Review of the Sighting procedure in the JARPA

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ABSTRACT

The Japanese Whale Research Program under Special Permit in the Antarctic (JARPA) has been conducted in a consistent way every year since 1987/88 in the Area IV and V. The sighting survey is the major part of JARPA program. The unique random sampling method to make unbiased data was adopted and improved on the course of this long-term program. A large amount of data and information on Antarctic minke whales and other whale species are accumulating, and some intermediate analyses were done. Unique sighting and sampling procedures to collect unbiased data and samples of minke whales was introduced in the JARPA program; (1) the track line was designed in order to cover the whole area uniformly, (2) the line transect sampling procedures sampled the schools proportionally according to the densities encountered, (3) all the schools sighted were targeted for sampling, and (4) animal (s) in a school was sampled. This paper reviews the methodology from sighting and sampling survey in JARPA program, and clarify of similarity and difference of sighting procedure between JARPA and IDCR/ SOWER cruises.

INTRODUTION

The Japanese Whale Research Program under Special Permit in the Antarctic (JARPA) has been conducted every year since the 1987/88 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 1989/90. The program is 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 ((*Balanoptera bonaerensis*), (Government of Japan, 1987, 1989, and 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.

Whales are heterogeneously distributed in the Antarctic spatially or other ways. Information from the past commercial whaling have demonstrated that larger animals of southern minke whales (mainly pregnant females) concentrated in waters near the ice-edge, while it was not well known about distribution of immature animals from the data of the commercial whaling.

The JARPA was designed to collect sample from the whole area uniformly to make unbiased estimation of population characteristics and abundance. To satisfy these conditions, line transect sighting and sampling procedure was adopted and the track line was designed so as to cover the whole area uniformly in Area IV and animal was randomly sampled from all minke school sighted. This paper introduces sighting procedure in the JARPA based on the Review of the Sighting Surveys in the JARPA (Nishiwaki *et al.*, 1997).

SURVEY ITEM

Research area

The cumulative numbers of minke whales taken by the commercial whaling in the past and the associated information on biological characteristics of minke whales were more concentrated in Areas IV and V together with the operational knowledge for catching such as sea and ice condition there. Area IV(70E－130E) and V (130E－170W) was selected to be surveyed under this program.

In the first two years (feasibility studies), only limited areas in Area IV and V were covered, however subsequent years entire areas in Areas IV and V were covered. Since the research area were divided into three north-south strata: 55S to 60S, 60S to the line of 45 n.miles from the ice-edge and 45 n.miles and ice-edge. In the waters 55S to60S, the limited surveys had been conducted during 1987/88 and 1991/92 (Fig. 1-3). Subsequent year sighting and sampling have been conducted in waters south of 60S. In the first period of 1989/90 and 1991/92, the survey area had expanded to 58S because the pack ice position in Area IV was encountered further north than expected.

The Special Monitoring Zone (SMZ) has been established to investigate seasonal variation of whale density from 1992/93 to 1994/95 (Fig. 4-6).

Since1995/96, eastern part of Area III and western part of Area VI since 1996/97 was tentatively surveyed to collect information on genetic variability of minke whales (Fig. 7-12).

Research vessels

Five research vessels engaged in the sighting activity through the previous research. In the feasibility studies, the Kyo-Maru No.1 and Toshi-Maru No.25 engaged in the first year (1987/88) and Toshi-maru No.18 was added to the following year (1988/89). These vessels are the hull that is called the Toshi-Maru type that the front of the upper-bridge has a barrel. As for the entire research, it was carried out the sighting and sampling activity with these vessels until 1997/98. Toshi-Maru No.18 was scrapped and Youshin－Maru joined as the new vessel from 1998/99. This ship is called the shohnan-Maru type that has a barrel on the truth of the upper bridge.

The dedicated sighting vessel was introduced from 1991/92. One of three SSVs designated to the sighing activity alternately and attended until 1994/95. Kyoshin-Maru No.2 joined as the dedicated sighting vessel from 1995/96. This ship is called the Kyoshin-Maru type that was modified from a long-line fishery ship and has a barrel on the truth of the upper bridge.

The research was conducting sighting activity with a Kyoshin-Maru type and conducting sighting/sampling activity with a Shonan-Maru type and two Toshi-Maru Types. A summary of ship deployment for each cruise is presented in Table 1a and 1c. The types of sighting platform in these vessels are shown in Fig. 15.

Transit survey

During transit cruises, sighting surveys were conducted in the area between south of 30° S and north of 60° S except for areas within national EEZs.

Research periods

Table 1 shows the research periods of each cruise. The survey is designed to cover entire feeding migration period of minke whales to the maximum extent to collect information including temporal heterogeneity of distribution and biological characteristics. Survey covered the area from early December to late march. During 1989/90－1991/92, the research area was surveyed twice in that season. From 1992/93, the research area was surveyed once since the SMZ was covered three times in a season.

Change of the Positioning (Navigation) system

Astronomical navigation had adopted and the Navy Navigation Satellite System (NNSS) had introduced in the earlier cruises. The Global Positioning System (GPS) further introduced from 1991/92 cruise. These systems improved the research activities (e.g. chasing, returning to the track-line and ice navigation etc.) and precision of the records (searching distance, calculation of the of the research area, decision of the ice-edge line etc.).

Installation of the graduated binocular

The graduated binoculars were used since 1987/88 cruise. This was used for the primary observer. SV was equipped with three to the barrels and two to the upper bridge. SSV was equipped with three in each platform. These binoculars are the same type that is used for the IDCR and SOWER cruise.

Installation of Angle board

The angle board that used direct measurement of a whale sighting position relative to the position and heading of the vessel was introduced from 1997/98. This equipment used by primary observer during searching and sighting. This angle board is the same type that is used for the IDCR and SOWER cruise.

Installation of digital anemometers

From 1995/96 cruise, digital anemometer had installed in the wheelhouse of research vessels. This equipment are useful for decision of start / end of searching by standard wind speed in each stratum. This anemometer is the same type that is used for the IDCR and SOWER cruise. The new anemometers indicate true wind speed and direction. The previous anemometers had measured relative wind speed (from which the true wind speed was calculated by vector analysis). This modification has facilitated data recording by the ships officers and it is considered there has been no significant change to the accuracy of the measurements of wind speed and direction.

Data entry

Since 1997/98 cruise, sighting, effort and weather records have been entered into computer files during the cruise. The data input is not in real time; the data is usually entered each evening, after the end of the research day.

SURVEY PROCEDURE

Design of track lines to cover the whole area uniformly

Since whales are expected to be highly heterogeneously distribution in the research area, it is critically important for the research track lines to be systematically allocated to covers the whole research area uniformly.

According to the theory, a billiard ball type track line design covers the whole area uniformly in the long term. In the feasibility studies (1987/88 and 88/89), this billiard ball type track lines were adopted. Although it was found that more survey effort tended to be necessary on the boundary region within the limited time scale of the survey, fixing the reflection angle to 70 degree solved this problem.

After the full-scale research started in 1989/90, the new design of the track line (saw tooth type) was adopted considering the wider area and the billiard type was abandoned. The starting point of the saw tooth track line was randomly selected from lines one n.miles apart. The following way-points were systematically set on the ice-edge and on the locus from the45 n.miles from ice-edge (southern stratum), on the 45 n.miles and 60S latitude line (northern stratum).

Cruise tracks

In the first two years of feasibility study, the cruise tracks in the northern part of research area (north of 60S) were drawn north south. In the southern strata, the track lines were established (like a trace of a billiard ball with fixed angle of 70 of reflection) systematically to give a uniform coverage in the research area. Cruise tracks in the feasibility study are shown in Fig. 1 to Fig. 12.

Table 1 shows a summary of track line design on strata. In the subsequent years, the cruise tracks were established like saw tooth pattern with randomly selected start point in the southern two strata based on pack ice line. In the northern strata and southeast stratum (Ross Sea in Area V), a zigzag line that is used in the IDCR survey was established. In the southern strata except for the Prydz Bay, the track lines were zigzagged from north to south at intervals of 4 degrees longitude. In the Prydz Bay, the pack ice line surveys were conducted every year before sighting and sampling survey started. Then the area divided into the north and the south zones, each of which had a latitudinal track line. These two track lines were diagonally connected and formed a Z-shaped track line.

Searching effort

Activities aboard the ship are classified in two principal groups: On-effort and Off-effort. In the sighting survey portion of the research, On-effort activities are times when full search effort is being executed and conditions (such as weather and sea conditions) are within acceptable parameters to conduct research. Off-effort activities are all activities that are not On-effort. All sightings recorded while the ship is On-effort are classified as primary sightings. All other sightings are secondary sightings.

A standard speed of 11.5 −12.0 knots was adopted. A constant watch was kept for 14 hours (12 hours since 1995/96) per day during 0600 hours to2000 (18:00) hours or from 30 minutes after the sunrise to 30 minutes before the sunset (1 hours since1995/96).

Sighting effort conducted by three primary observers were in the barrel (two men in 1987/88 and 1988/89 feasibility studies). Three or two primary observers (captain, gunner and quartermaster on SSV, captain and quartermaster on SV) on the upper bridge with other crew. Few secondary observers (researchers, chief radio operator and chief engineer or deputy) assisted these primary observers on the upper bridge or above the Asdic hut.

Closing for confirmation or sampling were conducted only for primary sightings of minke whales, and only when those sightings were no further than 3 n.miles from track line (In addition, closing to large baleen whales were made regardless of distance to take photograph for natural marking or for biopsy sampling). After completion of confirmation or sampling, the vessel normally returned at angle of 45 to the track line. When it returned at angle 90, the vessel went into top man-down steaming (no search effort) until it returned to the track line.

To obtain accurate estimates of sighting angle, angle boards were used both in the barrel and in front of the captain and gunner in the upper bridge. Reticule binoculars were used to estimate sighting distance from the vessel to the sightings. Sightings, effort and weather data were recorded in the similar format as used for IDCR

Sighting procedures

Sighting procedure in JARPA is based on sighting mode protocol of IDCR or SOWER. The three (two in feasibility study in 1987/88) sighting / sampling vessels (SSVs) operated in closing mode (when a sighting was made, the vessel closed to the sighting and confirmed the species and school size) on the predetermined track line when the weather was suitable for the research {minke visibility more than 1.5 n.miles and wind speed less than 20 (25 knots near pack ice-edge) knots per hour}. Searching began each day from a point where the predetermined distance from the previous day's starting point. Second and third vessels followed

followed track lines paralleled to the main but 6 n.miles apart (9 n.m. during 1989/90-92/93, 12 n.m. during 1993/94,94/95, 7 n.m. since 1995/96).

Closing mode

All primary sightings within an estimated perpendicular distance of 3 n.miles of the track line were to be closed with for confirmation of species, school size, and size composition. Secondary sightings of more than 3 n.miles perpendicular distance from the original track line would not be closed with, while if time were getting short no secondary sightings would not be closed with. Under the latter circumstances, when the ship return to track line all previously identified secondary sightings were not be counted as primaries. Further in regions of extremely high density rendering closure on every primary sighting impractical, only every third sighting would be closed with. After confirmation of all sightings had finished, searching would be immediately resumed on a course converging with the original track line.

Passing mode

No sightings would be closed with. Immediately a sighting was made, primary observer on the barrel would inform the upper bridge of his normal searching pattern in order to keep contact with the sighting. The observers on the upper bridge must attempt to locate the sighting made by the observer on the barrel and decide whether it is possible for them to confirm the species and number before it passes abeam of the vessel. The observer on the barrel gives no further information on the sighting to the upper bridge unless it happens to surface again within the normal searching pattern of observer on the barrel.

Introducing of the dedicated sighting vessel

The results of abundance estimate from the JARPA have been submitted to the IWC/SC every year. Some minor changes of the research program have been done by the reconsideration based on the results of previous cruises (Table 1).

In 1988/89 feasibility study, the paired vessels (located parallel between 0.3 n.miles apart) procedure was introduced to obtain information on effect of whales missed on the track line from the sighting /sampling vessel (SSV).

The pre-determined distance per day applied to JARPA in order to cover wide research area and the vessel had to make night steaming to the next starting point when the predetermined distance has not been achieved, this affect on the area covered in high density areas, especially Ross Sea in Area V. In order to investigate the effect of this activity, a dedicated sighting vessel (SV) has been introduced in 1991/92 in the southern strata and in all strata since 1992/93. The SV surveyed at least 12 n.miles ahead of the SSVs to avoid adverse effect from the sampling activities of the SSV and did not engage any sampling activities.

A series of survey have been conducted to cover the research area once since 1992/93. With the survey efforts concentrated in the peak distribution season of minke whales, to be comparable the procedure with the IDCR as much as possible.

The sighting survey using 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 passing mode by SV was adopted to elucidate distribution and abundance of prey species of Antarctic by hydro-acoustic survey using a active acoustic system since 1998/99 JARPA.

Sampling procedure

Sampling is conducted only on primary sightings of Antarctic minke whales. The dwarf form minke whale was not a target species for sampling since 1992/93 JARPA. School sighted within a range of 3 n.miles from

the track line, are approached for sampling in a closing mode. Schools sizes are determined and the whales to be targeted for sampling within the school are chosen using a series of tables of random sampling numbers, which are prepared according the size of schools.

During the 49th IWC Scientific Committee meeting, modification of the sighting and sampling method of JARPA was proposed (Schweder, 1998). Japan decided to conduct a limited scale feasibility study on whether the modified method was workable or not (Government of Japan, 1998). The feasibility study (S-experiment) was conducted in the East-south stratum in Area IV (1999/2000) and the West-south stratum in Area V (2000/2001). During the S-experiment period, All SSVs stayed at the point where the survey of the day was finished until next day. Different from the ordinal research manner, they never moved forward during night or in bad weather condition. Target for sample was selected according to the predetermined interval for each school size. One or two individuals were collected from the targeted school.

SIGHTING SURVEY RECORDS

Data collected

Details of each surveys and collection data in the JARPA program were presented in the cruise report, submitted to the IWC/SC each year. Outline of cruises in each season are summarized in Table 1.

Sighting, effort and weather information were recorded. Sighting is recorded at each sighting was made including time, distance and angle, number of animals in the school, etc. The officer on watch kept a chronological account of the vessel's activities on the Effort Record. Weather conditions were recorded by the officer at one-hour interval, and consisted of wind direction and speed, water surface temperature, visibility, ice cover and weather.

Sightings were classified into primary and secondary sightings. Primary sightings are those seen in normal searching mode (normal searching speed on the predetermined track line) and secondary sightings are those seen when not in normal searching mode (e.g. during closing, chasing handling, towing and drifting).

Search effort can be expressed as 'searching distance', that is the distance covered by all SSV and SV while in full searching mode. It is calculated from the time of spent in searching and the speed of the vessels.

Experiments

Outline of experiments in each cruise are summarized in Table 1. Details of each experiments and data collection were presented in the cruise report, submitted to the IWC/SC each year. To evaluate accuracy in estimates of sighting angle and distance, the estimated distance and angle experiments were conducted during the cruise in each season. Natural markings and biopsy skin samplings for blue, humpback and right whales have been conducted since 1990/91.Reactin monitoring experiments have been conducted during 1990/91 to 1992/93, to collect information on effect of the chasing activity of the SSV on the behavior of minke whales in undetected schools. Since 1993/94, effect of the sampling activity on behavior in undetected schools.

Preliminary experiments on use of echo sounder on minke whale behavior have been conducted since1993/94. An echo sounder is expected to use for the abundance estimation of krill in the future. A active acoustic system was installed on the Kyoshin-Maru No.2 to survey for krill since 1998/99. This system allowed both the whale sighting survey and the whale prey species survey such as krill distribution and abundance study simultaneously. Feasibility tests of satellite tagging system have been conducted since 1993/94. Behavioral observation of blue and Ziphiidae whales have been conducted from 1993/94 to 1998/99.

RESULTS

The similarity and difference of sighting procedure between JARPA and IDCR /SOWER cruises

Sighting procedure of JARPA and IDCR/SOWER cruises that was related with the analysis of abundance were described below to clarify similarity and difference of these two surveys.

The research period and timing

The schedule of each cruise was set in the peak season of the feeding migration of the Antarctic minke whales in the Antarctic. The period and the timing of the research in each cruise depend on days necessary in the research area. IDCR/SOWER cruises had shorter research period than the JARPA cruises because refueling was not available in the research area. JARPA research periods were longer than that of IDCR/SOWER to conduct samplings. The research periods were from early January to late February in the IDCR and SOWER cruises (Matsuoka *et al*, 2001) and those were from late December to early March in the JARPA cruises (Table1).

The covered research area in the south of latitude 60S

Table 2 (data from Branch and Butterworth, in press, Hakamada *et al*, 2001) showed the covered research area in the south of latitude 60S of each cruise in Antarctic area V. IDCR in 1985/86 was 924863 n.mile^2 which was the largest. The JARPA in 1996/97 followed it and was 917841 n.mile^2. Then, the IDCR in 1994/95 was 714033 n.mile^2 which was much smaller. The covered research area of the JARPA cruises was smaller than the IDCR cruises except for JARPA cruise in 1996/97. The difference of covered area was derived from change in ice extent.

The search effort in the research area

The IDCR in 1985/86 shows the highest abundance estimate among post IDCR/SOWER and JARPA cruises. Search effort density index (searching distance per 100 n.mile^2 of the research area), of 1985/86 showed high value in each stratum. In general, the search effort of SV is larger than that of SSV (Fig. 13).

The number of the primary observers

The number of the primary observers in each cruise was different among the type of sightings. In the closing mode at the IDCR and SOWER cruises, the primary observer were arranged each two persons on a barrel and upper-bridge. In the JARPA cruises, three primary observers were in the barrel (two persons in 1987/88 and 1988/89 feasibility studies) and three or two primary observers (captain, gunner and quartermaster on SSV, captain and quartermaster on SV) on the upper bridge.

The minke whale sighting angle and distance at the observation platform

Fig.14 shows distribution of minke whales primarily sighted in IDCR/SOWER and JARPA cruises in Area V. The number of sightings with narrow perpendicular distance were seen in 1985/86 IDCR cruise compared to the other cruises. Sightings with wide perpendicular distance were common in other cruises. The wider sighting distribution was more conspicuous for the SSVs than the SV. The difference of the sighting distribution between SV and SSV might be due to observer numbers at each sighting platform except the barrel. SSV had three primary observers on the upper bridge and a few secondary observers assisted these primary observers on the upper bridge and above the Asdic hut. The primary and the secondary observers around upper bridge of the SSV was one more person respectively than it of SV. It was indicated that the arrangement of the observation platform of research vessels influences such sighting distribution (Nishiwaki *et al*, 1995).

Density index

Table 3 (data from Branch and Butterworth, in press, Hakamada *et al*, 2001) shows the density index of each cruise in Area V. There is no noticeable difference in density index throughout the previous cruises and between SV and SSV. Yearly fluctuation of covered research area might influence to abundance estimates than the period and the timing of research in each stratum.

Mean school size

The mean school size of the closing mode in Area V is shown in the table 4(data from Branch and Butterworth, in press, Hakamada *et al*, 2001). 1985/86 IDCR cruise showed the highest value between IDCR and JARPA cruises. The difference between SV and SSV was not obvious. There might be yearly fluctuation in the mean school size of each stratum.

Effective search width

The effective search width by the closing mode in Area V is shown in the table 5 (data from Branch and Butterworth, in press, Hakamada *et al*, 2001). The effective search width of JARPA cruises is considerably wider than IDCR cruises. The effective search width of the SSV is substantially wider than the SV. It was considered that the number of the observers affected the sighting distribution.

DISCUSSION

Abundance estimates by closing mode are shown in the table 6 (data from Branch and Butterworth, in press, Hakamada *et al*, 2001). Abundance estimate in 1991/92 cruise became low remarkably compared with that in 1985/86 cruise. There was remarkable difference between 1991/92 IDCR and JARPA cruises. It was confirmed that the covered research area fluctuated remarkably by years (Table 2). And, the covered research area of the JARPA cruises was smaller than the IDCR cruises except for JARPA cruise in 1996/97. It was assumed that sea ice extent would influence those differences in the south strata. These would be negatively biased in abundance estimates because some areas inside the ice-edge cannot be surveyed. In Antarctic waters, higher density and higher crowding were observed in areas within bays than in areas of open waters. Mean school sizes were positively correlated with density (Kasamatsu *et al*, 1997). In the 1985/86 cruise, it encountered to the higher density than other cruises. Therefore, high mean school size would be brought with the density. It did not encounter to the high density in the other cruises than 1985/86 cruise. It was assumed that such a high density would influence to estimate abundance. JARPA encountered high density of minke whales in 1999/2000 and 2000/2001 cruises (Ishikawa et al, 2000, Nishiwaki et al, SC/53/O11). However, estimates of abundance based on the higher density and higher mean school size was still compared with 1985/86 IDCR cruise (Hakamada *et al*, 2001). The results might indicate the effective search width was wider in recent year. The smaller covered research area in these seasons including areas inside the ice edge which cannot be surveyed also affect negatively to the abundance estimation.

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Table 1. Summary of the JARPA cruises from 1987/88 to 2000/01.

Year	Survey period (Antarctic water)	Vessel	Survey area	Stratification		Trackline shape	# of trackline	# of SSV	# of SV	Pre-determined dait (n.mile) / day	Dist. between tracklines (n.mile)	Survey order by strata	Survey hour	Samling target spp.	Sampling method	Sampled animals	Experiment	Survey condition (Wind speed & minke visibility)	Topman	Mid-low lat. survey
	1988.1.17	NM3	Part of Area IV	N	55-60°S	N-S	2	2	0	No fixed dist.	6	N,S,N,S	6:00	M	2-1	273	MD	< Befort 6	2	0° - 55°S
1987/88	-3.26	K01		S	60°-Ice	B	2	2	0				-20:00	DM			XBT	> 1.5 n. mile Mi vis.		
(Feasibility)		T25	55S~ICE																	
			105E-115E																	
	1989.1.12	NM3	Part of Area V	N	55°-60°S	N-S	2	3	0	No fixed dist.	6	N,M,S	6:00	M	2-1*	241	MPO	Offshore - < 20kt	2	30°S - 52°S
1988/89	-3.31	K01		M	60°-69°S	B	2	3	0			S,M,N	-20:00	DM			XBT,MD	Near ice - < 24kt		
(Feasibility)		T25	52°S~ICE	S	69°S-Ice	B	2	3	0									> 1.5 n. mile Mi vis.		
		T18	168°E-180°			*Paired and single vessel survey metohod was used.									*Evry other primary sighting was choosen as target group in S and M strata.					
	1989.12.6	NM3	Area IV	N	55°-60°S	N-S	2	3	0	150'	9	N,SW,MW	6:00	M	2-1	330	XBT,MD	Offshore - < 20kt	3	30°S - 55°S
1989/90	-1990.3.12	K01		ME	60°S-45 mi line	Z	3	3	0	170'		SE,ME,	-20:00	DM				Near ice - < 25kt		
	Sighting only	T25		MW	60°S-45 mi line	Z	3	3	0	170'		SW,PB,						> 1.5 n. mile Mi vis.		
	after 2.14	T18		SE	45 mi line - Ice	RAT	3	3	0	100'		MW,SE,								
				SW	45 mi line - Ice	RAT	3	3	0	100'		ME,N								
				PB	S. of 66°S	Z	3	3	0	120'										
			*Northern limit of middle in first time period was 58°s																	
	1990.12.19	NM3	Area V	N	55°-60°S	N-S	3	3	0	150'	9	N,FSE,FME,	6:00	M	2-1	327	PH(B,H,R)	Offshore - < 20kt	3	25°S - 55°S
1990/91	-1991.3.22	K01		FME	60°S-45 mi line	Z	3	3	0	160'		SW,MW,	-20:00	DM			BI(H)	Near ice - < 25kt		
	Sighting only	T25		SME	60°S-69°S	Z	3	3	0	160'		SSE,SME,					CH,TAG	> 1.5 n. mile Mi vis.		
	after 3.15	T18		MW	60°S-45 mi line	Z	3	3	0	160'		SW,MW,N					XBT,MD			
				FSE	45 mi line - Ice	Z	3	3	0	140'										
				SE	S. of 69°S	Z	3	3	0	140'										
				SW	45 mi line - Ice	RAT	3	3	0	100'										
	1991.12.5	NM	Area IV	N	55°-60°S	N-S	3	3	0	150'	9	N,SW,MW,	6:00	M	2-1	288	PH(B,H,R)	Offshore - < 20kt	3	28°S - 55°S
1991/92	-1992.3.25	K01		ME	60°S-45 mi line	Z	3	2	1	150'		SE,ME,	-20:00 (SV)	DM			CH,XBT,MD	Near ice - < 25kt		
		T25		MW	60°S-45 mi line	Z	3	2	1	150'		SW,PB,	-19:00(SSV)					> 1.5 n. mile Mi vis.		
		T18		SE	45 mi line - Ice	RAT	3	2	1	Same dist as SV		MW,SE,								
				SW	45 mi line - Ice	RAT	3	2	1			ME,N								
				PB	S. of 66°S	Z	3	2	1											
			*Northern limit of middle in first time period was 58°s																	
	1992.12.3	NM	Area V	NE	60°S-69°S	Z	3	2	1	140'	9	FSMZ,	6:00	M	1-1	330	PH(B,H,R)	M - < 20kt	3	28°S - 60°S
1992/93	-1993.3.25	K01		NW	60°S-45 mi line	Z	3	2	1	140'	SV steam 12 mi	SE,NE	-20:00 (SV)	DM			BI(B,H,R)	S - < 25kt		
	Sighting only	T25	SMZ	SE	S. of 69°S	Z	3	2	1	140'	ahead of SSVs	SW,NW,	-19:00(SSV)				CH,J,XBT,MD	> 1.5 n. mile Mi vis.		
	after 3.22	T18	130°-155°E	SW	45 mi line - Ice	RAT	3	2	1	100'		SSMZ,					Blue whale survey (3.23-25)			
	1993.12.3	NM	Area IV	NE	60°S-45 mi line	Z	2	2	1	No fixed dist.	12	FSMZ,	6:00	M	1-1	330	PH(B,H,R)	N - < 20kt	3	20°S - 60°S
1993/94	-1994.3.19	K01		NW	60°S-45 mi line	Z	2	2	1		SV steam 12 mi	SE,NE,	-20:00 (SV)				BI(B,H,R)	S - < 25kt		
	Sighting only	T25	SMZ	SE	45 mi line - Ice	RAT	2	2	1		ahead of SSVs	SW,PB,	-19:00(SSV)				SA,TAG,AC,J	> 1.5 n. mile Mi vis.		
	after 3.18	T18	110°-130E	SW	45 mi line - Ice	RAT	2	2	1			NW,SSMZ					Blue,XBT,MD			
				PB	S. of 66°S	Z	2	2	1											
	1994.12.4	NM	Area V	NE	60°S-69°S	Z	2	2	1	No fixed dist.	12	FSMZ,	6:00	M	1-1	330	PH(B,H,R)	N - < 20kt	3	30°S - 60°S
1994/95	-1995.3.21	K01		NW	60°S-45 mi line	Z	2	2	1		SV steam 12 mi	SW,NW,	-20:00 (SV)				BI(B,H,R)	S - < 25kt		
	Sighting only	T25	SMZ	SE	S. of 69°S	Z	2	2	1		ahead of SSVs	SE,NE,	-19:00(SSV)				AC,TAG,J,SA	> 1.5 n. mile Mi vis		
	after 3.12	T18	165°E-170°W	SW	45 mi line - Ice	RAT	2	2	1			SSMZ					Blue,Zi			
																	XBT,MD			
	1995.11.26	NM	Area IV	NE	60°S-45 mi line	Z	3	3	1	No fixed dist.	7	IIIE,	6:00	M	1-1	440	AD,SA	N - < 20kt	3	30°S - 60°S
1995/96	-1996.3.22	K01		NW	60°S-45 mi line	Z	3	3	1		SV steam 12 mi	IVSW,	-18:00			III	PH(B,H,R)	S - < 25kt		
	Sighting only	T25		SE	45 mi line - Ice	RAT	3	3	1		ahead of SSVs	NW,PB,				II10	BI(B,H,R)	> 1.5 n. mile Mi vis.		
	after 3.13	T18		SW	45 mi line - Ice	RAT	3	3	1			NE,SE,				IV	AC,TAG,J,Blue			
		KS2		PB	S. of 66°S	Z	3	3	1			IIIE				330	Zi,XBT,MD			
			AreaIII East		60°S-Ice	Z	3	3	1											
	1996.11.30	NM	Area V	NE	60°S-69°S	Z	3	3	1	No fixed dist.	7	VIW,	7:00	M	1-1	440	AD,SA	N - < 20kt	3	30°S - 60°S
1996/97	-1997.3.13	K01		NW	60°S-45 mi line	Z	3	3	1		SV steam 12 mi	VNE, SW	-19:00			VI	AC,PH(B,H)	S - < 25kt		
		T25		SE	S. of 69°S	Z	3	3	1		ahead of SSVs	NW,SE,				II10	BI(B,H)	> 1.5 n. mile Mi vis.		
		T18		SW	45 mi line - Ice	RAT	3	3	1			VIW				V	Blue,Zi,TAG			
		KS2	Area VI west		60°S-Ice	Z	3	3	1							330	MD,XBT			

Table 1. Continued

Year	Survey period (Antarctic water)	Vessel	Survey area	Stratification		Trackline shape	# of trackline	# of SSV	# of SV	Pre-determined dist. (n.mile) / day	Dist. between tracklines (n.mile)	Survey order by strata	Survey hour	Samling target spp.	Sampling method	Sampled animals	Experiment	Survey condition	Topman	Mid-low lat. survey
1997/98	1997.12.7 -1998.3.14	NM	Area IV	NE	60°S-45 mi line	Z	3	3	1	No fixed dist.	7	IIIE, IVNW, SE,NE, SW,PB, IIE	7:00 -19:00	M	1-1	438	AD	N, IIIE - < 20kt	3	30°S - 60°S.
		K01		NW	60°S-45 mi line	Z	3	3	1							III	BI(B,H,R,M)	S,PB - <25kt		
		T25		SE	45 mi line - Ice	RAT	3	3	1		SV steamed 12 n. mile ahead of SSVs					110	PH(B,H,R)	> 1.5 n. mile Mi vis.		
		T18		SW	45 mi line - Ice	RAT	3	3	1							IV	Blue,Zi			
		KS2		PB	S. of 66°S	Z	3	3	1							328	TAG,SB,XCTD			
			Area III east		60°S-Ice	Z	3	3	1											
1998/99	1999.1.3 -3.31 (Due to the fire accident on NM the period was shorten.)	NM	Area V	NE	60°S-69°S	Z	3	3	1	No fixed dist.	7	VNE, NW,NE, NW,SW, SE, VIW	7:00 -19:00	M	1-1	389	AD	N, VIW - <20kt	3	30°S - 60°S.
		K01		NW	60°S-45 mi line	Z	3	3	1							V	BI(B,H,F)	S - < 25kt		
		T25		SE	S. of 69°S	Z	3	3	1		SV steamed 12 n. mile ahead of SSVs					329	PH(B,H)	> 1.5 n. mile Mi vis.		
		YS1		SW	45 mi line - Ice	RAT	3	3	1							VI	Blue,Zi,TAG			
		KS2	Area VI west		60°S-Ice	Z	3	3	1							60	SB,XCTD,CTD EPCS,KRLL			
1999/2000	1999.12.5 -2000.3.10 Sighting only after 3.11	NM	Area IV	NE	60°S-45 mi line	Z	3	3	1	No fixed dist.	7	IIIE, IVNW, NE,SE, SW,PB,	7:00 -19:00	M	1-1 (SWD in SE)	439	AD	N, IIIE - < 20kt	3	Go to 30°S - 58°S. Go out 30°S - 60°S.
		K01		NW	60°S-45 mi line	Z	3	3	1							IIIE	BI(B,H,F,M)	S,PB - <25kt		
		T25		SE	45 mi line - Ice	RAT	3	3	1							109	PH(B,H,R)	> 1.5 n. mile M vis.		
		YS1		SW	45 mi line - Ice	RAT	3	3	1		SV steamed 12 n. mile ahead of SSVs					IV	TAG			
		KS2		PB	S. of 66°S	Z	3	3	1							330	SB,XCTD,CTD EPCS,KRLL SW,MD			
			Area III east		58°S-Ice	Z	3	3	1											
2000/2001	2000.12.11 -2001.3.19	NM	Area V	NE	60°S-69°S	Z	3	3	1	No. fixed dist.	7	VIW, VNE, SE NW, SW	7:00 -19:00	M	1-1 (SWD in SW)		AD	N, VIW - < 20kt	3	30°S - 60°S.
		K01		NW	60°S-45 mi line	Z	3	3	1								BI(B,H,F,M)	S,PB - <25kt		
		T25		SE	S. of 69°S	Z	3	3	1		SV steamed 12 n. mile ahead of SSVs						PH(B,H,R)	> 1.5 n. mile Mi vis.		
		YS1		SW	45 mi line - Ice	RAT	3	3	1								TAG			
		KS2	Area VI west		60°S-Ice	Z	3	3	1								SB,XCTD,CTD EPCS,KRLL SW,MD			

Annotations

Vessel
NM3: Nissin-maru #3
NM : Nissin-maru
K01: Kyo-maru #1
Toshi-maru #25
T18: Toshi-maru #18
KS2: Kyoshin-maru #2
YS1: Yushin-maru
SV : Sighting vessel
SSV : Sighting & Sampling vessel

Area and sector
Area IV : 55°S-Ice edge, 70°E-130°E
VIE :55°S-Ice edge, 100°E-130°E
IVW :55°S-Ice edge, 70°E-100°E
Area V : 55°S-Ice edge, 130°E-170°W
VE : 55°S-Ice edge, 130°E-165°E
VW : 55°S-Ice edge, 165°E-170°W
IIIE :60°S-Ice edge, 35°E- 70°E
VIW : 60°S-Ice edge, 170°W-145°W

Trackline shape
B: Billiard
Z: Zigzag
RAT: Right angle triangle

Stratum
N North
S: South
M: Middle
MW : Middle-West
SW : South-West
ME : Middle-East
SE : South-East
PB : Prydz Bay
SMZ: Special Monitoring Zone
F: First period
S: Second period
Ice: Ice edge
45 mi line: Line at 45 n.miles north of ice edge

Cetacean spp.
B. Blue whale
H : Humpback whale
R : Right whale
M : Minke whale
DM: Dwarf minke whale
F : Fin whale

Sampling method
2-1: 2 animals from 1 group
1-1: 1 animal from 1group

Experiment
AD : Distance & Angle estimation ex.
BI : Biopsy ex.
PH : Photo-ID. ex.
AC : Active acoustic effect assessment ex.
CH : Chasing effect assessment ex.
SA : Sampling effect assessment ex.
Blue: Blue whale behavior observation ex.
Zi :Ziphids behavior observation ex.
SWD : Schweder ex.
MPC: Minke patchiness obsevation ex.

TAG : Satellite tagging ex.
XBT : XBT ex.
MD : Marine debris observation
J : Environment monitoring ex.
SB : Cetacean acustic recording ex.
XCTD : XCTD ex.
CTD : CTD ex.
EPCS : Sea surface env. monitoring ex.
KRLL : Scientific echo sounder

Table 2. The covered research area in the south of latitude 60S. These results quoted data from Branch and Butterworth (Southern Hemisphere minke whales: consistent abundance estimates from the 1978/79 to 1997/98 IDCR-SOWER surveys (impress)) and Hakamada *et al* (Abundance trend of Southern Hemisphere minke whales in Areas IV and V obtained from JARPA data (SC/53/IA12)).

Area V	IDCR(CPII)	IDCR(CPIII)	JARPA	JARPA	JARPA	JARPA	JARPA
Stratum	85/86	91/92	92/93	94/95	96/97	98/99	20/21
EN	279611	247210	290526	303617	363668	311050	334377
EM	165612	165429					
ES	107717	82039	180745	175421	208224	52553	105458
E-combine	552940	494678	471271	479038	571892	363603	439835
WN	100760	120700	332682	194879	305819	321375	249712
WM	166349	137734					
WS	104814	58643	43572	40116	40130	45455	64854
W-combine	371923	317077	376254	234995	345949	366830	314566
Total	924863	811755	847525	714033	917841	730433	754401

Table 3. The density index (schools/searching distance) of each cruise in Area V. These results quoted data from Branch and Butterworth (Southern Hemisphere minke whales: consistent abundance estimates from the 1978/79 to 1997/98 IDCR-SOWER surveys (impress)) and Hakamada *et al* (Abundance trend of Southern Hemisphere minke whales in Areas IV and V obtained from JARPA data (SC/53/IA12)).

Stratum	1985/86IDCR(CPII)		1991/92IDCR(CPIII)		1992/93JARPA				1994/95JARPA				1996/97JARPA				1998/99JARPA				2000/01JARPA			
	Closing		Closing		SV		SSV		SV		SSV		SV		SSV		SV		SSV		SV		SSV	
	n_s/L	CV	n_s/L	CV	n_s/L	CV	n_s/L	CV	n_s/L	CV	n_s/L	CV	n_s/L	CV	n_s/L	CV	n_s/L	CV	n_s/L	CV	n_s/L	CV	n_s/L	CV
EN	0.04	0.41	—	—	0.02	0.64	0.04	0.31	0.02	0.27	0.04	0.33	0.02	0.43	0.04	0.23	0.03	0.36	0.08	0.21	0.04	0.26	0.08	0.23
EM	0.13	0.26	0.18	0.21	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
ES	0.18	0.19	0.08	0.30	0.17	0.33	0.10	0.41	0.28	0.37	0.24	0.42	0.14	0.64	0.11	0.27	0.09	0.55	0.10	0.52	0.18	0.29	0.21	0.14
WN	0.03	0.52	—	—	0.05	0.46	0.03	0.38	0.04	0.76	0.03	0.40	0.02	0.28	0.03	0.38	0.05	0.36	0.06	0.25	0.02	0.38	0.02	0.44
WM	0.08	0.50	0.01	0.35	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
WS	0.06	0.25	0.04	0.35	0.11	0.24	0.08	0.37	0.10	0.33	0.05	0.31	0.03	0.66	0.05	0.36	0.15	0.33	0.13	0.19	0.05	0.53	0.09	0.20

Table 4. The mean school size by closing mode of each cruise in Area V. These results quoted data from Branch and Butterworth (Southern Hemisphere minke whales: consistent abundance estimates from the 1978/79 to 1997/98 IDCR-SOWER surveys (impress)) and Hakamada *et al* (Abundance trend of Southern Hemisphere minke whales in Areas IV and V obtained from JARPA data (SC/53/IA12)).

Stratum	1985/86IDCR(CPII)		1991/92IDCR(CPIII)		1992/93JARPA				1994/95JARPA				1996/97JARPA				1998/99JARPA				2000/01JARPA			
	Closing		Closing		SV		SSV		SV		SSV		SV		SSV		SV		SSV		SV		SSV	
	E[ssc]	CV	*E[ssc]*	CV	*E[ssc]*	CV	*E[ssc]*	CV	*E[ssc]*	CV	*E[ssc]*	CV	*E[ssc]*	CV	*E[ssc]*	CV	*E[ssc]*	CV	*E[ssc]*	CV	*E[ssc]*	CV	*E[ssc]*	CV
EN	2.69	0.14	—	—	2.58	0.32	1.53	0.10	1.76	0.13	1.41	0.06	1.57	0.18	1.58	0.06	1.94	0.24	2.23	0.10	2.44	0.30	1.70	0.04
EM	3.20	0.22	2.54	0.10	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
ES	3.33	0.11	1.41	0.10	1.91	0.07	2.01	0.07	4.09	0.10	2.28	0.06	3.70	0.11	3.24	0.14	1.61	0.21	1.98	0.06	1.87	0.12	2.42	0.05
WN	1.91	0.20	—	—	1.57	0.08	1.50	0.07	1.42	0.14	2.36	0.11	4.08	0.54	1.52	0.07	2.74	0.23	1.82	0.08	1.63	0.23	1.85	0.13
WM	1.93	0.18	1.41	0.10	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
WS	3.55	0.22	2.54	0.10	2.91	0.10	2.76	0.10	3.92	0.11	2.26	0.08	2.74	0.32	2.10	0.08	4.03	0.20	2.47	0.07	1.69	0.24	1.43	0.04

Table 5. The effective search width by closing mode of each cruise in Area V. These results quoted data from Branch and Butterworth (Southern Hemisphere minke whales: consistent abundance estimates from the 1978/79 to 1997/98 IDCR-SOWER surveys (impress)) and Hakamada *et al* (Abundance trend of Southern Hemisphere minke whales in Areas IV and V obtained from JARPA data (SC/53/IA12)).

Stratum	1985/86IDCR(CPII)		1991/92IDCR(CPIII)		1992/93JARPA				1994/95JARPA				1996/97JARPA				1998/99JARPA				2000/01JARPA			
	Closing		Closing		SV		SSV		SV		SSV		SV		SSV		SV		SSV		SV		SSV	
	w_s	CV	w_s	CV	w_s	CV	w_s	CV	w_s	CV	w_s	CV	w_s	CV	w_s	CV	w_s	CV	w_s	CV	w_s	CV	w_s	CV
EN	0.61	0.15	—	—	0.46	0.19	0.68	0.22	0.56	0.27	0.59	0.15	0.24	0.28	0.65	0.23	0.33	0.55	0.49	0.21	0.26	0.58	0.63	0.16
EM	0.36	0.26	0.49	0.22	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
ES	0.48	0.15	0.42	0.41	0.48	0.14	0.65	0.23	0.82	0.10	0.87	0.10	0.71	0.15	0.61	0.20	0.50	0.23	0.53	0.14	0.90	0.12	0.68	0.11
WN	0.46	0.36	—	—	0.45	0.17	0.45	0.15	0.46	0.40	0.75	0.16	0.54	0.26	0.55	0.31	0.65	0.20	0.42	0.25	0.45	0.22	0.61	0.23
WM	0.30	0.30	0.42	0.41	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
WS	0.63	0.14	0.49	0.22	0.48	0.26	0.96	0.14	0.78	0.15	0.82	0.21	0.77	0.40	0.65	0.23	0.43	0.29	0.52	0.14	0.27	0.33	0.74	0.17

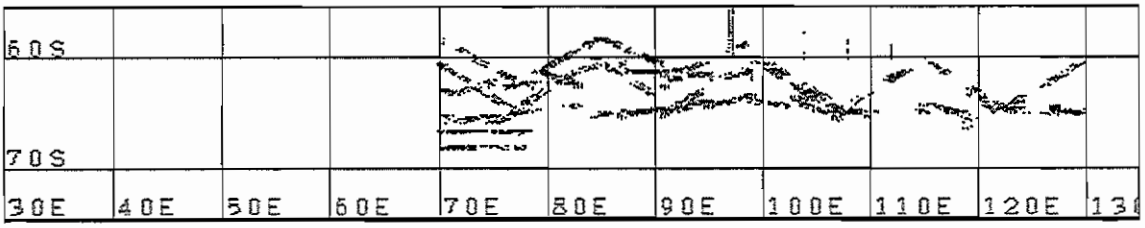


Fig. 1. Cruise track line of sighting / sampling vessels in 1989/90 JARPA

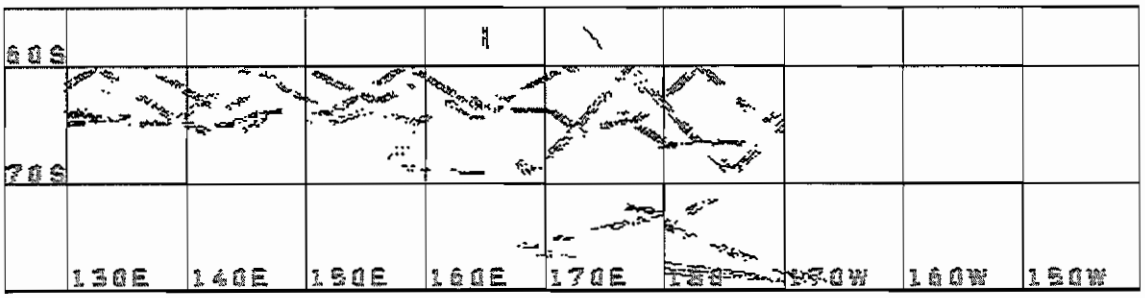


Fig. 2. Cruise track line of sighting / sampling vessels in 1990/91 JARPA

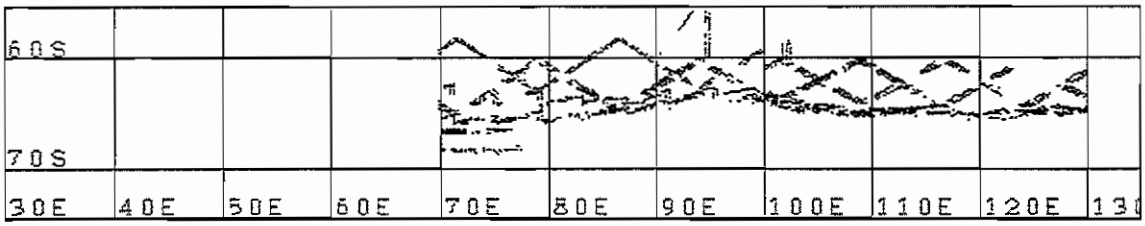


Fig. 3. Cruise track line of sighting / sampling vessels in 1991/92 JARPA

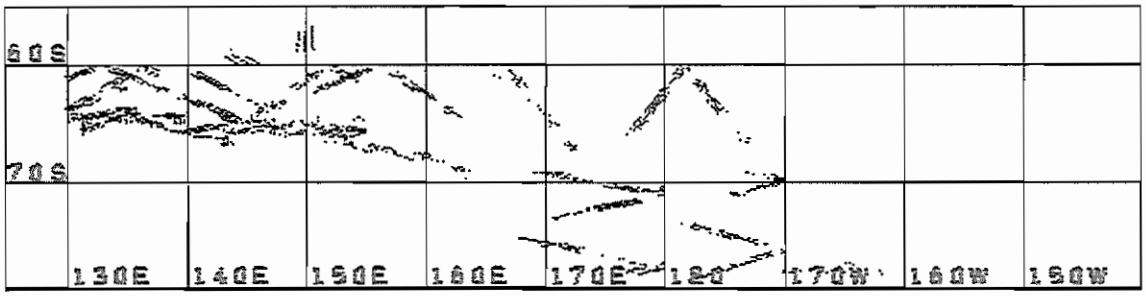


Fig.4. Cruise track line of sighting vessel and sighting / sampling vessels in 1992/93 JARPA

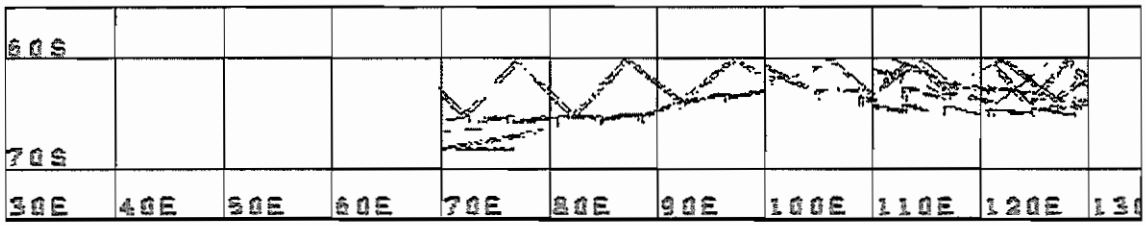


Fig.5. Cruise track line of sighting vessel and sighting / sampling vessels in 1993/94 JARPA

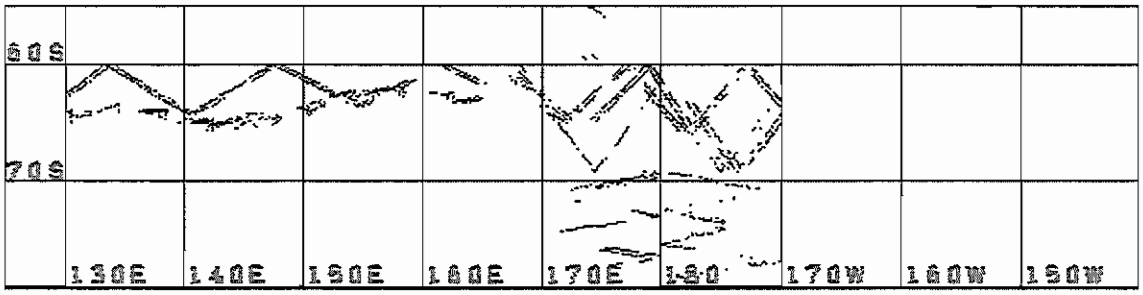


Fig.6. Cruise track line of sighting vessel and sighting / sampling vessels in 1994/95 JARPA

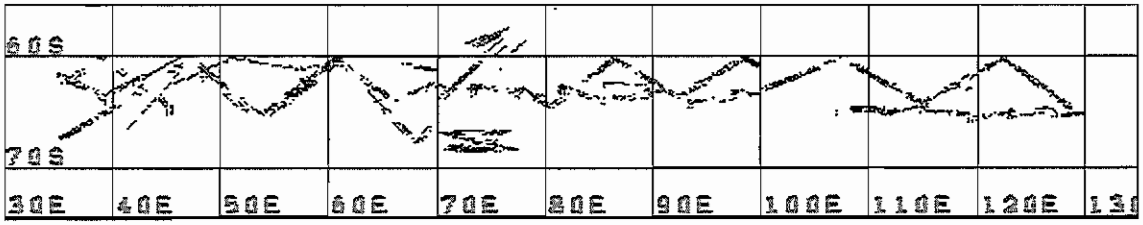


Fig.7. Cruise track line of sighting vessel and sighting / sampling vessels in 1995/96 JARPA

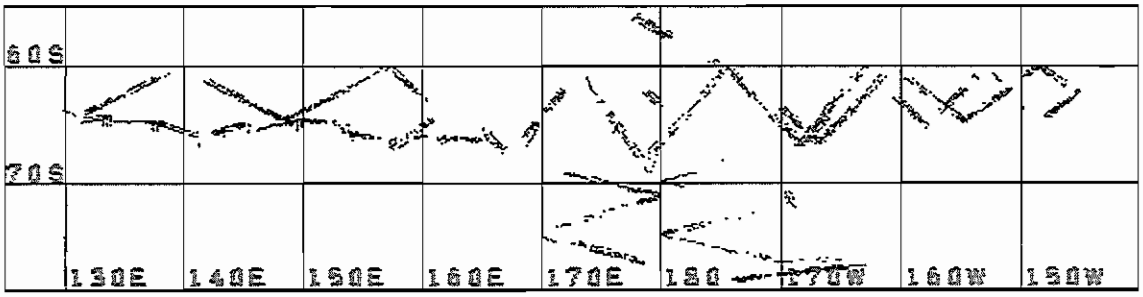


Fig.8. Cruise track line of sighting vessel and sighting / sampling vessels in 1996/97 JARPA

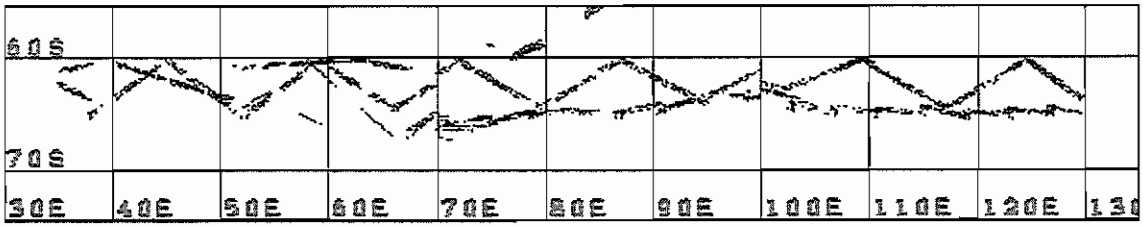


Fig.9. Cruise track line of sighting vessel and sighting / sampling vessels in 1997/98 JARPA

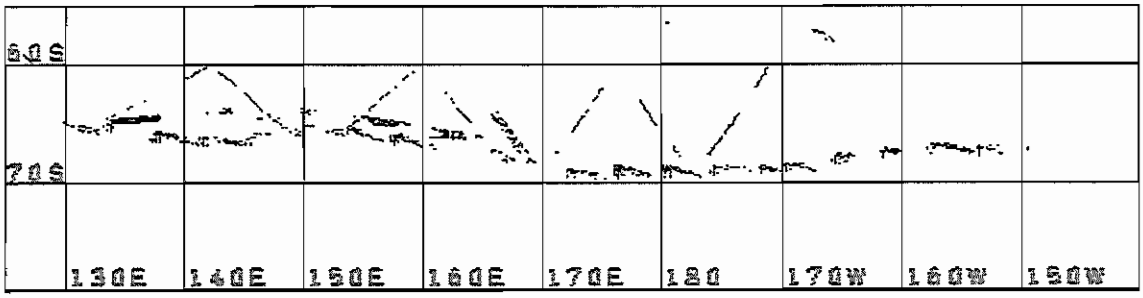


Fig.10. Cruise track line of sighting vessel and sighting / sampling vessels in 1998/99 JARPA

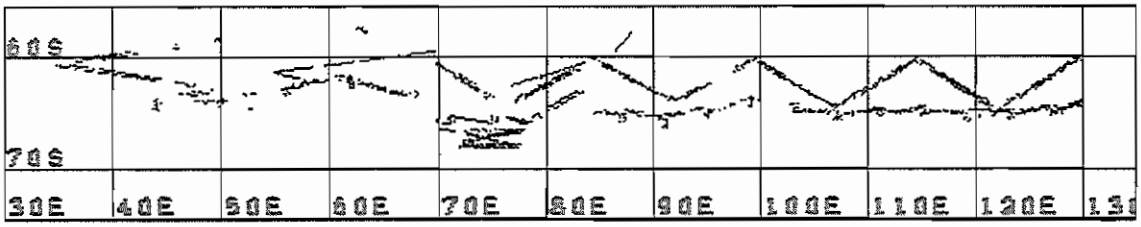


Fig.11. Cruise track line of sighting vessel and sighting / sampling vessels in 1999/2000 JARPA

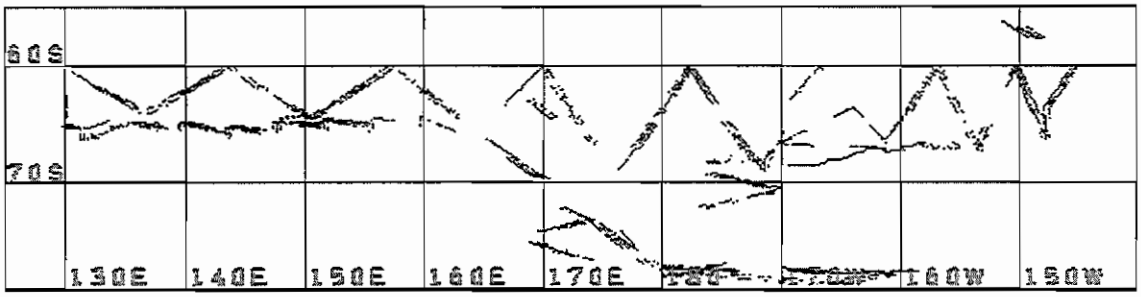


Fig.12. Cruise track line of sighting vessel and sighting / sampling vessels in 2000/2001 JARPA

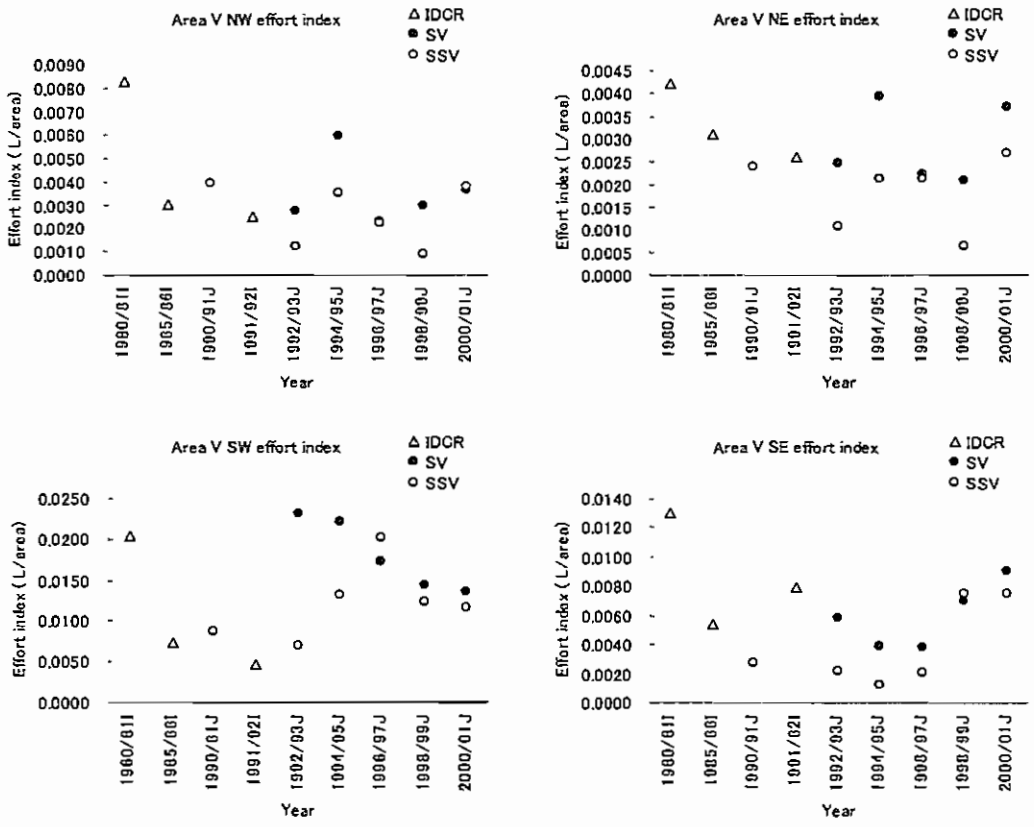


Figure 13. Comparison ofthe search effort density index (searching distance per 100 n.mile^2 of the research area) between IDCR and JARPA cruises. These results quoted data from Branch and Butterworth (Southern Hemisphere minke whales: consistent abundance estimates from the 1978/79 to 1997/98 IDCR-SOWER surveys (in press)) and Hakamada *et al* (Abundance trend of Southern Hemisphere minke whales in Areas IV and V obtained from JARPA data (2001)).

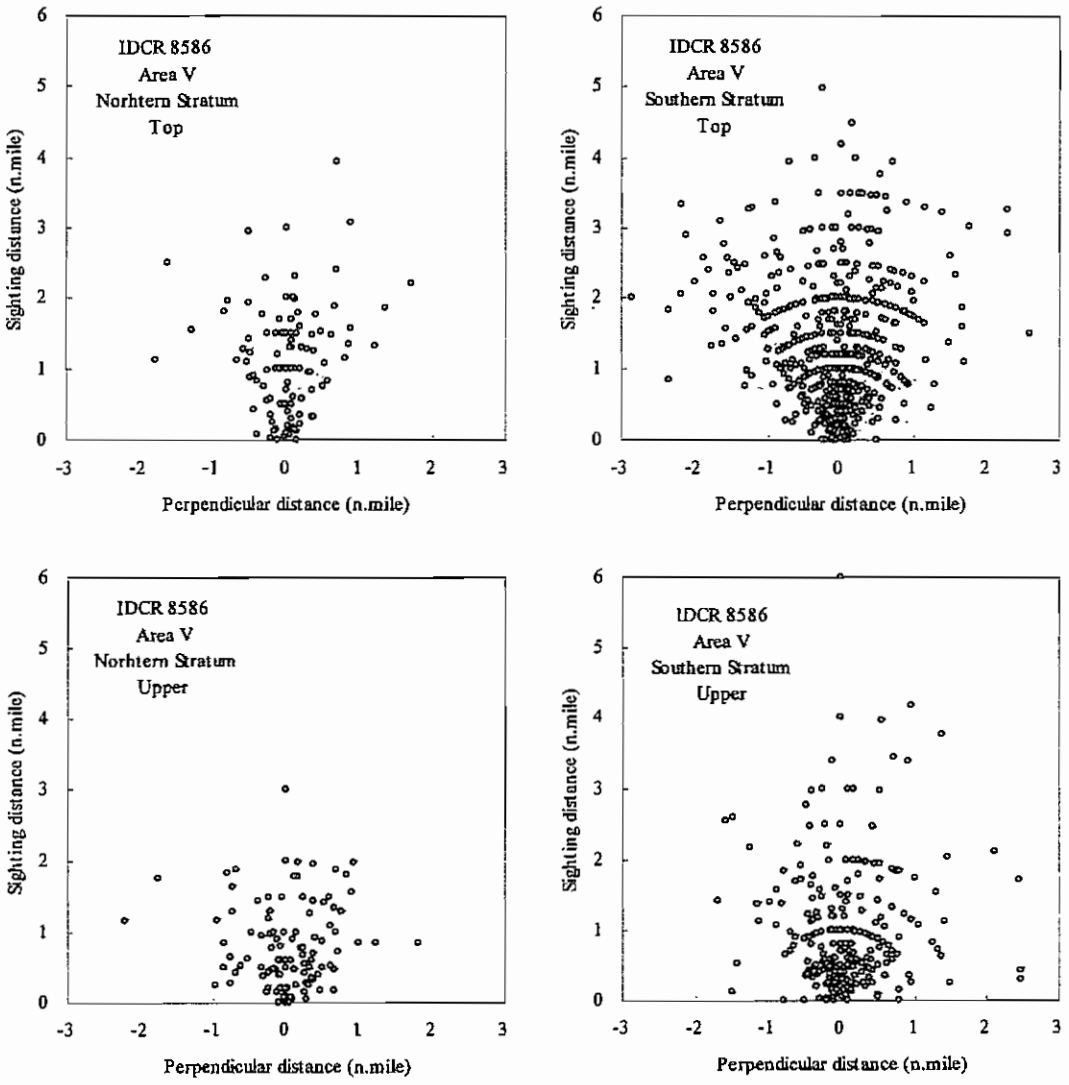


Figure 14a. Comparison of sighting distribution of minke whale primary sighted among sighting vessels in IDCR/SOWER and JARPA cruise in Area V.

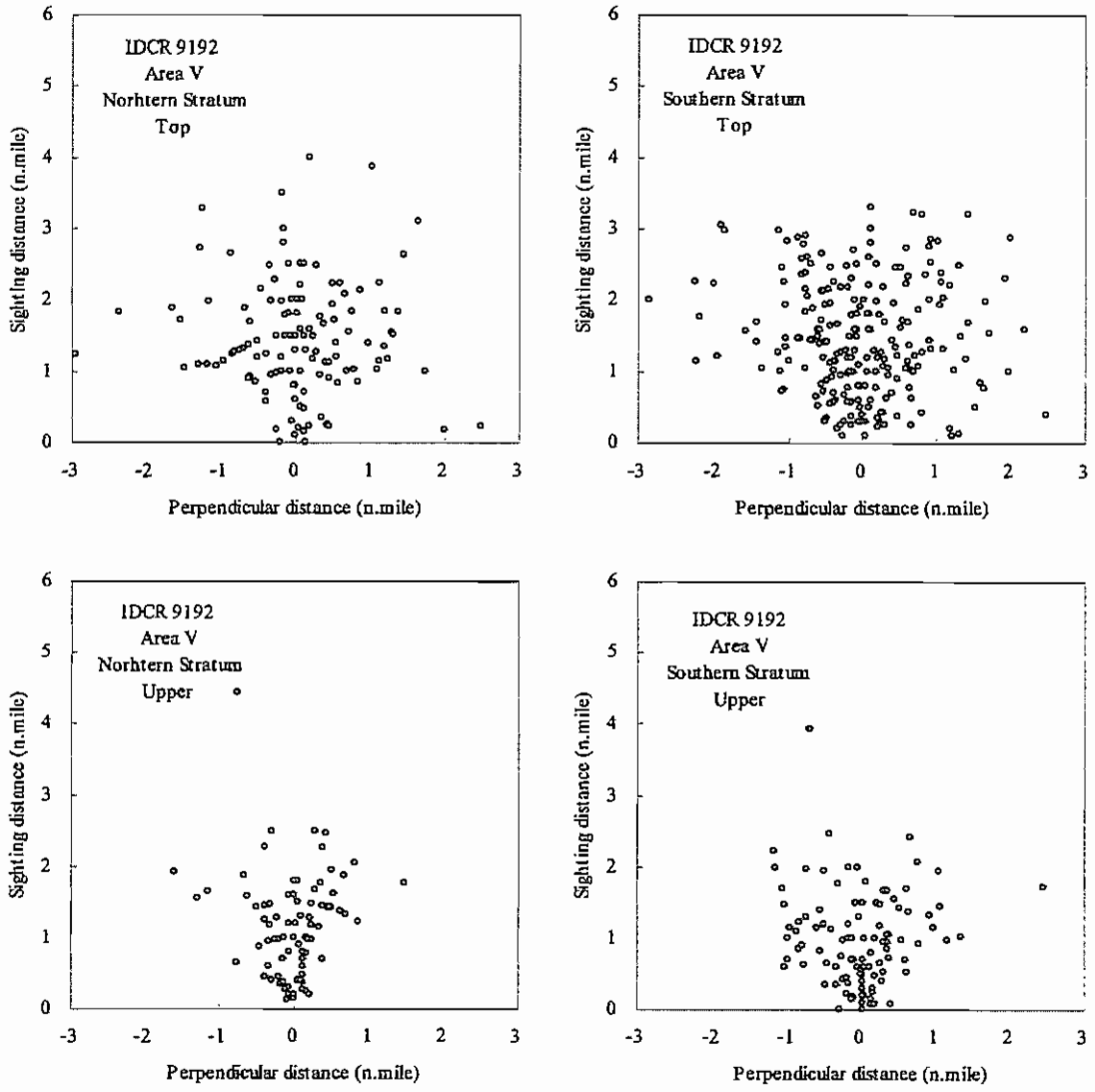


Figure 14b. Comparison of sighting distribution of minke whale primary sighted among sighting vessels in IDCR/SOWER and JARPA cruise in Area V.

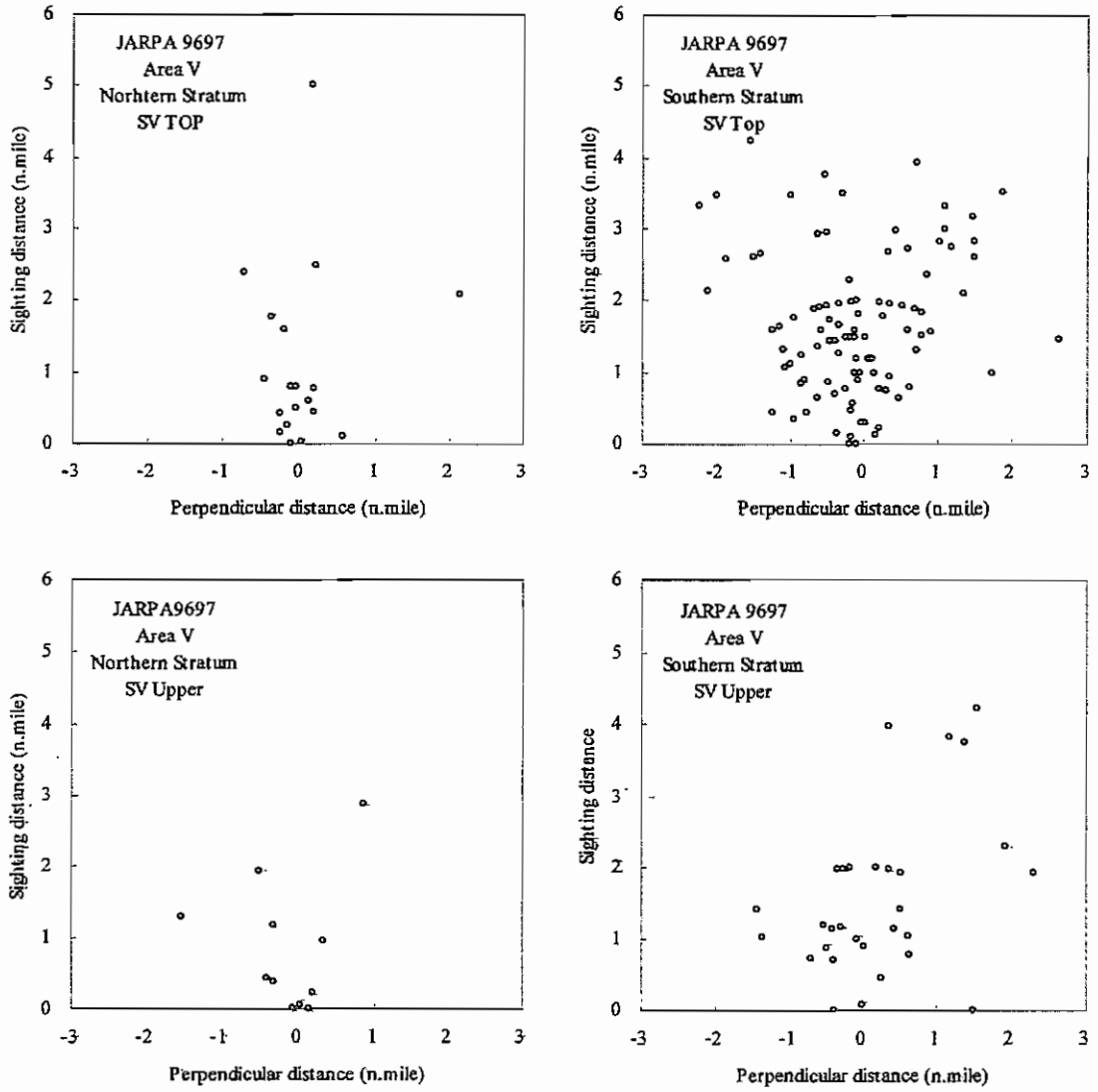


Figure 14c. Comparison of sighting distribution of minke whale primary sighted among sighting vessels in IDCR/SOWER and JARPA cruise in Area V.

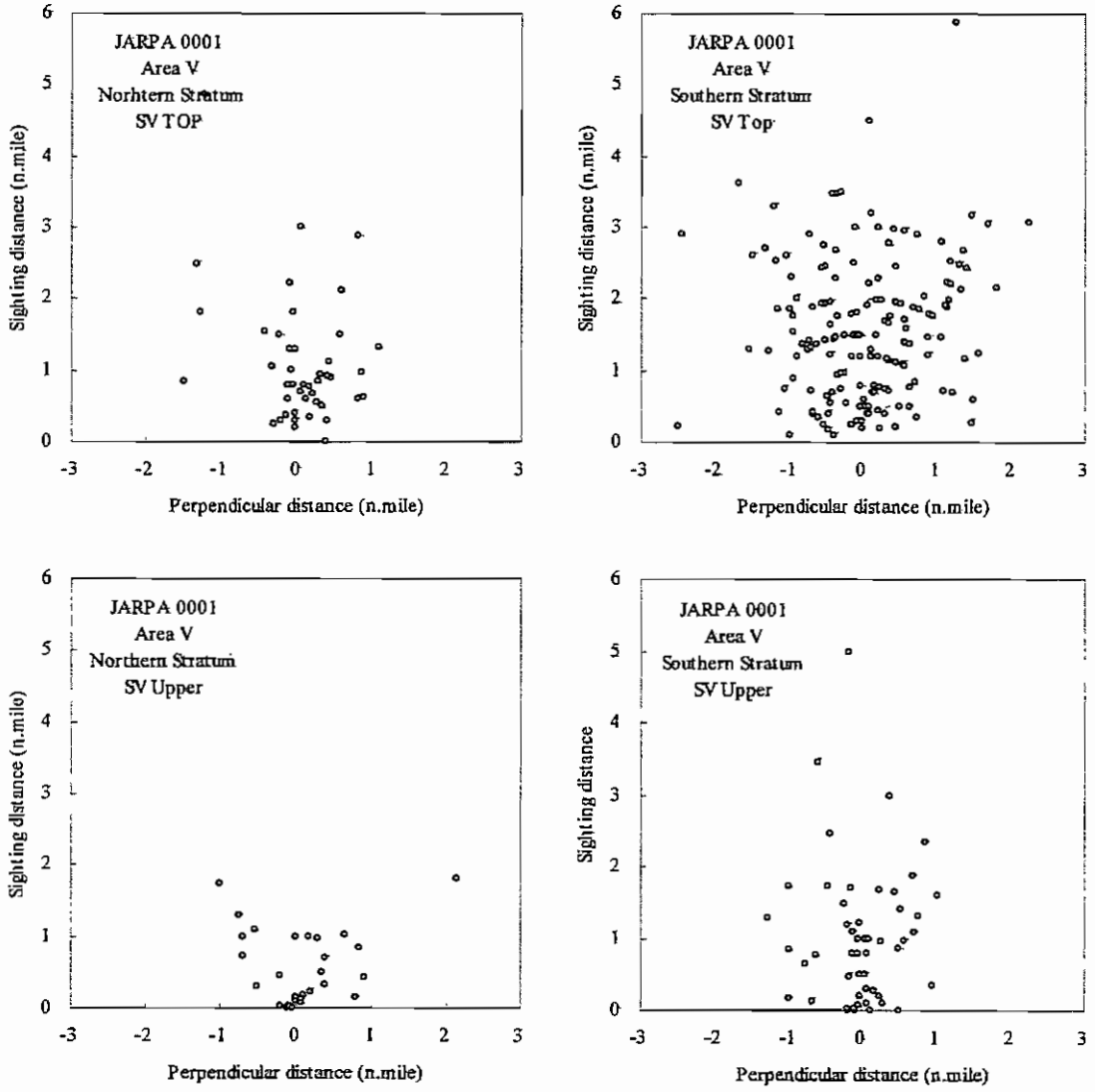


Figure 14d. Comparison of sighting distribution of minke whale primary sighted among sighting vessels in IDCR/SOWER and JARPA cruise in Area V.

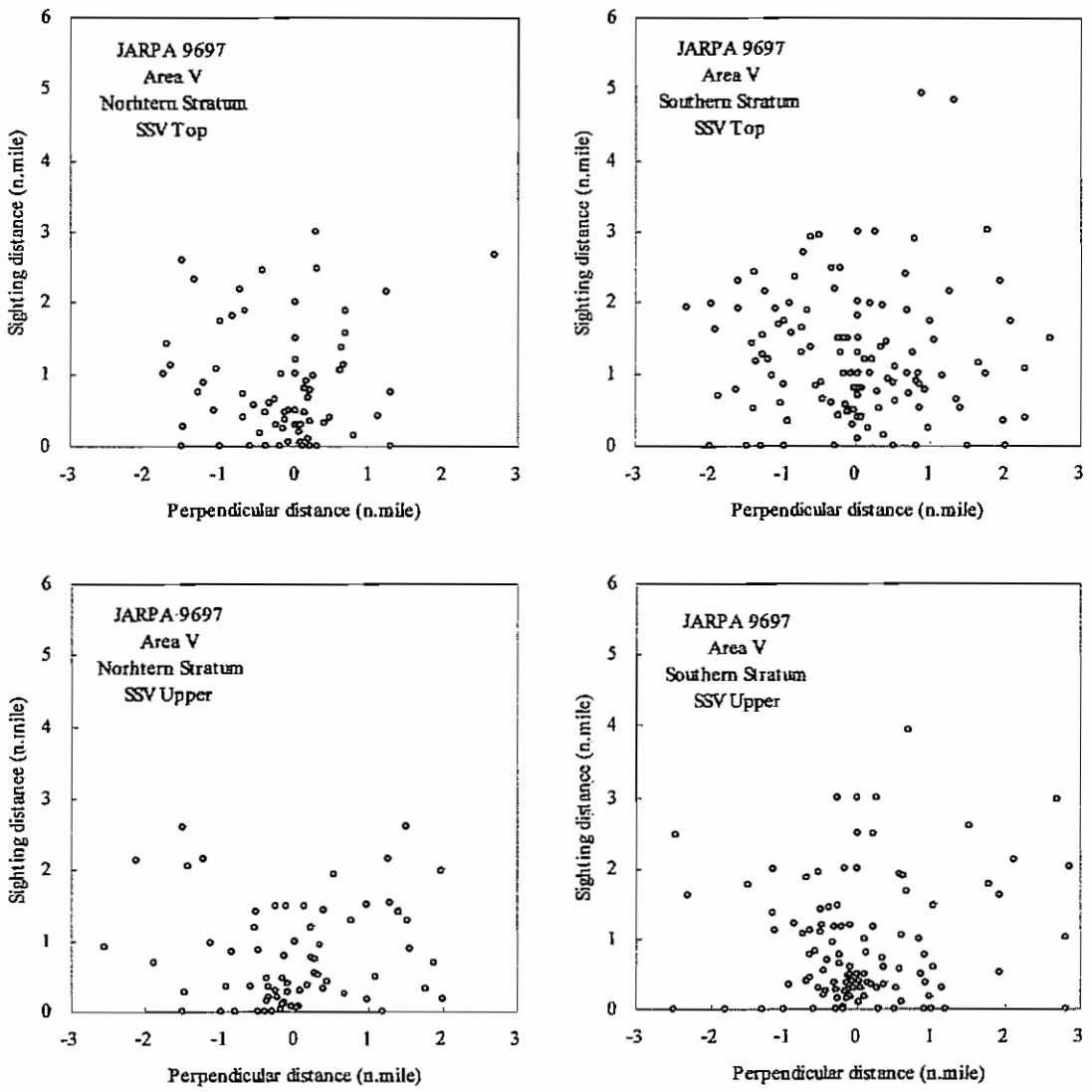


Figure 14e. Comparison of sighting distribution of minke whale primary sighted among sighting vessels in IDCR/SOWER and JARPA cruise in Area V.

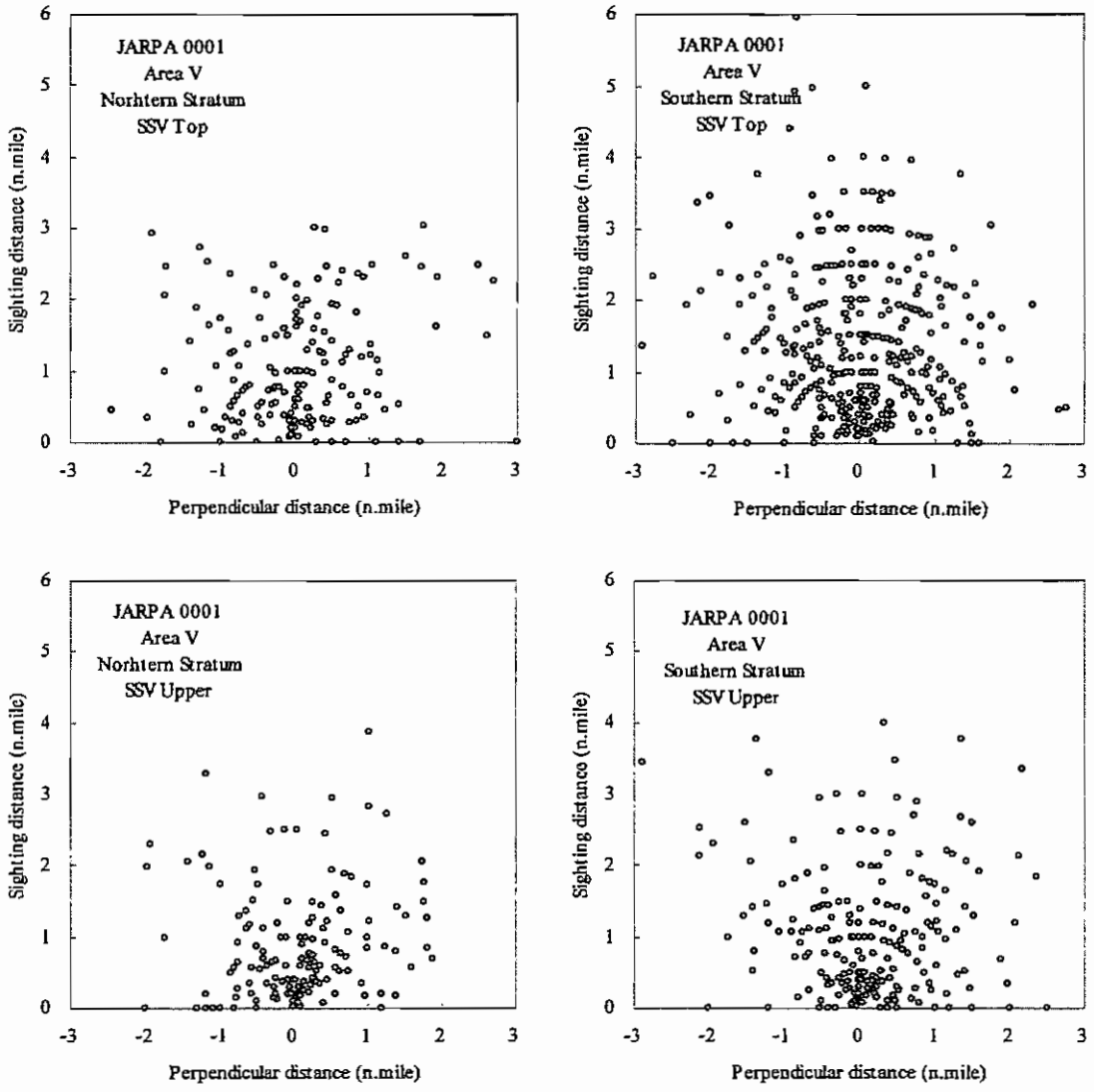
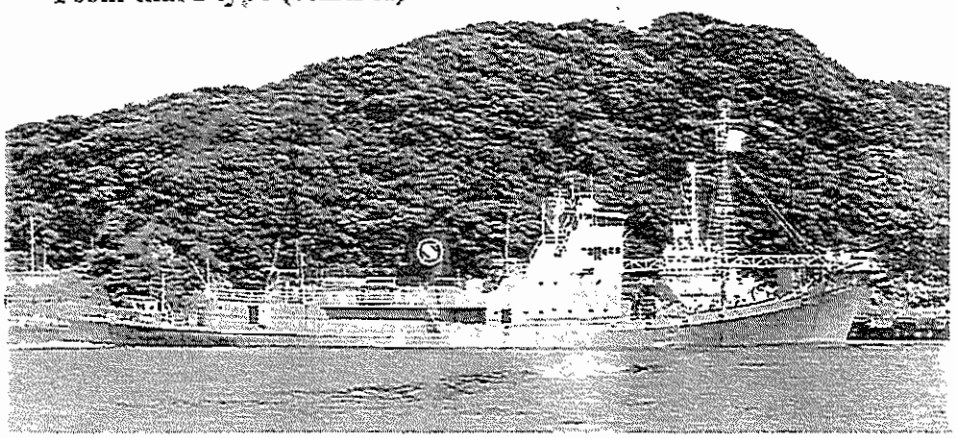
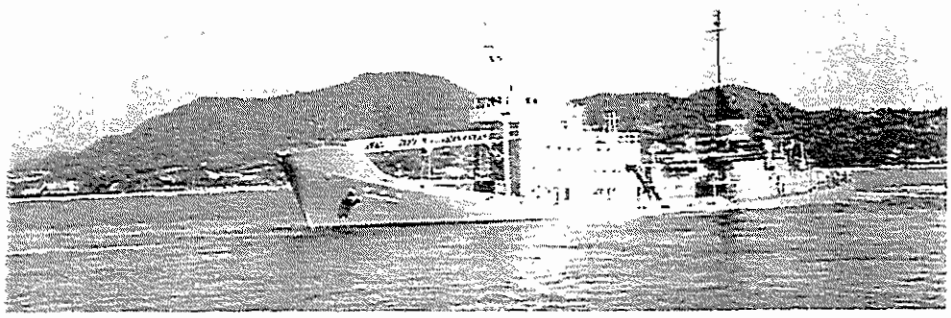


Figure 14f. Comparison of sighting distribution of minke whale primary sighted among sighting vessels in IDCR/SOWER and JARPA cruise in Area V.

Toshi-maru type (JARPA)



Shonan-maru type (IDCR)



Kyoshin-maru type (JARPA)

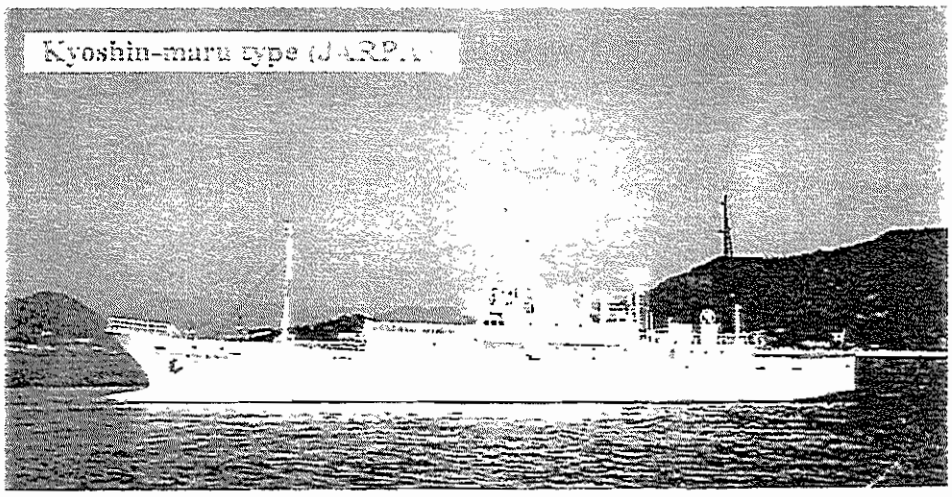


Figure 15. Comparison of the types of sighting platform in research vessels using IDCR/SOWER and JARPA cruises.