Cruise Report of the Japanese Whale Research Program under a Special Permit in the Antarctic (JARPA) Area V and Western Part of Area VI in 1998/99

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ABSTRACT

The twelfth Japanese Whale Research Program under Special Permit in the Antarctic (JARPA) was conducted in Area V and western part of Area VI from 13 January to 31 March 1999. This cruise was substantially delayed from the original plan due to a fire accident that occurred on the research base ship. Further, because of a delay of melting of the Ross Sea ice cover, the center and southern part of the Ross sea could not be surveyed. Therefore, the survey in the East- South stratum in the Area V was limited to the part on the northern side of hard pack ice. One dedicated sighting vessel (SV), three sighting and sampling vessels (SSVs) and one research base ship were engaged in the research. The SV covered 3,181.4 n.miles, and made the primary sightings of 286 schools/ 995 individuals of minke whales. A total of 35 biopsy samples were obtained from humpback, fin and blue whales. Three SSVs searched a total of 4,312.6 n.miles and sighted 540 schools/ 1,670 individuals of minke whales as primary sightings. Minke whales were the most dominant species throughout the whole research area and period. The sighting composition in the research cruise showed an increase for minke whales and a decrease for fin, sperm and southern bottlenose whales compared with previous surveys. A total of 435 minke whales were targeted for the random sampling, and a total of 389 individuals were collected (329 from Area V, 60 from VIW). Mature males were dominant throughout the research area. There were a few numbers of mature females except in the West- South stratum of Area V. No mature female was collected in the western part of Area VI. It was suspected that most of mature females existed in the ice-free water at the center and southern part of the Ross sea.

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 (ICRW). After two seasons of feasibility research in 1987/88 and 1988/89, the full-scale research started in the 1989/90 season (Government of JAPAN, 1989). The research program is designed to repeat surveys in the Antarctic Areas IV and V in alternate years during the sixteen year research period. From the 1995/96 season, the survey area was enlarged into a part of Area III and VI to improve the stock structure study (Government of Japan, 1995, 1996). The result of the DNA analysis of the samples collected in the 1996/97 season showed that a group of minke whales genetically similar to the Core stock (distributed from Area IV and V) were found in the western part of Area VI in the early survey season. This finding was not in conformity with the initial expectation of a putative Eastern stock, as a separate stock from the Core stock (Pastene and Goto, 1998), which can be assumed from the morphological differences indicated by Doroshenko (1979) and Kato (1982). Further work on this matter is required.

The research plan for the 1998/99 JARPA was submitted to the 50th International Whaling Commission and the Scientific Committee (IWC/SC) meeting (Government of Japan, 1998). 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 whale feeding ecology,
4) Elucidation of the effect of environmental changes on cetaceans,

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

This paper reports on the twelfth cruise of the JARPA, which was conducted from 13 January to 31 March 1999 in the Antarctic Area IV and western part of Area VI.

RESEARCH METHODS

1. Research area

The research area for the present survey was composed of the western part of Area VI (Area VIW, 170W-145W) and the entire Area V (130E-170W) in the area between south of 60S and the ice edge line (Fig. 1). Area V is divided into the east and west sectors by the longitudinal line of 165E and then farther divided into north and south strata. Because of a delay of melting of the Ross Sea ice cover, the northern boundary (near the line from 68S to 70S) of the East- South stratum in the Area V was covered with hard pack ice throughout the research period of the stratum. Therefore, the survey in this stratum was limited to the northern side of hard pack ice. It included the un-surveyed part of the southern side of the East-

North stratum. Because of the delay of the initial schedule due to the fire accident on the research base ship, the first half of the survey of Area VIW was cancelled and only the second half of the survey was conducted. The research period in this stratum was extended to late in March. Because of the newly developed pack ice, the survey in the Area VIW was conducted between the ice edge and a line 45n.miles northward from the ice edge line.

2. Research vessels

Three vessels, *Yushin Maru* (YS1; 720GT), *Kyo Maru No.1* (K01; 812.08GT) and *Toshi Maru No.25* (T25; 739.92GT) were engaged in sighting and sampling surveys. *Nisshin Maru* (NM; 7575GT) acted as a research base ship from which all biological surveys were conducted and samples collected. *Kyoshin Maru No.2* (KS2; 368GT) was dedicated to the sighting survey and conducted all experiments.

3. Cruise track line and sighting and sampling method

Construction method of the cruise track line was same as the previous research in 1996/97 (Nishiwaki *et al.* 1997). Fig. 2 shows the track line of the main course. A zigzag line that is used in the IWC/IDCR survey was used for the north strata in Area V. In the south strata in area V and the western part of area VI, the track line was zigzagged from west to east at intervals of four degree' longitudes.

The sighting and sampling procedures were as in the previous JARPA surveys (Nishiwaki *et al.* 1997) with some modifications. The sighting survey of 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 7n.miles apart, at a standard speed of 11.5 knots. The sighting survey of the sighting vessel (SV) was conducted in the passing mode (even if sighting was made on the predetermined track line, the vessel did not approach the whale and searching from 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 2n.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 a photo-identification experiment. One ordinary form minke whale was sampled randomly from a primary sighted school within 3n.miles of the track line. The dwarf form minke whale was not targeted for sampling.

4. Low and middle latitudinal sighting survey

During transit cruises, sighting surveys were conducted in the area between 30S and north of 60S except for national EEZs. The results from the survey will be reported in the near future.

5. Experiments

Sighting distance and angle experiment

This trial 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 large baleen species such as blue, humpback and right whales were targeted for photographic record of natural markings by the SV. The SSVs also took photographs of blue whales and other species opportunistically.

Biopsy sampling

The species targeted for the photo-identification experiment and other large baleen whales were targeted for biopsy skin sampling by the SV. On the YS1, practice firing was attempted opportunistically to introduce the compand-crossbow as a sampling instrument.

Observation of diving behavior pattern of blue whales

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

Observation of diving behavior patterns of beaked whales

This trial was conducted by the SV in order to collect information on the 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

To elucidate migration routes, attempts were made to attach a satellite tagging system (Nishiwaki *et al.*, 1994) to the body of a minke whale.

Oceanographic survey

The oceanographic surveys using CTD and EPCS system was carried out by the YS1 throughout the entire research area. The CTD survey is conducted at the end of the sighting survey of a day or during drifting. The EPCS system allows consecutive measuring of water surface temperature, of conductivity (SEACAT THERMOSALINOGRAPH, SEA-BIRD ELECTRONICS, INC), of surface chlorophyll-a (Model 10-AU-005, TURNER DESIGNS), of Dissolved Oxygen (Model2127, Oribisphere Laboratories), of surface particle (Model P-o5, Nippon Kaiyo), and of surface flow (Model EMARG2W, Aichi Tokai Denki).

A Passive acoustic system (SIMRAD EK500 38kHz, 120kHz, 200kHz) was installed on the SV to survey for krill. This system allowed both the whale sighting survey and the whale prey species survey such as krill distribution and abundance simultaneously. In addition, a XCTD system was introduced on the SV. The collection of oceanographic data will help to elucidate the marine ecosystem of the Antarctic Ocean and the role of whales within this ecosystem. All marine debris was recorded from the SV in the entire research area. Also all marine debris found in the stomachs of minke whales were recorded and collected.

Acoustics

Acoustic feasibility study was conducted principally on blue whales using reusable sonobuoy system

consisting of a hydro-phone, battery and DAT recorder.

OUTLINE OF THE RESEARCH ACTIVITIES

An outline the research activities conducted during the 1998/99JARPA survey is as follows.

EVENTS	DATE	VESSEL
Departure from Japan	6 November 1998	NM, SV and SSVs
Return to Japan because of fire	14 December 1998	YS1 and T25
	15 December 1998	KS2
	20 December 1998	NM and K01
Departure from Japan	22 December 1998	YS1 and KS2
	2 January 1999	K01 and T25
	5 January 1999	NM
Sighting survey in transit area	5 January-12 January 1999	YS1
	7 January-13 January 1999	KS2
	16 January-23 January 1999	K01 and T25
Sighting survey in the East- North stratum in Area V	13 January-23 January 1999	YS1
Sighting survey in the West- North stratum in Area V	14 January-28 January 1999	KS2
Sighting and sampling survey in the East- North stratum in Area V	24 January-30 January 1999	YS1, K01 and T25
Sighting and sampling survey in	30 January-2 February 1999	KS2
the West- North stratum in Area V	30 January-3 February 1999	YS1, K01 and T25
Sighting and sampling survey in	3 February-21 February 1999	KS2
the West- South stratum in Area V	4 February-25 February 1999	YS1,K01 and T25
Sighting and sampling survey in	22 February-13 March 1999	KS2
the East- South stratum in Area V	26 February-16 March 1999	YS1, K01 and T25
Sighting and sampling survey in	14 March-28 March 1999	KS2
the Western part of Area VI	17 March-31 March 1999	YS1, K01 and T25
Sighting survey in transit area	30 March-6 April 1999	KS2
	4 April-12April 1999	YS1, K01 and T25
Arrival at Japan	23 April 1999	KS2
	26 April 1999	NM
	26 April 1999	YS1, K01 and T25

RESULTS

1. Searching effort

The searching distances (n.miles) of the SV and three SSVs in each stratum is shown in Table 1. The total searching distance during the 78day research period was 8,063.6 n.miles (Area V; 6,952.0, Area VIW; 1,111.6). The searching distance in this cruise was 9,692.0 n.miles shorter than that in the 1996/97 JARPA (Nishiwaki *et al.*, 1997), therefore the search effort was less than for the previous cruise. The research period was reduced by the fire accident on the research base ship. For this reason, the first half of the survey in the Area VIW was canceled and the sighting and sampling survey in the northern strata of Area V was abridged. The search effort in the southern strata was also shorter than that of the previous cruise. Because the density of minke whale was high compared with the previous cruise, sampling activity reduced searching efforts of SSV in the southern strata.

2. Species sighted

Tables 2a-2b summarize the sightings. Minke whales were the most dominant species throughout the whole research area and period. As for ordinary form minke whales, 1,027 schools (3,392 individuals) were sighted, including the primary sightings of 826 schools (2,665 individuals) and secondary sightings of 201 schools (727 individuals). Minke whales accounted for 63.8% of the sighting composition, which was higher than for the previous cruise. As for dwarf form minke whales, the primary sightings of two schools (2 individuals) occurred in the northern strata of Area V.

For baleen whales other than minke whales, 106 schools (203 individuals) of the humpback whales were primarily sighted and 27 schools (60 individuals) were secondarily sighted. Humpback whales were the second dominant species of baleen whales. Fin whale sightings of 59 schools (274 individuals) and blue whale sighting of 7 schools (16 individuals) were confirmed. No sei whale sightings were confirmed. One school (one individual) right whale was only secondary sighted. Sightings of unidentified baleen whales amounted 140 individuals to 48 schools. There was a tendency for humpback and fin whales sightings to occur in the same place.

For toothed whales, 49 schools (50 individuals) of the sperm whales were primarily sighted and 5 schools (6 individuals) were secondarily sighted. Sperm whales were the most dominant of the toothed whales. This was followed by 62 schools (120 individuals) of ziphiid whales which included 23 schools (53 individuals) of southern bottlenose whales and one school (5 individuals) of Arnoux's beaked whales. In addition, 42 schools (459 individuals) of killer whales and 5schools (22 individuals) of the hourglass dolphin were sighted.

The sighting composition from this cruise showed an increase of minke whales and a decrease of fin, sperm and southern bottlenose whales compared to the previous cruise.

3. Sightings and sampling of minke whale

The geographical locations of sightings of the minke whales (including dwarf formed minke whales) were plotted in Fig. 3. In the Area VIW, minke whales were widely distributed in the sea condition that surface of the sea became sherbet and was covered with pancake ice. In the Area V, they were widely

distributed in the entire research area and the highest number of minke whale sightings was observed in the West- South stratum. The pattern of distribution of minke whales was different from those observed in the previous surveys (Nishiwaki *et al.*, 1995, 1997). Dwarf form minke whales were observed only in the north strata in Area V.

Table 3 shows the density indices (DI) which are calculated as the number of minke whale schools primarily sighted per 100 n.miles searched and the mean school size (MSS). The DI in the West- South stratum (15.47) was the highest of all research strata and the MSS was also high (4.32) in this stratum. Minke whales in this stratum were not concentrated in the limited part, but distributed throughout the whole stratum. The DI in the south strata (15.47 and 10.06) was higher than north strata (5.54 and 5.74), whereas the MSS in the western part was higher than for the eastern part of Area V.

Out of 540 schools (1,670 individuals) of ordinary minke whales sighted by three SSVs, 435 individuals were targeted for sampling. A total of 389 individuals were collected (329 from Area V, 60 from VIW). Technical sampling efficiency (the rate of sampling for targeted individuals) is shown in Table 4. In the Area VIW, it was 0.82. In Area V, the value ranged from 0.87 to 0.94. These values were high compared with the previous research. Of target individuals, 43 could not be taken. 24 individuals were missed because of their swimming activity (fast speed, long diving or quick mobility). 4 individuals were canceled to sample because of time restraints and excessive burden on the research base ship. Sampling was abandoned for 8 individuals because they escaped into the pack ice. 7 individuals were missed due to technical reasons.

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

4. Experiments

The SV and the three SSVs conducted the sighting distance and angle experiment on 18 February and on 21 and 22 February, respectively. A total of 456 experiments were conducted with participation of 36 persons.

Table 5 shows the summary of other experiments. Photographs of natural markings were taken from 7 schools of blue and 24 schools of humpback whales. Biopsy skin samples were collected from 2 blue, 30 humpback and 3 fin whale individuals. Natural behavior patterns of diving were observed for a total of 95 minutes from a school of blue and a school of southern bottlenose whales.

The attempts were made to attach the satellite tag on 5 schools (41 individuals) of minke and a school (two individuals) of humpback whales on the SV in the West- South stratum of Area V, but all attempts failed.

The XCTD casts were conducted at 33 points in the East- South stratum of Area V and at 27 points in the Area VIW. The CTD and the EPCS surveys were carried out on the YS1. The CTD casts were conducted at 66 locations in the whale research area. The EPCS survey was recorded in the whole research area through 78 days.

Acoustic estimates of distribution and abundance of krill were conducted on the SV with a Simrad EK 500. A total of 4,365.5 n.miles was covered over the whole research area for this experiment.

Acoustic survey for the purpose of signal analysis was conducted on two blue, one fin, two humpback and

one southern bottlenose whale schools with a sonobuoy system. The total recording time was 563 minutes. Marine debris was not confirmed during the research period. A plastic cap was found from the stomach contents of a female animal, 7.19m in body length, sampled on 3 February 1999 (64° 34' N, 136° 33' E).

5. Biological research

Biological information was collected on the research base ship for all whales sampled (247 males, 142 females). Table 6 summarizes data and samples collected. From the 72 pregnant females, 2 fetuses were lost after harpooning during catching operations. Since one female had twin fetuses, 71 fetuses were collected.

6. Products

All of the whales collected were processed on the *Nisshin Maru* after biological sampling was completed, according to the provisions of Article VIII of the ICRW. A total of 1,728.653 tons of meat, blubber, viscera, etc. were produced.

7. Preliminary analyses of biological information

Sex ratio and reproductive status

Table7 shows 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 400 g was determined to be mature and others were classified in immature.

Mature males were dominant in all the research area. Among the males, mature animals overwhelmed immature animals even in the southern strata. Maturity rate of the males was relatively high in every stratum (66.7 % - 91.0 % in Area V, 65 % in Area VIW). There were a few pregnant females except for the West- South stratum of Area V. In the Area VIW, no mature female was collected. Maturity rate of females in Area V was the highest in the West- South stratum (75.9 %) and the lowest in the West- North stratum (22.2 %).

Length composition

Table 8 shows the mean body length of minke whales collected in each stratum. Maximal length of the samples was 9.63 m in males and 10.11 m in females. Minimal length was 5.11 m and 5.12 m, respectively. Mean body length in each sexual maturity class was not significantly different among stratum except for immature females. In the western part of Area V, mean body length of immature females was higher than other strata. This is because many immature females over 8 m in the body length were collected.

DISCUSSION

Minke whales accounted for 63.8% of the sighting composition and highly concentrated in the West-South stratum. When compared with previous survey (*Nishiwaki et al.* 1997), the DI and the MSS of

minke whales in the present survey is higher in all strata except for the East- South stratum. Because of a delay of melting of the Ross Sea ice cover, the East- South stratum in the present survey was limited to the part on the northern side of this stratum. However, taking account of the fact that the southern side in this stratum could not be surveyed, the DI and the MSS of minke whales in the East- South stratum is similar to that of other strata. On the other hand, the DI and the MSS in the West- South stratum were the highest in 3 previous surveys (DI / MSS: 1994/95; 7.73 / 3.10, 1996/97; 4.93 / 3.68). During the present survey, good weather conditions for the research activity continued and bad weather was not encountered for more than one week throughout the research period. It is suggested that such weather condition was one of reasons for high number of minke whales sightings.

In the present survey, there were a few mature females in the East- South stratum of Area V and no pregnant females were collected in the Area VIW. The proportion of pregnant females in these strata was very high in previous surveys (Nishiwaki *et al.*, 1997). On the other hand, the proportion of mature females in the West- South stratum was similar to the previous survey. Because it is known the fact that the minke whales occur also within the ice-edge (Leatherwood *et al.*, 1981: Naito, 1982), one possible explanation for the situation observed in stratum East-South of Area V and Area VIW, is that the mature females could have migrated into the ice-free areas of the Ross Sea. The other explanation is that these whales migrated into another unknown areas. Further investigation is needed to clarify this situation.

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Table 1. Searching distance (n.miles) by a SVand three SSVs in each stratum of the research area.

Stratum	SV	SSVs	Total
Area V			
East - North	652.8	574.1	1226.9
East -South	377.3	1183.7	1561.0
West - North	961.8	868.8	1830.6
West - South	647.5	1686.0	2333.5
Total	2639.4	4312.6	6952.0
Area VI West	542.0	569.6	1111.6

Table 2a. Summary of sightings (no. schools/no. individuals) conducted by a SV and three SSVs in each stratum of Area V and Area VI West.

Area V Northern stratum

	SV				SSVs			
	West sector		East sector		West sector		East sector	
Species	Primary	Secondary	Primary	Secondary	Primary	Secondary	Primary	Secondary
Minke whale	53 / 301	21 / 151	22 / 45	5 / 6	52 / 97	6 / 8	46 / 122	9 / 14
Dwarf minke whale	1 / 1		1 / 1					
Like minke whale	5 / 18	2 / 2	1 / 1	3 / 4				1 / 1
Blue whale	2 / 4	3 / 9						
Fin whale	4 / 17	4 / 16	4 / 14		4 / 16	4 / 17	2 / 2	
Humpback whale	8 / 21	4 / 12	5 / 10	1 / 2	4 / 7	1 / 2	17 / 29	6 / 14
Baleen whales	4 / 6	2 / 3	6 / 13		3 / 5	1 / 5	5 / 7	
Sperm whale	9 / 9		9 / 9	3 / 4	12 / 13			
S. bottlenose whale	4 / 9		2 / 7		1 / 1			
Arnoux's beaked whale	1 / 5							
Ziphiid whales	2 / 3	1 / 3	9 / 13		3 / 3		4 / 4	
Killer whale	2 / 4		2 / 18	1 / 5	1 / 30		5 / 48	
Hourglass dolphin	1 / 5	1 / 3			2 / 7	1 / 7		
Unidentified dolphin	2 / 5							
Unidentified whales	3 / 3		8 / 9		6 / 6		2 / 2	

Area V Southern stratum

	SV				SSVs			
	West sector		East sector		West sector		East sector	
Species	Primary	Secondary	Primary	Secondary	Primary	Secondary	Primary	Secondary
Minke whale	114 / 476	59 / 192	36 / 105	57 / 194	247 / 1082	18 / 110	121 / 269	9 / 33
Like minke whale	15 / 27	3 / 3	3 / 5		2 / 6		2 / 2	
Blue whale			1 / 2		1 / 1			
Fin whale			11 / 96	3 / 11	3 / 4		12 / 58	2 / 6
Humpback whale	15 / 31	2 / 4	4 / 11	5 / 10	16 / 26	1 / 2	31 / 58	4 / 8
Right whale						1 / 1		
Baleen whales			7 / 33		4 / 9	2 / 16	12 / 40	1 / 1
Sperm whale	4 / 4	1 / 1	1 / 1		7 / 7	1 / 1	6 / 6	
S. bottlenose whale	1 / 3		2 / 4		4 / 11		5 / 12	
Ziphiid whales	1 / 1		2 / 2		6 / 18	1 / 2	5 / 7	1 / 3
Killer whale	6 / 45	4 / 31			15 / 223	1 / 6	4 / 41	1 / 8
Unidentified whales	8 / 8				26 / 26		20 / 20	

Area VI West

	SV		SSVs	
Species	Primary	Secondary	Primary	Secondary
Minke whale	61 / 68	14 / 16	74 / 100	3 / 3
Like minke whale	2 / 2		3 / 3	
Fin whale	4 / 13		1 / 2	1 / 2
Humpback whale	3 / 4	3 / 6	3 / 6	
Baleen whales			1 / 2	
Sperm whale	1 / 1			
S. bottlenose whale	2 / 3		2 / 3	
Ziphiid whales	2 / 2		1 / 1	
Unidentified whales	1 / 1		13 / 13	

Table 2b. Summary of sightings (no. schools/no. individuals) conducted by a SV and three SVVs in Area V and Area VI West.

Area V

	SV		SSVs		Total	
Species	Primary	Secondary	Primary	Secondary	Primary	Secondary
Minke whale	225 / 927	142 / 543	466 / 1570	42 / 165	691 / 2497	184 / 708
Dwarf minke whale	2 / 2				2 / 2	
Like minke whale	24 / 51	8 / 9	4 / 8	1 / 1	28 / 59	9 / 10
Blue whale	3 / 6	3 / 9	1 / 1		4 / 7	3 / 9
Fin whale	19 / 127	7 / 27	21 / 80	6 / 23	40 / 207	13 / 50
Humpback whale	32 / 73	12 / 28	68 / 120	12 / 26	100 / 193	24 / 54
Right whale				1 / 1		1 / 1
Baleen whale	17 / 52	2 / 3	24 / 61	4 / 22	41 / 113	6 / 25
Sperm whale	23 / 23	4 / 5	25 / 26	1 / 1	48 / 49	5 / 6
S. bottlenose whale	9 / 23		10 / 24		19 / 47	
Arnoux's beaked whale	1 / 5				1 / 5	
Ziphiid whales	14 / 19	1 / 3	18 / 32	2 / 5	32 / 51	3 / 8
Killer whale	10 / 67	5 / 36	25 / 342	2 / 14	35 / 409	7 / 50
Hourglass dolphin	1 / 5	1 / 3	2 / 7	1 / 7	3 / 12	2 / 10
Unidentified dolphins	2 / 5				2 / 5	
Unidentified whales	19 / 20		54 / 54		73 / 74	

Area VI West

	SV		SSVs		Total	
Species	Primary	Secondary	Primary	Secondary	Primary	Secondary
Minke whale	61 / 68	14 / 16	74 / 100	3 / 3	135 / 168	17 / 19
Like minke whale	2 / 2		3 / 3		5 / 5	
Fin whale	4 / 13		1 / 2	1 / 2	5 / 15	1 / 2
Humpback whale	3 / 4	3 / 6	3 / 6		6 / 10	3 / 6
Baleen whale			1 / 2		1 / 2	
Sperm whale	1 / 1				1 / 1	
S. bottlenose whale	2 / 3		2 / 3		4 / 6	
Ziphiid whales	2 / 2		1 / 1		3 / 3	
Unidentified whale	1 / 1		13 / 13		14 / 14	

Table 3. DI and MSS of minke whales sighted primarily by a SV and three SSVs in each stratum of the research area.

	SV				SSVs				Combined			
Stratum	Sch.	Ind.	DI	MSS	Sch.	Ind.	DI	MSS	Sch.	Ind.	DI	MSS
Area V												
East - North	22	45	3.37	2.05	46	122	8.01	2.65	68	167	5.54	2.46
East - South	36	105	9.54	2.92	121	269	10.22	2.22	157	374	10.06	2.38
West - North	53	301	5.51	5.68	52	97	5.99	1.87	105	398	5.74	3.79
West - South	114	476	17.61	4.18	247	1082	14.65	4.38	361	1558	15.47	4.32
Western part of Area VI	61	68	11.25	1.11	74	100	12.99	1.35	135	168	12.14	1.24

Table 4. Efficiencies of sampling of minke whales.

Stratum	Sightings [1] A / B	Targeted [2] C	Sampled [3] D	Efficiency D/B [4]	Efficiency D/C [5]
Area V					
East - North	46 / 122	44	40	0.33	0.91
East - South	121 / 269	121	105	0.39	0.87
West - North	52 / 97	30	27	0.28	0.90
West - South	247 / 1082	167	157	0.15	0.94
Western part of Area VI	74 / 100	73	60	0.60	0.82

1) Primary sightings of SSVs (schools/individuals).
2) Number of targeted individuals including the second target in the same school.
3) Number of sampled individuals.
4) The ratio of samples taken from the primary sighted individuals.
5) The ratio of samples taken from targeted individuals.

Table 5. Summary of the results of experiment conducted by a SV. SSVs also conducted Photo-ID experiment and biopsy sampling with the compand-crossbow system on same opportunity. B, F, HP and SB represent blue, fin, humpback and southern bottlenose whales, respectively.

Stratum	Photo I.D. (schools)		Biopsy (samples)			Acoustic record (min.)				Behavioral observation (min.)		Scientific echo sounder	XCTD	CTD	EPCS
	B	Hp	B	Hp	F	B	F	Hp	SB	B	SB	(n.miles)	(points)	(points)	(days)
Area V															
East-North		2		1										17	17
East-South	1	2		2	3		136					655.6	33	14	18
West-North	5	6	2	7		205		158		13		1999.6		4	5
West-South	1	12		19					64		82	1107.2		20	22
Combined	7	22	2	29	3	205	136	158	64	13	82	3762.4	33	55	62
Area VI West		2		1								603.1	27	11	16
Grand total	7	24	2	30	3	205	136	158	64	13	82	4365.5	60	66	78

Table 6. 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[1)]	247	142	389
Body length and sex identification	247	142	389
Measurement of external body proportion	247	142	389
Body weight	247	142	389
Body weight by total weight of parts	29	21	50
Skull measurement (length and breadth)	230	135	365
Craniometric study	1	0	1
Standard measurements of blubber thickness (five points)	247	142	389
Detailed measurements of blubber thickness (fourteen points)	29	21	50
Mammary grand; lactation status and measurement	-	138	138
Breadth measurement of uterine horn	-	140	140
Testis and epididymis weight	247	-	247
Weight of stomach content in each compartment	246	140	386
Photographic record of foetus	(41)	(29)[2)]	(71)[3)]
Foetal length and weight	(41)	(28)[2)]	(69)[3)]
External measurements of foetus	(41)	(26)[2)]	(67)[3)]
Number of ribs	247	142	389
-Sample-			
Diatom film record and sampling	242	141	383
Serum sample for physiological study	244	141	385
Earplug for age determination	247	142	389
Earplug for chemical analysis (one of the pair)	10	9	19
Tympanic bulla for age determination	247	142	389
Largest baleen plate for age determination	64	58	122
Baleen plate for morphologic study	247	142	389
Vertebral epiphyses sample	247	142	389
Ovary	-	142	142
Histological sample of endometrium	-	137	137
Histological sample of mammary gland	-	137	137
Milk sample for chemical analysis	-	2	2
Histological sample of testis	238	-	238
Histological sample of epididymis	238	-	238
Testis and epididymis stamp smear for sperm detection	247	-	247
Blubber, muscle, liver, kidney and heart tissues for genetic study	247	142	389
Muscle, liver and kidney tissues for heavy metal analysis	247	142	389
Blubber and liver tissues for organochlorine analysis	247	142	389
Muscle, liver and blubber tissues for lipid analysis	29	21	50
Stomach contents for food and feeding study	136	44	180
Stomach contents for heavy metal analysis	12	8	20
Stomach contents for organochlorine analysis	11	5	16
Stomach contents for lipid analysis	14	4	18
External parasites	35	29	64
Internal parasites	24	12	36
Fetus	(0)	(1)	(2)[3)]
Blubber, muscle, liver, kidney and heart tissues for genetic study (fetus)	(41)	(28)[2)]	(69)
Pituitary gland for reproductive study	0	63	63
Testis for reproductive study	30	-	30
Pancreas for histological study	6	1	7
Pancreas for physiological study	1	0	1

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

2): including a fetus of the twin.

3): including a fetus of sex unidentified.

Table 7. 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 mature and others were classified immature.

Stratum	Male			Female					
	Immature	Mature	Total	Immature	Mature				Total
					Ovulating	Resting	Pregnant	Preg.+Lact.	
Area V									
East-North	7	25	32	3	-	-	5	-	8
	(17.5)	(62.5)	(80.0)	(7.5)			(12.5)		(20.0)
East-South	12	67	79	13	-	2	11	-	26
	(11.4)	(63.8)	(75.2)	(12.4)		(1.9)	(10.5)		(24.8)
West-North	6	12	18	7	-	1	1	-	9
	(22.2)	(44.4)	(66.7)	(25.9)		(3.7)	(3.7)		(33.3)
West-South	7	71	78	19	3	2	53	2	79
	(4.5)	(45.2)	(49.7)	(12.1)	(1.9)	(1.3)	(33.8)	(1.3)	(50.3)
Combined	32	175	207	42	3	5	70	2	122
	(9.7)	(53.2)	(62.9)	(12.8)	(0.9)	(1.5)	(21.3)	(0.6)	(37.1)
Area VI									
West	14	26	40	20	-	-	-	-	20
	(23.3)	(43.3)	(66.7)	(33.3)					(33.3)
Grand Total	46	201	247	62	3	5	70	2	142
	(11.8)	(51.7)	(63.5)	(15.9)	(0.8)	(1.3)	(18.0)	(0.5)	(36.5)

Table 8. 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 7.

Stratum	Male		Female	
	Immature	Mature	Immature	Mature
Area V				
East-North	6.52±1.10	8.41±0.43	6.24±0.51	8.82±0.20
	(5.47-8.29)	(7.57-9.37)	(5.53-6.70)	(8.58-9.08)
East-South	6.03±0.65	8.35±0.38	6.05±0.76	8.94±0.38
	(5.20-7.52)	(7.34-9.63)	(5.12-7.75)	(8.08-9.35)
West-North	6.40±0.66	8.56±0.41	6.48±0.85	8.79±0.35
	(5.49-7.31)	(7.86-9.28)	(5.64-8.11)	(8.43-9.14)
West-South	6.31±0.61	8.45±0.33	6.83±1.10	8.97±0.46
	(5.52-7.21)	(7.54-9.16)	(5.12-8.22)	(7.96-10.11)
Combined	6.27±0.79	8.41±0.38	6.49±0.99	8.95±0.44
	(5.20-8.29)	(7.34-9.63)	(5.12-8.22)	(7.96-10.11)
Area VI				
West	5.70±0.40	8.20±0.34	5.94±0.61	-
	(5.11-6.73)	(7.45-8.72)	(5.28-7.62)	
Grand Total	6.09±0.74	8.39±0.38	6.31±0.92	8.95±0.44
	(5.11-8.29)	(7.34-9.63)	(5.12-8.22)	(7.96-10.11)

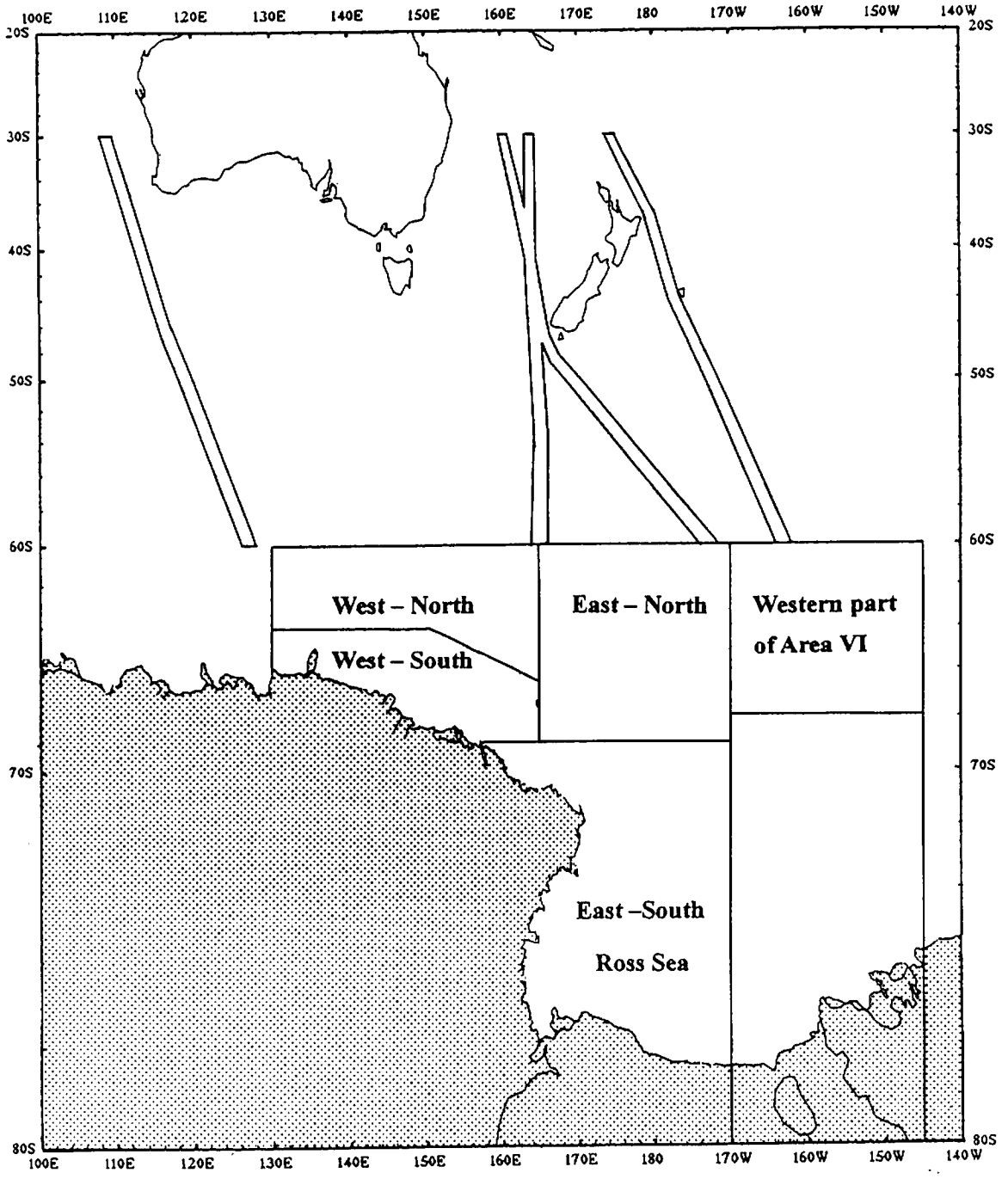
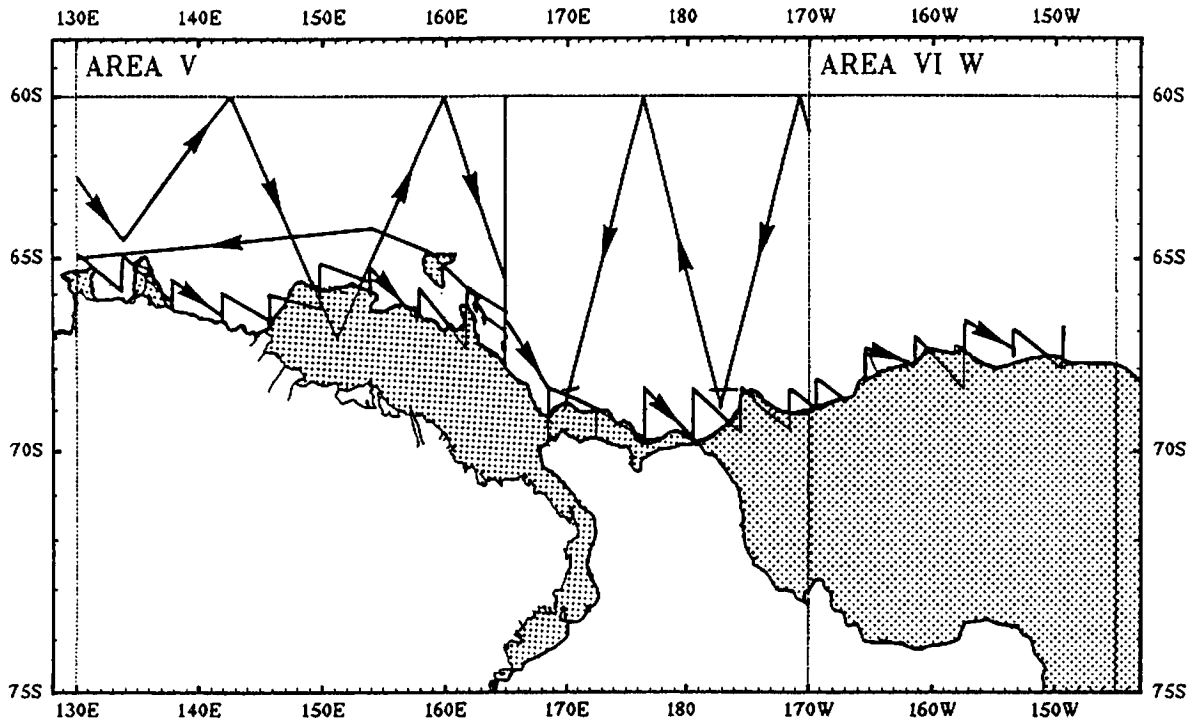


Fig 1. Geographic location of the 1998/99 JARPA research area and the low and middle latitudinal sighting survey area.



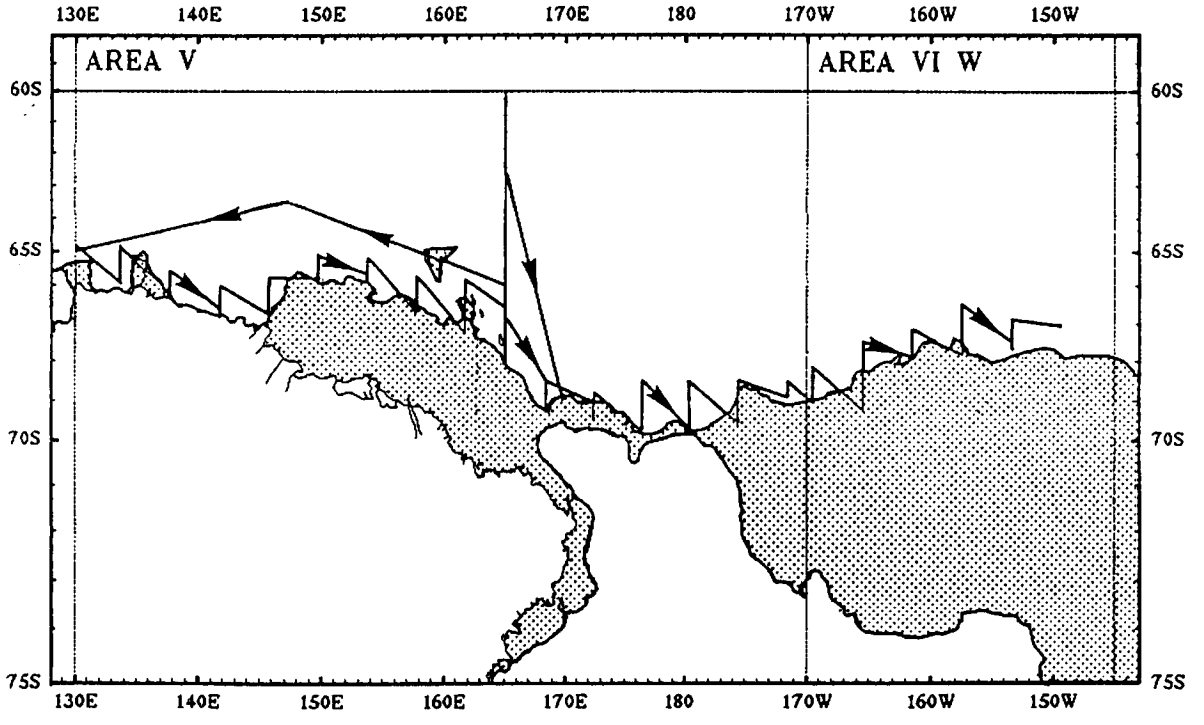
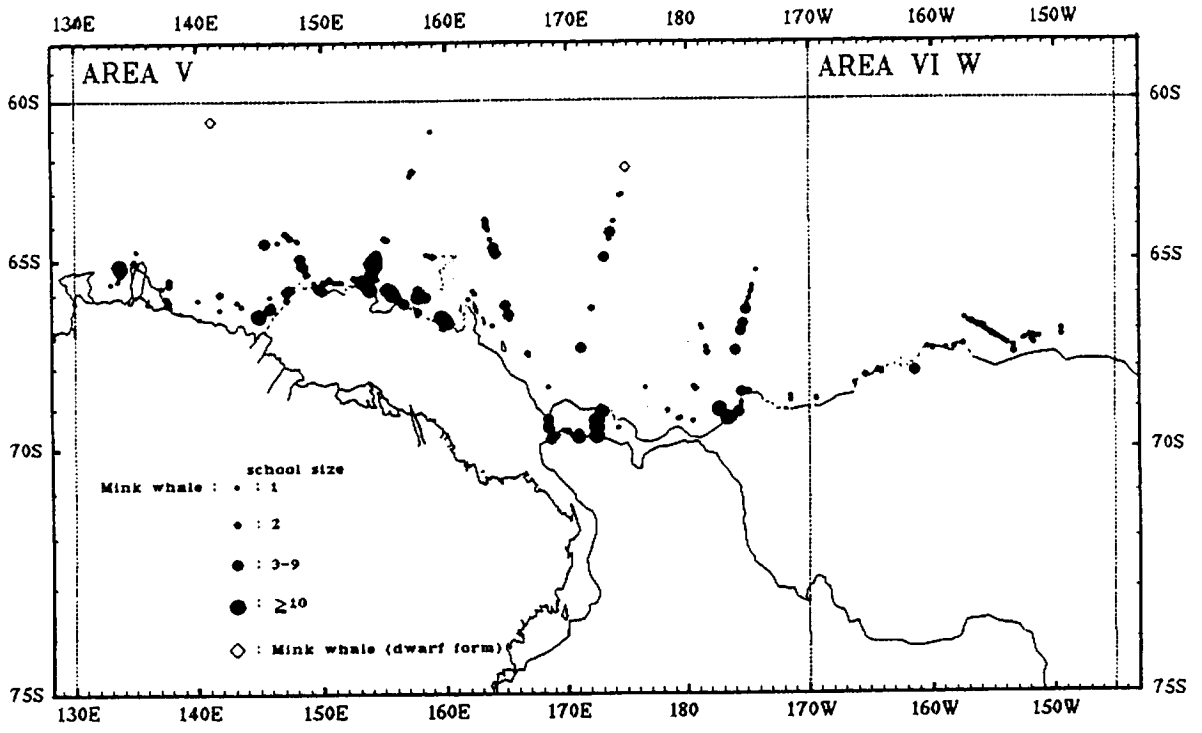


Fig. 2. Cruise tracks of the SV (above) and the SSVs (below). Estimated ice condition (shadow area) based on the information both from the observation of those vessels and from the National Ice Center (NIC) are also shown.



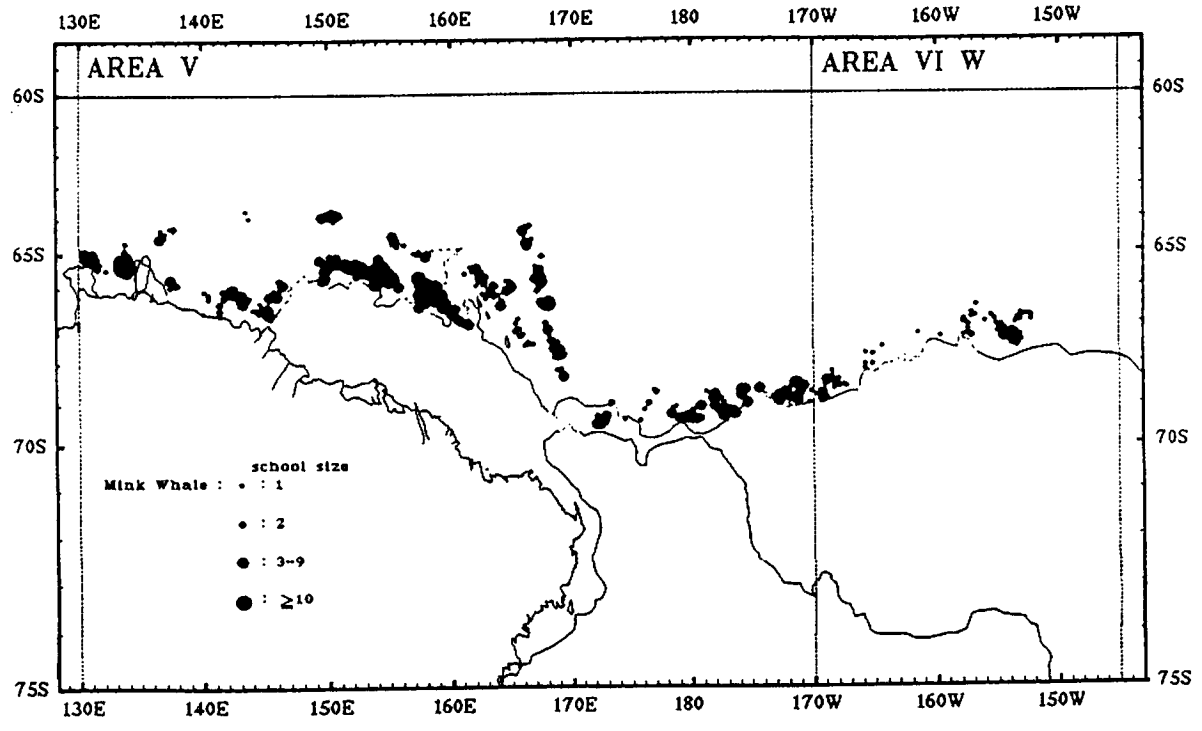


Fig. 3. Distribution of primary and secondary sightings of minke whales on the cruise tracks of the SV (above) and the SSVs (below).