

Cruise Report of the Japanese Whale Research Program under Special Permit in the Antarctic (JARPA) Area V and Western Part of Area VI in 2004/2005

Shigetoshi Nishiwaki¹, Daisuke Tohyama², Mutsuo Goto¹, Toshihiro Mogoe¹, Tatsuya Isoda¹, Masaomi Tsunekawa², Kiyokazu Yoshimura², Hidenori Kasai¹, Takuya Teraoka¹, Takehisa Koyanagi¹, Shin Ito¹, Akihiro Kitajima¹, Mitsuhiro Ogihara¹, Atsushi Hasegawa¹ and Takuma Fujihira³

Contact e-mail: nisiwaki@cetacean.jp

1) *The Institute of Cetacean Research, 4-5 Toyomi-cho, Chuo-ku, Tokyo 104-0055 Japan.*

2) *Kyodo Senpaku Kaisya, Ltd., 4-5 Toyomi-cho, Chuo-ku, Tokyo 104-0055 Japan.*

3) *Department of Animal Science, Obihiro University of Agriculture and Veterinary Medicine, Inada-cho, Obihiro-city, Hokkaido, 080-0833 Japan.*

ABSTRACT

The eighteenth Japanese Whale Research Program under Special Permit in the Antarctic (JARPA) was conducted in Area V and western part of Area VI (VIW) from 7 December 2004 to 8 March 2005. One sighting vessel (SV), three sighting/sampling vessels (SSVs) and one research base ship were engaged in the research. Total searching distance of one SV and three SSVs was 18,712.0 n.miles (Area VIW; 4,118.5 n.miles, Area V; 14,593.5 n.miles). The eight whale species managed by International Convention for the Regulation of Whaling were conformed in this cruise. Antarctic minke whales were the most dominant species observed in the whole research areas which except for the West-North stratum in the Area V and widely distributed in the entire research area. The total sightings of the Antarctic minke whales by the four research vessels were 4,400 individuals of 1,711 schools. Many sightings occurred following the Antarctic minke whale in order of the humpback whale, the sperm whale, the fin whale and the southern bottlenosed whale in whole research Area except for the East-South stratum in the Area V. Out of 1,049 schools (3,045 individuals) in the primary sightings of Antarctic minke whales by SSVs, 467 schools (1,167 individuals) were targeted for sampling. A total of 440 individuals were sampled (110 from Area VIW, 330 from Area V). Sampling efficiency (the rate of succeeded sampling for targeted individuals) was 94%. Two discovery marks attached at western part of Area V (66°16'S, 140°57'E) in 1981 were collected from mature female captured in eastern part of Area V (72°59' S, 172°12'E). Mature females were dominant in the East-South stratum, whereas mature males were dominant in the North strata in Area V and Area VIW. Pregnant females were most dominant in the East-South stratum and a few immature individual of both sexes were sampled in the same stratum. Pregnant females were 182 individuals in the whole research areas and they had 182 fetuses. A total of 70 targeted individuals in the photo-ID experiment were photographed (five blue, 62 humpback and three southern right whales). A total of 42 biopsy skin samples were collected (one southern right, two fin, 38 humpback whales and one carcass of Antarctic minke whale). Regarding to the oceanographic survey, CTD, XCTD and XBT castings were conducted at 62, 100 and 12 locations, respectively, and EPCS survey was conducted for 90 days by KS2 and 93 days by YS2. It conducted the quantitative echo sounder survey which ranges over 11,488.2 n.miles in the whole research area by KS2. Several features of this cruise are following; 1) East-South stratum in Area V (Ross Sea) opened most widely compare to past cruises, 2) relatively warm surface water (from 1°C to 4°C) widely distributed in the western part of Area V, and 3) cooperative survey with R/V *Kaiyo Maru* had conducted in the Eastern part of Area V for the elucidation of Antarctic marine ecosystem.

KEYWORDS: ANTARCTIC MINKE WHALE; SOUTHERN HEMISPHERE; SCIENTIFIC PERMITS

INTRODUCTION

The Japanese Whale Research Program under Special Permit in the Antarctic (JARPA) was planned as long-term program of eighteen years including two years of feasibility study in compliance with Article VIII of the International Convention for the Regulation of Whaling (ICRW). After two seasons of feasibility survey in 1987/88 and 1988/89, the full-scale research started in 1989/90. The program was designed to repeat surveys in the Antarctic Areas IV and V alternatively in each of sixteen years of the research period. From 1995/96, the survey area was expanded into a part of Areas III and VI to improve the stock structure study of Antarctic minke whales (*Balaenoptera bonaerensis*) (Government of Japan, 1987, 1989, 1995). The original objective of expansion to the eastern part of Area III and western part of Area VI was a feasibility study on stock identity to examine the hypothesis of the occurrence of more than one stock in Areas IV and V (Government of Japan, 1995; 1996) and to clarify the distribution pattern of hypothesized Core Stock.

The research plan of the 2004/2005 JARPA was submitted to the 56th Annual Meeting of the International Whaling Commission and the Scientific Committee (IWC/SC) meeting (Government of Japan, 2004). The objectives of the research were 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.

This cruise is the final one of eighteen years of JARPA program. This paper reports the eighteenth cruise of JARPA, which was conducted from 7 December 2004 to 8 March 2005 in the Antarctic Area V and VIW. Furthermore the first cooperative survey with R/V *Kaiyo Maru* had conducted in the Eastern part of Area V for the elucidation of Antarctic marine ecosystem. Details of this cruise were reported in SC/57/O16.

RESEARCH METHODS

Research area

The research area for the present survey was composed of the western part of Area VI (Area VIW, 170°W-145°W) and the entire Area V (130°E-170°W) in the area between south of 60°S and the ice edge line (Fig.1).

Area V was divided into the eastern and western parts by longitudinal line of 165°E and then farther divided into northern and southern strata. The western part was separated into northern and southern by a line of offshore between 60 and 100 n.miles from the ice edge line. For the eastern part, the area between 60°S and 69°S was designed as the northern stratum, and south of 69°S (i.e. Ross Sea) as the southern stratum. Consequently, the entire research area in Area V was divided into four strata (East-North, East-South, West-North and West-South). Area VIW was treated as one stratum.

Research vessels

Kyoshin Maru No.2 (KS2; 372GT) was dedicated to sighting survey and most of all experiments were conducted by this ship (sighting vessel; SV). Three vessels, Yushin Maru (YS1; 720GT), Yushin Maru No.2 (YS2; 747GT) and Kyo Maru No.1 (K01; 812.08GT) were engaged in sighting and sampling surveys (sighting / sampling vessels; SSVs). Nisshin Maru (NM; 7,575GT) served as a research base on which all biological examinations of collected samples were conducted.

Cruise track line, sighting and sampling method

Fig. 2 shows the track line of the main course. The method for establishment of the cruise track line in Area V was same as the previous JARPA surveys (Nishiwaki *et al.* 1997 and 1999). A zigzag line was used both the western part of Area VI and all strata in entire Area V. The sighting information was collected during steaming on the set track lines as well as during transit and experiments. Pack ice lines were estimated by the direct observation of research vessels and the information from Near real-time DMSP SSM / I daily polar gridded sea ice concentrations data set available from the National Snow and Ice Center (NSIDC, Cavalieri *et al.*, 1999), US.

Sighting and sampling procedures were same as in the previous JARPA surveys (Nishiwaki *et al.* 1999, 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 the whale and species and school size were confirmed). One Antarctic minke whale was sampled randomly from each primary sighted school within 3n.miles of the track line. The dwarf form minke whale was not a target for sampling. Three SSVs advanced along parallel track lines 7 n.miles apart, at a standard speed of 11.5 knots.

The sighting survey by SV was conducted under limited closing mode and passing mode (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 and 20 knot in the north strata and visibility was over two n.miles). In addition to the sighting of Antarctic minke whales or whales suspected to be Antarctic minke whales, the SV approached blue (*B. musculus*), humpback (*Megaptera novaeangliae*), southern right (*Eubalaena australis*), pigmy right (*Caperea marginata*), fin (*B. physalus*), sei (*B. borealis*), sperm (*Physeter macrocephalus*) and southern bottlenose (*Hyperoodon planifrons*) whales for conducting some experiments. The SSVs also approached the same whale species as experiments in SV while they engaged in sighting survey.

Low and middle latitudinal sighting survey

During transit cruises, sighting surveys were conducted in the area between 30°S and 60°S except for Areas within national EEZs. The results of these surveys are not shown in this report.

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 by SV and SSVs: blue, humpback and southern right whales.

Biopsy sampling

In addition to the species targeted for the photo-identification experiment, pygmy right, fin, sei, sperm, southern bottlenose whales were targeted for biopsy skin sampling by the SV and SSVs using compound-crossbow. All collected sample were preserved at -80°C.

Oceanographic and acoustic survey

SV conducted the following oceanographic survey.

- 1) Hydro-acoustic survey using a scientific echo sounder (EK500 with operating frequencies at 38kHz, 120kHz, 200kHz, SIMRAD, Norway) to elucidate distribution and abundance of prey species of Antarctic whales
- 2) Consecutive measuring of water surface temperature, conductivity, surface chlorophyll, dissolved oxygen, surface particle and surface flow by Electric Particle Counting and Sizing System (EPCS)
- 3) XCTD and CTD survey
- 4) Marine debris recording in the research area.

In addition to these surveys mentioned above, SV deployed Argo profiling floats (profiling devices), which collected high quality oceanographic data of upper and middle layers of the world ocean almost simultaneously with very high space-time resolution, during this cruise in cooperation with Japan Marine Science and Technology Center (JAMSTEC) (See http://w3.jamstec.go.jp/ARGO/J_ARGOe.html).

SSV (YS2) also conducted EPCS survey. All marine debris found in the stomach of Antarctic minke whales was

recorded and collected on NM.

Biological research

Biological researches on all sampled whales were conducted on the research base ship (NM).

RESULTS

Outline of the research activities

Table 1 shows an outline of the research activities. The research period in the Antarctic Area V and VIW was 92 days between 7 December 2004 and 8 March 2005.

Searching effort

Table 2 shows the searching distance (n.miles) by each stratum. The SV covered 5,878.9 n.miles and three SSVs covered 12,833.1 n.miles. Total searching distance of one SV and three SSVs was 18,712.0 n.miles (Area VIW; 4,118.5 n.miles, Area V; 14,593.5 n.miles). Total searching efforts during this cruise was similar to the past JARPA cruises. For each stratum, however, searching effort of all strata except for the western part of Area VI and East-South stratum in Area V was low compare with past JARPA cruises because of the stormy weather continued through the whole research period by influence of developing low pressures. On the other hand, the searching effort of the East-South stratum (Ross Sea) during this cruise was 9,182.1 n.miles which was the longest searching distance through the past JARPA cruises because sea ice in this stratum opened most widely compare to past cruises. For comparison, this stratum was the narrowest in the 2002/03 JARPA and searching effort of this stratum was 2,111.9 n.miles.

Whale species sighted

Table 3a through 3c show the summary of whale species and number of sightings by SV and SSVs. The eight whale species managed by International Convention for the Regulation of Whaling were conformed in this cruise. Baleen whale were confirmed following six species; Antarctic minke, blue, fin, sei, humpback and southern right whales, and two toothed whales; sperm and southern bottlenose whales.

Antarctic minke whale was the most dominant species in the whole research areas and widely distributed in the entire research area except for the West-North stratum in the Area V. The number of total sightings of Antarctic minke whales by the four research vessels was 1,711 schools (4,400 individuals). For the other large whales, humpback whale (381 individuals of 224 schools), the sperm whale (118 individuals of 115 schools), the fin whale (126 individuals of 53 schools) and the southern bottlenosed whale (83 individuals of 47 schools) were observed.

Distributions of confirmed whale species in the research areas

Fig. 3 shows distribution of primary sightings of Antarctic minke whales in Areas VIW and V. Antarctic minke whales widely distributed in the research areas throughout the research periods. High concentrated areas were conformed in the southern part of Areas VIW and V. The distribution of Antarctic minke whales in northern part of the whole research area was few compared with the southern part in the whole research area. In addition to the bad weather described above, such distribution might be caused by warm surface water from the Antarctic convergence projected to the southward through the survey period.

Fig. 4 shows distribution of sightings of fin, sei and humpback whales in research areas. Fin whales and humpback whales widely distributed in the entire research area except for the East-South stratum of Area V. These sightings overlapped to those of Antarctic minke whale in northern strata but were very few in the East-South stratum of Area V where Antarctic minke whales were highly concentrated.

Fig. 5 shows distribution of sightings of blue and southern right whales. Sightings of blue whales were widely dispersed in the entire research area, although they were observed at limited areas in the past research cruises. Southern right whales were sighted in the limited area in southern part of the West-South stratum in Area V.

Fig. 6 shows distribution of sightings of sperm and southern bottlenose whales. They were widely distributed in the entire research areas except the southern part of the East-South stratum in Area V.

Mean school size and density index of Antarctic minke whale

Table 4 shows density indices (DI; number of schools sighted/100 n.miles searching distance) and mean school size (MSS) of primary sightings of Antarctic minke whale by vessels and stratum. MSS of SV and SSVs in Area VI were comparable to the past surveys and the DI of SV and SSVs was relatively higher than the past cruises. The DI of northern strata in the Area V showed the relatively lower than previous JARPA surveys. Regarding to the southern strata in Area V, DI of East-South stratum and West-South stratum are relatively low and high in comparison with past cruises, respectively. The MSS of West-South stratum by SSVs shows the highest value compare with past cruises and other strata/vessels showed same values with previous surveys.

Sampling of Antarctic minke whale

Out of 1,049 schools (3,045 individuals) in the primary sightings of Antarctic minke whales by SSVs, 467 schools (1,167 individuals) were targeted for sampling. A total of 440 individuals were sampled (110 from Area VIW, 330 from Area V). Sampling efficiency (the rate of succeeded sampling for targeted individuals) was 94%. This value was highest among the previous JARPA surveys.

Of targeted individuals, 27 individuals could not be sampled. Among those, seventeen individuals were missed because of their swimming activity (fast speed, long diving or quick mobility). Five individuals were canceled to take because of bad chasing condition (foggy or sunset). Sampling was abandoned for four individuals because they escaped into the pack ice. One individual was the cases of struck and lost.

Experiments

A sighting distance and angle experiment was preformed on 8 January 2005 by the SV and SSVs. The results of this experiment will be used in calculation of abundance estimates.

Table 5a summarizes the results of photo-ID and biopsy sampling. The photo-ID experiment was conducted within the entire research areas. A total of 70 targeted individuals were photographed (5 on blue, 62 on humpback and 3 on southern right whales). A total of 42 skin biopsy samples were collected from humpback whales (n=38), fin (n=2), southern right (n=1) and carcass of Antarctic minke whales (n=1).

Table 5b shows the summary of oceanographic and acoustic surveys. CTD, XCTD and XBT castings were conducted at 62, 100 and 12 locations, respectively. EPCS survey was conducted for 90 days by KS2 and 93 days by YS2 in total. KS2 conducted the quantitative echo sounder survey which ranges over 11,488.2n.miles in the whole research area.

The marine debris survey was carried out concomitant with the sighting survey of the SV in all research areas. A total of four debris (four buoys) were confirmed. Seven cases of alien substances from the stomach content of the collected whale were confirmed; one case of pebbles from the western part of Area VI, a piece of wood from the East-South stratum and two and three sheets of feather from West-North stratum and West-South stratum of Area V, respectively.

Biological research

Biological research was conducted on the research base ship for all whales sampled (177 males, 263 females). Table 5 summarizes biological data and samples collected.

Mark recapture

Two discovery marks (39128 of UK, 39130 of UK) were collected from mature female with the 8.87 m body length. This animal was captured at the 72°59' S, 172°12' E on 5th February in 2005. These discovery marks were attached at 66 °16' S, 140°57' E on 4th January in 1981 by the IDCR cruise and the estimated body length was 29 ft (8.84 m).

It was fourth case detected during JARPA research program started from 1987/88. The other discovery marks were detected from animals taken in Area IV in 1991/1992 (Fujise *et al.*, 1993a) in Area V, in 1992/1993 (Fujise *et al.*, 1993b) in Area IV and in 2001/ 2002 (Ishikawa *et al.*, 2002) during JARPA cruises. All cases including present study animals were captured at same Area with attached position.

Products

All the whales collected were processed on NM after biological survey was completed, according to the provisions of Article VIII of the Convention. A total of 1,892 tons of meat, blubber, viscera, etc. was produced.

Preliminary analyses of biological information

Sex ratio and reproductive status

Table 7 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 testis weight according to Kato (1986), i.e., testis over than 400g were determined to be mature while others were classified as immature. Maturity of female was determined by existence of corpus luteum or albicans in ovaries.

The composition of reproductive status of collected Antarctic minke whales is shown in Fig. 8. Mature females were dominant in the East-South stratum (74.3%), whereas mature males were dominant in the North strata (41.38% in East and 75.0% in West) in Area V and Area VIW (47.3%). Pregnant females were most dominant in the East-South stratum (65.1%) and a few immature individual of both sexes was sampled in the same stratum (1.1% in male, 7.0% in female). Pregnant females were 182 individuals in the whole research areas and they had 182 fetuses.

Length composition

Table 8 shows mean body length of Antarctic minke whales collected in each stratum. Maximum length of the sample was 9.26m for male and 9.91 m for female, minimum length was 4.50m and 4.73m, respectively.

DISCUSSION

The eighteenth JARPA survey was conducted in Area V and western part of Area VI (VIW) from 7 December 2004 to 8 March 2005 for 142 days. Characteristic results of this research cruise were as follows,

- 1) East-South stratum in Area V (Ross Sea) opened most widely compare to past research cruises,
- 2) relatively warm surface sea water (from 1°C to 4°C) widely distributed in the western part of Area V, and
- 3) cooperative survey with R/V *Kaiyo Maru* had conducted in the Eastern part of Area V for the elucidation of Antarctic marine ecosystem.

Regarding to 1), the searching distance in the East-South stratum in the Area V (Ross Sea) was 9,182.1 n.miles and it was 4.3 times longer than the same stratum in 2002/03 research cruise (2,111.9 n.miles) (Nishiwaki *et al.*, 2003). Reason for such a large searching effort on this stratum was to be made the most widely open sea compare with previous JARPA cruises and it was relatively good weather condition during this cruise. Consequently, we could allocate the largest effort on this stratum during 32 days compare to past JARPA cruises. On the other hand, the sighting density index of Antarctic minke whale in this stratum was approximately 5 times lower than the same stratum in 2002/03 research cruise. Ross Sea opened very narrowly in 2002/03 cruise and Antarctic minke whales were highly concentrated in this stratum. These results mean that reason for low density of Antarctic minke whale in present cruise was due to disperse of animals in the wide open sea. This situation is resembled to that of 1996/97 research cruise which was widely opened following present cruise (Nishiwaki *et al.*, 1997).

In relation to 2), the sighted composition of whales during this research cruise resembles closely between eastern and western parts of Area V except southern two strata. The whale species composition in the western sector of Area V is different from the other strata. The widely distributed relatively warm surface water may be influenced for such a difference of whale species composition. This warm surface sea water condition of this cruise is resembled to that of 2000/01 research cruise (Nishiwaki *et al.*, 2001). In the West-North stratum, the humpback whale became a dominant species instead of the Antarctic minke whale, although sighting effort was low compare with other strata. Relatively many sightings of the whale species such as the fin and southern bottlenosed whales which appear to the warm surface water area were observed in this stratum. Antarctic minke whales might be forced to concentrate in the southward of the

West-South stratum because warm surface water was invaded to southward. Humpback and the fin whales were also distributed near the ice-edge in this stratum. Sampling effort and the number of samples in the West-North stratum were limited due to terrible bad weather and the low number of Antarctic minke whale sightings.

With regard to 3), the first cooperative survey with R/V *Kaiyo Maru* had conducted in the Eastern part of Area V for 65 days between 25th December 2004 and 27th February 2005 to collect data simultaneously on Antarctic krill, other zooplanktons and its predator whales to relate their distribution and abundance in relation with physical and biological environment in a meso-scale in the Ross Sea and its adjacent waters (Naganobu *et al.* this meeting). Such a cooperative study will be useful for the elucidation of Antarctic marine ecosystem. In relation to this survey, Fig. 9 shows the preliminary analysis on stomach contents of Antarctic minke whale in the East-South stratum in Area V. The average of net weight of first stomach contents of 186 individuals taken in this stratum was 13.08Kg±2.09 and this value was the lowest compare with past four surveys. This value would be influenced by higher rate (41.4%) of empty stomach contents than past cruises (1996/97; 35.2%, 2000/01; 15.9%, 2002/03; 11.4%). Such a situation might be related to the ice pack condition in the Ross Sea. The largest average value was detected in 2002/03 cruise and sea ice was not melt in the eastern part of longitude 180° in same year. On the other hand, sea ice melted and made open sea in the eastern part of longitude 180° in greater or lesser degree in another years. These results suggested that prey species (mainly krill) would concentrate when the open sea was narrow and consequently the average of the weight of stomach contents was high, and that would disperse when the sea was widely opened, the average was low. Therefore average of the weight of stomach contents might be depended on the density of krill distribution in relation to size of open sea. Detailed analyses on the feeding ecology will be presented in the future.

These results would indicate that the feeding migration and segregation pattern of cetaceans were strongly influenced by yearly change of oceanic environmental condition such as sea water temperature and ice-pack distribution. Therefore long-term monitoring for the elucidation of Antarctic marine ecosystem should be necessary.

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Table1. Outline of the research activities

Event	Date	Vessels
Departure from Japan	12/Nov./2004	NM,SV,SSVs
Low and middle latitudinal sighting survey in transit area	29/Nov./2004 to 5/Dec./2004	NM,SV,SSVs
Sighting and sampling survey in Area VIW	7/Dec./2004 to 25/Dec./2004	NM,SV,SSVs
Sighting and sampling survey in East-north stratum in Area V	26/Dec./2004/ to 13/Jan./2005 14/Jan./2005/ and 15/Jan./2005 27/Dec./2004/ to 13/Jan./2005	SV NM and SSVs
Sighting and sampling survey in East-south stratum in Area V	14/Jan./2005 to 13/Jan./2005 14/Jan./2005 to 15/Jan./2005	SV NM and SSVs
Sighting and sampling survey in West-north stratum in Area V	17/Jan./2005 to 23/Jan./2005 7/Jan./2005 and 8/Jan./2005 19/Jan./2005 to 24/Jan./2005	SV NM and SSVs
Sighting and sampling survey in West-south stratum in Area V	23/Jan./2005 to 7/Jan./2005 25/Jan./2005 to 8/Jan./2005	SV NM and SSVs
Low and middle latitudinal sighting survey in transit area	10/Jan./2005 to 16/Jan./2005	NM,SV,SSVs
Arrive in Japan	31/Jan./2005	NM,SV,SSVs

SV:Sighting Vessel, NM:Nisshin-Maru (Research base vessel), SSVs:Sighting and Sampling Vessels

Table2. Searching distances (n.miles) of one sighting vessel (SV) and three sighting / sampling vessels (SSVs) in each stratum.

Area	Stratum	Block	SV			SSVs			Grand Total
			Closing	Passing	Sub Total	Closing	Passing	Sub Total	
VI	West	North	85.1	248.6	333.7	1146.0	0.0	1146.0	1479.7
		South	157.9	636.6	794.5	1680.5	0.0	1680.5	2475.0
		Transit	20.9	36.2	57.1	106.7	0.0	106.7	163.8
		Sub Total	263.9	921.4	1185.3	2933.2	0.0	2933.2	4118.5
V	East North	North	92.7	287.5	380.2	1160.9	0.0	1160.9	1541.1
		Middle	120.5	303.6	424.1	832.4	86.9	919.3	1343.4
		South	84.3	147.8	232.1	111.5	2.7	114.2	346.3
		Transit	0.0	172.5	172.5	132.6	48.9	181.5	354.0
		Sub Total	297.5	911.4	1208.9	2237.4	138.5	2375.9	3584.8
	East South	East	192.7	719.8	912.5	1720.7	0.0	1720.7	2633.2
		West	196.6	509.1	705.7	1405.1	0.0	1405.1	2110.8
		North	325.0	672.7	997.7	2297.5	0.0	2297.5	3295.2
		Transit	0.0	226.2	226.2	114.5	802.2	916.7	1142.9
		Sub Total	714.3	2127.8	2842.1	5537.8	802.2	6340.0	9182.1
		West North	69.7	202.1	271.8	698.2	0.0	698.2	970.0
		West South	57.7	313.1	370.8	485.8	0.0	485.8	856.6
	Total	1403.1	4475.8	5878.9	11892.4	940.7	12833.1	18712.0	

Table 3-a. Summary of whale sightings conducted by SV and SSVs in western part of Area VI.

Vessel type	SV						SSVs							
	Prim./Sec.		Prim.		Sec.		Total		Prim.		Sec.		Total	
	Species		Sch.	Ind.	Sch.	Ind.	Sch.	Ind.	Sch.	Ind.	Sch.	Ind.	Sch.	Ind.
Antarctic minke whale	46	81	1	1	47	82	133	216	4	4	137	220		
Like minke whale	2	2	0	0	2	2	2	2	0	0	2	2		
Blue whale	2	2	0	0	2	2	2	2	0	0	2	2		
Fin whale	11	29	0	0	11	29	12	22	1	2	13	24		
Humpback whale	29	45	1	2	30	47	29	43	2	2	31	45		
Unidentified baleen whale	21	29	3	5	24	34	2	3	0	0	2	3		
Sperm whale	9	9	1	1	10	10	22	22	1	1	23	23		
Southern bottlenose whale	7	14	0	0	7	14	8	17	1	1	9	18		
Unidentified cetaceans	6	6	0	0	6	6	25	25	0	0	25	25		
Total	133	217	6	9	139	226	235	352	9	10	244	362		

Table 3-b. Summary of whale sightings conducted by SV and SSVs in eastern part of Area V.

North stratum

Vessel type	SV						SSVs							
	Prim./Sec.		Prim.		Sec.		Total		Prim.		Sec.		Total	
	Species		Sch.	Ind.	Sch.	Ind.	Sch.	Ind.	Sch.	Ind.	Sch.	Ind.	Sch.	Ind.
Antarctic minke whale	61	81	3	3	64	84	93	143	1	1	94	144		
Like minke whale	3	3	0	0	3	3	1	1	0	0	1	1		
Blue whale	0	0	1	1	1	1	1	1	0	0	1	1		
Fin whale	4	13	1	2	5	15	9	12	0	0	9	12		
Humpback whale	42	78	3	3	45	81	63	99	4	7	67	106		
Unidentified baleen whale	20	29	1	2	21	31	6	7	0	0	6	7		
Sperm whale	15	15	0	0	15	15	16	16	2	2	18	18		
Southern bottlenose whale	10	17	0	0	10	17	11	16	1	3	12	19		
Unidentified cetaceans	3	3	0	0	3	3	35	35	0	0	35	35		
Total	158	239	9	11	167	250	235	330	8	13	243	343		

South stratum

Vessel type	SV						SSVs							
	Prim./Sec.		Prim.		Sec.		Total		Prim.		Sec.		Total	
	Species		Sch.	Ind.	Sch.	Ind.	Sch.	Ind.	Sch.	Ind.	Sch.	Ind.	Sch.	Ind.
Antarctic minke whale	395	819	10	30	405	849	690	1601	16	27	706	1628		
Like minke whale	4	6	0	0	4	6	17	17	0	0	17	17		
Blue whale	1	2	0	0	1	2	1	2	1	1	2	3		
Fin whale	0	0	0	0	0	0	1	1	0	0	1	1		
Humpback whale	1	2	0	0	1	2	9	17	0	0	9	17		
Unidentified baleen whale	25	33	0	0	25	33	4	8	3	4	7	12		
Sperm whale	13	15	0	0	13	15	23	23	2	2	25	25		
Southern bottlenose whale	1	2	0	0	1	2	4	5	0	0	4	5		
Unidentified cetaceans	8	107	0	0	8	107	39	42	0	0	39	42		
Total	448	986	10	30	458	1016	788	1716	22	34	810	1750		

Table 3-c. Summary of whale sightings conducted by SV and SSVs in western part of Area V.

North stratum

Vessel type	SV						SSVs							
	Prim./Sec.		Prim.		Sec.		Total		Prim.		Sec.		Total	
	Species	Sch.	Ind.	Sch.	Ind.	Sch.	Ind.	Sch.	Ind.	Sch.	Ind.	Sch.	Ind.	
Antarctic minke whale	5	5	0	0	5	5	5	11	0	0	5	11		
Blue whale	2	3	0	0	2	3	0	0	0	0	0	0		
Fin whale	1	1	0	0	1	1	9	24	0	0	9	24		
Sei whale	0	0	0	0	0	0	1	1	0	0	1	1		
Humpback whale	11	21	0	0	11	21	10	22	2	5	12	27		
Southern right whale	1	1	0	0	1	1	0	0	0	0	0	0		
Unidentified baleen whale	5	8	0	0	5	8	0	0	0	0	0	0		
Sperm whale	3	4	0	0	3	4	7	7	1	1	8	8		
Southern bottlenose whale	1	2	0	0	1	2	2	4	0	0	2	4		
Unidentified cetaceans	1	1	0	0	1	1	5	5	0	0	5	5		
Total	30	46	0	0	30	46	39	74	3	6	42	80		

South stratum

Vessel type	SV						SSVs							
	Prim./Sec.		Prim.		Sec.		Total		Prim.		Sec.		Total	
	Species	Sch.	Ind.	Sch.	Ind.	Sch.	Ind.	Sch.	Ind.	Sch.	Ind.	Sch.	Ind.	
Antarctic minke whale	111	251	3	8	114	259	128	1074	6	44	134	1118		
Like minke whale	0	0	0	0	0	0	3	3	1	2	4	5		
Blue whale	3	4	0	0	3	4	0	0	0	0	0	0		
Fin whale	0	0	0	0	0	0	3	18	1	2	4	20		
Humpback whale	2	4	0	0	2	4	15	29	1	2	16	31		
Southern right whale	1	1	0	0	1	1	1	1	0	0	1	1		
Unidentified baleen whale	10	14	0	0	10	14	1	3	1	3	2	6		
Southern bottlenose whale	0	0	0	0	0	0	1	2	0	0	1	2		
Unidentified cetaceans	1	1	0	0	1	1	12	12	0	0	12	12		
Total	128	275	3	8	131	283	164	1142	10	53	174	1195		

Table 4. Density indices (DI, number of schools per 100 n.miles) and mean school size (MSS) of Antarctic minke whale primary sightings by SV and SSVs.

Area	Stratum	Block	SV					SSVs				
			Ser. Dist. (n.mile)	Antarctic minke primary sighting				Ser. Dist. (n.mile)	Antarctic minke primary sighting			
				Sch.	Ind.	DI	MSS		Sch.	Ind.	DI	MSS
VI	West	North	333.7	1	1	0.3	1.0	1146.0	14	14	1.2	1.0
		South	794.5	45	80	5.7	1.8	1680.5	117	200	7.0	1.7
		Transit	57.1	0	0	0.0	0.0	106.7	2	2	1.9	1.0
		Sub Total	1185.3	46	81	3.9	1.8	2933.2	133	216	4.5	1.6
V	East North	North	380.2	1	1	0.3	1.0	1160.9	9	10	0.8	1.1
		Middle	424.1	23	33	5.4	1.4	919.3	55	71	6.0	1.3
		South	232.1	15	21	6.5	1.4	114.2	26	58	22.8	2.2
		Transit	172.5	22	26	12.8	1.2	181.5	3	4	1.7	1.3
	Sub Total	1208.9	61	81	5.0	1.3	2375.9	93	143	3.9	1.5	
	East South	East	912.5	223	526	24.4	2.4	1720.7	302	979	17.6	3.2
		West	705.7	45	49	6.4	1.1	1405.1	113	125	8.0	1.1
		North	997.7	93	187	9.3	2.0	2297.5	224	428	9.7	1.9
		Transit	226.2	34	57	15.0	1.7	916.7	51	69	5.6	1.4
	Sub Total	2842.1	395	819	13.9	2.1	6340.0	690	1601	10.9	2.3	
	West North	271.8	5	5	1.8	1.0	698.2	5	11	0.7	2.2	
	West South	370.8	111	251	29.9	2.3	485.8	128	1074	26.3	8.4	
	Total		5878.9	618	1237	10.5	2.0	12833.1	1049	3045	8.2	2.9

Table 5a. Summary of photo-ID and biopsy sampling.

Photo ID

Species	Stratum					Total
	Area VI West	Area V				
		East-North	West-North	East-South	West-South	
Southern right whale					3	3
Blue whale	1			4		5
Humpback whale	13	27	13	9		62

Biopsy samples

Species	Stratum					Total
	Area VI West	Area V				
		East-North	West-North	East-South	West-South	
Southern right whale					1	1
Fin whale	2					2
Humpback whale	7	18	5	8		38
Antarctic minke whale (Carcass)		1				1

Table 5b. Summary of oceanographic and acoustic survey.

Stratum	CTD	XCTD	XBT	EPCS		Quantitative echo sounder n.miles
				KS2 Days	YS2 Days	
	Stations	Stations	Stations	Days	Days	
Area VI West	22	0	0	19	20	2,301.0
Area V						
East-North	9	40	8	22	22	2,814.8
East-South	27	21	4	31	33	4,533.5
West-North	2	17	0	8	6	807.6
West-South	2	22	0	10	12	1,031.3
Total	62	100	12	90	93	11,488.2

Table 6. Summary of biological data and samples collected

Samples and data	Number of whales		
	Male	Female	Total
-Data-			
Photographic record of external character	177	263	440
Body length and sex identification	177	263	440
Measurement of external body proportion	177	263	440
Body weight	177	263	440
Body weight by total weight of parts	26	39	65
Skull measurement (length and breadth)	165	245	410
Standard measurement of blubber thickness (five points)	177	263	440
Detailed measurement of blubber thickness (fourteen points)	26	39	65
Mammary gland; lactation status and measurement	-	263	263
Breadth measurement of uterine horn	-	263	263
Testis and epididymis weight	177	-	177
Weight of stomach content in each compartment	177	263	440
Photographic record of fetus	83	87	185*
Fetal length and weight	83	86	170**
External measurements of fetus	83	87	170
Number of ribs	177	263	440
-Sample-			
Diatom film record and sampling	177	263	440
Serum sample for physiological study	176	263	439
Earplug for age determination	176	263	440
Earplug for chemical analysis (one of the pair)	12	8	20
Tympanic bone for age determination	57	76	133
Largest baleen plate for age determination	177	263	440
Largest baleen plate for morphologic study	177	263	440
Vertebral epiphyses sample	177	263	440
Ovary	-	263	263
Histological sample of endometrium	-	263	263
Histological sample of mammary gland	-	263	263
Milk sample for chemical analysis	-	7	7
Histological sample of testis	177	-	177
Histological sample of epididymis	177	-	177
Testis and epididymis stamp smear for sperm detection	177	-	177
Skin, blubber, muscle, liver, kidney and heart tissues for genetic study	177	263	440
Muscle, liver and kidney tissues for heavy metal analysis	177	263	440
Blubber and liver tissues for organochlorine analysis	177	263	440
Muscle, liver and blubber tissues for lipid analysis	26	39	65
Stomach contents for food and feeding study	52	64	116
Stomach contents for heavy metal analysis	10	12	22
Stomach contents for organochlorine analysis	12	8	20
Stomach contents for lipid analysis	9	16	25
External parasites	39	72	111
Internal parasites	56	70	126
Fetus	-	-	9
Fetal skin, blubber, muscle, liver, kidney and heart tissues for genetic study	83	87***	170
Oocyte for in-vitro fertilization (IVF)	-	206	206
Fetal serum for culture	-	9	9
Skin sample	12	13	25
Placenta for histological study	-	82	82
Placenta for immunohistochemical study	5	6	11
Fetal humerus for histological study	-	6	6
Liver, kidney, spleen, testis, brain for histological study	1	1	1
Fetal brain and upper jaw for histological study	-	17	17
Marine debris	3	3	6

* : including a fetus of sex unidentified.

** : Since a fetus was broken by harpoon, external measurement was partly done.

*** : including a partly broken fetus whose skin, blubber, muscle, kidney and heart.

Table 7. 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, which had corpus luteum, but fetus was not observed.

Stratum	Male			Female						
	Immature	Mature	Total	Immature	Pregnant	Resting	Preg+Lac	Ovulating	Unknown	Total
Area VI west	15 (13.6)	52 (47.3)	67 (60.9)	25 (22.7)	17 (15.5)	1 (0.9)	0 (0.0)	0 (0.0)	0 (0.0)	43 (9.9)
Area V										
East-North	15 (23.8)	26 (41.3)	41 (65.1)	17 (27.0)	4 (6.4)	0 (0.0)	1 (1.6)	0 (0.0)	0 (0.0)	22 (5.0)
East-South	2 (1.1)	32 (17.2)	34 (18.3)	13 (7.0)	121 (65.1)	12 (6.5)	2 (1.1)	3 (1.6)	1 (0.5)	152 (34.5)
West-North	0 (0.0)	3 (75.0)	3 (75.0)	0 (0.0)	1 (25.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (0.2)
West-South	2 (2.6)	30 (39.0)	32 (41.6)	4 (5.2)	39 (50.7)	2 (2.6)	0 (0.0)	0 (0.0)	0 (0.0)	45 (10.2)
Combined	19 (5.8)	91 (27.6)	110 (33.3)	34 (10.3)	165 (50.0)	14 (4.2)	3 (0.9)	3 (0.9)	1 (0.3)	220 (50.0)
Grand total	34 (7.7)	143 (32.5)	177 (40.2)	59 (13.4)	182 (41.4)	15 (3.4)	3 (0.7)	3 (0.7)	1 (0.2)	263 (59.8)

Table 8. 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 7.

Stratum	Male			Female		
	Immature	Mature	Total	Immature	Mature	Total
Area VI West	6.42 ± 0.97 (4.50 - 7.82)	8.24 ± 0.36 (7.02 - 9.23)	7.83 ± 0.94 (4.50 - 9.23)	6.26 ± 1.02 (4.73 - 7.77)	8.60 ± 0.48 (7.52 - 9.53)	7.24 ± 1.43 (4.73 - 9.53)
Area V						
East-North	6.04 ± 0.86 (4.80 - 7.40)	8.39 ± 0.39 (7.59 - 9.26)	7.53 ± 1.29 (4.80 - 9.26)	6.42 ± 1.04 (5.04 - 7.91)	8.74 ± 0.78 (7.84 - 9.62)	6.95 ± 1.39 (5.04 - 9.62)
East-South	7.48 ± 1.07 (6.72 - 8.23)	8.32 ± 0.25 (7.64 - 8.85)	8.27 ± 0.36 (6.72 - 8.85)	7.70 ± 0.58 (6.52 - 8.36)	8.89 ± 0.37 (8.00 - 9.91)	8.79 ± 0.52 (6.52 - 9.91)
West-North	-	8.68 ± 0.11 (8.55 - 8.77)	8.68 ± 0.11 (8.55 - 8.77)	-	8.46	8.46
West-South	6.85 ± 0.12 (6.76 - 6.93)	8.40 ± 0.35 (7.36 - 8.90)	8.30 ± 0.51 (6.76 - 8.90)	8.06 ± 0.70 (7.04 - 8.61)	8.86 ± 0.37 (8.01 - 9.76)	8.79 ± 0.46 (7.04 - 9.76)
Combined	6.72 ± 0.94 (4.80 - 8.23)	8.38 ± 0.33 (7.36 - 9.26)	8.02 ± 0.93 (4.80 - 9.26)	7.10 ± 1.09 (5.04 - 8.61)	8.88 ± 0.39 (7.84 - 9.91)	8.60 ± 0.85 (5.04 - 9.91)
Grand total	6.34 ± 0.94 (4.50 - 8.23)	8.33 ± 0.35 (7.02 - 9.26)	7.95 ± 0.94 (4.50 - 9.26)	6.74 ± 1.13 (4.73 - 8.61)	8.85 ± 0.40 (7.52 - 9.91)	8.38 ± 1.09 (4.73 - 9.91)

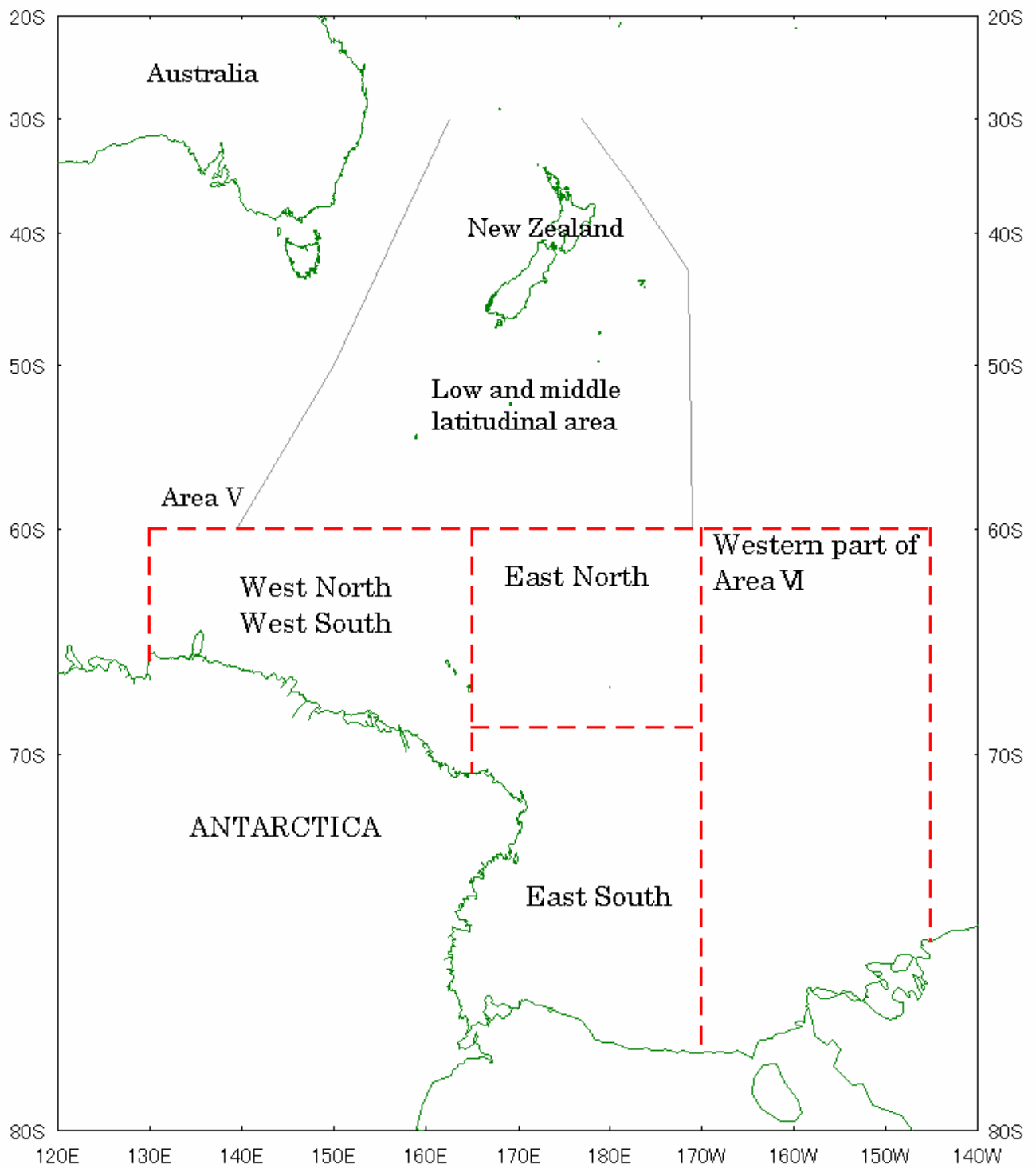


Fig. 1. Geographic location of research area of the 2004/2005 JARPA surveys.

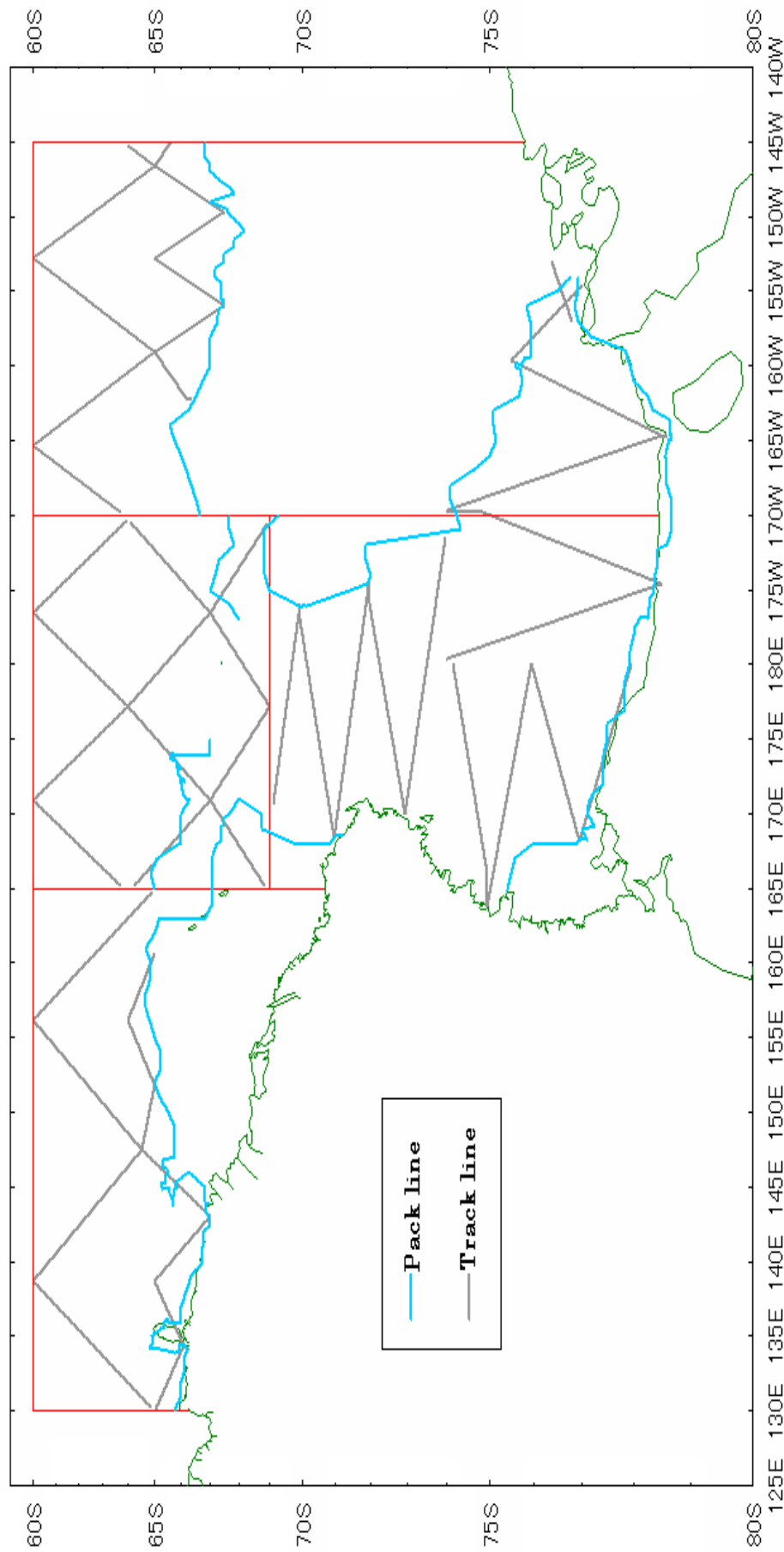


Fig. 2. Cruise track line of sighting vessel and sighting / sampling vessels in 2004/2005 JARPA. Pack ice lines are estimated by observation of research vessels and the information from Near real-time DMSP SSM / I daily polar gridded sea ice concentrations data set available from the National Snow and Ice Center (NSIDC, Cavalieri *et al.* 1999), US.

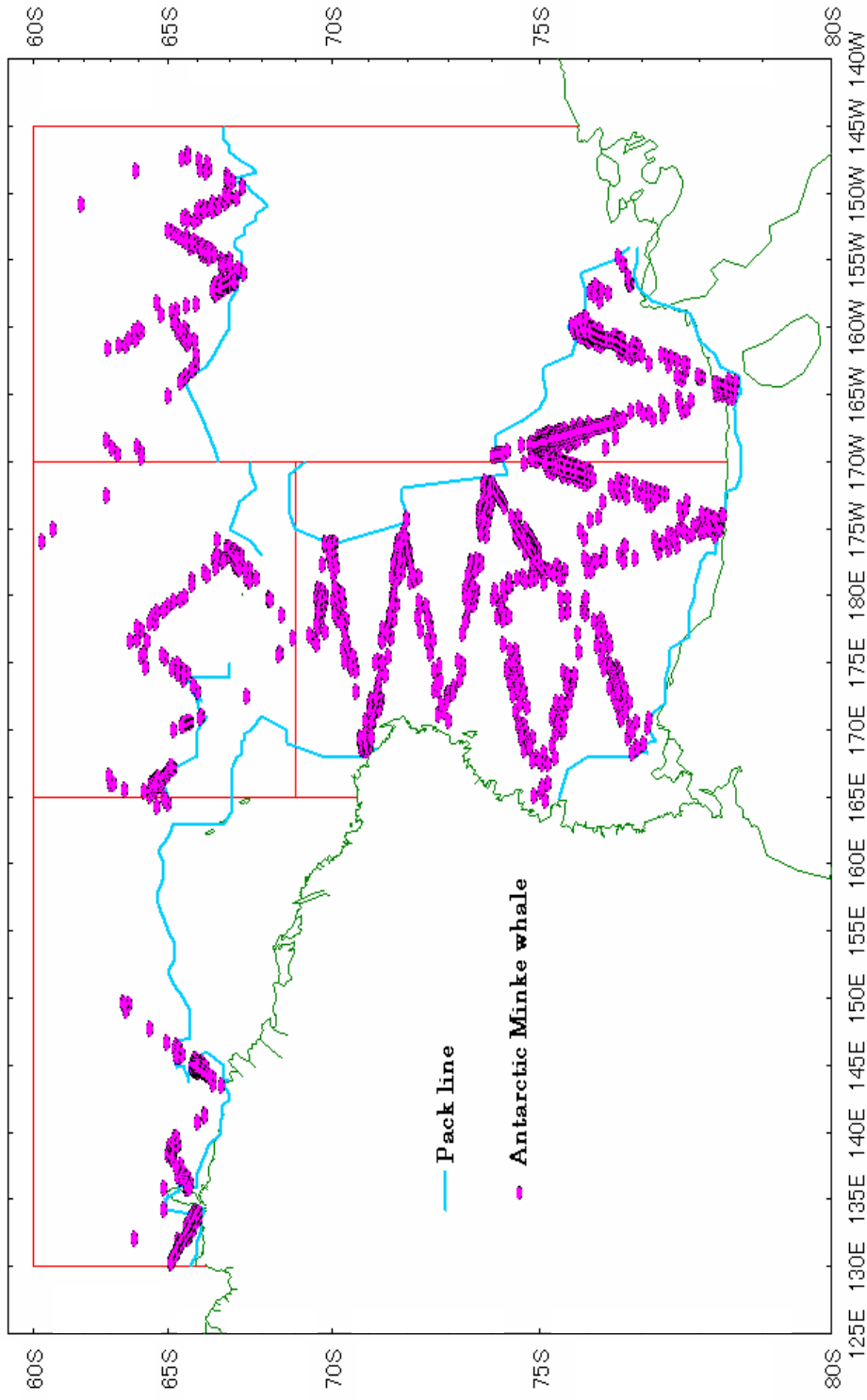


Fig. 3. Distribution of primary sightings of Antarctic minke whales sighted by SV and SSVs in 2004/2005 JARPA

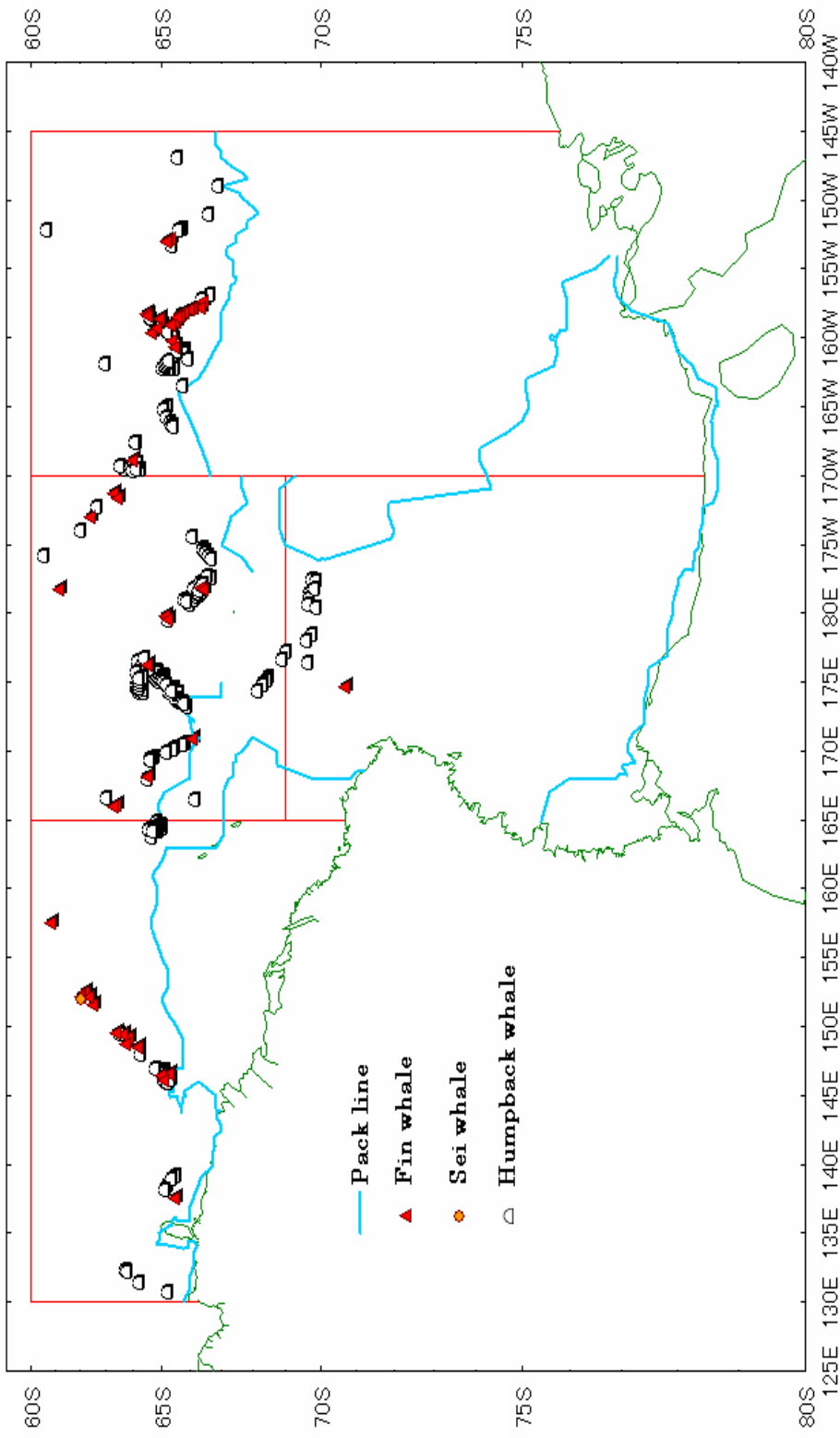


Fig. 4. Distribution of primary sightings of fin, sei and humpback whales sighted by SV and SSVs in 2004/2005 JARPA

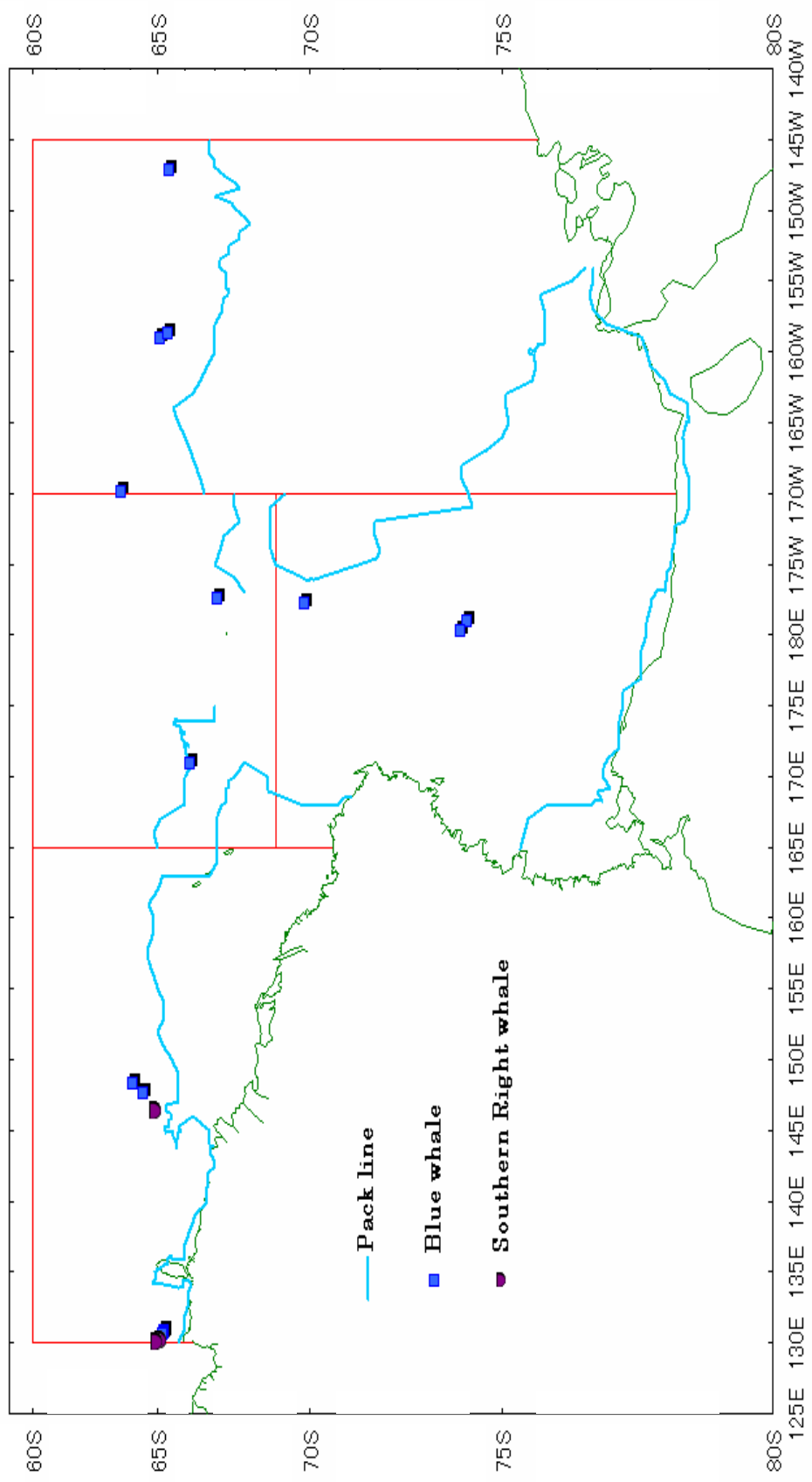


Fig. 5. Distribution of sighting of blue and southern right whales sighted by SV and SSVs in 2004/2005 JARPA

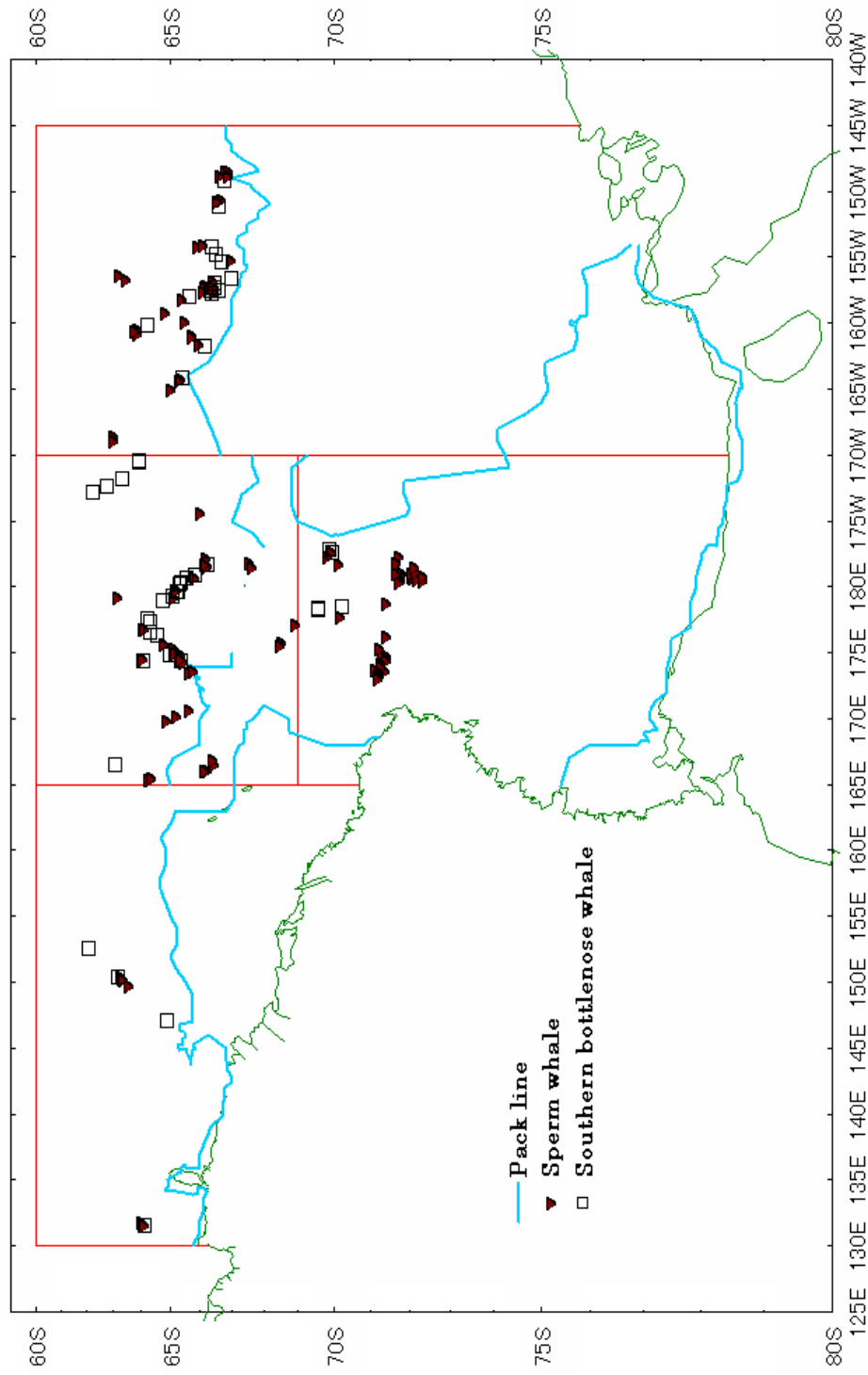


Fig. 6. Distribution of primary sightings of toothed whales sighted by SV and SSVs in 2004/2005 JARPA.

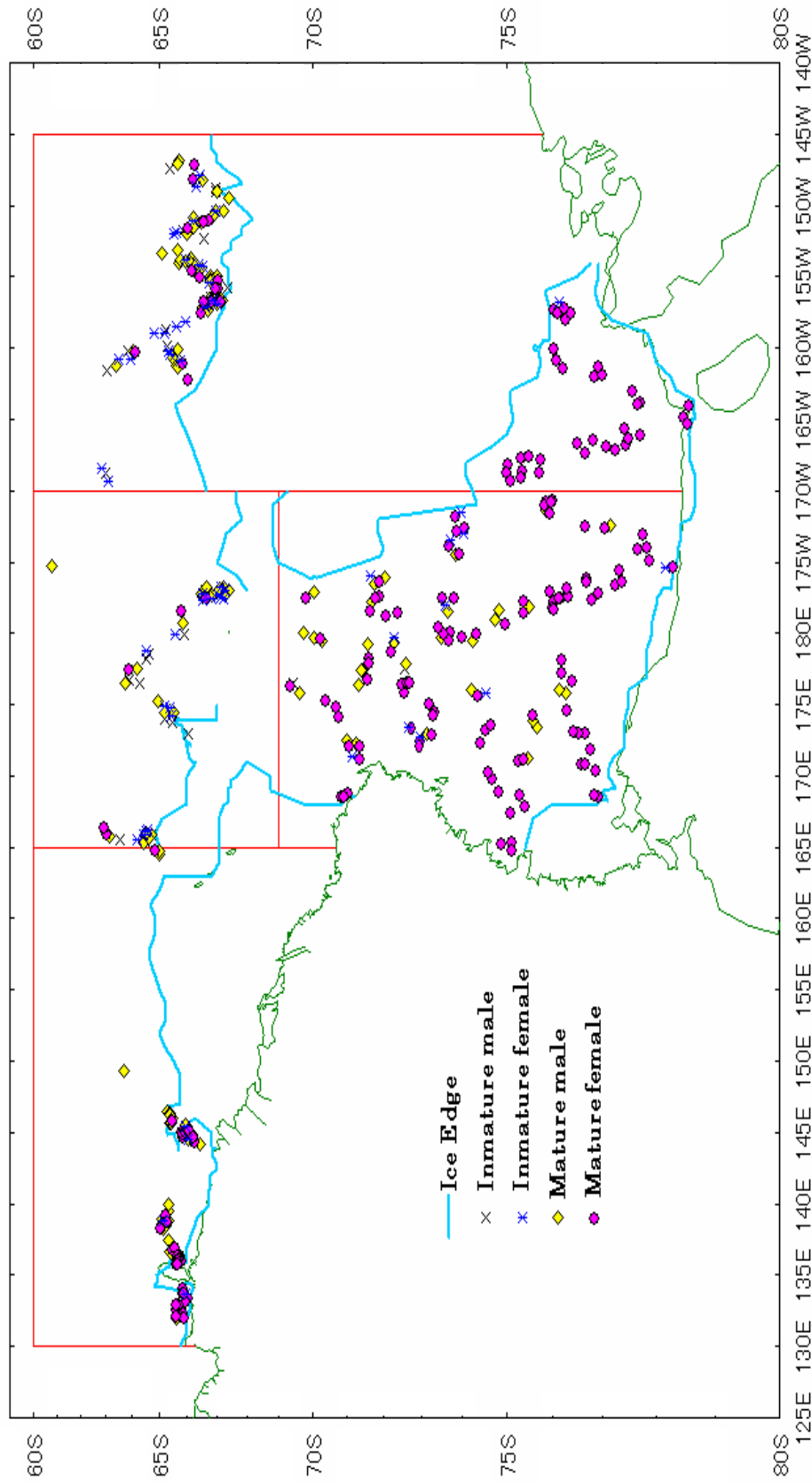


Fig. 7. Sighted position of sampled Antarctic minke whales by sex and reproductive status in 2004/2005 JARPA.

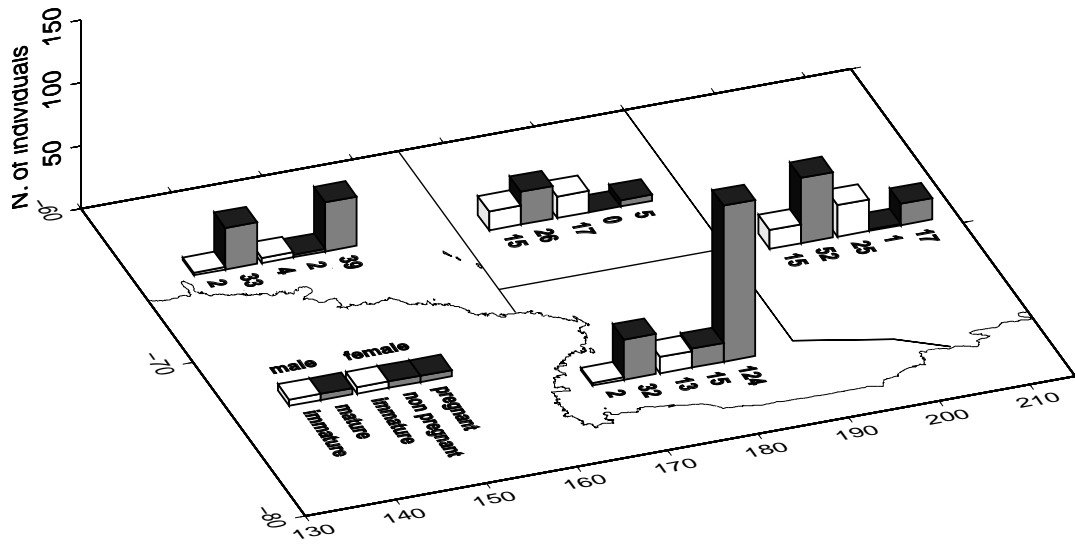


Fig. 8. The composition of reproductive status of Antarctic minke whales collected

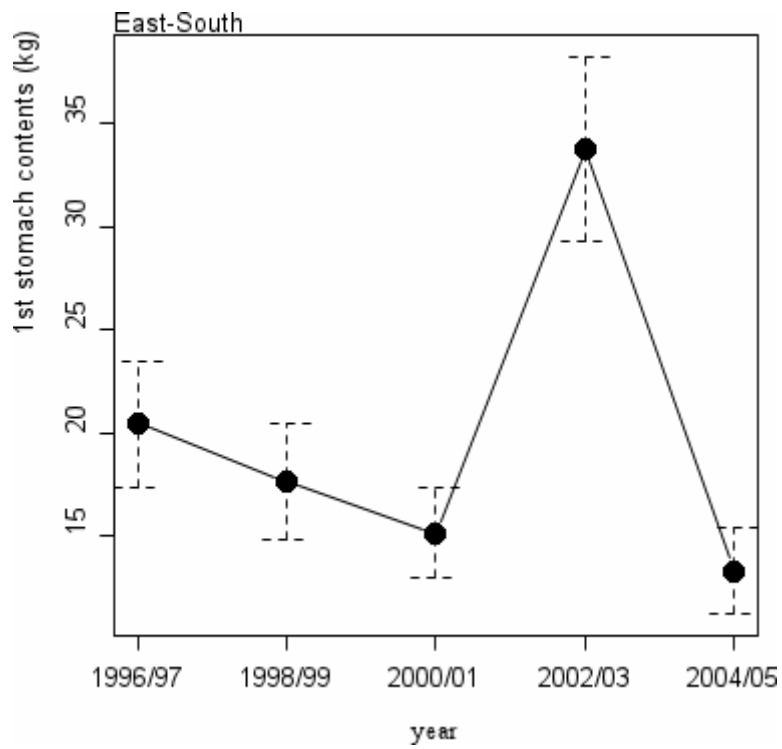


Fig. 9. The composition of net weight of first stomach contents of Antarctic minke whales collected in the East-South stratum by year