	26	43	69
Stomach contents for food and feeding study	55	52	107
Stomach contents for heavy metal analysis	11	12	23
Stomach contents for organochlorine analysis	15	8	23
Stomach contents for lipid analysis	8	14	22
External parasites	40	51	91
Internal parasites	5	10	15
Fetus	0	0	18*
Skin, blubber, muscle, liver, kidney and heart tissues of fetus for genetic study	61***	51	112
Oocyte for *in-vitro* fertilization (IVF)	-	207	207
Fetal serum for oocyte culture	30	22	52
Fetal skin for cell culture	2	0	2
Fetal reproductive organ for histological study	37	30	67
Adult testis for immunohistochemical study	20	-	20
Placenta for immunohistochemical study	-	64	64
Adult caudal vertebrae and humerus for histological study	4	4	8
Fetal caudal vertebrae and humerus for histological study	9	7	16

* : including a fetus of sex unidentified.

** : External measurement of a fetus was partly done, as it was broken by harpoon.

*** : One liver sample of fetus could not be collected because of harpoon damage.

Table 6. Reproductive status of Antarctic 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). "Resting" represents non-pregnant mature female without corpus luteum, "Preg+Lac" represents pregnant and lactating female and "Ovulating" represents female that had corpus luteum but fetus was not observed.

Stratum	Male			Female					
	Immature	Mature	Total	Immature	Mature				
					Pregnant	Resting	Preg.+Lac.	Ovulating	Total
Area III East									
First-period	9	25	34	16	27	1	2	2	48
	(11.0)	(30.5)	(41.5)	(19.5)	(32.9)	(1.2)	(2.4)	(2.4)	(58.5)
Second-period	2	18	20	8	0	0	0	0	8
	(7.1)	(64.3)	(71.4)	(28.6)	(0.0)	(0.0)	(0.0)	(0.0)	(28.6)
Combined	11	43	54	24	27	1	2	2	56
	(10.0)	(39.1)	(49.1)	(21.8)	(24.5)	(0.9)	(1.8)	(1.8)	(50.9)
Area IV									
East-North	10	26	36	9	13	1	3	1	27
	(15.9)	(41.3)	(57.1)	(14.3)	(20.6)	(1.6)	(4.8)	(1.6)	(42.9)
East-South	11	24	35	20	55	0	1	1	77
	(9.8)	(21.4)	(31.3)	(17.9)	(49.1)	(0.0)	(0.9)	(0.9)	(68.8)
West-North	12	21	33	21	15	0	0	0	36
	(17.4)	(30.4)	(47.8)	(30.4)	(21.7)	(0.0)	(0.0)	(0.0)	(52.2)
West-South	11	27	38	13	9	1	0	0	23
	(18.0)	(44.3)	(62.3)	(21.3)	(14.8)	(1.6)	(0.0)	(0.0)	(37.7)
Prydz Bay	0	5	5	1	17	1	1	0	20
	(0.0)	(20.0)	(20.0)	(4.0)	(68.0)	(4.0)	(4.0)	(0.0)	(80.0)
Combined	44	103	147	64	109	3	5	2	183
	(13.3)	(31.2)	(44.5)	(19.4)	(33.0)	(0.9)	(1.5)	(0.6)	(55.5)
Grand total	55	146	201	88	136	4	7	4	239
	(12.5)	(33.2)	(45.7)	(20.0)	(30.9)	(0.9)	(1.6)	(0.9)	(54.3)

Table 7. Mean body length (m) with standard deviation and body length range of Antarctic 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	6.64 ± 1.13	8.52 ± 0.39	8.02 ± 1.06	6.87 ± 0.94	8.89 ± 0.43	8.22 ± 1.15
	(5.34 - 8.36)	(7.67 - 9.14)	(5.34 - 9.14)	(5.13 - 8.60)	(7.97 - 9.89)	(5.13 - 9.89)
Second-period	5.72 ± 0.75	8.51 ± 0.31	8.24 ± 0.93	6.57 ± 1.09	—	6.57 ± 1.09
	(5.19 - 6.25)	(7.90 - 8.93)	(5.19 - 8.93)	(5.59 - 8.37)	—	(5.59 - 8.37)
Combined	6.47 ± 1.10	8.52 ± 0.36	8.10 ± 1.01	6.77 ± 0.97	8.89 ± 0.43	7.98 ± 1.28
	(5.19 - 8.36)	(7.67 - 9.14)	(5.19 - 9.14)	(5.13 - 8.60)	(7.97 - 9.89)	(5.13 - 9.89)
Area IV						
East-North	6.68 ± 1.03	8.43 ± 0.47	7.94 ± 1.03	6.74 ± 0.71	9.03 ± 0.37	8.27 ± 1.21
	(5.21 - 8.07)	(7.55 - 9.33)	(5.21 - 9.33)	(5.62 - 7.38)	(8.32 - 9.60)	(5.62 - 9.60)
East-South	6.79 ± 0.77	8.43 ± 0.38	7.91 ± 0.93	7.44 ± 0.86	8.92 ± 0.34	8.53 ± 0.83
	(5.75 - 7.95)	(7.43 - 9.16)	(5.75 - 9.16)	(5.50 - 8.56)	(7.94 - 9.54)	(5.50 - 9.54)
West-North	5.94 ± 0.71	8.51 ± 0.34	7.57 ± 1.35	6.48 ± 0.96	9.09 ± 0.55	7.57 ± 1.54
	(4.87 - 7.28)	(7.93 - 9.09)	(4.87 - 9.09)	(4.95 - 7.97)	(8.11 - 10.22)	(4.95 - 10.22)
West-South	6.81 ± 1.11	8.46 ± 0.31	7.98 ± 0.99	6.37 ± 0.91	8.93 ± 0.40	7.48 ± 1.49
	(4.93 - 7.82)	(7.85 - 9.07)	(4.93 - 9.07)	(5.21 - 7.96)	(8.25 - 9.56)	(5.21 - 9.56)
Prydz Bay	—	8.63 ± 0.25	8.63 ± 0.25	8.28	9.07 ± 0.39	9.03 ± 0.42
	—	(8.37 - 8.94)	(8.37 - 8.94)	—	(8.51 - 9.75)	(8.28 - 9.75)
Combined	6.54 ± 0.96	8.46 ± 0.37	7.89 ± 1.07	6.82 ± 0.99	8.98 ± 0.39	8.23 ± 1.23
	(4.87 - 8.07)	(7.43 - 9.33)	(4.87 - 9.33)	(4.95 - 8.56)	(7.94 - 10.22)	(4.95 - 10.22)
Grand total	6.53 ± 0.98	8.48 ± 0.37	7.94 ± 1.06	6.81 ± 0.98	8.96 ± 0.40	8.17 ± 1.24
	(4.87 - 8.36)	(7.43 - 9.33)	(4.87 - 9.33)	(4.95 - 8.60)	(7.94 - 10.22)	(4.95 - 10.22)

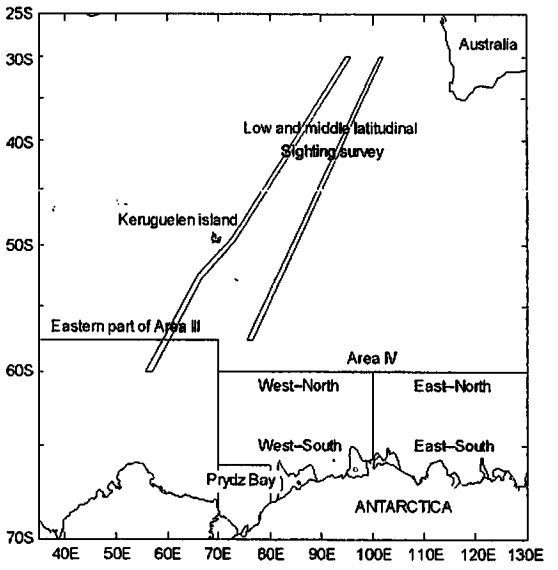

Fig. 1. Geographic location of research area of the 2001/2002 JARPA surveys and cruise tracks of sighting survey between research area and Japan.

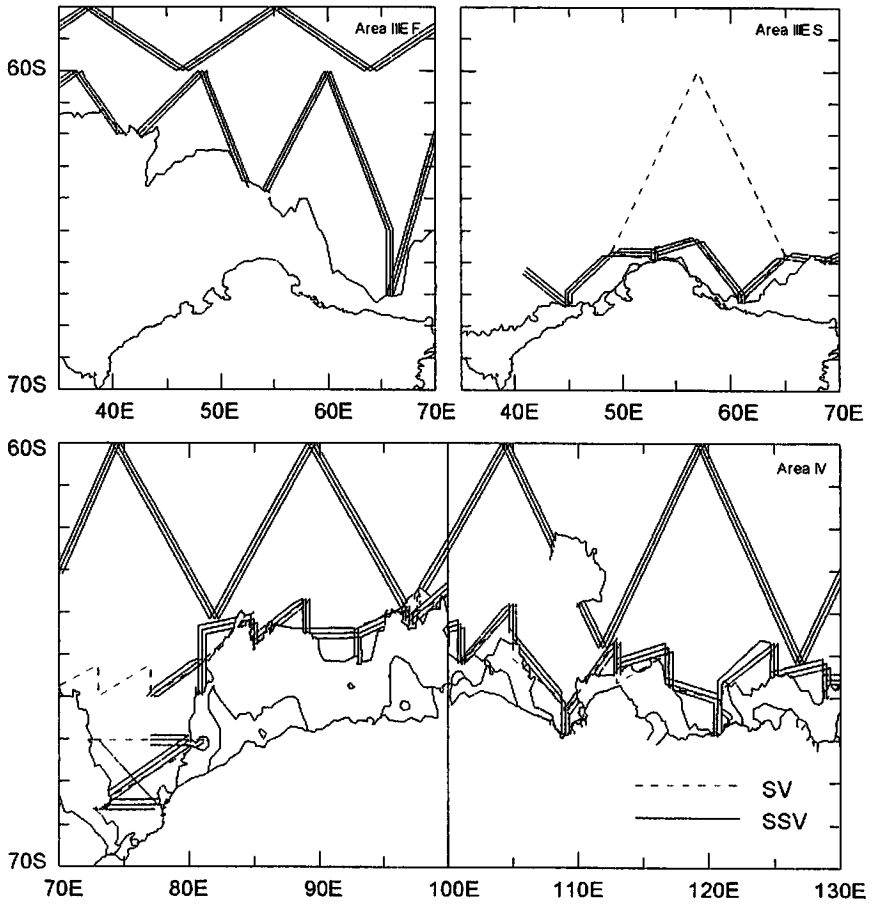

Fig. 2. Cruise track line of sighting vessel (SV, broken line) and sighting/ sampling vessels (SSVs, solid line) in 2001/2002 JARPA. Pack ice lines are estimated by observation of research vessels and the information from National Ice Center (NIC).

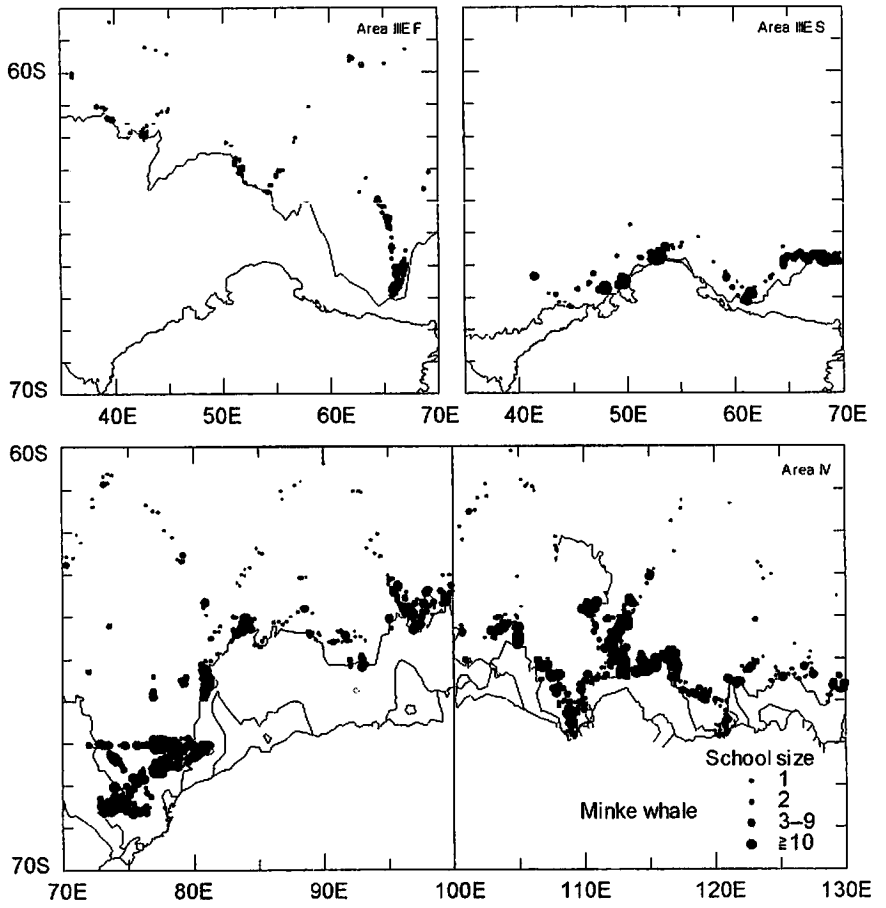

Fig. 3. Distribution of sightings of Antarctic minke whales sighted by SV and SSVs in 2001/2002 JARPA.

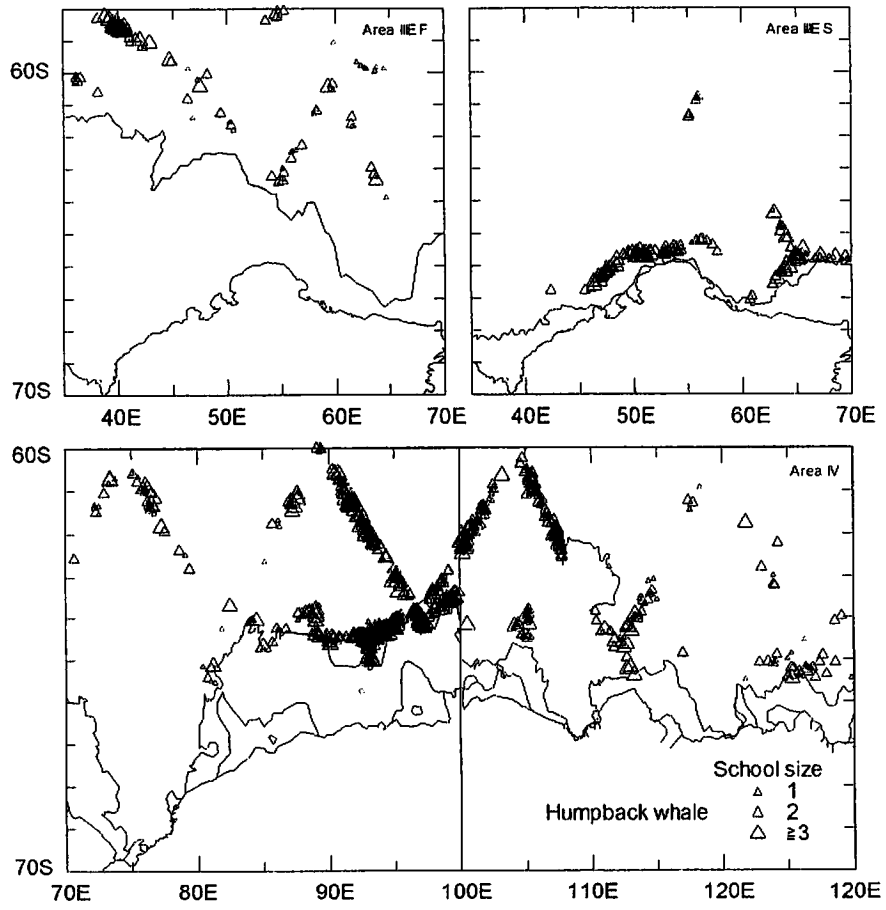

Fig. 4. Distribution of sightings of humpback whales sighted by SV and SSVs in 2001/2002 JARPA.

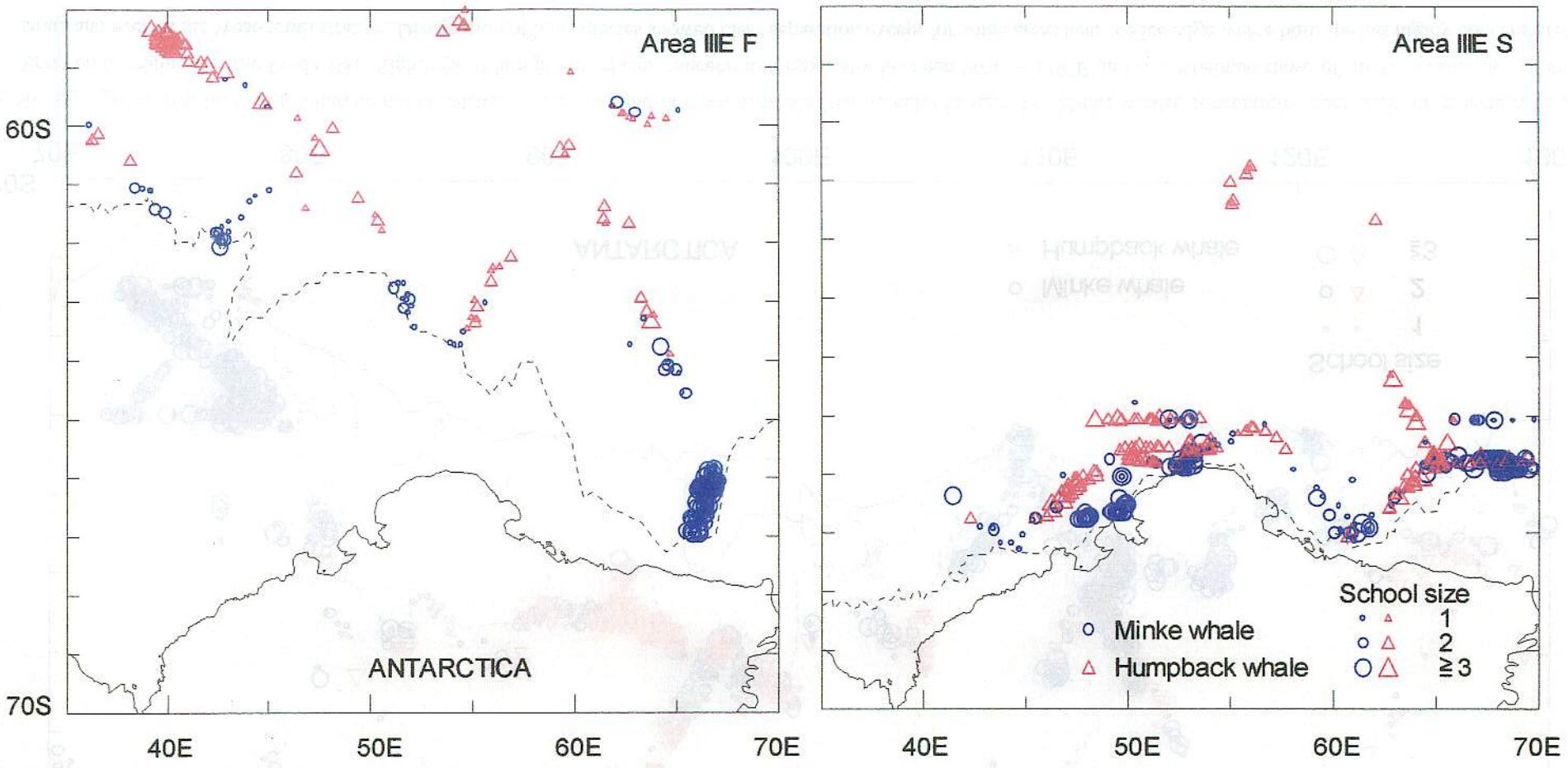

Fig. 5a. Segregative distribution of Antarctic minke whale (blue circle) and humpback whale (red triangle) in Area IIIE. In the first period, humpback whales widely distributed off the ice edge while minke whales concentrated near the ice edge. In the second period, minke whales highly concentrated along the ice edge and humpback whales also concentrated at a few miles off the ice edge.

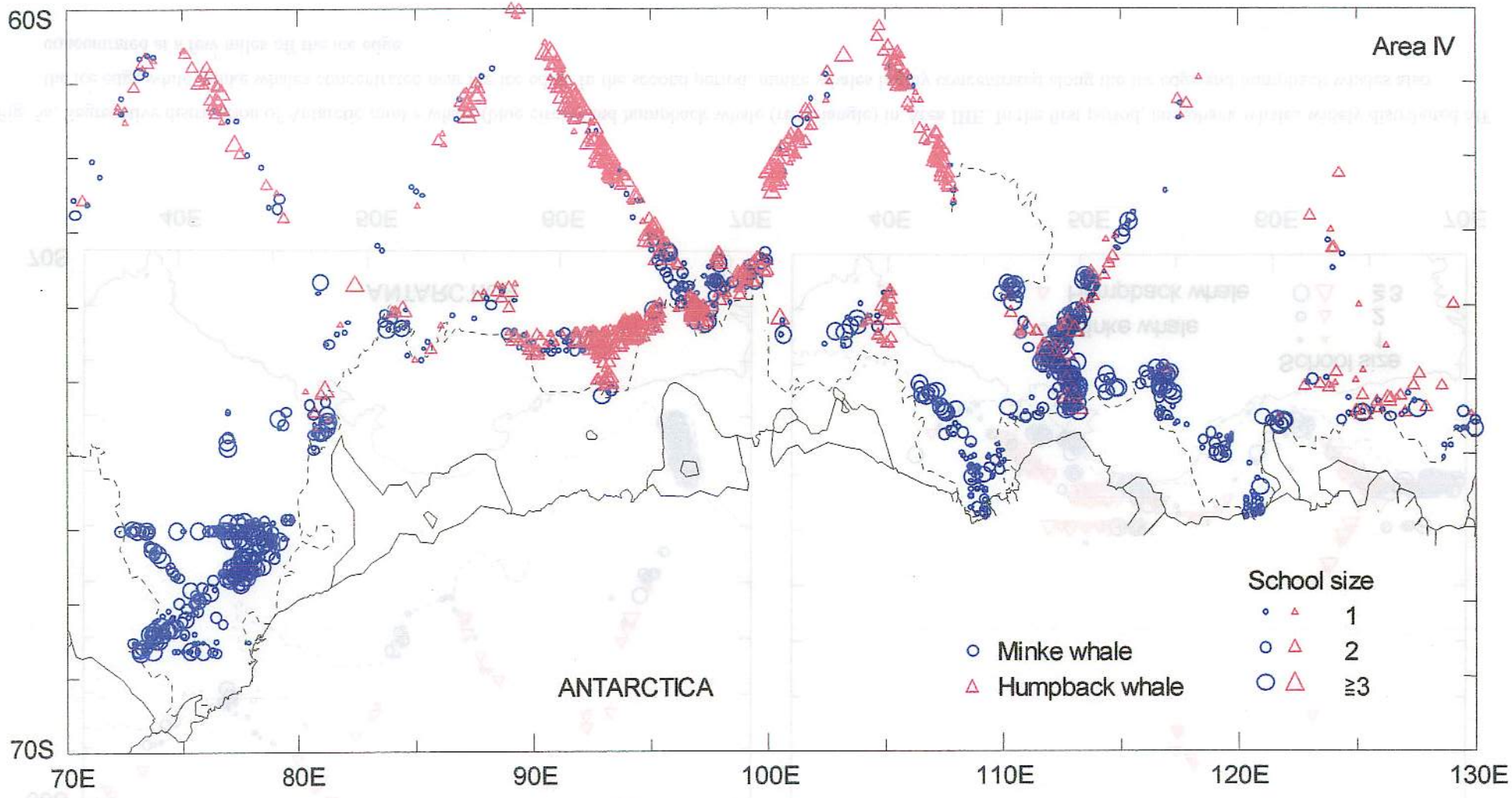

Fig. 5b. Segregative distribution of Antarctic minke whale (blue circle) and humpback whale (red triangle) in Area IV. Minke whales concentrated near pack ice especially in the East-south stratum and the Prydz Bay. Sightings of humpback whales concentrated especially between 90°E – 110°E and overwhelmed those of minke whales in the north strata and even in the West-south stratum. Distribution of both species showed clear separation except for some areas near the ice edge where both species highly concentrated.

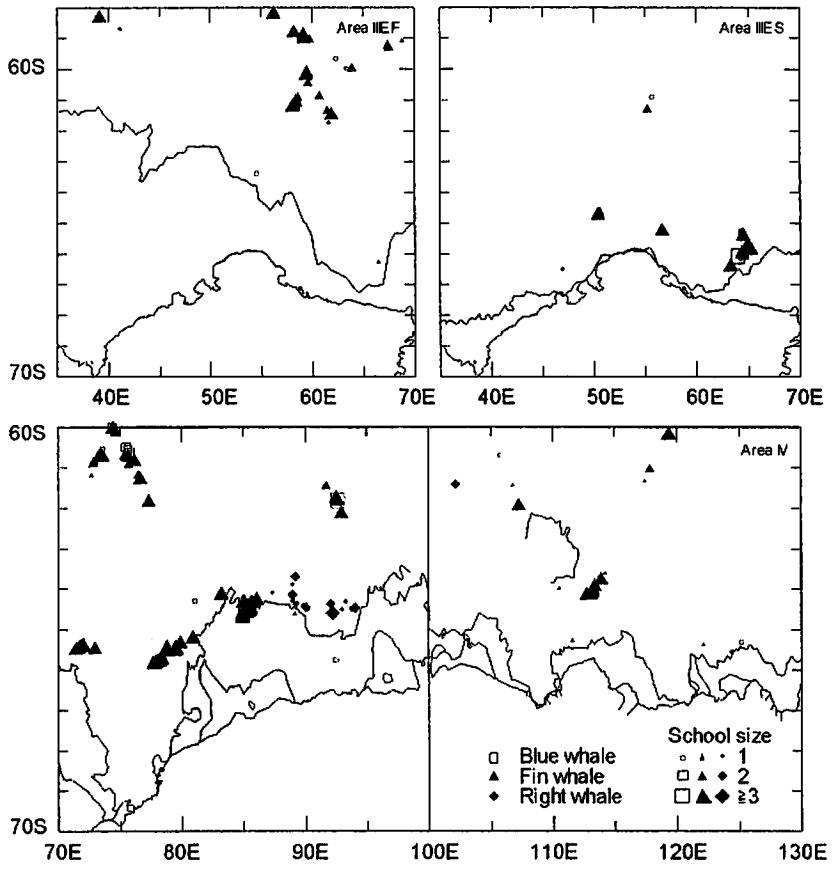

Fig. 6. Distribution of sightings of blue, fin and right whales sighted by SV and SSVs in 2001/2002 JARPA.

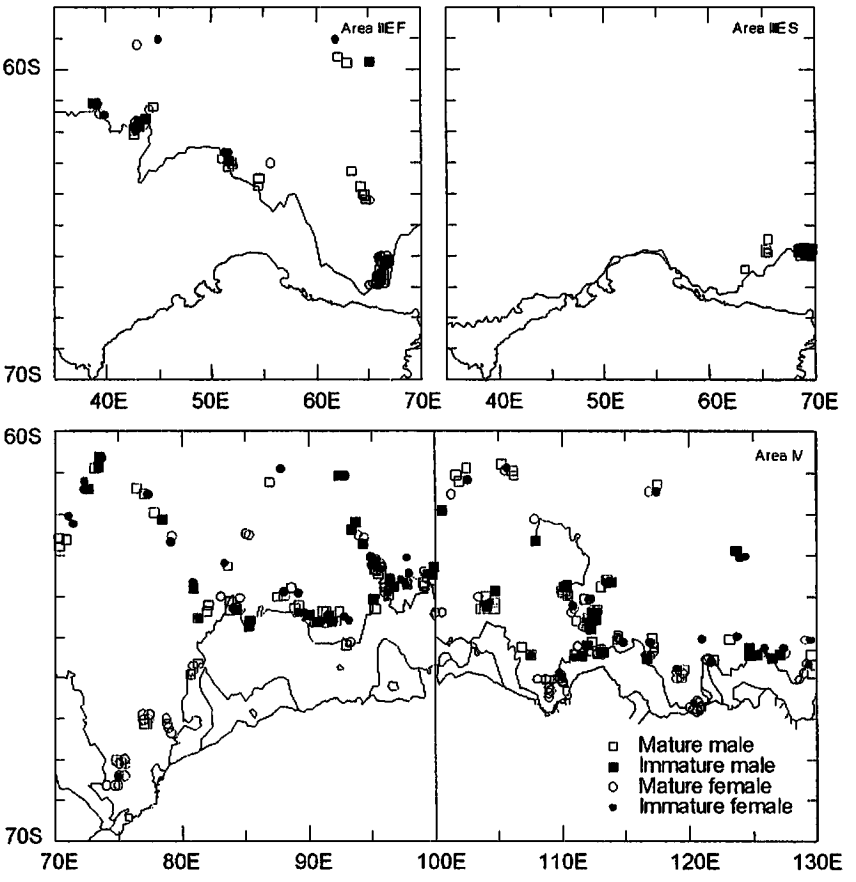

Fig. 7. Sighted position of sampled Antarctic minke whales by sex and reproductive status in 2001/2002 JARPA.

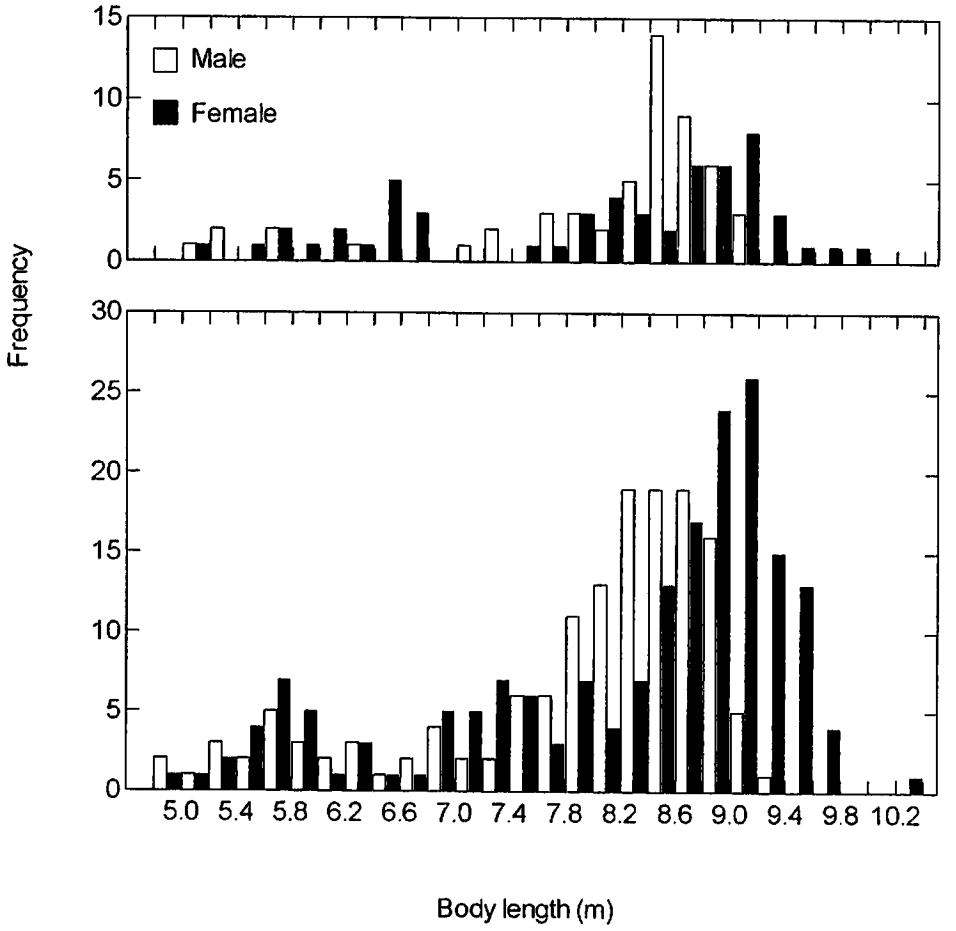

Fig. 8. Body length compositions (20 cm intervals) by sex and Area. White and black lines represent males and females, respectively. Upper: Area IIIE, lower: Area IV.

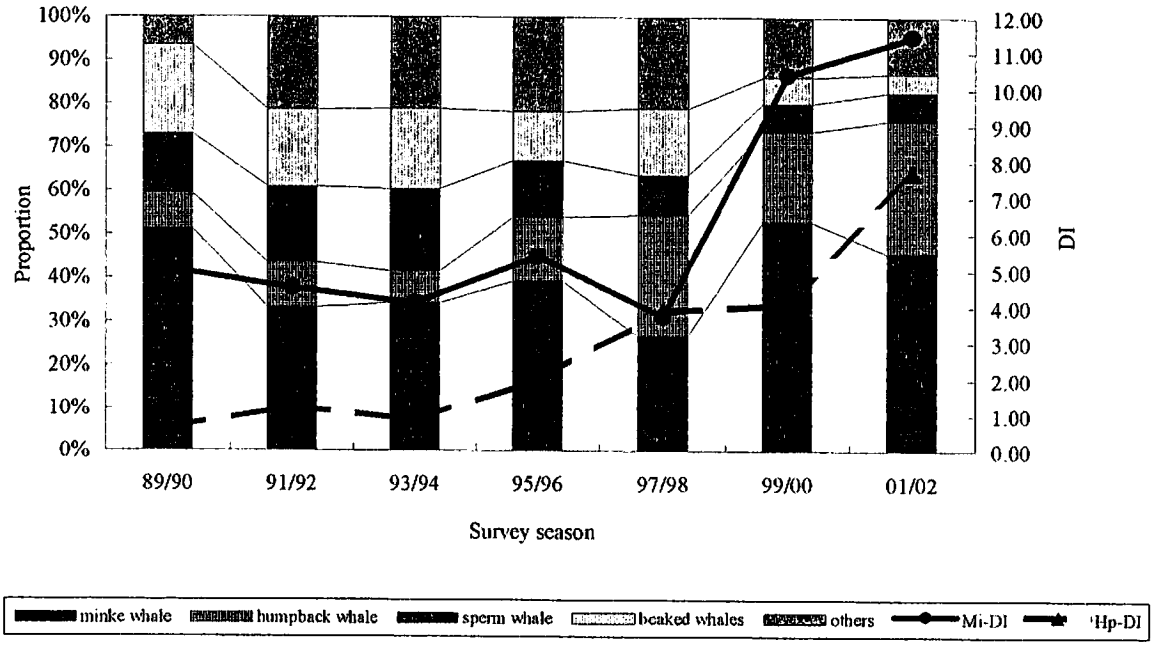

Fig. 9. Yearly change of species composition of sightings and DI of minke and humpback whales