Review of the Sighting Surveys in the JARPA

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Abstract

The Japanese Whale Research Programme under Special Permit in the Antarctic (JARPA) has been conducted in a consistent way every year since 1987/88 season in the Areas 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 programme. The programme is passing the mid-point of scheduled period of 16 years. A large amount of data, samples and information on southern hemisphere minke whales and other whale species are accumulating, and some intermediate analyses were done.

The four surveys in Area IV (1989-1995) and three surveys in Area V (1990-1994) provided abundance estimates with good precision. It was suggested that the yearly fluctuation in abundance estimation of minke whales was within the variations of the sampling variance, suggesting no or small process error in Areas IV and V.

The absolute values of the abundance estimates were smaller than the ones from IWC/IDCR surveys. It was considered that differences of the survey mode, the searching behavior due to the type of vessels, sampling activity and analysis method might bring the difference in abundance estimates between JARPA and IDCR. Detailed analysis will be done in the future or after the completion of programme. Information on abundance and biomass composition of other baleen whales also provided by JARPA.

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1. Background

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) are concentrated in waters near the pack ice-edge (Fig.1), while it was not well known about distribution of immature animals from the data of the commercial whaling.

In order to obtain unbiased and reliable biological parameters, required for the management of the whale population, the Government of Japan put forward a research plan in 1987 that included the taking of southern hemisphere minke whales under a special permit. The principal objective of the program is to obtain information on unbiased biological parameters including age composition through systematic random sampling carried out in combination with systematic sighting surveys. The surveys should be 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 trackline was designed so as to cover the whole area uniformly in Areas IV and V, and animal(s) was randomly sampled from all minke school sighted.

JARPA is a long-term (16 years) programme. At the start of JARPA, two feasibility studies were conducted in 1987/88 and 1988/89 in the Area IV and V , respectively. The full-scale survey started 1989/90 season and covered the Area IV four times and the Area V three times since then, and the forth survey in Area V is now conducting. The survey procedures have been improved by the comments and suggestions from the Scientific Committee (IWC/SC) as well as the experiences from the previous surveys.

This paper review the methodology and interim results from sighting survey which is a major component of JARPA programme. A large amount of data and information on minke whales in the Areas IV and V have been accumulated through JARPA. In addition, the program is expected to provide extensive information on status of cetaceans in the Antarctic, especially blue and humpback whales which had been heavily exploited in the past as well as changes of composition in cetacean community in the Antarctic.

2. Methodology

Unique sighting and sampling procedures to collect unbiased data and samples of minke whales was introduced in the JARPA program; (1) the trackline 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 randomly sampled.

2.1. Design of tracklines to cover the whole area uniformly

Since whales are expected to be highly heterogeneously distributed in the research area, it is critically important for the research tracklines to be systematically allocated to cover the whole research area uniformly.

According to the theory, a billiard ball type trackline design covers the whole area uniformly in the long term. In the feasibility studies (1987/88 and 88/89), this billiard ball type tracklines 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, this problem was solved by

fixing the reflection angle to 70°.

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

2.2 Estimates of number of schools and abundance

The vessels surveyed along the pre-determined trackline and were engaged in line transect sighting and sampling. The line transect methodology (Burnham *et al.*, 1980; Butterworth 1982; Butterworth *et al.*, 1984; Buckland et al., 1993) was applied to estimate number of schools in the research area. The probability that a school of whales sighted at y n.miles in perpendicular distance from the trackline in the line transect methodology is denoted as $g(y)$. As noted previously, biological characteristics of whales are thought to be heterogeneous among different school sizes, and number of schools were estimated by school size. The effective search half-width of school size i (w_i) are estimated by $w_i = \int_0^c g_i(y)dy$, where c >0 indicates the limitation of perpendicular distance of the schools sighted and adopted for the analysis. The hazard rate model $g_i(y)=1-exp[-(y/a)^{1-b}]$ (Hayes and Buckland, 1983, Buckland, 1985, 1987) was applied for $g_i(y)$, here a and b are free parameters to be estimated. The sightings data were grouped into the sub-intervals of the perpendicular distances $[y_{ij-1}, y_{ij}]$ $(j=1,...,J)$, $J=20)$. c was set to 2.0 n.miles. The multinominal distribution defined by the probabilities of the sub-intervals obtained from the normalized detection function $f_i(y)=g_i(y)/\int_0^c g_i(y')dy'$ was fitted to the distribution of the numbers of sightings n_{ij} $(j=1,...,20)$. Under the assumption that all whales on the trackline should be detected, i.e., $g_i(0)=1$, an estimate of w_i is obtained by $w_i=1/f_i(0)$, where $f_i(0)$ denotes the fitted value of $f_i(0)$. If the area effectively covered is A, the number of schools in the area can be estimated as;

$$P_i = \frac{n_i A}{2w_i L} = \frac{n f_i(0) A}{2L}. \quad \text{..... (1)}$$

Total number of animals was obtained by summing up the estimated numbers of whales in all school sizes;

$$P = \sum i P_i.$$

where n_i in the number of schools of school size i sighted. The mean density of schools is estimated by;

$$D_i = \frac{n_i}{2w_i L} = \frac{n f_i(0)}{2L}. \quad \text{..... (2)}$$

2.3 Sampling variability

Under the assumptions that the distribution of the perpendicular distances and the number of the schools sighted are independent to each other, the square of the coefficient of variation of D_i can

be expressed as the sum of that of sightings per unit effort n_i/L and that of the estimate of $f_i(0)$;

$$CV\{D_i\}^2 = CV\{n_i/L\}^2 + CV\{f_i(0)\}^2 \quad \ldots\ldots (3).$$

The bootstrap resampling procedure (Efron, 1979; Hall, 1988) is applied to the evaluation of the variance of $f(0)$ and n/L. Taking into account the fluctuation of weather and whale density, it can be regarded the sighting as a two-stage sampling where the survey area of each leg (between way points) defines the primary unit and the schools of whales define the secondary unit. The bootstrap procedure was replicated 100 times by each leg. Details of the basic methodology can be seen in Kishino *et al.* (1991b), Kasamatsu *et al.* (1990) and Nishiwaki *et al.* (1992).

3. Surveys and Data Collection

Details of each surveys and data collections in the JARPA program were presented in the cruise report, submitted to the IWC/SC each year (Kato *et al.*, 1989; Kato *et al.*, 1990; Fujise *et al.*, 1990; Kasamatsu *et al.*, 1993; Fujise *et al.*, 1993a ; Fujise *et al.*, 1993b ; Nishiwaki *et al.*, 1994; Nishiwaki *et al.*, 1995 and Nishiwaki *et al.*, 1996). Outline of cruises in each season are summarized in Table 1.

3.1 Research area and stratification

The cumulative numbers of the 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 than other Areas. Consequently, the stocks which migrating into high latitudes of Area IV and V were relatively abundant together with the operational knowledge for catching such as sea and ice condition there. Area IV (70°E-130°E) and V (130°E-170°W) was selected to be surveyed under this programme.

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: 55°S to 60°S, 60°S to the line of 45 n.miles from the ice-edge, and ice-edge to 45 n.miles from the ice-edge (Fig. 2). In the waters 55°S to 60°S, the limited surveys had been conducted during 1987/88 and 1991/92.

Subsequent years sighting and sampling have been conducted in waters south of 60°S. In the first period of 1989/90 and 1991/92, the survey area had expanded to 58°S because the pack ice position in Area IV was encountered further north than expected. Survey areas covered are shown in Fig. 3. Since 1992/93, the Special Monitoring Zone (SMZ) has been established to investigate seasonal variation of whale density. In 1995/96 season, eastern part of Area III was tentatively surveyed to collect information on genetic variability of minke whales (Fig.3.2-5).

3.2 Survey period

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. Surveys 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 which was covered three times in a season. Survey periods and other associated information on the operation are listed in Table 1.

3.3 Cruise tracks

In the first two years of feasibility study, the cruise tracks in the northern part of research area (north of 60°S) were drawn north-south. In the southern strata, the tracklines 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.3.1.

In the subsequent years, the cruise tracks were established like sawtooth pattern with randomly selected start point in the southern two strata based on pack ice line. In the northern strata and south- east strata (*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 zigzaged 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 (Fig.3.2-3.5).

3.4 Sighting procedures

The three (two in feasibility study in 1987/88) sighting/sampling vessels (SSV) 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 trackline 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. The another second or third vessels followed tracklines 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. during 1995/96), at a standard speed of 11.5-12.0 knots. A constant watch was kept for 14 hours (12 hours since 1995/96) per day during 0600 hours to 2000 (1800) hours or from 30 minutes after the sunrise to 30 minutes before the sunset.

While searching, three men were in the barrel (two men in 1987/88 and 1988/89 feasibility studies). They were assisted by the further four (captain, gunner, quartermaster and researcher) on the upper bridge, and one or two (chief engineer and radio operator) on the platform above the Asdic hut (Table 2.2).

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 the trackline. (In addition, closing to blue, humpback and right whales were made regardless of distance to take photograph for natural marking or for biopsy sampling). After the completion of confirmation or sampling, the vessel normally returned at angle of 45° to the trackline. If, however, the vessel found itself more than 3 n.miles from the trackline, it returned at angle 90°. In this case, the vessel went into topman-down steaming (no search effort) until it returned to the trackline.

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 distances from the vessel to the sightings. Sightings, effort and weather data were recorded in the similar format as used for IDCR.

3.5 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 programme 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. mile apart) procedure was introduced to obtain information on effect of whales missed on the

trackline from the sighting/sampling vessel (SSV). Details of these operation is discribed in the Paragraph 4.5.2 (see page 10). However, this procedure had not been conducted because of many problems for data.

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 pre-determined 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 season in the southern strata and in all strata since 1992/93 season. 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 engag any sampling activities (Table 2.1-2).

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

3.6 Data collected

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., and the typical sighting format is shown in Fig. 4.1. A chronological account of the vessel's activities was kept on the Effort Record by the officer on watch (Fig.4.2). 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 (blue sky, cloudy, fog, etc.).

Sightings were classified into primary and secondary sightings. Primary sightings are those seen in normal searching mode (normal searching speed on the predetermined trackline) 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.

3.7 Experiments

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. Reaction 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 echosounders on minke whale behavior have been conducted since 1993/94. A echosounder is expected to be used for the abundance estimation of krill in the future. Feasibility tests of satellite tagging system have been conducted since 1990/91 except 1991/92 and 1992/93. Behavioral observation of blue and *Ziphiids* have been conducted since 1993/94. Table 3. shows the list of experiments in each season.

4. Analysis and Results

4.1 Estimates of search half-width and mean school size

Only primary sightings within 3 n.m. from each trackline were used to estimate number of schools. The perpendicular distance data were smeared using method 2 of Buckland and Anganuzzi (1988) and the search half-width was estimated by fitting the hazard rate model truncated at 2.0 n.miles. The search half-width of SSV were estimated by the sighting data of two or three tracklines of the SSV, because the research vessels exchanged their tracklines every day in principal. The sighting rate and search half-widths were grouped into solitary animals (n1/L, w1) and schools of two or more animals (n2/L, w2). The search half-width by school size and by year were shown in Table s 4.1-2.

The bootstrap method was applied to evaluate the variance of the estimate *f(0)* and n/L. 100 resamplings were made based on the leg (which divided up according each way- point) data set, not daily set. It has been argued that the observed average school size overestimated the true mean school size in the population, because larger schools were more easy to be detected.

Although the mean school size was not used in JARPA analysis, mean school sizes can be calculated by dividing the estimated numbers of individuals by the estimated number of schools that calculated by treating schools as units in the analysis. Estimated abundance (P) of each strata were shown in Tables 4.1-2.

4.2 Total abundance

Fig. 5 and Table 5 shows abundance estimates of ordinary minke whale in Areas IV and V (south of 60° S). Total abundance estimates of SSV ranged 21,213 to 26,359 in Area IV and 54,970 to 84,320 in Area V . The final abundance estimates were calculated, using average estimated value from two or three tracklines of the SSV.

The CVs of the estimated abundance in Area IV ranged from 0.16 to 0.29 and for Area V ranged from 0.19 to 0.20. The variance of the estimated of individuals was obtained by summing the bootstrap variances and covariance among the tracklines and the school sizes. These CVs were smaller than those of IDCR. Since the JARPA made more effort in searching than IDCR, which case have been enabled with the number of vessels organizing the JARPA.

Process error reflects the extent to which abundance estimates from repeat surveys of the same area in successive years will vary more than would be expected on the basis of the sampling error alone, for example due to variations in the numbers of whales moving into or out of the survey area. IWC/SC discussed extensively about the process error (IWC, 1994, 1995 and 1996). Information on the level of the process error is critically important in particular when an abundance estimate with a low CV and a large process error. The level of the process error could be derived from the differences of the abundance estimates in same area in successive years. IWC/SC analyzed the IDCR estimates of minke whale abundance. However, IWC/SC has not yet provided the estimate of the unbiased process error from the IDCR surveys because the survey procedures and coverage of research area of the IDCR differed by year (IWC, 1994).

The JARPA surveys were conducted in same area, same period with same vessels and same procedures. Such successive abundance estimates under almost the same procedures have not been presented in the history of whale research. Fig. 5 shows total abundance estimates with S.D. in Area IV and V in each season. Variation of the abundance estimates in Area IV was lower than those in Area V. As noted in the cruise reports of the IDCR, distribution of minke whales was influenced by the position or condition of the ice-edge. The ice-edge lines and ice condition in Area V (especially in and around *Ross Sea*) was significantly fluctuated by year than those in Area IV. Variation of the abundance estimates in Areas IV and V were well reflected this

whales sampled during an early (May-June) and late (June-September) period of migration in sub-area 9. No significant differences were found between these two groups regarding sexual composition, maturity and conception date (SC/50/RMP12).

Y. Fujise and R. Zenitani continued the examination of external characteristics of minke whales in the North Pacific and Antarctic. Results will be reported in a future meeting.

B- Co-operative research

S. Tanabe and his colleagues of Ehime University and Y. Fujise conducted a comparative study on the specific accumulation level of persistent organochlorines in minke whales from the Antarctic and North Pacific. They also examined the utility of pollutant accumulation in studies on stock structure in the North Pacific minke whale. A part of this study was published (see section X).

T. Kuramochi (National Science Museum), K. Nagasawa (NRIFS) and their colleagues found different infection rates of parasites between whales eating mainly Pacific anchovy and whales eating mainly Pacific saury. Furthermore they are investigating the residue time of parasites, especially *Anisakis symplex*, in the stomachs of whales. Results will be reported in the near future.

U. Lindstrom (Norwegian Institute of Fisheries and Aquaculture) and T. Tamura continued the examination of stomach contents in the western North Pacific minke whale to elucidate the feeding ecology of the species in this region. A part of this study was published (see section X).

I. Martinez (Norwegian Institute of Fisheries and Aquaculture) and L.A. Pastene conducted random amplification of genomic DNA (RAPD) to type minke whales from the eastern North Atlantic and western North Pacific. The latter samples were from JARPN 1996 survey.

3- Other

L. A. Pastene, H. Yoshida, M. Goto and H. Kato (NRIFS) conducted a comparative genetic study on the ordinary type Bryde's whale from the western North Pacific (three localities), eastern Indian Ocean (one locality), western South Pacific (one locality) and eastern South Pacific (one locality). The biochemical method used was the sequencing of a part of the mtDNA control region in a total of 221 individuals. The statistical comparison involved the Hst and Kst statistics (Doc. SC/50/RMP9).

L.A. Pastene and S. Ohsumi conducted a brief review of the information on distribution and abundance of Bryde's whale in the eastern South Pacific (Doc. SC/50/CAWS6).

VIII- STRANDING

The ICR has continued the collection of information related to stranding of cetacean species in coastal Japan. As it was reported before, H. Ishikawa has constructed a database. The catalog contains information on stranding in nine species of baleen whales (227 cases), 30 species of odontoceti (1,150 cases), nine species of pinnipedia (101 cases) and one species of

less searching in remaining high density area).

Differences in sighting rate (n1/L, n2/L), search half-width (w1, w2), and mean school size (mss) between the SSV and the SV were analyzed preliminary. The regression lines were fitted to the data for comparison whether the slope was significantly different from 1.0. Figs 6.1-6.2 show each values and the regression lines. In northern strata in each Area, these values were not significantly different except n2/L and w2 in Area IV and n2/L in Area V. In southern strata, n1/L, n2/L and w1 were significantly different from those in Area IV, n2/L and w1 were significantly different between the SSV and the SV (Table 6). Large differences in mean school size (mss) were observed between SSV and SV, although the differences were not statistically significant.

In 1995/96 season, another new type of vessel, Kyosin-maru No.2 (vessel type was somewhat different from the traditional type of vessels but was similar to IDCR type) had joined survey as the SV. The search half width of this vessel was smaller than traditional type of vessels (Table 4.2). This could explain the improvement of the detected probability of whales. However, as we have only three complete sets of the SV data, one set of Area IV and two sets of Area V, further extensive study of these differences will be conducted in near future.

4.5 Temporal heterogeneity of whale density

Temporal heterogeneity of whale density has been investigated in each Area since 1989/90. In 1989/90, 90/91 and 91/92, each research area had surveyed two times. The first period was surveyed from early Dec. to late of Jan., the second period surveyed from late of Jan. to middle of Mar.. From 1992/93 to 94/95 season the SMZ had surveyed three times during one season in Antarctic, early Dec., late of Jan. to early Feb. and late of Feb. to middle of Mar.

Table 8 shows the temporal change of abundance of minke whales in each Area. In the entire research area, abundance estimates of the second period probably be larger than the first period. In the SMZ, the seasonal change of abundance was observed through the abundance estimates in different timing of the survey period.

4.6 Results of the Experiments

4.6.1 Distance and Angle estimation

This experiment has been conducted every survey since 1987/88 season by the same guidelines as for the dive time experiment on IDCR . These results also has been used to correct in each abundance analyses.

4.6.2 Pair ship experiment

This experiment had conducted only in 1988/89 season to obtain information on the effect of sighting miss of whales from the SSV on the trackline. Three SSVs were grouped into two vessels "pair" and one vessel "single" which were allocated to each tracklines. Three SSVs rotationally changed to each tracklines every day in principal. For the pair group, each two vessels had their own trackline and these two tracklines were located 0.3 n.miles away. When one vessel sighted a school, the other vesesl stopped searching at the same time of the sighting.

However, in pair vessels (located parallel 0.3 n.mile), there was a bias for sighting data between pair operation and single operation. This could be explained that concentration for searching made by the observer from pair operation tended to be higher than single operation, because the pair vessels were close to each other and the observers in each pair vessels were likely to be strained to make better sighting result than the other, while the observer in the single operation did not encounter such situation, details are shown in the paper Kato et. al. (1990).

4.6.3 Observation of minke whale patch in high density area

Although experimental data collection in "the high density area" for identification of the density distribution had been planned in 1988/89 season, no chance to do that during survey.

4.6.4 Biopsy skin sampling

This experiment had been conducted since 1990/91 season. Skin biopsy samples were corrected by ICR system of air gun by SSV and SV. Target spices were blue, humpback and right whales. These samples have analyzed by Pastene *et al.*,(in prep. by May).

4.6.5 Natural marking

This experiment had been conducted since 1990/91 season by SSV and SV. Target species were blue, humpback and right whales. Details of this study and list of samples were reported to the IWC (Pastene and Fujise, 1994.: ICR, 1996).

4.6.6 Monitoring Reaction from chasing vessel

This experiment had conducted since 1990/91 to 1992/93 season in order to assess the effects on the whales of the chasing activity of the SSV. One vessel commenced navigation along a trackline and other two monitoring vessels drifted at a distance of 10 n.miles ahead from the chasing vessel. The monitoring vessels located between 6 n.miles apart. The chasing vessel made a normal procedure of sampling but the whales were not taken. If the vessel reached a point of 11 n.miles ahead of the starting point, the trial was terminated.

During chasing, two monitoring vessels observed the reaction of other minke whales around the vessels. All surfacing cues were counted in these cases. Details of the procedure were presented by Kasamatsu et al. (1993). Total time of the experiment was 26 hours and 22 minutes and 127 minke schools were observed from observation vessels. No obvious change of the behavior of the schools was observed by the chasing activities.

4.6.7 Monitoring Reaction from sampling vessel

This experiment has been conducted since 1993/94 season. The experiment procedure is similar to the experiment of Monitoring reaction from chasing vessel. Details of the procedure were presented by Nishiwaki *et al.* (1994a). However, the experiment was canceled in 1993/94 season as it was found that the density of minke whales in the area was much lower than previously expected. In 1994/95 season, the experiment was canceled by obstruction of research by a vessel.

Total 12 minke schools (17 animals) were observed from observation vessels in 1995/96 season. No effects of sampling activity were observed through reactions of minke whales.

4.6.8 Observation of the behavior of blue whales

This experiment have been conducted since 1993/94 season by the same guidelines as for the dive time experiment on IWC/IDCR. All surfacing cues were counted in these cases. During the three seasons, 10 schools (19 animals) of the blue whale were observed.

4.6.9 Observation of the behavior of beaked whales

This experiment have been conducted since 1993/94 season. Thirteen schools (20 animals) of beaked whale species (*Ziphiidae*) were sighted and approached for the observation of their behaviors. Out of these species, 34 schools (80 animals) of the southern bottlenose whale , 1 school of Gray's beaked whale and 1 school (2 animals) of the Arnoux's beaked whale were identified and observed.

4.6.10 Attachment of a satellite telemetry tag to minke whales

This experiment have been planned since 1990/91 season in the high density area of minke whales. One satellite telemetry successfully attached to a minke whale, approximately 8 meters in length, which was swimming at a location near the ice edge (65-19'S and 123-54'E) on 15 March 1994. No chance of experiment was carried out after 1994/95.

4.6.11 Assessment of the effect on whales' behavior by the use of a sonic device

This experiment was planned to be carried out in addition to the reaction monitoring experiment in the areas where minke whales were expected to be abundant. However, there was no chance to conduct this experiment during 1993/94 and 1994/95 season.

Kyosin-maru No.2, the new type of the dedicated sighting vessel engaged in two assessments of the effect on whales' behavior by the use of a sonic device (echo sounder and scanning sonar). In the experiment by echo sounder, searching in the passing mode using echo sounder was conducted along the track line for a period of 30 minutes after the regular research time. The result of observation of whale reaction were recorded during experiment. The observations were conducted 56 times during research periods. Searching times were 804 minutes in total, and searching distance was 300.4 n.miles in total.

The experiment by scanning sonar were conducted in the same procedure of echo sounder during transit along the pack ice. These were conducted 18 times during research periods, searching time was 525 minutes, and searching distances were 94.8 n.miles in total. No reaction was observed.

5. Other Contribution

5.1 Segregation between whales species

In order to understanding more about the ecosystem of the Antarctic Ocean, it is necessary to study the distribution of other whale species of whales such as the humpback, sperm and beaked whales, besides of minke whale.

As for the distributions of the minke and humpback whales, minke whales were mainly sighted in the southern strata. While humpback occurred frequently sighted in the northern strata but scattered in the south strata. This is indicative that the two species may segregate their habitats. Similar segregation between sperm whales and beaked whales was observed.

It was known that the distribution of minke whales entered in areas within the ice edge (Leatherwood *et al.*, 1981: Naito, 1982). Presumable, minke whales go beyond the pack ice to avoid the competition with the humpback whales. It is likely that the distribution and density of minke whales in the south stratum be underestimated when pack ice was expanded further north.

5.2 Monitoring whale populations

In the Antarctic Ocean, catch of right, humpback, blue, fin, and sei whales was prohibited in 1932, 1963, 1964, 1976, and 1978, respectively. Sixty years passed already since right whale has been protected, and more than 30 years have passed since humpback whale and blue whale have been protected. In coastal waters of southeast America, South Africa and east and west coasts of Australia, significant recovery of right whale and humpback whale are reported recently in these breeding areas. On the other hand, the information on the present status of pelagic species, such as blue, fin and sei whales that consist of large part of total biomass of whale community, shows no distinctive recovery after the cease of commercial whaling.

Information on the status of the pelagic species is now provided from the IDCR cruises.

The IDCR, however, is not sufficient enough for the monitoring of ecosystem, as survey covers the same area once in every 6 years. In this situation, the JARPA programme continues providing more useful information about the present status and ever provide the temporal changes of whale stocks including blue whales.

Fig. 9.1 shows the temporal changes in abundance of blue, fin, humpback and right whale in Areas IV and V (south of 60S). These abundance were estimated by using the same method of equation (1)-(3) except mean school size. The mean school size was calculated as mean school size observed within 1.0 n.mile from the trackline as same as IDCR applied.

Fig.9.2 shows the temporal changes in biomass of major five species in waters south of 60° S in the Antarctic Ocean. These figures suggested a strong possibility of recent increase of protected large species in the Antarctic Ocean. It is also clear that biomass composition of baleen whale species in the Antarctic Ocean begins to change greatly, as well. Details of the abundance estimate of large whales will be submitted to the Tokyo Meeting in May 1997 as separated paper.

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Table 1. Summary of Surveys in JARPA

Season	Area	Period	Strata	Trackline	No. of tracklines	No. of vessels	Dedicated distance per day (n.m.)	Distance between tracklines (n.m.)	No. of topman barrel
1987/88*	IV	17 Jan.-	North (55S-60S)	North-south	2	2	not decided	6	2
	(105E-115E)	26 Mar.	South (60S-Iceedge)	Billiard type	2	2	not decided	6	2
1988/89*	V	12 Jan.-	North (55S-60S)	North-south	2	3	not decided	6	2
	(168E-178E)	31 Mar.	Middle (60S-69S)	Billiard type	2	3	not decided	6	2
			South (69S-Iceedge)	Billiard type	2	3	not decided	6	2
1989/90	IV	6 Dec.-	Transit (55S-60S)	Sighting only	3	3	150	9	3
	(70E-130E)	12 Mar.	North (60S-45nm line)	ZigZag type	3	3	170	9	3
			South (Iceedge-45nm)	Sawteeth type	3	3	100	9	3
1990/91	V	12 Dec.-	Transit (55S-60S)	North-south	3	3	150	9	3
	(130E-170W)	22 Mar.	North (60S-45nm line)	ZigZag type	3	3	160	9	3
			South (Iceedge-45nm)	Sawteeth type	3	3	100	9	3
1991/92	IV	5 Dec.-	Transit (55S-60S)	North-south	3	3	150	9	3
	(70E-130E)	25 Mar.	North (60S-45nm line)	ZigZag type	2	3	150	9	3
			South (Iceedge-45nm)	Sawteeth type	2	3**	not decided	9	3
1992/93	V	3 Dec.-	Transit (55S-60S)	Sighting only					
	(130E-170W)	25 Mar.	North (60S-45nm line)	ZigZag type	3	3**	140	9	3
			South (Iceedge-45nm)	Sawteeth type	3	3**	100	9	3
1993/94	IV	3 Dec.-	Transit (55S-60S)	Sighting only					
	(70E-130E)	19 Mar.	North (60S-45nm line)	ZigZag type	2	3**	80	12	3
			South (Iceedge-45nm)	Sawteeth type	2	3**	80	12	3
1994/95	V	4 Dec.-	Transit (55S-60S)	Sighting only					
	(130E-170W)	22 Mar.	North (60S-45nm line)	ZigZag type	2	3**	100	12	3
			South (Iceedge-45nm)	Sawteeth type	2	3**	120	12	3
1995/96	IV, IIIE	26 Nov.-	Transit (55S-60S)	Sighting only					
	(70E-130E)	22 Mar.	North (60S-45nm line)	ZigZag type	3	4**	80	7	3
	(35E-70E)		South (Iceedge-45nm)	Sawteeth type	3	4**	80	7	3

Remarks; * : Feasibility surveys.

** : included one dedicated sighting vessel.

Table 2.1. Arrangement of the sighting/sampling vessel (SSV) and dedicated sighting vessel (SV) in each Area.

Area IV	SSV	SV
1987/88	●	
1989/90	●	
1991/92	●	●*
1993/94	●	●
1995/96	●	●**

Area V	SSV	SV
1988/89	●	
1990/91	●	
1992/93	●	●
1994/95	●	●

* : Southern strata only.
** : Kyosin-maru type.

Table.2.2. Comparison of the number of observer in each platform in research vessel.

survey	mode	type of vessel	number of trackline	observer (person) Top	Upper	Asdic hut	Front	other
JARPA	SSV	T	2 or 3	3	3	3	0	1
JARPA	SV	T	1	3	3	2 to 3	0	1
JARPA	SV	K	1	3	0	0	2	2
IDCR	SV	S	1	2	0	0	2	4
IDCR	SV	T	1	2	2	0	0	4

Asdic hut : secondary observer.
other : secondary observer (including researchers).

T : Toshi-maru type. Top mast is located ahead of upper bridge.
K : Kyosin-maru type. Top mast is located on the upper bridge.
S : Shonan-maru type. Top mast is located on the front bridge.

Table 3. List of experiments in JARPA.

	DA	PA	PT	BI	PH	CH	TAG	AC	SA	BI	Zi	XBT	MD
1987/88	●											●	●
1988/89	●	●	●									●	●
1989/90	●											●	●
1990/91	●			●	●	●	●					●	●
1991/92	●			●	●	●						●	●
1992/93	●			●	●	●						●	●
1993/94	●			●	●		●	●	●	●	●	●	●
1994/95	●			●	●		●	●	●	●	●	●	●
1995/96	●			●	●		●	●	●	●	●	●	●

DA : Distance and angle estimation.
PA : Pair ship experiment.
PT : Observation of minke whale patch in high density area.
BI : Biopsy skin sampling.
PH : Photo ID.
CH : Reaction monitoring experiment from chasing vessel.
Tag: Attachment of a satellite tag for minke whale.
AC : Assessment of the effect on whales behavior by the use of a sonic device.
SA : Reaction monitoring experiment from sampling vessel.
Bl : Observation of the behavior of blue whale.
Zi : Observation of the behavior of beaked whale.
XBT: Oceanographical survey with XBT.
MD : Recording of Marine debris.

Table 4.1. Searching distance (n.m), sighting rate, estimates of search half-width (n.m), mean school size and abundance in each Area surveyed during Jan. to Feb. by SSV. n1/L is the sighting rate of schools of solitary, n2/L is schools of 2 or more whales. w1 is the search half-width of solitary whales. w2 is that of schools 2 or more whales, mss is the mean school size, P is the estimated population abundance (individual).

Area IV

		distance	n1/L	n2/L	w1	(c.v.)	w2	(c.v.)	mss	P	(c.v.)
1989/90	East-North	1,960.6	0.013	0.012	0.620	0.162	0.740	0.219	2.20	8,393	0.466
	East-South	1,345.5	0.029	0.070	0.586	0.111	0.924	0.090	2.77	6,332	0.276
	West-North	1,967.4	0.020	0.008	0.549	0.229	0.941	0.171	1.33	5,886	0.403
	West-South	2,518.7	0.017	0.017	0.436	0.419	0.732	0.249	1.99	2,241	0.187
	Pryze-Bay	843.6	0.027	0.023	0.719	0.045	0.820	0.084	1.74	2,016	0.083
1991/92	East-North	2,163.7	0.008	0.002	0.914	0.410	0.861	0.427	1.30	1,838	2.590
	East-South	1,335.8	0.013	0.014	0.430	0.235	0.828	0.222	1.86	1,358	0.521
	West-North	2,482.2	0.017	0.012	0.452	0.333	0.518	0.208	1.73	10,833	0.262
	West-South	1,135.2	0.018	0.032	0.570	0.396	0.944	0.251	2.28	2,304	0.713
	Pryze-Bay	383.8	0.070	0.115	1.006	0.209	0.622	0.123	2.51	9,618	0.514
1993/94	East-North	1,912.6	0.020	0.011	0.494	0.260	0.462	0.531	1.75	9,196	0.355
	East-South	1,419.2	0.016	0.032	0.580	0.232	0.877	0.317	2.81	3,336	0.467
	West-North	2,493.0	0.013	0.006	0.654	0.159	0.549	0.322	1.38	5,033	0.215
	West-South	1,352.8	0.033	0.047	0.698	0.153	1.024	0.137	2.28	3,421	0.335
	Pryze-Bay	597.1	0.018	0.050	0.433	0.929	0.467	0.336	2.05	5,373	0.212
1995/96	East-North	2,124.0	0.021	0.010	0.461	0.360	1.359	0.200	1.73	8,022	0.310
	East-South	1,483.0	0.035	0.049	0.426	0.320	1.027	0.130	2.52	3,816	0.220
	West-North	2,746.0	0.009	0.012	0.779	0.220	1.191	0.170	2.34	5,013	0.500
	West-South	2,138.0	0.031	0.040	0.752	0.160	1.226	0.080	2.18	2,098	0.190
	Pryze-Bay	847.0	0.074	0.040	0.849	0.170	1.331	0.090	1.45	2,265	0.320

Area V

		distance	n1/L	n2/L	w1	(c.v.)	w2	(c.v.)	mss	P	(c.v.)
1990/91	East-North	2,467.0	0.010	0.012	0.183	0.658	0.819	0.216	2.13	18,100	0.545
	East-South	1,613.6	0.038	0.045	0.441	0.310	0.948	0.198	2.67	29,890	0.338
	West-North	2,720.7	0.027	0.021	0.443	0.309	0.617	0.213	2.27	22,630	0.333
	West-South	1,631.6	0.021	0.041	0.330	0.655	0.951	0.094	2.71	6,940	0.577
1992/93	East-North	944.4	0.026	0.013	0.586	0.222	0.966	0.158	1.51	11,525	0.141
	East-South	1,127.0	0.045	0.056	0.952	0.179	0.901	0.379	2.28	22,900	0.235
	West-North	1,377.0	0.017	0.011	0.353	0.277	0.641	0.148	1.50	14,240	0.468
	West-South	902.9	0.023	0.063	0.718	0.200	1.202	0.138	3.83	6,305	0.447
1994/95	East-North	1,567.0	0.026	0.015	0.565	0.275	0.823	0.205	1.63	14,950	0.317
	East-South	606.0	0.097	0.147	0.891	0.109	1.046	0.097	2.73	59,680	0.724
	West-North	2,060.0	0.014	0.013	0.832	0.187	0.905	0.233	2.36	6,830	0.445
	West-South	1,584.1	0.021	0.030	0.650	0.244	1.439	0.214	2.68	2,860	0.491

Table 4.2. Searching distance (n.m), sighting rate, estimates of search half-width (n.m), mean school size and abundance in each Area surveyed during Jan. to Feb. by SV. n1/L is the sighting rate of schools of solitary, n2/L is schools of 2 or more whales. w1 is the search half-width of solitary whales. w2 is that of schools 2 or more whales, mss is mean school size, P is the estimated population abundance (individual).

Area IV

		distance	n1/L	n2/L	w1	(c.v.)	w2	(c.v.)	mss	P	(c.v.)
1991/92	East-North	-	-	-	-	-	-	-	-	-	-
	East-South	904.1	0.009	0.019	0.125	3.406	0.993	0.244	2.84	2,454	0.497
	West-North	-	-	-	-	-	-	-	-	-	-
	West-South	1,010.0	0.012	0.033	0.291	0.481	0.464	0.540	3.42	5,887	0.586
	Pryze-Bay	218.6	0.146	0.192	0.757	0.098	1.151	0.122	4.42	18,930	0.815
1993/94	East-North	1,250.0	0.011	0.005	0.801	0.214	0.251	1.346	1.65	6,393	1.349
	East-South	839.3	0.023	0.050	0.336	0.723	1.215	0.262	3.33	3,830	1.051
	West-North	1,667.0	0.013	0.002	0.324	0.168	0.258	0.441	1.28	7,507	0.459
	West-South	1,023.0	0.022	0.018	0.477	0.471	0.957	0.416	2.70	2,218	0.433
	Pryze-Bay	477.5	0.025	0.021	0.416	0.243	0.542	0.257	1.50	2,559	0.653
1995/96	East-North	857.0	0.014	0.008	0.136	0.270	0.311	0.114	2.16	13,340	0.479
	East-South	794.0	0.010	0.011	0.057	0.186	0.947	0.071	2.35	7,730	0.179
	West-North	579.0	0.043	0.054	0.373	0.348	0.638	0.120	3.09	12,560	0.535
	West-South	736.0	0.014	0.039	0.209	0.800	0.574	0.270	2.74	4,926	0.438
	Pryze-Bay	451.0	0.033	0.022	0.364	0.252	0.963	0.483	1.96	2,368	0.384

Area V

		distance	n1/L	n2/L	w1	(c.v.)	w2	(c.v.)	mss	P	(c.v.)
1992/93	East-North	717.3	0.007	0.015	0.361	0.153	0.530	0.049	8.44	52,530	0.701
	East-South	1,025.0	0.082	0.080	0.438	0.164	0.751	0.164	3.50	75,270	0.576
	West-North	923.2	0.030	0.019	0.654	0.170	0.822	0.230	1.57	20,450	0.562
	West-South	1,005.0	0.032	0.075	0.299	0.686	0.999	0.148	4.21	11,390	0.462
1994/95	East-North	983.5	0.013	0.011	0.316	0.233	0.665	0.527	1.96	14,250	0.271
	East-South	685.8	0.099	0.200	0.650	0.147	0.996	0.093	4.17	114,400	0.290
	West-North	1,167.0	0.026	0.018	0.615	0.366	1.376	0.394	3.63	13,480	0.570
	West-South	885.0	0.024	0.063	0.590	0.506	0.829	0.295	3.95	8,540	0.544

Table 5. Trend of ordinary minke whale abundance in Areas IV and V (south of 60° S) surveyed during Jan. to Feb. in JARPA.

1) SSV data

Area IV

Stratum	1989/90	(C.V)	1991/92	(C.V)	1993/94	(C.V)	1995/96	(C.V)
East-North	8,393	(0.466)	1,838	(2.590)	9,196	(0.355)	8,022	(0.310)
East-South	6,332	(0.276)	1,358	(0.521)	3,336	(0.467)	3,816	(0.220)
West-North	5,886	(0.403)	10,833	(0.262)	5,033	(0.215)	5,013	(0.500)
West-South	2,241	(0.187)	2,304	(0.713)	3,421	(0.335)	2,098	(0.190)
Prydz Bay	2,016	(0.083)	9,618	(0.514)	5,373	(0.212)	2,265	(0.320)
Total	24,868	(0.168)	25,951	(0.293)	26,359	(0.161)	21,213	(0.180)

Area V

Stratum	1990/91	(C.V)	1992/93	(C.V)	1994/95	(C.V)
East-North	18,100	(0.545)	11,525	(0.142)	14,950	(0.317)
East-South	29,890	(0.338)	22,900	(0.236)	59,680	(0.724)
West-North	22,630	(0.333)	14,240	(0.470)	6,830	(0.445)
West-South	6,940	(0.577)	6,305	(0.450)	2,860	(0.491)
Total	77,560	(0.201)	54,970	(0.189)	84,320	(0.507)*

* is a special case in 1994/95 when the research faced substantial loss of the searching distance due to unexpected human events in the East-South stratum.

2) SV data

Area IV

Stratum	1989/90	(C.V)	1991/92	(C.V)	1993/94	(C.V)	1995/96	(C.V)
East-North	-	-	-	-	6,393	(1.349)	13,340	(0.479)
East-South	-	-	2,454	(0.497)	3,830	(1.051)	7,730	(0.179)
West-North	-	-	-	-	7,507	(0.459)	12,560	(0.535)
West-South	-	-	5,887	(0.586)	2,218	(0.433)	4,926	(0.438)
Prydz Bay	-	-	18,930	(0.815)	2,559	(0.653)	2,368	(0.384)
Total	-	-	27,271	(0.723)	22,507	(0.415)	40,924	(0.251)

Area V

Stratum	1990/91	(C.V)	1992/93	(C.V)	1994/95	(C.V)
East-North	-	-	52,530	(0.701)	14,250	(0.271)
East-South	-	-	75,270	(0.576)	114,400	(0.290)
West-North	-	-	20,450	(0.562)	13,480	(0.570)
West-South	-	-	11,390	(0.462)	8,540	(0.544)
Total	-	-	159,640	(0.383)	150,670	(0.230)

Table 6. Comparision of sighting rate, search half width and mean school size between SSV and SV in each Area.

			slope	confidence interval(95%)	
Area IV	northern stratum	n1/L	0.71	0.36	1.05
		n2/L	0.43	-0.22	1.07
		mss	1.03	0.82	1.25
		w1	0.48	-0.50	1.46
		w2	0.48	0.00	0.96 *
Area IV	southern stratum	n1/L	1.17	0.61	1.73
		n2/L	1.33	0.72	1.95
		mss	1.31	1.09	1.53 *
		w1	0.58	0.41	0.74 *
		w2	0.83	0.53	1.13
Area V	northern stratum	n1/L	0.76	-0.40	1.92
		n2/L	1.17	0.51	1.83
		mss	2.11	-0.90	5.11
		w1	0.77	0.14	1.39
		w2	0.95	0.24	1.67
Area V	southern stratum	n1/L	1.17	0.63	1.72
		n2/L	1.37	1.10	1.63 *
		mss	1.34	0.96	1.71
		w1	0.60	0.27	0.94 *
		w2	0.76	0.48	1.03

* : Confidence interval does not contain 1.

Table 7. The comparision of the estimated population abundance in each Area. P, P' and P" are obtained by three alternative procedures. P is to estimate by 2.2 (page 3). Second (P') is to estimate the population abundance by multiplying the estimated number of schools by the corrected mean school size. The other (P"), which was considered by Cooke (1984,1987) and further modified by Taga (1991), calculates the coverage probability of the location of each sighting. The numbers in parentheses are the standard errors. The standard errors of the estimates by Cooke's procedure were obtained from the variances among the three tracklines. (From Kishino *et al.* (1991) and Nishiwaki *et al.* (1992)).

Area Ⅳ (1989/90)

Subarea	P		P′		P″	
The First Period						
East-North	10,879	(5,717)	11,056	(4,058)	10,075	(2,995)
East-South	7,889	(3,546)	8,897	(3,185)	7,311	(617)
West-North	5,033	(3,176)	5,041	(2,702)	6,158	(449)
West-South	1,739	(546)	1,515	(608)	1,971	(226)
Total	25,540	(6,255)	26,509	(4,470)	25,515	(3,099)
The Second Period						
East-North	14,626	(1,365)	12,917	(2,764)	15,000	(4,007)
East-South	7,525	(1,354)	9,084	(2,244)	6,817	(392)
West-North	8,064	(1,965)	6,401	(2,266)	7,048	(737)
West-South	4,670	(844)	4,302	(1,304)	5,935	(530)
Total	34,885	(4,747)	32,704	(3,767)	34,800	(4,127)

Area Ⅴ (1990/91)

Subarea	P		P′		P″	
The First Period						
East-North	4,607	(4,214)	4,343	(3,973)	3,285	(467)
East-South	812	(350)	558	(241)	447	(102)
West-North	30,480	(11,882)	19,842	(7,735)	29,780	(5,000)
West-South	5,737	(1,427)	3,683	(916)	4,735	(398)
Total	41,636	(12,685)	28,425	(8,660)	38,247	(5,039)
The Second Period						
East-North	21,207	(7,654)	19,725	(7,119)	19,336	(3,810)
East-South	37,990	(10,121)	30,038	(8,002)	30,135	(3,669)
West-North	4,806	(6,568)	4,024	(5,499)	6,133	(1,199)
West-South	11,198	(3,987)	8,293	(2,953)	8,267	(1,225)
Total	75,201	(14,839)	62,080	(12,250)	63,871	(5,424)

Table 8. Seasonal variations of minke whale abundance in Areas IV and V. (See Fig.3.3-3.4).

1) Entire research area (1989/90-1991/92)

Year		Firsi period early Dec. - late Jan. P	(c.v.)	Second period late Jan. - Mar. P	(c.v.)
1989/90	East-North	8,393	(0.466)	13,420	(0.171)
(Area IV)	East-South	6,332	(0.276)	9,569	(0.505)
	West-North	4,268	(0.637)	5,886	(0.403)
	West-South	1,893	(0.401)	2,241	(0.187)
	Pryze-Bay	-	-	2,016	(0.083)
1991/92	East-North	1,838	(2.590)	0	-
(Area IV)	East-South	1,358	(0.521)	2,025	(0.532)
	West-North	4,187	(1.205)	10,833	(0.262)
	West-South	1,867	(0.515)	2,304	(0.713)
	Pryze-Bay	-	-	9,618	(0.514)
1990/91	East-North	4,784	(0.302)	18,100	(0.545)
(Area V)	East-South	857	(0.612)	29,890	(0.331)
	West-North	22,630	(0.333)	6,067	(0.338)
	West-South	6,940	(0.577)	12,804	(0.435)

2) SMZ (1992/93 - 1994/95)

Year		First period Dec. P	(c.v)	Second period late Jan. - early Feb. P	(c.v)	Third period late Feb. - Mar. P	(c.v)
1993/94	North	5,396	(0.396)	4,795	(0.499)	-	-
(110E-130E)	South	1,952	(0.940)	1,659	(0.503)	1,157	(0.832)
1992/93	North	7,659	(0.326)	6,061	(0.079)	-	-
(130E-155E)	South	4,934	(0.787)	3,766	(0.601)	2,011	(0.470)
1994/95 (165E-170W)	N + S	1,194	(0.325)	14,950	(0.317)	18,905	(0.444)

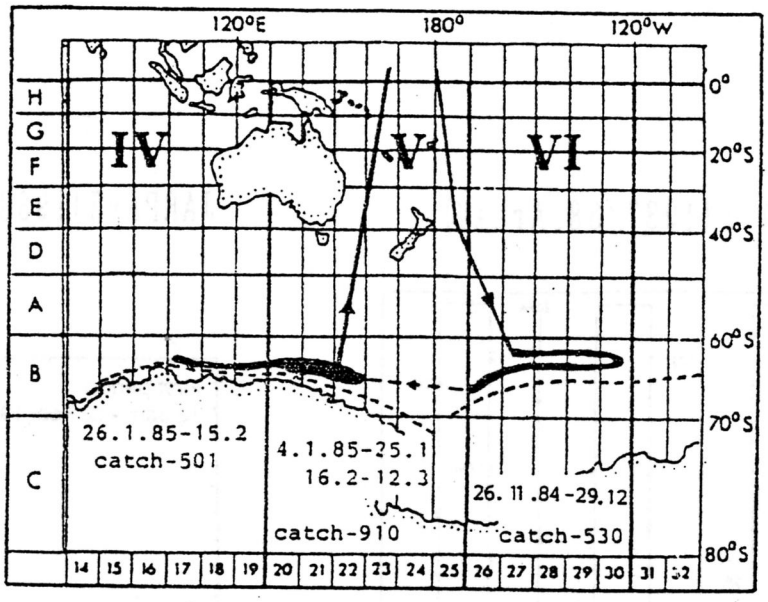


Fig. 1. A standard Japanese commercial whaling grounds in the Antarctic. In 1984/85 season from Kasamatsu and Shimadzu (1986). Broken line : Pack-ice line.

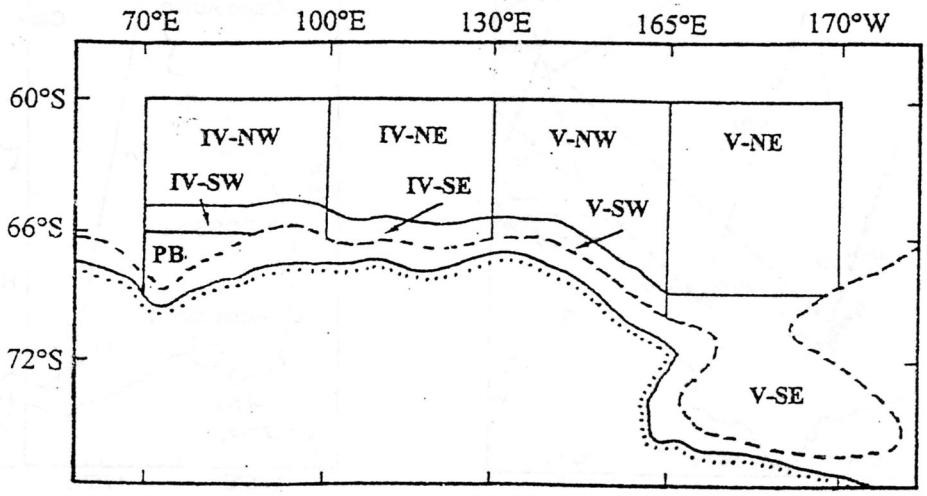


Fig. 2. Separation of sub-areas in Areas IV and V in JARPA. Solid line with dot : Continental line, broken line : Pack-ice line. IV : Area IV, V : Area V, NW : West-North, SW : West-South, NE : East-North, SE : East-South, PB : Prydz-Bay.

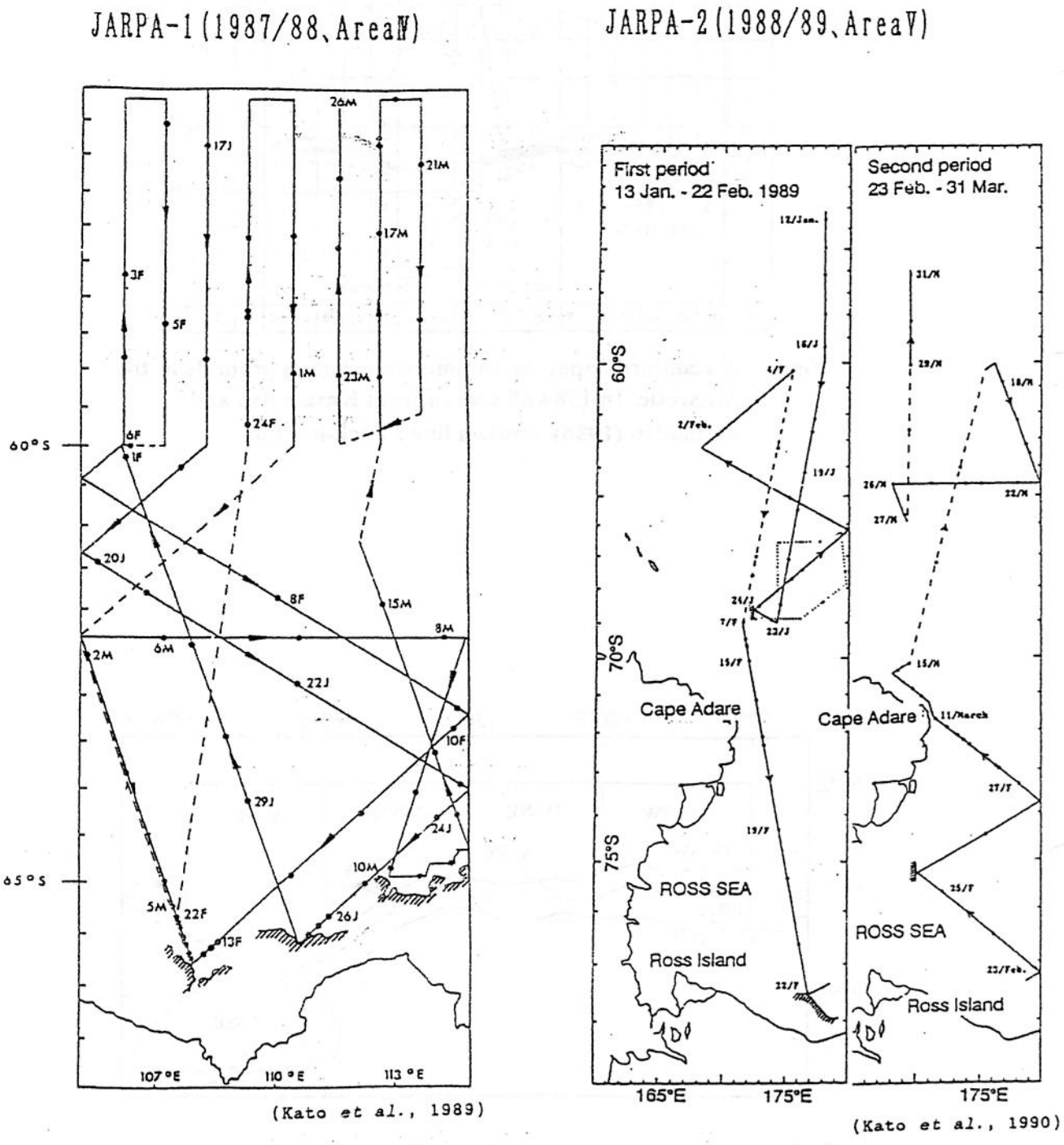
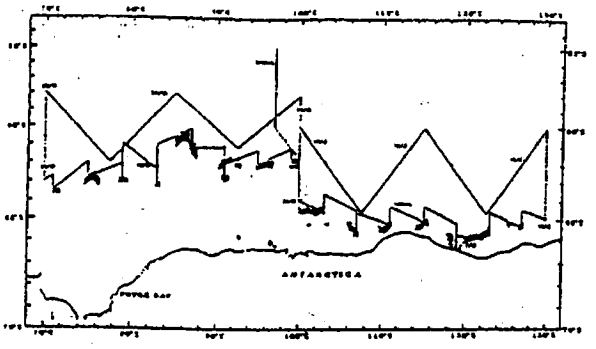


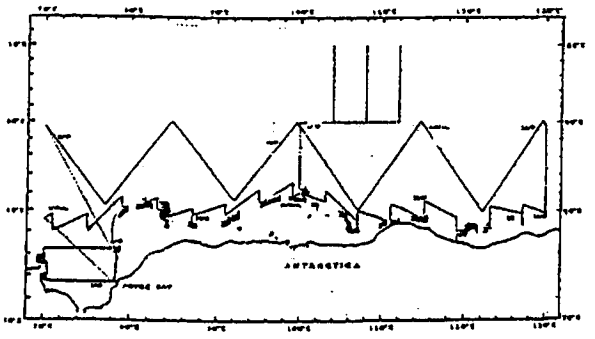
Fig. 3.1 Cruise tracks in 1987/88 and 1988/89 season (fesibility study). The northern and southern strata were defined as north and south water of 60° S. The solid line and the broken line represent the main trackline of the searching and the moving between stratum, respectively. Two sub-trackline 6 n.miles away from either sides of the main track line which was ramdomly established.

JARPA-3 (1989/90, Area W)

First period



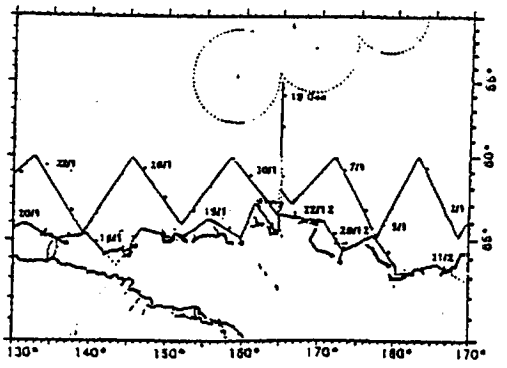
Second period



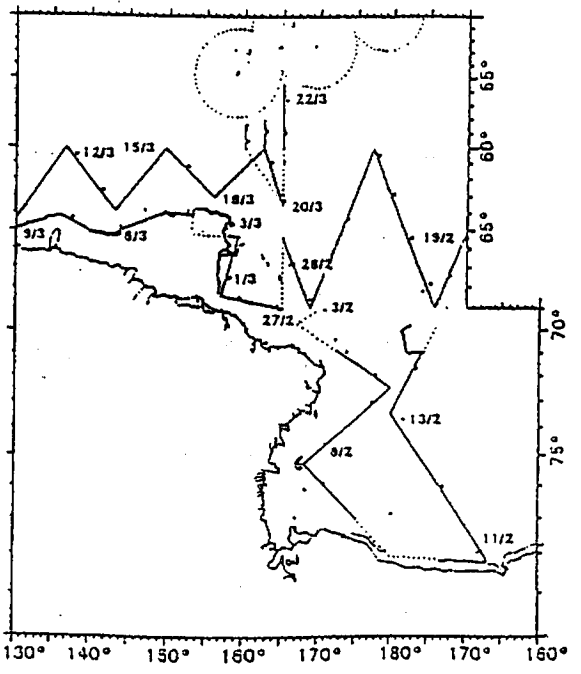
(Fujise *et al.*, 1990)

JARPA-4 (1990/91, Area V)

First period



Second period

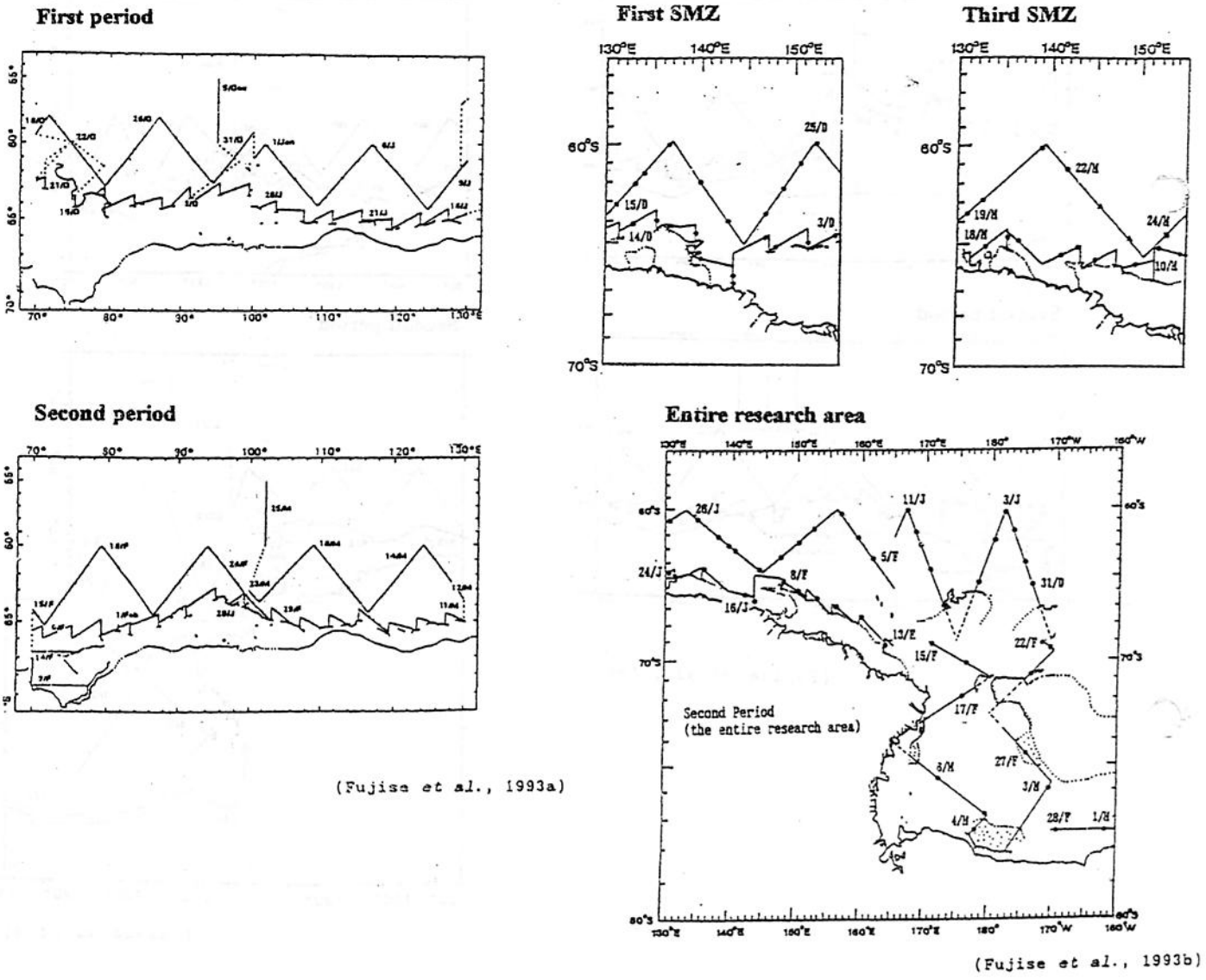


(Kasamatsu *et al.*, 1993)

Fig. 3.2 Cruise tracks in 1989/90 and 1990/91 season. The solid line and the broken line represent the main trackline of the searching and the moving between stratum, respectively. Two sub-trackline 9 n.miles away from either sides of the main track line which was ramdomly established.

JARPA-5 (1991/92, Area Ⅳ)

JARPA-6 (1992/93, Area Ⅴ)



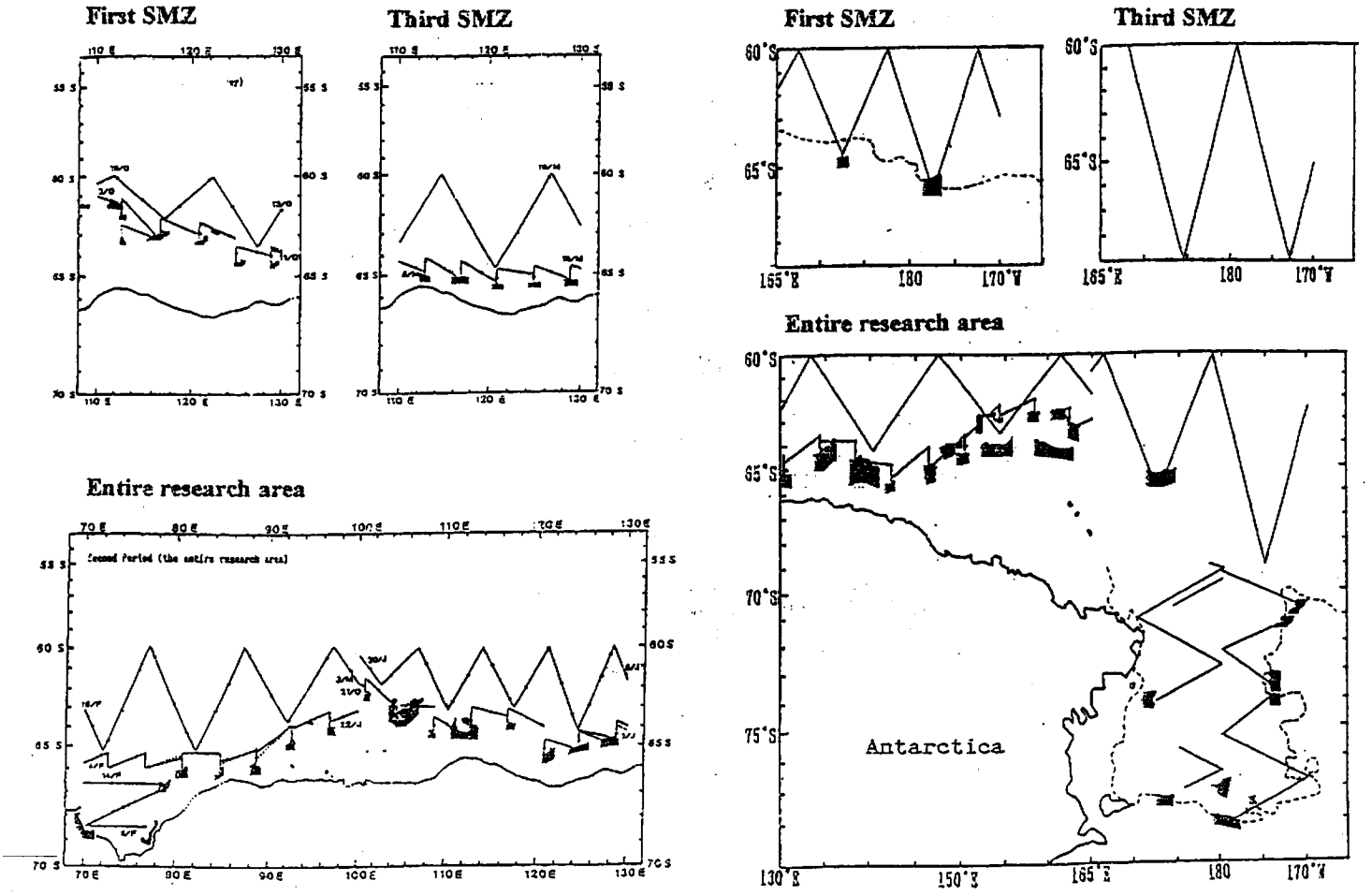
(Fujise et al., 1993a)

(Fujise et al., 1993b)

Fig. 3.3 Cruise tracks in 1991/92 and 1992/93 season. The solid line and the broken line represent the main trackline of the searching and the moving between stratum, respectively. Two sub-trackline 9 n.miles away from either sides of the main track line which was ramdomly established.

JARPA-7(1993/94、AreaW)

JARPA-8(1994/95,AreaV)

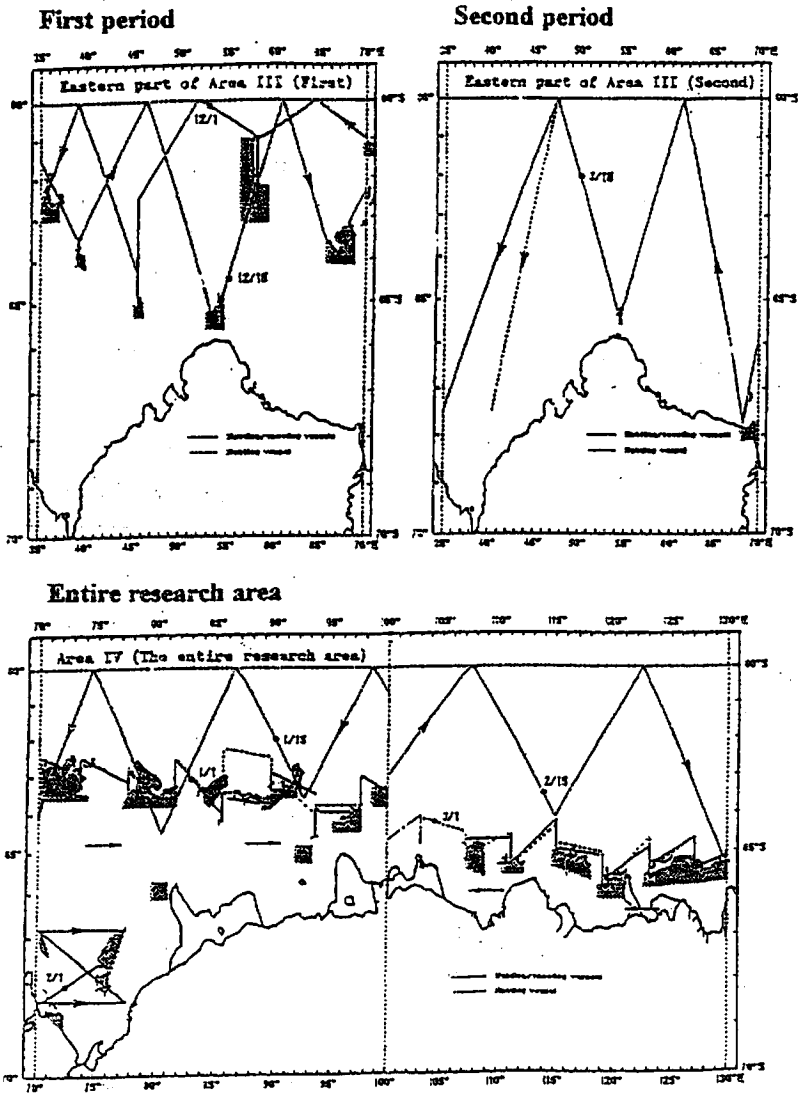


(Nishiwaki *et al.*, 1994a)

(Nishiwaki et al.,1995)

Fig. 3.4 Cruise tracks in 1993/94 and 1994/95 season. The solid line represent the main trackline of the searching, The sub-trackline 12 n.miles away from one side of the main trackline which was ramdomly established.

JARPA-9(1995/96,AreaIV)



(Nishiwaki et al.,1996)

Fig. 3.5 Cruise tracks in 1995/96 season. The solid line represent the main trackline of the searching, The two sub-trackline 7 n.miles away from one side of the main trackline which was ramdomly established.

1995/96 JARPA
SIGHTING RECORD DATA FORM

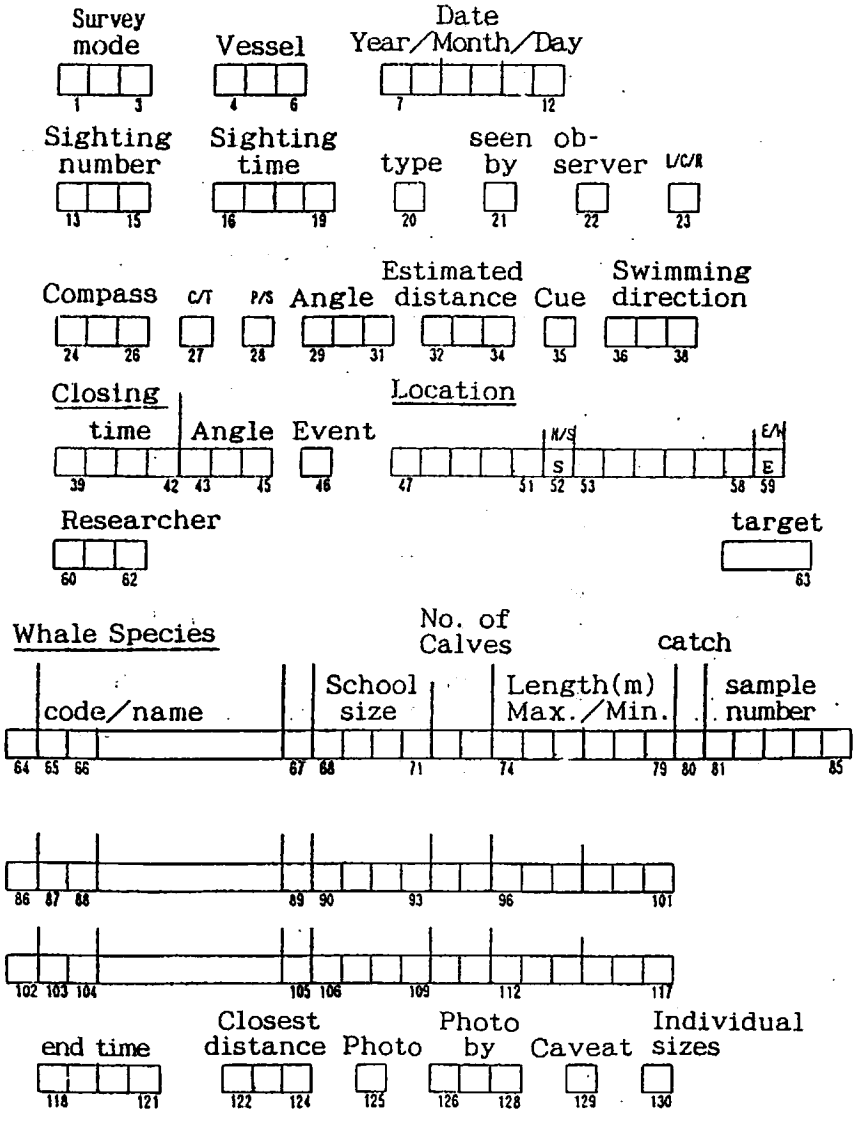
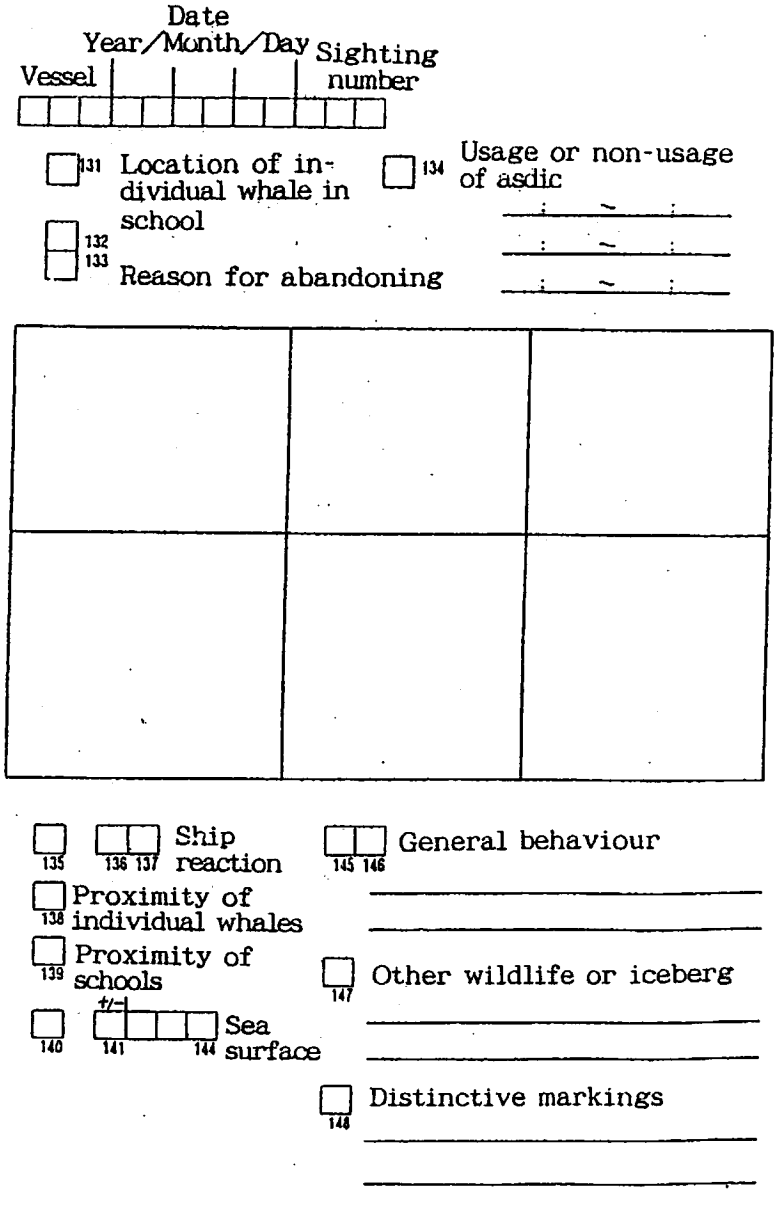
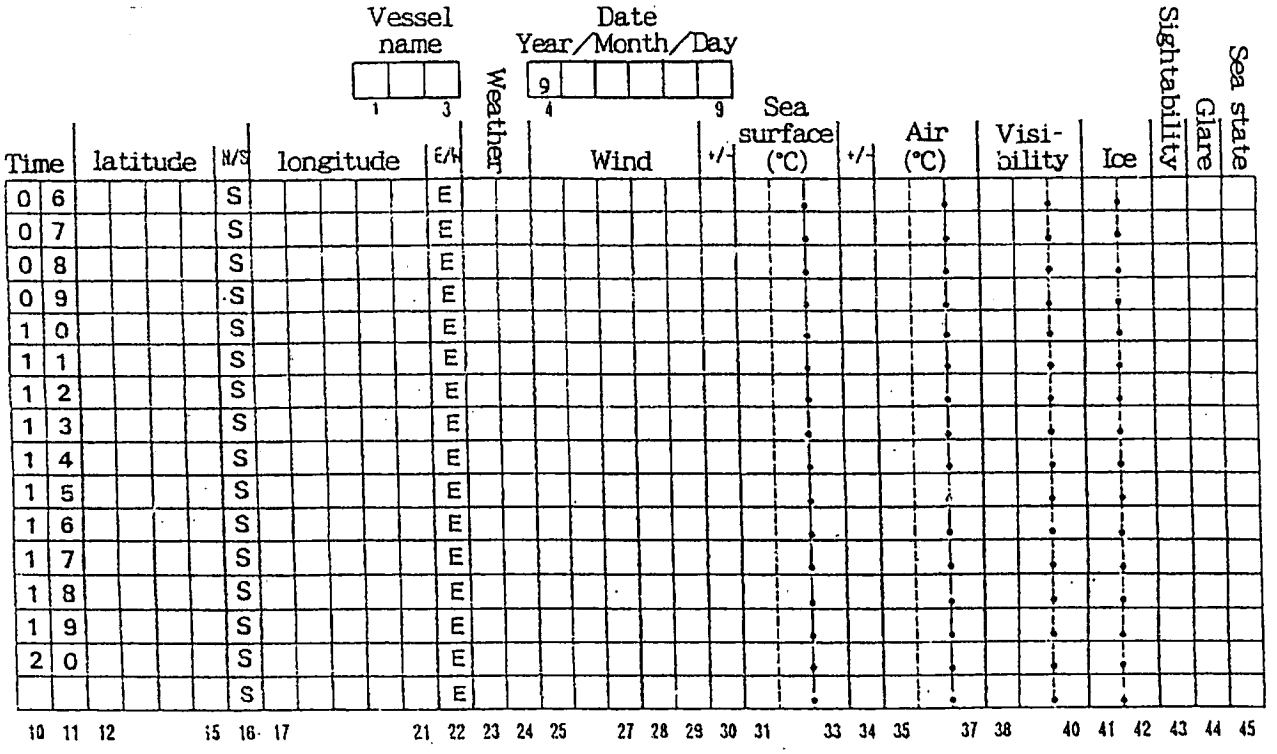


Fig. 4.1 Sample of the sighting record sheet in JARPA.

(Back of the form)



1995/96 JARPA
WEATHER RECORD DATA FORM



1995/96 JARPA
EFFORT RECORD DATA FORM

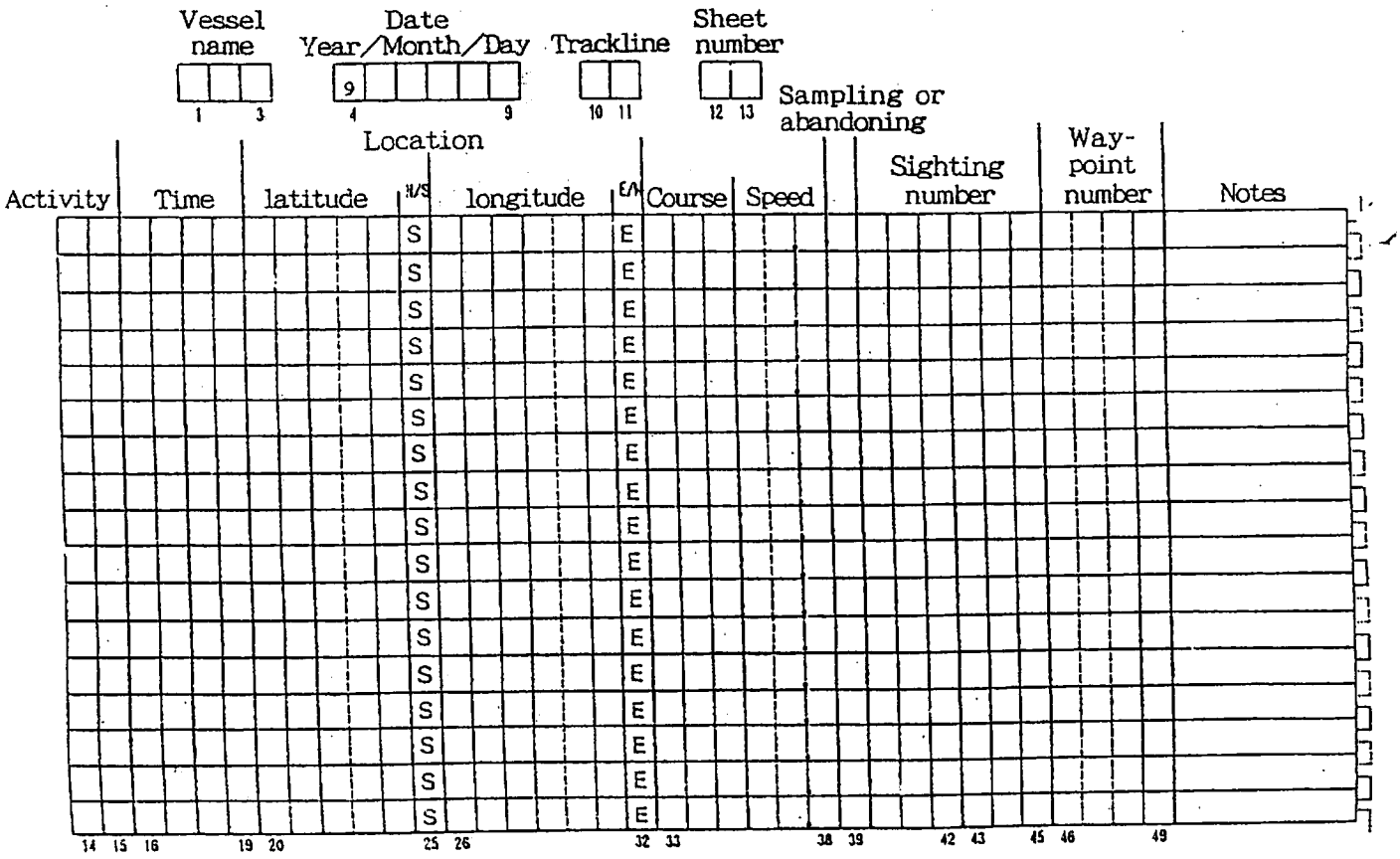
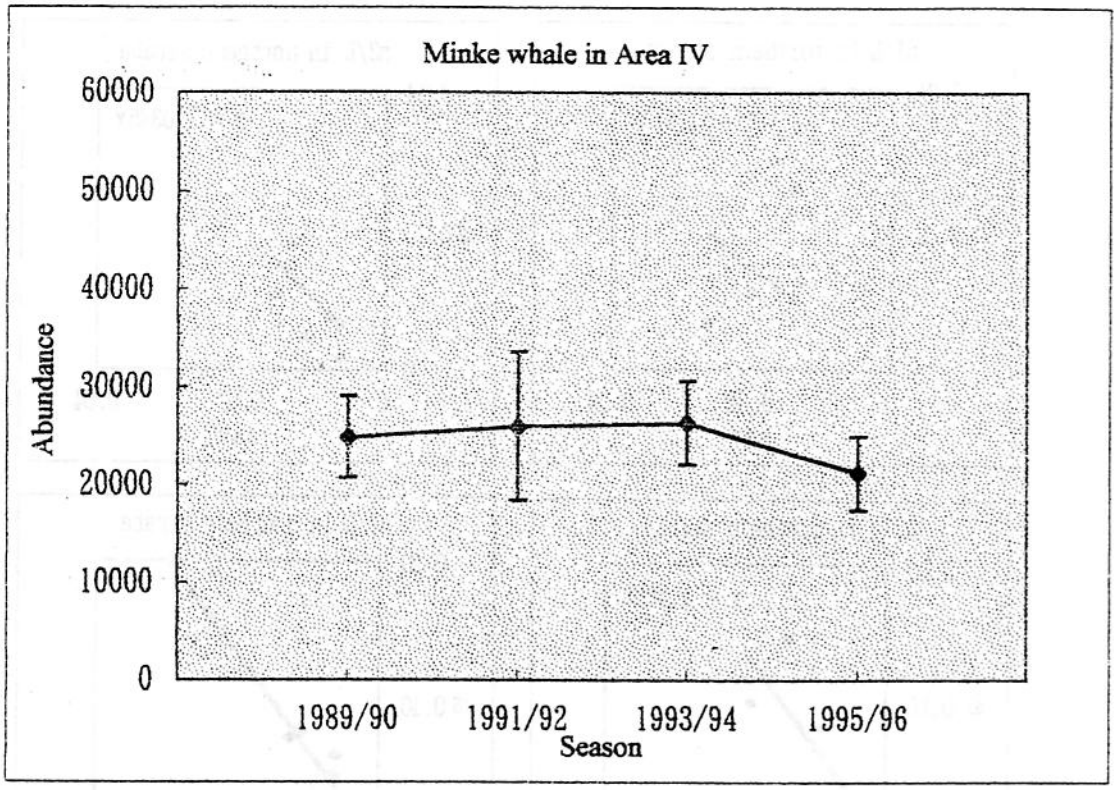


Fig. 4.2 Sample of the weather and the effort record sheet in JARPA.



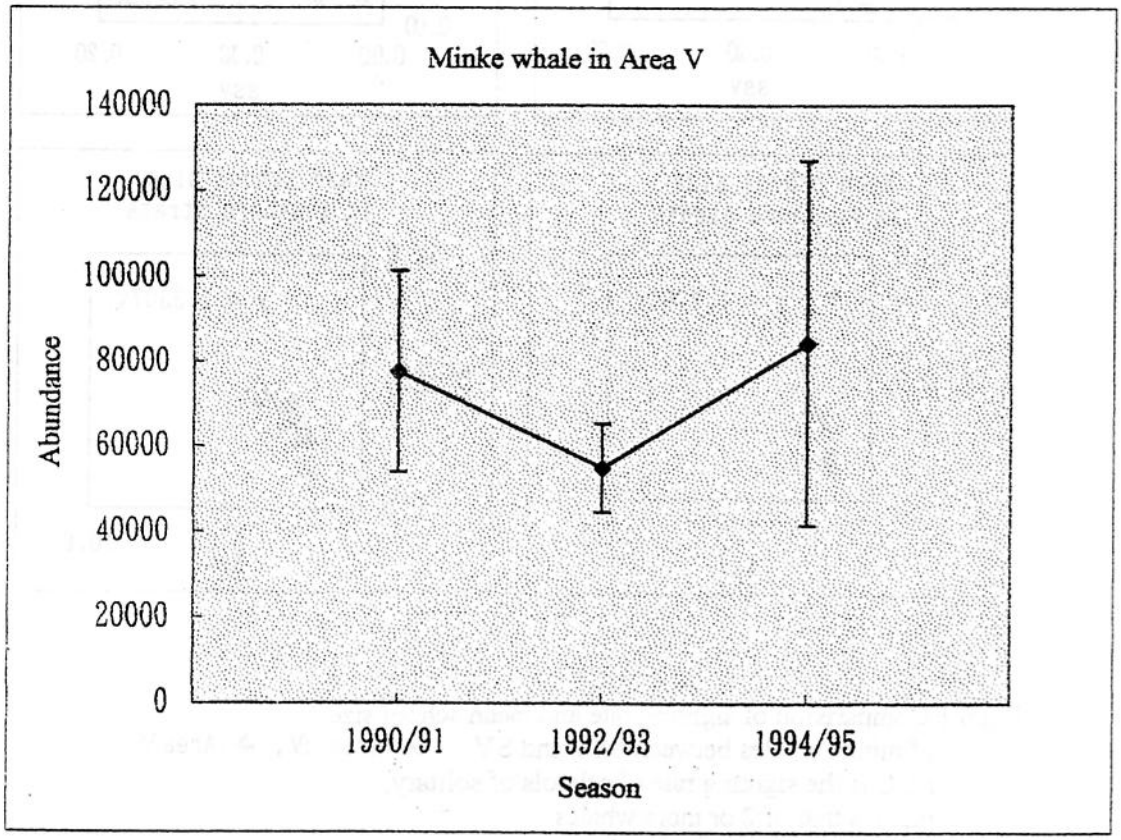


Fig. 5. Trend of ordinary minke whale abundance estimates with S.D.in Areas IV and V (south of 60° S) surveyed during Jan. to Feb. by SSV.

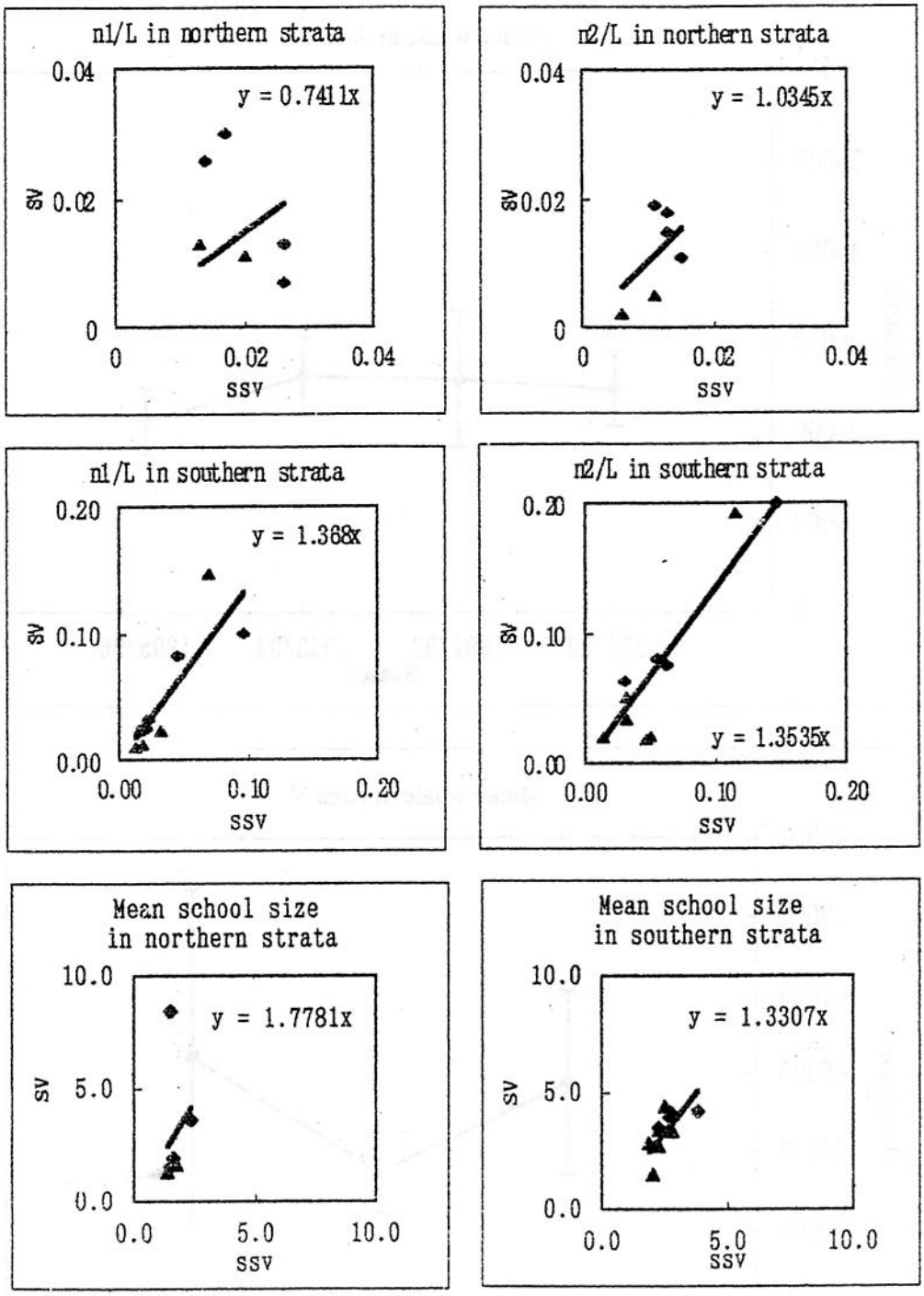


Fig.6.1 Comparision of sighting rate and mean school size of minke whales between SSV and SV. ▲:Area Ⅳ, ◆:Area Ⅴ
n1/L is the sighting rate of schools of solitary,
n2/L is that of 2 or more whales.

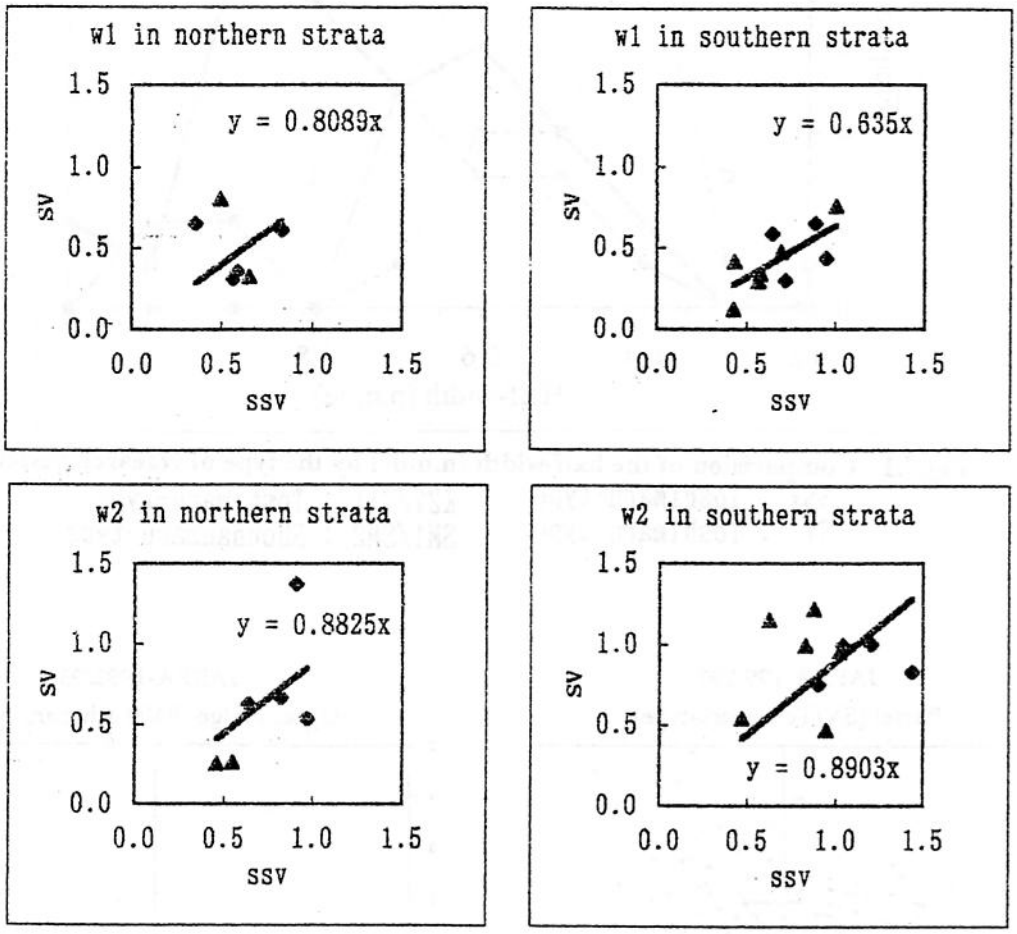


Fig.6.2 Comparision of search half-width(n.m) of minke whales between SSV and SV. ▲:Area Ⅳ, ◆:Area Ⅴ
w1 is the search half-width of solitary whale, w2 is that of school 2 or more whales.

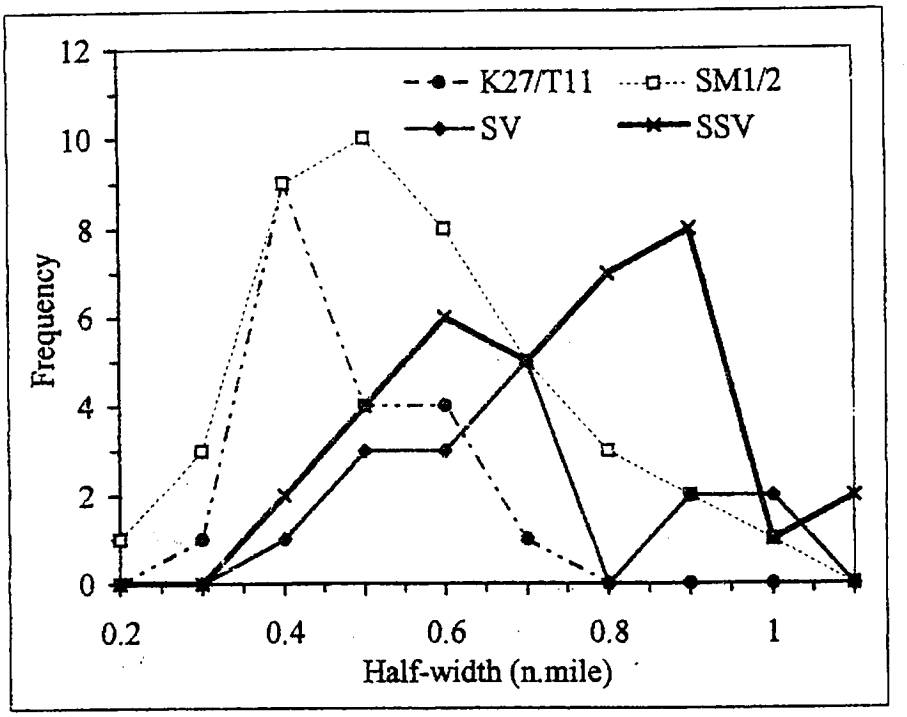


Fig.7.1 Comparision of the half-width (n.mile) by the type of research vessel.
SSV : Toshimaru-type K27/T11 : Toshimaru-type
SV : Toshimaru-type SM1/SM2 : Shounanmaru-type

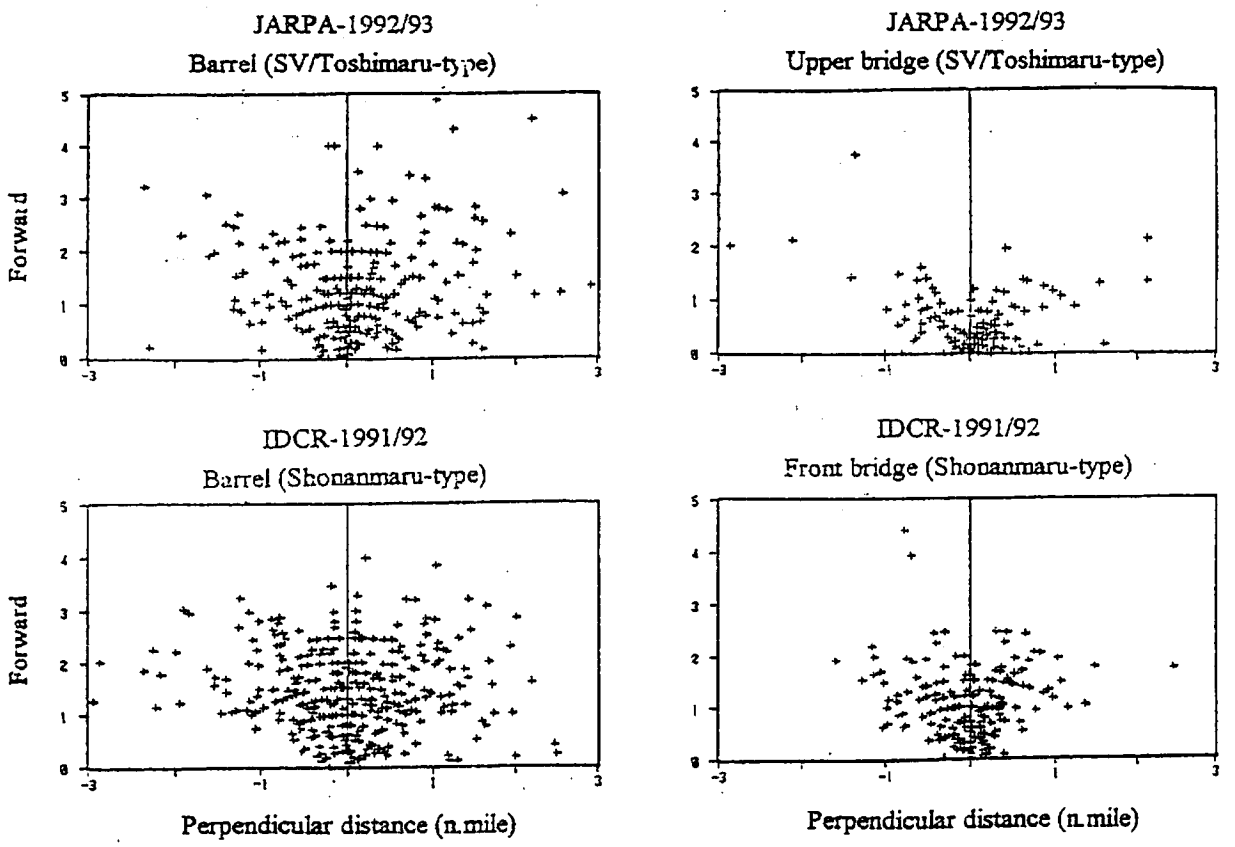
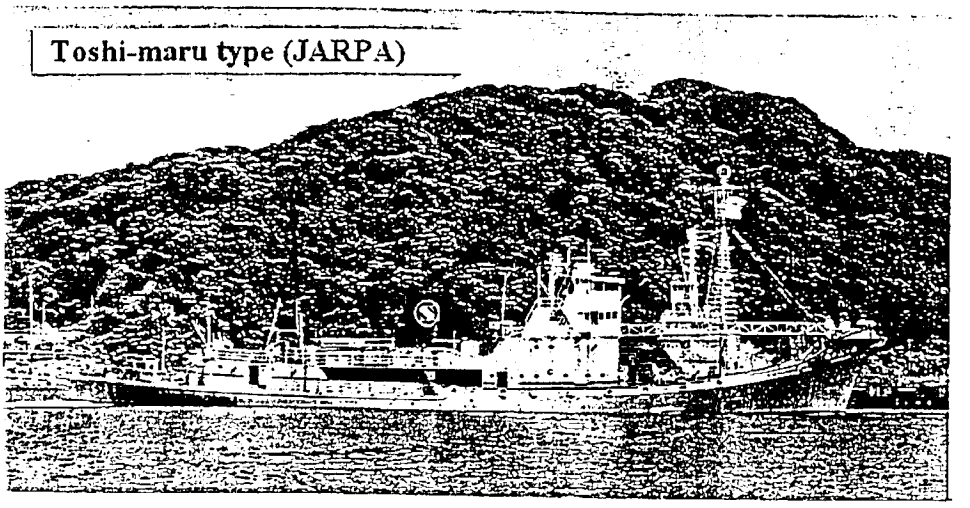
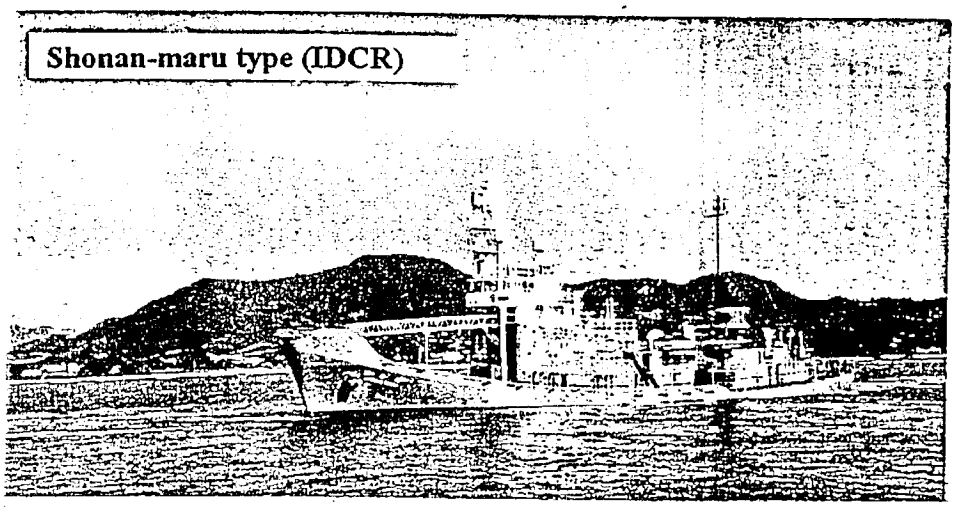


Fig. 7.2 Comparison of the sighting distribution of minke whale primary sighted by platform and by the type of vessels in JARPA (1992/93) and IDCR (1991/92).





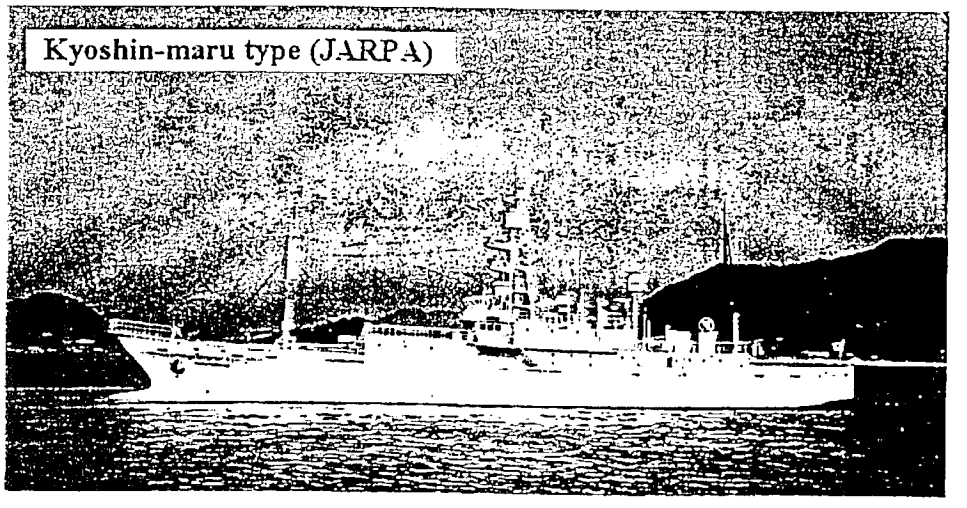
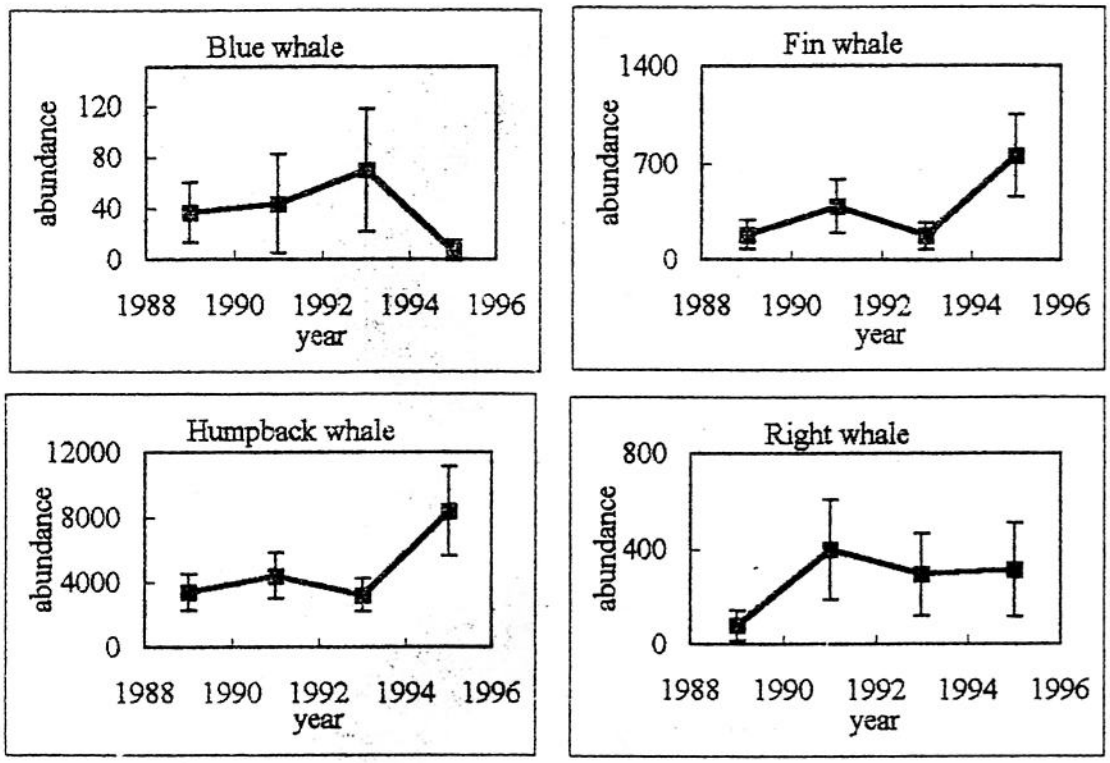


Fig. 8. Comparison of the type of research vessels between JARPA and IDCR.

Area IV



Area V

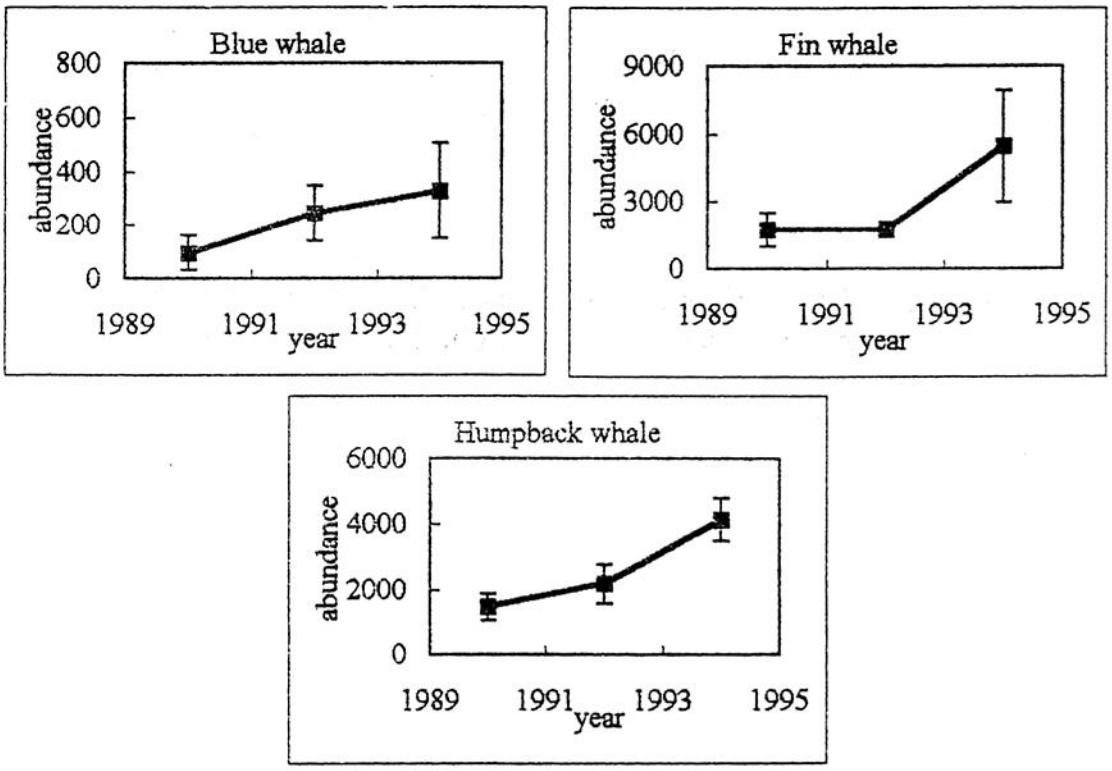


Fig. 9.1. Temporal change in abundance of baleen whales in Areas IV and V from the JARPA data. Vertical lines show standard derivations.

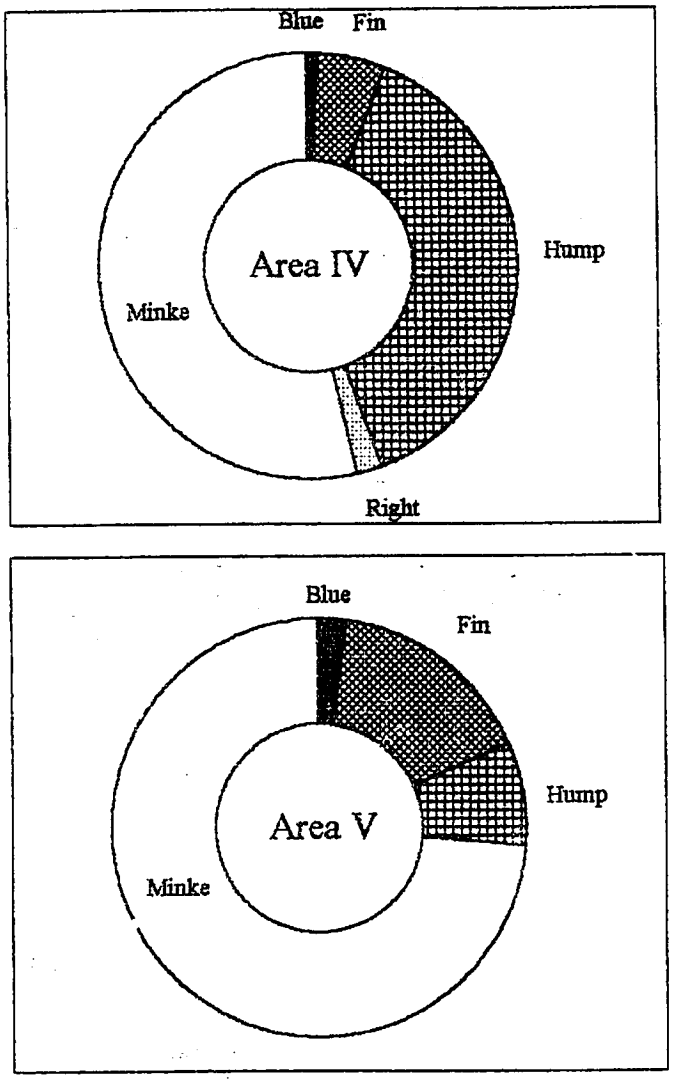


Fig. 9.2 Temporal change in biomass composition of baleen whales in the Antarctic derived from abundance in Fig. 9.1

APPENDIX

Scientific works based on the JARPA sighting survey.

Fujise, Y., Zenitani, R., Saino, S., Itoh, S., Kawasaki, M., Matsuoka, K. and Tamura, T. 1993. Cruise report of the 1992/93 Japanese research under the special permit for Southern Hemisphere minke whales. Paper SC/45/SHB12 presented to the IWC Scientific Committee, April 1993 (unpublished). 39pp.

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