SC/41/SHMi14

# CRUISE REPORT AND PRELIMINARY ANALYSES OF THE FEASIBILITY STUDY ON SOUTHERN MINKE WHALES IN 1988/89 UNDER THE JAPANESE PROPOSAL TO THE SCIENTIFIC PERMIT

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## ABSTRACT

The second feasibility research cruise for Japanese proposal of the special permit to take southern minke whales was conducted during the period from January 12 to March 31, 1989, with using one research base and three sampling vessels. The survey covered latitudinally wider waters from 53°S to the bottom of Ross sea (77°30'S) between longitudes 168°E and 180°. The present cruise employed the systematic sighting survey incorporating the paired vessels allocated on the one of two cruising courses every day. A total of 630 schools (1,599 individuals) of minke whale sightings comprising 340 schools (743 ind.) of the primary and 290 schools (856 ind.) of the secondary sightings was made by the three sampling vessels during the total searching of 9614.2 n.miles. Employing the random sampling scheme, a total of 241 individuals including 236 ordinal forms (85 males, 151 females) and five dwarf forms (one male, four females) was taken from 290 targeted primary sightings (428 ind.). Sampling efficiency by school size had improved by the incorporation of the paired vessel for school size three though it was still lower for the solitary whale. Following items were indicated by the preliminary analyses: (1), the body lengths of the samples were smaller than those of catches by the commercial in both sexes. (2), Mature males and immature animals dominated in the northern zones, while the pregnant female dominated in the high concentration areas of minke whales such as waters off Cape Adare and highly dominated with few mature males and no immature animals in inside of Ross sea. (3), Mature male and immature animals tend to be in the solitary and mature female in larger schools, but this feature had varied depending on the localities. (4), No distinctive periodical change of the biological characteristics was found though decreasing of density was observed in the waters around Cape Adare.

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## 1 INTRODUCTION

Japan proposed a research program on southern minke whales (*Balaenoptera acutorostrata* Lacépède, 1807) in 1987 under the scientific permit (The Government of Japan, 1987a), subsequently carried out the feasibility cruise in 1987/88 to the research program above in a part of Area IV, where the geographical and ice condition are generally believed to be simple (The Government of Japan, 1987b; Kato, Hiroyama, Fujise and Ono, 1988). The feasibility cruise in 1987/88 had provided much improved age composition for the estimating population one from those by commercial catches as well as providing the distinct nature of sexual and reproductive segregation of southern minke whales (Kato, Kishino and Fujise, 1989; Kishino, Koto, Kasamatsu and Fujise, 1989).

However, some points to be improved in the feasibility cruise in 1987/88 were noted at the 40th annual meeting of scientific committee of IWC, such as the low sampling efficiency

of animals from smaller school sizes (International Whaling Commission, 1989). Then, the Government of Japan planned again a feasibility cruise with introducing one additional sampling vessel (three sampling vessels were used as a total) for the 1988/89 season in order to improve the sampling efficiency as well as to improve g(0) estimate and to examine whether the current sampling scheme, which was proposed in the original program, could functionalized in a geographically and oceanographically complex waters such as a Area V including the Ross Sea (The Government of Japan, 1988).

This report covers the feasibility cruise in the Antarctic Area V, which was conducted between December 17 1988 and April 24 1989, and presents some preliminary analyses on the biological data obtained from this cruise. The sighting cruises in lower and middle latitudes which were done under the same research plan will be reported separately.

During the period between January 24 and February 4, the research activities were considerably disturbed by the interferences of GREENPEACE vessel "Gondowana". This report refers briefly to those in the section 2.5.1.

## 2 AN OUTLINE OF THE CRUISE

### 2.1 Detail of the Research fleet

Three sampling vessels, *Kyomaru #1* (*K01*; 812.08GT), *Toshimaru #25* (*T25*; 739.92GT) and *Toshimaru #18* (*T18*; 739.92GT), engaged in sighting and sampling surveys. *Nisshinmaru #3* (*N03*; 23,107.85GT) acted as a research base in which general matters including planning of daily research strategy, setting cruising course, arrangement of sampling vessels, weather forecasting and others were dealt with. The collection of biological materials and the processing of whale carcases were made on *N03*. The principal specification of each vessel is given in Appendix 1.

### 2.2 Research personnel

Research personnel and their assignments are given in Appendix 2.

### 2.3 Research area

The research area was established within a southern part of 52°S of Antarctic Area V; west of 180° and east of 168°E outside of the Ross Sea, and west of 180° to the ice edge inside of the Ross Sea, excluding 200 n.miles zone of New Zealand. The research area was stratified latitudinally to three strata; north (52°S-60°S), middle (60°S-69°S) and south zone (69°S-ice edge). Fig. 1 shows the geographical locality of the present research area with those of the sighting cruises in lower latitudes.

### 2.4 Research method

#### 2.4.1 Searching course and arrangement of sampling vessels

As in the previous season, we established two sub-courses six

miles away from either sides of the main course which was randomly established. Two sub-courses located at right and left side of the main were defined as "sub-course B" and "sub-course A", respectively, at the beginning of survey in each zone. This naming remained throughout the research period within a research zone even when the relative position of two sub-courses swapped each other by the reflection of the main course at the boundaries.

Three sampling vessels were grouped into two vessels ("pair") and one vessel ("single") which were allocated to each sub-course. In pair group, one vessel searched on the sub-course (named as "chief") and the other searched on the course located 0.3 miles outside of the sub-course to the main ("follower"). This arrangement was rotated daily (Appendix 3).

The main course was established by the following rule in each zone:

North: The starting points are randomly chosen from 23 positions divided by each 30' by using random digits table at 52°S and 60°S in first and second halves, respectively. The main course is set along the longitudinal lines from the selected point, only one leg between 52°S and 60°S is surveyed in each half.

Middle: The starting point corresponds the end point of the main course at 60°S in the north zone. The main course is established by using "the set angle reflection method" as applied in the previous season (Kato *et al.*, 1988). Initial direction of the main course is randomly chosen from 17 directions divided by each 10 degree between compass directions (dir.) 90° and 270°, by using random digits table. An angle of reflection at the boundaries such as ice edge, 60°S, 69°S, 168°E and 180° lines had been selected to be 70 degree prior to the present cruise. In this season, reflection points at 168°E and 180° lines locate three miles inside of each line. If we can have two directions to either sides at boundaries, one of two is randomly selected. Resuming point of survey in the second half is succeeded to the ending point in the first half.

South: The starting point is randomly chosen from 10 points divided equally on 69°S line between expected ice edge point based on the best available information and 180°. The initial direction and cruising course are determined by the same manner as that in the middle zone.

### 2.4.2 Sighting manner

The principal sighting manner was similar to that has been adopted in the current IWC/IDCR southern minke whale sighting cruises. The survey was principally made with 12 knot during the day time either between 06:00 and 20:00 or between the hours 30 minutes after sunrise and before sunset, and the sampling vessels resumed survey everyday from ending point of the previous

day. The sampling vessels closed to only primary sightings which were thought to be minke whales and appeared within three miles (perpendicular distance) from the searching course. For paired vessels, when one vessel made minke whale sighting the other vessel also suspended searching and followed the former, therefore, the two vessels were always paralleled during the searching.

After confirming or sampling activities, the vessels returned to the position on the searching course vertically corresponded to the position of whales appeared and resumed searching there. Any activities during the sighting survey and sampling were classified and recorded on the effort data sheet similar to that in IWC/IDCR cruises.

2.4.3 Sampling scheme

The samplings were tried to the only primary minke whale sightings which were made within three miles away from the searching courses. Although all primary sightings of minke whales were targeted in the most of period, we tried to sample on every other primary sighting to control sample size in some length of the period in the middle zone. It was scheduled to be sampled with a maximum two individuals from each school (school size $\geq$ 2) according to the same random sampling scheme to that in the previous season (see section 4 of Kato *et al.* 1988), using tables of random sampling digits prepared by different school sizes.

In the sampling activities to the school sizes two or over two by the pair group, it was scheduled that the first target whale was chosen and taken by the vessels which found the school herself and the second target was chosen again from the remained member of the school and taken by the other vessel. However, when the school separated into several sub-groups before taking the first target moreover the second target belonged to the different sub-group(s) comprizing the first target, the other vessel could take the second target before taking the first target by the vessel firstly sighted the original school.

2.5 Narrative of the cruise

The fleet left Japan on 17 - 18th of December 1988 (*NO3* from Yokohama on 17th; three sampling vessels from Shimonoseki on 18th). After refueling of sampling vessels and having a pre-cruise meeting on December 31, the fleet cruised to southward and arrived at 53°10'S-178°E where was randomly chosen as the starting point in the north zone on January 12 1989. During the southward cruising above the sampling vessels carried out sighting survey with 12 knot in the day time (steamed in the night time) in the outside waters of 200 nautical mile zones of Australia and New Zealand. The same logistics of sighting survey was also incorporated during the returning cruise from the Antarctic.

The research lasted for 79 days from January 12 to March 31 1989. We described briefly an outline of the cruise as below with dividing the first and second halves of the research period.

The track line of the main course is shown in Fig. 2. We described time of this section with using local time advanced 11 hours of GMT, and most of positions used in this section were represent as those for the main course.

2.5.1 The first half (January 12 - February 22 1989)

*North zone*

The fleet commenced searching with dir.180° from 53°10'S-178°E at 09:00 on January 12 under the relatively good weather condition. The initial arrangement of the sampling vessels in the north zone was that *T25*(chief)-*T18*(follower) cruised on sub-course A and *K01* on sub-course B. As mentioned previous section, this arrangement rotated daily. After about five days searching, the fleet reached to 60°S - 178°E where was the ending point of the north zone at 14:00 on January 16. During this period, 12 whales including 11 ordinal form minkes and one dwarf form were sampled from 14 schools (15 individuals) of the primary sighting.

*Middle zone*

We had immediately opened the survey of the middle zone at 60°S-178°E on January 16, with changing cruising direction to dir.190° which was randomly chosen, after ending the north zone. The arrangement of the sampling vessels of the January 16 in the north zone was succeeded, that was, *K01*(chief)-*T18*(follower) on sub-course A and *T25* on sub-course B. The fleet cruised with keeping dir.190° during a week and reached to 69°S-174°17'E where was bottom of the middle zone at about 09:00 on January 23. During the searching of this leg 43 schools (64 individuals) were sighted as the primary sighting. We targeted on every other school of a primary sighting for the sampling, consequently 22 ordinal form and two dwarf form minke whales were taken from them (hereafter, all primary sightings were targeted for the sampling).

The main course was taken to dir.300° at 69°S-174°14'E in the morning on January 23, according to the cruising rule as mentioned in the previous section. Subsequently, the fleet changed the direction of the main course to dir.50° at 68°35'S-172°20'E on January 24 (08:00-14:00), because we met compact pack ice which was formed along the line from north to south there. A total of 26 schools (33 animals) were sighted as the primary sighting and 16 whales were taken from them around this corner.

In the afternoon (15:45) on January 24, an unknown vessel approached the fleet. This vessel was identified later to be "Gondowana" which had been chartered by GREENPEACE. To avoid the accident the fleet once suspended the searching at 68°35'S-172°20'E in the evening on January 24 and the sampling vessels carried out the experiment for evaluating the accuracies of sighting distance and angle around there, through a day on January 25. It was preliminary planned, to avoid the accident further, that the fleet engaged in only sighting survey between positions of the present and the next reflection point on 180° boundary (66°09'S-179°53'E), because "Gondowana" stated direct action to interfere the sampling work. According to this

preliminary plan, *NO3* steamed toward to 66°09'S-179°53'E via 68°53'S-176°12'E in the evening on January 25, and three sampling vessels drifted around the suspended position. "Gondowana" had been chasing to *NO3* during the steaming above.

Although *NO3* arrived at around the next reflection point (66°09'S-179°53'E) on January 26, weather condition had been getting rough, *NO3* had drifted until around the noon on January 27. On the other hand, the sampling vessels begun to sighting survey at 15:00 on January 27 at the suspended position (68°35'E-172°20'E) since the weather condition had recovered. Due to limitation of time available for the present cruise, the fleet decided to re-open the sampling work. Then, *NO3* steamed toward to the ending point of the sighting survey of January 27 (67°56'S-174°27'E) via 66°40'S-174°10'E.

In the morning on January 28, *NO3* jointed the sampling vessels and the fleet begun the survey at 67°56'S-174°27'E with dir.50 under the arrangement of *T18*(chief)-*KO1*(follower) on sub-course A and *T25* on sub-course B. Since then, all research works of the fleet had been considerably disturbed by interferences of "Gondowana" using not only herself but also her helicopters and high-speed motor boats. In spite of the disturbance by "Gondowana", the fleet continued the sampling work with keeping dir.50 and reached to the reflection point on 180° boundary (66°09'S-179°53'E) at noon on January 30. During this leg between the suspended position and the reflection point above, 20 schools (40 individuals) were sighted as the primary sighting and 17 whales were taken from them.

After the reflection point at 180°, the fleet continued sampling survey with taking dir.300° and took one whale from primary sightings of two schools (three individuals) and one from one school (two individuals) on January 30 and 31, respectively. However, the fleet had to suspend sampling survey after the final whale transferring from *KO1* to *NO3* on January 31 from the considerations of keeping safeties of both the fleet and "Gondowana", because the magnitude of attackings by "Gondowana" had been escalating. After then, the sampling vessels, therefore, engaged in only sighting survey and found a total of 21 minke whale schools (24 individuals) as the primary sighting on February 1 and 2. The fleet reached to the west boundary at 168°E (63°15'S-168°07') in the morning (08:00) on February 2 and took course to dir.50° there. "Gondowana" left the fleet in the afternoon (14:45) on February 2 at around 62°31'S-170°04'E.

The fleet resumed sampling survey in the morning (06:00) on February 3 and continued to cruise with dir.50° on February 4, with sometimes top-down steaming due to rough weather. In the morning on February 4, one dwarf form minke was sighted and sampled (60°38'S-175°07'E). Because it was not expected, however, to recover weather condition, we decided to finish all survey of the middle zone in the first half at 60°21'S-175°28'E in the evening (17:45) on February 4. And the fleet begun to move the starting point of the south zone.

*South zone*

The fleet arrived at 69°S-171°36'E, the starting point of the south zone that was randomly chosen, in the early morning on

February 7. However, we could not open the survey due to strong wind over (Beaufort's) wind-class 9 until the weather recovery on February 10. The fleet begun to survey toward to south with dir.170°, which was randomly chosen according to the cruising rule in the afternoon (14:00) on February 10. After 12 days of survey, the fleet reached to the ice shelf at 77°30'S-176°58'E in the afternoon on February 22. During this southward survey, 75 whales were taken from 95 schools (261 individuals) of primary sightings. We met relatively high density areas of minke whales at around 69°30'S-171°50'E and 72°10'S-173°20'E.

2.5.2 The second half (February 23 - March 31)

*South zone*

The fleet turned from edge of the ice shelf (77°30'S-176°58'E) in the afternoon on February 22 and took course to dir.60°. On February 23, the fleet begun the survey at 77°20'S-178°43'E and reached to a reflection point on the east boundary (77°12'S-179°47'E) in the morning (08:30), then the main course was taken to dir.310°. After two days of the survey, we met the compact pack ice which was formed along the line from north to south at 75°16'S-170°06'E and took again the main course to dir.60° there in the evening on February 25. Subsequently the fleet reached to 73°46'S-179°49'E that was a reflection point on the east boundary in the morning on February 27. During this zigzag cruising, only eight whales were taken due to mainly bad weather, unsuitable sea color and elusive behavior of whales though 38 schools (43 individuals) of the primary sightings were sighted.

In the morning on February 27, the fleet took the main course to dir.310° at 73°46'S-179°49'E. After about 12 days of the survey with keeping dir.310° and drifting sometimes due to poor visibility or strong wind, we located 15 miles east from the position of 10 miles south from the north point of Cape Adare in the morning on March 11. By the ice edge searching, it was confirmed that there was open waters off the west side of the peninsula. Then, according to the cruising rule, the fleet took once the main course to dir.345° at 71°41'S-171°29'E and returned to dir.310° at 71°13'S-171°05'E where was 9 miles northeast from the north point of Cape Adare, to take a roundabout course of this peninsula. The fleet surveyed with keeping dir.310° and reached to the west boundary at 70°25'S-168°09'E on March 14 (09:30-14:20), hereafter, took the main course to dir.60°. On March 15, the weather condition changed to be rough and it would be estimated to be rough further judging from satellite information. Therefore, we decided to finish the survey of the south zone in the second half at 70°08'E-169°34'E and begun to move the suspended position in the middle zone (the first half) in the afternoon (13:40) on March 15. During the period between February 27 and March 15 above, a total of seven days was spent for only drifting because of having rough weather frequently. Under the weather condition above, 73 whales were taken from 71 schools (221 individuals) of minke whale primary sightings. Relatively high concentration of minke whales were around areas of 72°54'S-176°13'E and 72°13'S-173°32'E.

*Middle zone*

After a total of 611 n.miles steaming, we arrived at 60°21'S-175°28'E in the early morning (06:00) on March 18, where the fleet suspended the survey in the first half, and begun to search immediately with dir.50°. The daily rotation for the arrangement of sampling vessels in the first half was succeeded as; *T25*(chief)-*T18*(follower) on sub-course A and *KO1* on sub-course B. The fleet reached to a reflection point on the north boundary of the middle zone (60°S-176°16E) at 09:00 on March 18 and took the main course to dir.160°. In the evening (20:00) on March 21, the fleet reached to 64°37'S-179°53'E on the east boundary, subsequently took the main course to dir.270° from the boundary on March 22 (06:00). After about five days westward searching with drifting sometimes due to rough weather, the fleet met the west boundary at 64°37'S-168°07'E on 26 March (12:00). During the period between March 18 and the noon on March 26, 15 schools (25 individuals) were sighted as primary sightings of minke whales and eight whales, including one dwarf form minke appeared in 62°S, were taken from them.

We were able to choice either direction of dir.20° or dir.160° as that for the main course after the reflection point on the west boundary (168°E). Consequently dir.160° was randomly chosen, the fleet begun to search along this direction from 64°37'S-168°07'E in the afternoon on 26 March. Due to limitation of time available for the present cruise, we finished the survey of the middle zone in the second half at 65°52'S-169°12'E in the evening (16:20) on 27 March and moved to the starting point of the north zone. A total of seven whales were taken from nine schools (17 individuals) of minke whale primary sightings, after the reflection on the west boundary.

*North zone*

At around the noon (12:30) on March 29, the fleet commenced the survey of the north zone in the second half at 60°S-169°30'E where was randomly chosen, under the relatively gentle weather condition which lasted until the evening on March 28. We ended all the surveys on March 31 (12:30) at 56°S-169°30'E where was southern limit of 200 n.miles zone of New Zealand. During this final searching leg, no minke whale was sighted.

## 3 SIGHTING AND SAMPLING

### 3.1 Searching effort

The present survey collected all items of sighting information which were currently required in the analyses of population size by IWC/SC, using same data formats which have been adopted in the current IWC/IDCR southern minke whale sighting cruises.

Although we introduced the searching by the paired vessels cruising in parallel on one of two sub-courses in each day during the present survey, the searching effort by the paired vessels were tentatively treated separately by vessel in the present report.

Table 1 indicates the distribution of searching distance

(n.miles) by one degree square in each period. A total searching distance of the fleet combined three sampling vessels was 9,614.2 n.miles comprising 1,828, 5,410 and 2,376.2 n.miles in the north, the middle and the south zone, respectively. The searching distance in the first half (5,466.2 n.miles) was about 1,300 n.miles longer than that in the second half (4,148 n.miles).

The searching effort was allocated throughout all latitudes and longitudes in the first half, but it was higher in the east side of the research area and zones between 62° S and 68° S. Although there was no effort between zones 66° S and 69° S, in the second half, it was allocated almost equally throughout the remaining all latitudes except 64° S where much effort was spent by the westward cruising.

## 3.2 Sighting

### 3.2.1 Species and number sighted

Table 2 indicates lists of whale species with their numbers of school and individuals which were sighted during the present survey in each zone, with dividing by the type of sighting and the period. Four mysticeti-species and at least seven odontoceti-species appeared during the entire period of the survey.

Minke whale (ordinal form) was obviously the dominant species throughout three zones being 340 schools (743 individuals) of the primary sighting and 290 schools (856 individuals) of the secondary sighting in a total. The numbers of minke whale schools sighted were almost equal between two periods in the south zone, whereas the number of schools of the first half was much higher than that of the second half in the middle zone. But we can't say simply that this difference represents seasonal change because fewer searching effort was spent on the second half.

A total of five schools (five individuals) of "dwarf form minke whale" was sighted in the north and middle zone, this is described further in the later section (3.4). Several schools of fin (*Balaenoptera physalus*), humpback (*Megaptera novaeangliae*) and blue whale (*B. musculus*) were sighted in the middle zone, while there was only one sighting of blue whale in the south zone.

Sperm whale (*Physeter catodon*) appeared mainly in the middle zone being 67 schools (77 individuals) of the primary sighting, while only seven schools (seven individuals) and five schools (five individuals) in the north and south zone, respectively. The most of them were obviously solitary bull. Ziphiids whales were also frequent in the middle (49 schools - 119 individuals) and the north zone (12 schools - 33 individuals). Killer whale (*Orcinus orca*) appeared through three zones, but was relatively frequent in the south zone. Several odontoceti-species including long finned pilot whale (*Globicephala melaena*), False killer whale (*Pseudorca crassidens*), hourglass dolphin (*Lagenorhynchus crusiger*) and southern right whale dolphin (*Lissodelphis peroni*) were sighted in the north and middle zone.

### 3.2.2 Distribution and density of minke whale

Table 3 indicates density indices and mean school size of the minke whale primary sighting by one degree square in the each half (excluding five dwarf forms). Density index (DI) represents the number of schools of the primary sighting per 100 n.miles searching. Fig. 3 shows the spatial distribution of the minke whale sightings including both the primary and the secondary sightings.

Although minke whale was sighted throughout the most of latitudes between 53°S and 77°S and longitudes between 168°E and 180° except for the north zone in the second half, their concentrations presented in several localities. Based on the values of density and mean school sizes, the three local waters located around following positions could be regarded as the relatively high concentrations: 68°30'S-172°30'E (DI, 3.60-10.67; mean school size, 1.6-2.5), 69°20'E-172°E, (21.96-55.0; 3.3-5.1) and 73°S-176°30'E (28.5-40.46; 3.18-3.86). The first two localities were present among off shore icebergs.

The waters off Cape Adare was the highest concentration throughout the survey, and surveyed twice at the interval of about 20 days. The density and mean school size of this water (62.5-110.0; 5.20-5.82) in the first survey (17-19/Feb./'89) were higher than those (58.82-63.64; 3.18-3.86) in the second survey (9-11/March/'89).

### 3.2.3 Duplicated sightings by the paired vessels

Since when one vessel sighted a whale school the other ceased the searching at the same time in the survey by the paired vessels, we had principally no duplicated sighting. However, as listed in Table 4, three duplicated and one same-time sightings were made by the paired vessels during the present survey. In such cases, the second sightings of the duplicated one were made before receiving the call of the first sightings from the other vessel. We treated those duplicated sightings as both the primary sighting in this report.

### 3.2.4 Sighting experiment

Experiments for evaluating the accuracy of the estimated sighting distances and angles were carried out in each sampling vessel on February 25, under the relatively gentle weather condition (Beaufort wind class - 2), with the visibility of which minke whale could be found from four n.miles apart. We adopted, as the previous season, the similar manner to that in IWC/IDCR minke whale sighting cruises using the artificial subject (similar form of whales blow) equipped radio reflector. All the personnel (major observer) who had a chances to engage in the searching at the "crow's nest (top)" and/or the upper bridge had participated this experiment.

A total of 220 experiments combined three sampling vessels were made with 40 different combinations of a distance and an angle by a total of 22 testee from their normal place at which

they engaged in the searching. The result of this experiment will be reported in the separate paper.

Although experimental data collection in "the high density area" for identification of the density distribution had been planned, we had no chance to do that.

## 3.3 Sampling

### 3.3.1 Distribution of samples taken

A total of 241 minke whales comprising 236 ordinal and five dwarf forms were taken throughout the entire period of the survey. Fig. 4 shows the spatial distribution of those animals by sighted position, during two halves with different two symbols.

Respective numbers of samples by zone were: 12, 58 and 75 for the north, middle and south zone in the first half; 15 and 81 for the middle and south zone in the second half. With refracting by sighting distribution shown in Fig. 3, several concentrations of samples could be observed as in; off Cape Adare (around 72°S-173°30'E) and off-shore iceberg area (around 68°30'S-172°30'E). A small concentration was also present in the north zone (53°S-56°S, 178°E). On the other hand, samples tend to be distributed in scattering in inside of Ross sea and waters between 62°S and 68°S. We were not able to obtain samples from west side waters inside of Ross sea due to no searching effort spent and west side in the north zone due to no sighting.

Table 5 shows number of ordinal minke whale samples by latitudes, with their proportions to number of primary sightings. All sightings were to be sample in the north latitudes of 57°S. Although there was no samples between latitudes 57°S and 61°S, we could widely obtained samples from latitudes between 64°S and 74°S and their proportions to the sightings were almost constant between 0.30 and 0.43, excepting relatively high value of 0.50 in 66°S.

As mentioned in the previous section, five dwarf form minke whales were sighted, and all of those were taken. This was mentioned further in the latter section (3.4).

### 3.3.2 Sampling efficiency

Excluding five dwarf form minke whales, a total of 236 ordinal form minke whales were taken under the sampling scheme mentioned in section 2.4.3. Table 6 indicates the proportion of ordinal form samples taken to the primary sightings and to the sightings targeted by the status of the arrangement of the sampling vessels in each zone with separately by the survey period. Targeted school for the sampling represents the primary sightings excluding the primary ones which were made during the period engaged in only sighting survey and/or were nontarget ones for the sample size control mentioned in the sub-section 2.5.1. As in the previous season, two individuals (as a maximum) were scheduled to be randomly taken from a school with regardless its size if it was consisted with two or more individuals. We defined, here, the proportions of samples taken to the targeted

individuals as "the technical sampling efficiency" and that to the primary sightings as "the true sampling efficiency".

Throughout the surveys in all zones and periods, 236 individuals were taken from 428 targeted individuals of the 340 primary sightings (743 individuals), therefore mean technical and true sampling efficiencies were 0.55 and 0.32, respectively. All sightings were targeted and most of them were taken in the north zone, therefore, both sampling efficiencies of to sighted and targeted on them revealed higher value as 0.79. The difference between the status of sampling vessels (single or pair) was insignificant. The technical sampling efficiencies for the middle zone in the first half were relatively high being 0.65-0.69, but true sampling efficiencies were lower than the former, because we had to engage in the only sighting survey in several days when considerable number of primary sightings had been made, due to disturbance by "Gondowana". On the other hand, the technical sampling efficiencies for the middle zone in the second half were lower than those in the first half, while the true sampling efficiency were almost same between halves at around 0.34. In the south zone, there was no significant difference in the values of both technical and true efficiencies between the halves, however, those by paired vessels were consistently higher than by single vessel as 0.60-0.53 to 0.45-0.49 for the technical and 0.34-0.32 to 0.28-0.24 for the true sampling efficiency.

Table 7 indicates numbers of the primary sighting and the targeted school, sampling efficiencies and school size with separately by the status of sampling vessels. The sampling status were classified into three cases as taken none, one and two individuals from a school. Among the total of 340 sightings, about 70% of them were sighted in a solitary or a pair, the remaining 30% were in larger schools over two. The technical sampling efficiency was relatively low in the solitary school, while it remained constant between 0.70-0.80 among the school sizes over two. The true sampling efficiency from solitary school was also relatively low as being 0.28 and rate decreased with increasing school sizes with peak of 0.43 in school sizes two and three. This decreasing was clearly due to sampling size limitation from a school among larger school sizes.

Between the different status of vessel arrangements, the technical sampling efficiencies by the single were slightly higher and effectively higher in school size two, than that by the paired vessels.

### 3.3.3 Cause of failure in the insufficient sampling

As indicated in Table 6 and 7, a total of 192 individuals which were targeted was not to be sampled. The causes of those failures by school size were summarized in Table 8, with separately by the status of the arrangement of the sampling vessels.

The major causes of the failure through all school sizes were sea conditions such as poor visibility, strong wind, high swell and unsuitable sea color for the sampling and the quick mobile behavior followed this. These two causes occupied about 76% of

the total and occupied more higher proportion in the solitary class as being 83% and 90% in the single and paired vessels, respectively. In class of the school size two, quick mobile was the most frequent cause for failure by a single vessel, while this cause was not so serious for the paired vessels.

### 3.4 Dwarf form minke whale

During the present cruise, a total of five dwarf form minke whales were taken as; one from the north zone in the first half, three from the middle zone in the first and one from the middle in the second half. The information of those animals was summarized in Table 9, and their sighted positions of were also shown in Figs. 3 and 4.

As indicated in Table 9, all animals of this form were sighted in a solitary between latitudes 55°22'S and 62°07'E in the approximate column along 177°E line. Except one whale, they were sighted around 62°S. These are obviously the most southerly record for this form. It seems that southern limit of these sighted position (62°07'S-176°58'E) located in just north side of the Antarctic convergence in this area (see section 5.3).

It was noteworthy that ordinal form minkes also sighted in the column above. A total of 15 schools (16 individuals) of ordinal forms were sighted and 11 whales were taken from them between latitudes 53°S and 62°S in the first half (see Figs 3 and 4). The most northerly sighted position of them was 53°27'S-177°50'E. This indicates that northern limit of ordinal form and the southern limit of dwarf form overlapped somewhat in the mid summer around the just north side of the Antarctic convergence.

The timings of identity of dwarf form from ordinal one were: during the confirming - one, during the chasing - one, after the hit - three cases.

The reproductive status of dwarf form minkes for females were: two females (4.5m, 5.7m) were identified to be sexually immature and other two females were to be mature by the ovary examinations. One females (7.0m) of sexually mature was pregnant having a foetus (119 cm, male). While the pregnancy of the other (7.0m) was not able to be confirmed due to damaging its uterine horn by harpoon. But it seems to be pregnant judging from stretch mark of uterine tissue. The reproductive status of a male (6.6m) having a heavier testis of 195g, taken from the middle zone, has not been examined.

The detailed analyses of dwarf form minke whales including one taken in the previous season will be reported somewhere in near future.

## 4 BIOLOGICAL DATA AND SAMPLE COLLECTION

Biological data and sample collection was made on all whales taken, comprising 86 males including one dwarf form and 155 females including four dwarf forms, on the deck of *NO3*. The techniques or methods for the present biological survey were principally same as those in the previous season (see section 5 of Kato *et al.*, 1988). However, beside adding several research

items to those in the previous season, the following two points should be noted:

(1) Whole body weight of all whales taken were measured by the hydro-scale which can weigh up to 15,000kg.
(2) Stomach contents weight or volume of all whales having diets in their stomachs were measured.

Table 10 summarized research items of the biological data and sample collection and numbers of whales surveyed in each item. Details of the analyses of those will be reported somewhere.

Extensive biological surveys including of morphometrics, osteology, reproduction, age and growth, physiology, food and feeding habits, pollution, parasitology and others were made on the all dwarf form minke whales taken during the cruise, those result is expected to be reported in the near future.

## 5 OTHER SURVEYS

### 5.1 Mark recapture (Discovery tag)

No mark was recaptured throughout the present survey.

### 5.2 Biopsy experiment

Following the previous season, 12 experiments were carried out on the deck of *NO3* for the development of biopsy dart head using whale carcase of 8.5m male on January 14 1989. For the present experiment, we examined four different types of dart heads which were three types newly developed (Kasamastu, Mermoz, Zorin and Silva, 1989) in addition to B2 type used in the previous season (Kato *et al.*, 1988), using crossbow (Barnett Thunderbolt; 71cm in length, 81cm in width) and crossbow arrow as a dart body (Fig. 5). The end of dart was linked with a line (#200), however for the present experiment, we adopted free-release without a fishing reel based on the experience of the previous season.

The shootings were made from the left wing of the mid-ship house (3m above the deck) to the targeted whale lain on its face on the deck, under the condition that shooting distance, angles of aspect and incidence were set as 15m, 20° and 30°, respectively.

As indicated in Table 11, head type "D" having largest stopper (25mm) was few trouble for tissue sampling and dart recover. However, we didn't have a chance to examine this dart head for a living whale from the sampling vessel.

### 5.3 Oceanographical survey

In addition to routine recording of weather and sea condition in every one hour, oceanographical surveys including the surface temperature by sampled water and vertical thermal distribution by XBT were carried out on board of *KO1* (by H. Yoshida) during the whole research period. The survey was normally conducted after the ending of sampling and sighting surveys of the day. The

substantial analysis will be reported somewhere by the certain oceanographer. This section provided only tentative ones which were made just after the cruise.

### 5.3.1 Surface temperature

The surface temperature was taken by using sampled water from surface and the standard thermometer at 56 points during the entire period of the survey. Fig. 6 shows the isotherms by the interval of 0.5 degree based on the data obtained from the 56 points above, with separately by the conventional two periods as January 12 - March 13 1989 and March 18 - 30.

The convergence of isotherms of from +4.0°C to +1.0°C could be observed at the latitudes between 62°S and 64°S and those of colder than 0.0°C was in the waters off Adare. On the other hand, water temperature was relatively constant in the inside of Ross sea, though small convergence presented at around 77°S-177°E. The thermal line of +0.5°C slightly moved to north from 67°S in the middle of January to 65°S in the late of March.

### 5.3.2 XBT survey

For this survey, we used XBT (TURUMI XBT, MK2A) and probes by which water temperatures could be vertically recorded from 0 to 760m in depth. The survey was made on a total of 56 points.

Fig. 7 shows vertical isotherm based on the 21 points sampled along the approximate strait line from 54°S-178°E to 77°S-173°E during January 12 and February 21. It could be observed that the colder waters than +1.0°C extend from ice shelf in Ross sea to about 62°S on the zone up to 200m in depth and the water between +1.0°C and +2.0°C presented below the colder waters in out side of the continental shelf. The warmer water than +2.0°C presented clearly in the north of 61°30'S throughout all zones of depth. From the above, it seemed that the Antarctic convergence located at around 62°S in the research area.

## 5.4 Marine debris

The sighting survey of marine debris had been made on the wheel house of *NO3* (average height from sea level; 21m) based on the sighting manner by Japan Fisheries Agency. A total searching hour was 164.5 hours comprising 37.0 hr., 117.5 hr. and 10.0 hr. in the north, middle and south zone, respectively.

Same surveys were also made during the cruise between the research area and adjacent waters off Japan. Those data of both Antarctic and the round cruises are scheduled to be used in the analyses by the marine debris project of Japan Fisheries Agency.

No marine debris was found from stomach contents of whales taken.

# 6 PRELIMINARY ANALYSES OF SAMPLES TAKEN

This section presents preliminary analyses of only ordinal form minke whale samples, which were made during the returning cruises from the Antarctic. Detailed analyses of samples taken and

population estimate will be done in the future study.

## 6.1 Biological characteristics by the time-areal group

### 6.1.1 Grouping of samples taken

For the grouping of samples, some patchnesses in the sighting and sample distribution (see Figs. 3 and 4) were taken account as a major factor. Through some considerations, we conventionally proposed the following five time-areal groups with the tentative namings for them (Fig. 8):

| | |
|---|---|
| North group; | 11 individuals taken from latitudes between 53° S-56° S during January 12 - 14. |
| Middle group; | 26 individuals taken from latitudes between 62° S-67° S during January 17 -21 and January 28 - February 4 and March 19 - 27. |
| Iceberg group; | 73 individuals taken from latitudes between 67° S-69° S during January 22 -29 and February 10 - 13. |
| Adare group; | 100 individuals taken from latitudes between 70° S-73° S during February 16 - 18 and February 27 - March 14. |
| Ross sea group; | 26 individuals taken from latitudes between 73° S-77° S during February 19 and 27. |

### 6.1.2 Sex ratio and reproductive status

Table 12 indicates male sex ratios and reproductive structure by the time-areal group. Female reproductive status was determined by examinations of ovary, uterus and mammary gland. Although male reproductive status should be determined by the histological examination, we took tentatively the traditional threshold weight of testis for the sexual maturity (animals having a testis 400g or over in weight are classified into sexual maturation; Ohsumi, Masaki and Kawamura (1970) and Kato (1986)) due to incompleteness of testis and epididymides preparation.

A total of 85 males was obtained throughout the present survey, therefore, the proportion of males to the total samples (male sex ratio) was 0.360. However, male sex ratio varied by the group as: its value was higher in the Middle (0.731) and the North group (0.545), while it was considerably low in the southern groups, especially in the Ross sea group (0.192) and in the Adare group (0.268). In the North group, mature male and immature female were dominant, and it should to be noted that one lactating/pregnant female (foetus, 17.4 cm in length) which was not accompanied by the calf appeared. Mature male was dominant in the Middle group as occupying 50%, while mature female dominated slightly (36%) in the Iceberg group. With decrease of male proportion, the pregnant female was to be dominant being 50% in the Adare group. The pregnant female highly dominated as 76% in the Ross sea group, it was notable that there was no immature individuals of sexes there.

### 6.1.3 Body length composition

Body length compositions with pooling each 20cm interval and mean lengths in each group are given in Fig. 9, separately by sex.

It was distinctive that there was few males smaller than 8.0m in the both of North and Ross sea group, as indicated by larger male mean lengths 8.2 - 8.5m. On the other hand, length compositions for the other three groups were very close each other with mean lengths 7.8 or 7.9m. The proportions of smaller females than 7.0m were higher in the North and relatively higher in the Middle groups as indicated by mean lengths of 6.4m and 7.5m, respectively. The female length composition of the Iceberg was similar to that of Adare groups, the means were very close as 8.3 and 8.4m, but it seemed larger females over 8.8m more frequently occurred in the Adare than in Iceberg group. It should be also noted as in male, there was no female smaller than 8.0m and length composition considerably skewed to the larger side with mode of 9.0m in the Ross sea group.

When all groups were combined, the mean (8.3m) and mode (8.8-8.9m) of female were considerably larger than those of male (mean-7.9m, mode-8.2m). This difference may exceed the natural difference of body length between sexes at the asymptotic stage of the growth.

## 6.2 Biological characteristics by school size

### 6.2.1 Reproductive status

In order to examine the differences in reproductive conditions between different school sizes, we pooled some groups due to small sample size as following three groups; (North and Middle), (Iceberg and Adare) and (Ross sea). Table 13 indicated compositions of reproductive status by school size in each group combined above. The following trends was observed:

North and Middle: Higher proportions of immature animals of both sexes was noted in the school size one, while mature males dominated in the school size two and three.

Iceberg and Adare: Immature male was relatively frequent in school sizes one and two. Mature male dominated as 47.4% in school size one, while females including both status of mature and immature were dominant in the other school sizes. Although the proportion of pregnant female was relatively lower in school size one, there was no specific trend depending on school size among pregnant female in the other school sizes (40.9 - 46.9%), immature females showed also no specific trend throughout all school size classes.

Ross sea: The most of animals were taken from school size one and two and pregnant female exclusively dominated.

### 6.2.2 Body length composition

Because of difficulty to examine length compositions separately by time-areal group due to small sample size, we examined those by using the data of all the groups combined.

Fig. 10 shows body length compositions in each school size

class with values of mean lengths and their standard deviations, separately by sex. Although relatively frequent occurrence of smaller individuals than 7.0m of both sexes in school size one were noted and their mean values (7.8 and 8.0m for males and females respectively) were smaller than those of the other school sizes (male, 7.8 - 8.2; female, 8.4 - 9.1m), the length compositions for both sexes were considered to be similar throughout all school size classes.

### 6.3 Periodical changes in whale density and biological structure

As mentioned in the section 3.2.2, the waters off Cape Adare was surveyed twice with interval of about 20 days. Then we examined changes in whale density (number of school sighted per 100 miles searching) and biological structure between the period using samples obtained from this area (equivalent to Adare group) as an object for this examination using the data of the Adare group classified in the previous section 6.2. Although surveyed localities in the first and second halves were not coincided strictly, the changes for the Middle group was also supplementary examined.

Table 14 compared whale density (DI; based on the data given in Table 1 and 3), mean school size and composition of reproductive status between the period. For the Adare group, the whale density and mean school size in the first half were higher than those in the second half as about 2.8 and 1.7 folds, respectively. Although sample size in the first half (28 ind.) was smaller than that in the second half (72 ind.), biological structure was almost same between the two periods as follows; male sex ratio was 0.21 in the first to 0.28 in the second, sexual maturity rates were 0.83 to 0.75 and 0.68 to 0.67 for males and females, respectively.

It was noted for the Middle group that the male sex ratio of the second period (0.93) was considerably higher than the even sex ratio in the first half (Table 14). However, it was not clear whether this change represented real one, because we did not surveyed in the latitudes between 66°S and 68°S.

## 7 DISCUSSIONS

The present survey had lasted 79 days during January 12 and March 31 1989, however, we were not able to carry out the sampling survey during hours corresponded to the total of 38 days (48.0% to the total days of survey) due to rough sea conditions such as strong wind, high swell and poor visibility or the moving between research zones. In addition, the research fleet was disturbed by the interferences of "GONDOWANA" during ten days. These circumstances caused to the shortage of time available and lead to the shortage of searching distances and sample size.

Under the above circumstance, however, the present survey collected certainly much information to contribute the planning of future cruise and increasing of knowledge. This section discussed major three points among them, full analyses and consideration is expected to be made in the future study.

## 7.1 Biological aspects of minke whale in the Ross sea and the north waters of Ross sea

The present survey covered wide latitudes from 53°S to 77°30'S including central waters of Ross sea, and the most northerly and southerly samples were taken from 53°27'S-177°50'E and 77°34'S-177°25'E, respectively.

The occurrence of lactating female, at 55°53'S-178°10'E, should be noted, and large amount of milk flowed out from its mammary gland. This female was not accompanied by the calf, however thickness of mammary gland of this animal (9.1cm) was in the range of lactating females off Durban (Best, 1982). Therefore, it was possibly that the calf had been weaned just before. It should be noted further that this female had foetus of 17cm in length by which this female had conceived possibly by the post-partum oestrus.

Among the two major patchnesses of minke whale such as the Adare and Iceberg groups located between 67°S and 73°S, the pregnant females dominated and the mature males and immature animals of both sexes followed them, which is the normal pattern in the high concentrations of minke whales as pointed out the survey of the previous season (Kato *et al.*, 1988) and previous works (Ohsumi *et al.*, 1970; Ohsumi and Masaki, 1975; Best 1982; Kato, 1983). On the other hand, for northern groups such as the North and Middle groups, the mature males and immature animals of both sexes dominated and few sexually mature female, which is also similar pattern to that in the northern area in the previous season.

It is noted further, the present female highly dominated while there were few mature males and no immature animals. It seems that this pattern is the characteristics of the inside of Ross sea. However, because the present survey had not covered east and west bottom of Ross sea at which baleen whales have been believed to be concentrated, this aspect is not clear.

## 7.2 Different feature of the samples from the commercial one

Fig. 11 compares body length compositions of respective sexes of the present samples collected from the Iceberg and Adare groups (the research sample) with those from the Area V (the commercial sample in 1986/87). Both localities from which whales were taken are approximately coincided each other.

The mode of males of the research sample exist in 8.2m and is smaller than commercial sample 8.6m, while for female both modes are almost same at around 9.0m. However, it is distinctive in both sexes that the proportions of smaller animals than the modes above are considerably higher in the research samples than those in the commercial samples (Fig. 11). Reflecting above compositions, mean lengths of the research samples of respective sexes (male 7.8m, female 8.4m) were statistically smaller than those in the commercial ones (male 8.6m, female 9.0m; t-test, $p<0.001$), and standard deviations of the research are higher than those of the commercial.

## 7.3 Sampling biases and effects of the paired vessels

It was pointed out that, in the discussion of sampling result of the previous season at the 40th scientific meeting of IWC, it had proved more difficult to sample animals in schools of three or less individuals than those in larger schools (IWC, 1989). In this relation, the present survey has incorporated one additional sampling vessels to overcome this point above.

As examined in the section 3.3.2 (see Table 7), the (technical) sampling efficiency on school size three has been improved and shows almost same values for those over three. Although a certain contribution by the paired vessels are recognized, the sampling efficiencies on school sizes one and two were still lower than those on larger school sizes over two (Table 7).

On the other hand, the effects of the incorporation of paired vessels could be found the number of sightings, as shown in the section 3.3.2 (see Table 6 and 7), in which number of sightings by the pair exceed about 25% than that by the single vessel. We point out further the saving time for the sampling as an another effect of the incorporation of the paired vessels. Although there was no difference between the single and the paired vessel for the chasing time spent for taking one whale sample, the working time spent to take two samples from a school (time from biginning of chasing the first target to hitting on the second target) by the paired vessels is about 30 minutes shorter than that by the single (Fig. 12).

Table 15 compares the mean estimated body lengths of samples taken with those targeted but lost in each school size class, which were estimated before taking or chasing at the sampling vessels, in the middle and south zones. The differences between two lengths above are statistically insignificants in each the school size.

## 8 ACKNOWLEDGMENT

We are largely indebted to Dr Ikuo Ikeda, project leader of the present feasibility cruise (Director of the Institute of Cetacean Research), for his leadership of the present plan. We thanks to the researchers, Messers Hiroshi Okamoto, Syuichi Kawashima and Hiroshi Miyakoshi, and research technicians, Messers Tameo Ryono, Katsuji Gomi, Tomiya Yomashita, Shigeo Tabata and Yutaka Eguchi, for their contributions to the completion of many researches.

Finally, we would not be able to carry out the research works and overcome several accidents happened during the cruise without the cooperations of following captains and their crew; Captains Kazuhiko Yamashita (*Kyomaru #1*), Kunihiko Mochizuki (*Nisshinmaru #3*), Shigeo Suzuki (*Toshimaru #25*) and Tokuya Sumihara (*Toshimaru #18*).

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Table 1. Searching distances (n.miles) by one degree square, with combining the three sampling vessels in each half.

The first half (12/JAN - 22/FEB/'89)

| Latitude | Longitude (E) | | | | | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 168°- | 169°- | 170°- | 171°- | 172°- | 173°- | 174°- | 175°- | 176°- | 177°- | 178°- | 179°- | |
| North zone | | | | | | | | | | | | | |
| 53°S - | — | — | — | — | — | — | — | — | — | 49.0 | 89.0 | — | 138.0 |
| 54°S - | — | — | — | — | — | — | — | — | — | 80.0 | 60.0 | — | 140.0 |
| 55°S - | — | — | — | — | — | — | — | — | — | 116.0 | 63.0 | — | 179.0 |
| 56°S - | — | — | — | — | — | — | — | — | — | 59.0 | 118.0 | — | 177.0 |
| 57°S - | — | — | — | — | — | — | — | — | — | 68.0 | 66.0 | — | 134.0 |
| 58°S - | — | — | — | — | — | — | — | — | — | 90.0 | 77.0 | — | 167.0 |
| 59°S - | — | — | — | — | — | — | — | — | — | 60.0 | 116.0 | — | 176.0 |
| Middle zone | | | | | | | | | | | | | |
| 60°S - | — | — | — | — | — | — | 69.0 | 20.0 | — | 113.0 | 70.0 | — | 272.0 |
| 61°S - | — | — | — | 82.0 | 12.0 | — | — | — | — | 176.0 | — | — | 270.0 |
| 62°S - | 37.0 | 105.0 | 97.0 | 27.0 | — | — | — | — | 72.0 | 75.0 | — | — | 413.0 |
| 63°S - | 144.0 | 96.0 | 69.0 | 16.0 | — | — | — | — | 137.0 | 36.0 | — | — | 498.0 |
| 64°S - | — | — | 23.0 | 68.0 | 88.5 | 82.0 | 31.5 | 36.0 | 108.0 | — | — | — | 437.0 |
| 65°S - | — | — | — | — | — | — | 13.0 | 135.0 | 148.0 | 83.0 | 79.0 | 42.0 | 500.0 |
| 66°S - | — | — | — | — | — | — | 10.0 | 145.0 | 2.0 | 45.0 | 81.0 | 109.0 | 392.0 |
| 67°S - | — | — | — | — | — | 6.0 | 139.0 | 107.0 | 53.0 | 40.0 | — | — | 345.0 |
| 68°S - | — | — | — | — | 75.0 | 117.0 | 169.0 | 5.0 | — | — | — | — | 366.0 |
| South zone | | | | | | | | | | | | | |
| 69°S - | — | — | — | 59.2 | 20.0 | — | — | — | — | — | — | — | 79.2 |
| 70°S - | — | — | — | — | 25.0 | — | — | — | — | — | — | — | 25.0 |
| 71°S - | — | — | — | — | 70.0 | 90.0 | — | — | — | — | — | — | 160.0 |
| 72°S - | — | — | — | — | 8.0 | 10.0 | — | — | — | — | — | — | 18.0 |
| 73°S - | — | — | — | — | — | 12.0 | 9.0 | — | — | — | — | — | 21.0 |
| 74°S - | — | — | — | — | — | — | 89.0 | 40.0 | — | — | — | — | 129.0 |
| 75°S - | — | — | — | — | — | — | 29.0 | 99.0 | 18.0 | — | — | — | 146.0 |
| 76°S - | — | — | — | — | — | — | — | 77.0 | 79.0 | — | — | — | 156.0 |
| 77°S - | — | — | — | — | — | — | — | — | 36.0 | 64.0 | 28.0 | — | 128.0 |
| Total | 181.0 | 201.0 | 189.0 | 252.2 | 298.5 | 317.0 | 558.5 | 664.0 | 653.0 | 1154.0 | 847.0 | 151.0 | 5466.2 |

The second half (23/FEB - 31/MAR/'89)

| Latitude | Longitude (E) | | | | | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 168°- | 169°- | 170°- | 171°- | 172°- | 173°- | 174°- | 175°- | 176°- | 177°- | 178°- | 179°- | |
| North zone | | | | | | | | | | | | | |
| 53°S - | — | — | — | — | — | — | — | — | — | — | — | — | — |
| 54°S - | — | — | — | — | — | — | — | — | — | — | — | — | — |
| 55°S - | — | — | — | — | — | — | — | — | — | — | — | — | — |
| 56°S - | — | 181.0 | — | — | — | — | — | — | — | — | — | — | 181.0 |
| 57°S - | — | 187.0 | — | — | — | — | — | — | — | — | — | — | 187.0 |
| 58°S - | — | 179.0 | — | — | — | — | — | — | — | — | — | — | 179.0 |
| 59°S - | — | 170.0 | — | — | — | — | — | — | — | — | — | — | 170.0 |
| Middle zone | | | | | | | | | | | | | |
| 60°S - | — | — | — | — | — | — | — | 66.5 | 188.5 | 20.0 | — | — | 275.0 |
| 61°S - | — | — | — | — | — | — | — | — | 35.0 | 151.0 | — | — | 186.0 |
| 62°S - | — | — | — | — | — | — | — | — | — | 32.0 | 117.0 | — | 149.0 |
| 63°S - | — | — | — | — | — | — | — | — | — | — | 88.0 | 66.0 | 154.0 |
| 64°S - | 124.0 | 62.0 | 73.0 | 63.0 | 78.0 | 71.0 | 76.0 | 65.0 | 73.0 | 63.0 | 67.0 | 160.0 | 975.0 |
| 65°S - | 140.0 | 38.0 | — | — | — | — | — | — | — | — | — | — | 178.0 |
| 66°S - | — | — | — | — | — | — | — | — | — | — | — | — | — |
| 67°S - | — | — | — | — | — | — | — | — | — | — | — | — | — |
| 68°S - | — | — | — | — | — | — | — | — | — | — | — | — | — |
| South zone | | | | | | | | | | | | | |
| 69°S - | — | — | — | — | — | — | — | — | — | — | — | — | — |
| 70°S - | 86.0 | 100.0 | 25.0 | — | — | — | — | — | — | — | — | — | 211.0 |
| 71°S - | — | 3.0 | 38.0 | 92.5 | 26.2 | 5.0 | — | — | — | — | — | — | 164.7 |
| 72°S - | — | — | — | — | 17.3 | 38.6 | 54.4 | 39.0 | 13.6 | 0.4 | — | — | 163.3 |
| 73°S - | — | — | — | — | — | — | — | — | 11.0 | 61.0 | 94.0 | 75.0 | 241.0 |
| 74°S - | — | — | — | — | — | 22.0 | 53.0 | 52.0 | 57.0 | 48.0 | 38.0 | 6.0 | 276.0 |
| 75°S - | — | — | 35.0 | 46.0 | 49.0 | 21.0 | 4.0 | — | — | — | — | — | 155.0 |
| 76°S - | — | — | — | — | 0.5 | 24.5 | 40.0 | 44.0 | 40.0 | 37.0 | 27.0 | 11.0 | 224.0 |
| 77°S - | — | — | — | — | — | — | — | — | — | — | 31.0 | 48.0 | 79.0 |
| Total | 350.0 | 920.0 | 171.0 | 201.5 | 171.0 | 182.1 | 227.4 | 266.5 | 418.1 | 412.4 | 462.0 | 366.0 | 4148.0 |

Table 2. Lists of sighting (no. individuals/no. schools) combined three sampling vessels by species, type of sighting and period in each zone.

North(53°30'S-60°S, the first half; 56°S-60°S, the second half)

| Species | First half (12-16/JAN/'89) | | Second half(29-31/MAR/'89) | | Total | |
|---|---|---|---|---|---|---|
| | primary | secondary | primary | secondary | primary | secondary |
| Minke whale (ordinal) | 14/13 | — | — | — | 14/13 | — |
| Minke whale (dwarf) | 1/1 | — | — | — | 1/1 | — |
| Sperm whale | 6/6 | — | 1/1 | — | 7/7 | — |
| Ziphiids | 29/11 | 4/1 | 4/1 | — | 33/12 | 4/1 |
| Killer whale | 4/1 | — | — | — | 4/1 | — |
| Pilot whale | 1/1 | — | — | — | 1/1 | — |
| Hourglass dolphin | 25/6 | 10/1 | — | — | 25/6 | 10/1 |
| unidentified dolphin | 163/22 | 36/5 | 35/3 | — | 198/25 | 36/5 |

Middle (60°S-69°S) (18-27/Mar.)

| Species | First half (16/JAN-4/FEB/'89) | | Second half(~~29-31/MAR/'89~~) | | Total | |
|---|---|---|---|---|---|---|
| | primary | secondary | primary | secondary | primary | secondary |
| Minke whale (ordinal) | 164/100 | 56/39 | 42/24 | 3/3 | 206/124 | 59/42 |
| Minke whale (dwarf) | 3/3 | — | 1/1 | — | 4/4 | — |
| Humpback whale | 2/1 | — | — | — | 2/1 | — |
| Fin whale | 6/3 | — | 12/5 | 1/1 | 18/8 | 1/1 |
| Blue whale | — | — | 2/1 | — | 2/1 | — |
| Sperm whale | 73/64 | 9/9 | 5/4 | 2/2 | 77/67 | 11/11 |
| Ziphiids | 92/34 | 8/5 | 27/15 | 2/1 | 119/49 | 10/6 |
| Killer whale | 34/9 | 6/1 | 14/6 | 1/1 | 48/15 | 7/2 |
| F. killer whale | — | — | — | 30/1 | — | 30/1 |
| Pilot whale | 4/1 | — | — | — | 4/1 | — |
| Hourglass dolphin | 25/2 | — | 2/1 | — | 27/3 | — |
| S. right whale dolphin | 15/1 | — | — | — | 15/1 | — |
| unidentified dolphin | 42/7 | — | 18/2 | — | 60/9 | — |

South(69°S-77°30'S)

| Species | First half (7-22/FEB/'89) | | Second half(23/FEB-15/MAR/'89) | | Total | |
|---|---|---|---|---|---|---|
| | primary | secondary | primary | secondary | primary | secondary |
| Minke whale (ordinal) | 261/95 | 501/139 | 262/108 | 296/109 | 523/203 | 797/248 |
| Blue whale | — | — | — | 1/1 | — | 1/1 |
| Sperm whale | 1/1 | — | 4/4 | 10/7 | 5/5 | 10/7 |
| Ziphiids | 3/1 | 6/3 | — | — | 3/1 | 6/3 |
| Killer whale | 3/1 | 27/3 | 53/8 | 24/3 | 56/9 | 51/6 |
| unidentified dolphin | 5/1 | — | — | — | 5/1 | — |

Table 3. Density indices (no. of schools sighted per 100 n.miles searching) and mean school sizes (in parenthes) of minke whale primary sightings by one degree square in the each half.

The first half (12/JAN - 22/FEB/'89)

| Latitude | Longitude (E) | | | | | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 168° - | 169° - | 170° - | 171° - | 172° - | 173° - | 174° - | 175° - | 176° - | 177° - | 178° - | 179° - | |
| North zone | | | | | | | | | | | | | |
| 53° S - | — | — | — | — | — | — | — | — | — | 2.04 (1.00) | 2.25 (1.00) | — | 2.17 (1.00) |
| 54° S - | — | — | — | — | — | — | — | — | — | 0.00 (0.00) | 1.67 (1.00) | — | 0.71 (1.00) |
| 55° S - | — | — | — | — | — | — | — | — | — | 0.86 (1.00) | 4.76 (1.33) | — | 2.23 (1.25) |
| 56° S - | — | — | — | — | — | — | — | — | — | 1.69 (1.00) | 0.85 (1.00) | — | 1.13 (1.00) |
| 57° S - | — | — | — | — | — | — | — | — | — | 0.00 (0.00) | 1.52 (1.00) | — | 0.75 (1.00) |
| 58° S - | — | — | — | — | — | — | — | — | — | 1.11 (1.00) | 1.30 (1.00) | — | 1.20 (1.00) |
| 59° S - | — | — | — | — | — | — | — | — | — | 0.00 (0.00) | 0.00 (0.00) | — | 0.00 (0.00) |
| Middle zone | | | | | | | | | | | | | |
| 60° S - | — | — | — | — | — | — | 0.00 (0.00) | 0.00 (0.00) | — | 0.00 (0.00) | 0.00 (0.00) | — | 0.00 (0.00) |
| 61° S - | — | — | — | 0.00 (0.00) | 0.00 (0.00) | — | — | — | — | 0.00 (0.00) | — | — | 0.00 (0.00) |
| 62° S - | 5.41 (1.00) | 0.95 (2.00) | 2.06 (1.00) | 3.07 (1.00) | — | — | — | — | 4.17 (1.00) | 0.00 (0.00) | — | — | 2.18 (1.11) |
| 63° S - | 1.39 (1.00) | 3.13 (1.00) | 10.14 (1.14) | 0.00 (0.00) | — | — | — | — | 2.19 (1.33) | 0.00 (0.00) | — | — | 3.01 (1.13) |
| 64° S - | — | — | 0.00 (0.00) | 2.94 (1.50) | 1.13 (1.00) | 0.00 (0.00) | 0.00 (0.00) | 2.78 (1.00) | 2.78 (1.33) | — | — | — | 1.60 (1.29) |
| 65° S - | — | — | — | — | — | — | 15.38 (2.00) | 1.48 (1.00) | 0.68 (1.00) | 1.20 (2.00) | 0.00 (0.00) | 0.00 (0.00) | 1.20 (1.50) |
| 66° S - | — | — | — | — | — | — | 0.00 (0.00) | 2.76 (1.50) | 0.00 (0.00) | 2.22 (1.00) | 2.47 (1.50) | 0.92 (1.00) | 2.04 (1.38) |
| 67° S - | — | — | — | — | — | 0.00 (0.00) | 3.60 (1.60) | 10.28 (2.45) | 1.89 (2.00) | 0.00 (0.00) | — | — | 4.93 (2.18) |
| 68° S - | — | — | — | — | 10.67 (2.50) | 7.69 (1.67) | 12.43 (1.71) | 0.00 (0.00) | — | — | — | — | 10.38 (1.87) |
| South zone | | | | | | | | | | | | | |
| 69° S - | — | — | — | 21.96 (3.31) | 55.00 (5.09) | — | — | — | — | — | — | — | 30.30 (4.13) |
| 70° S - | — | — | — | — | 12.00 (2.00) | — | — | — | — | — | — | — | 12.00 (2.00) |
| 71° S - | — | — | — | — | 12.86 (1.78) | 6.67 (1.33) | — | — | — | — | — | — | 9.38 (1.60) |
| 72° S - | — | — | — | — | 62.50 (5.20) | 110.00 (5.82) | — | — | — | — | — | — | 88.89 (5.63) |
| 73° S - | — | — | — | — | — | 0.00 (0.00) | 22.22 (1.00) | — | — | — | — | — | 9.52 (1.00) |
| 74° S - | — | — | — | — | — | — | 11.24 (1.10) | 10.00 (1.00) | — | — | — | — | 10.85 (1.07) |
| 75° S - | — | — | — | — | — | — | 3.45 (1.00) | 2.02 (1.00) | 0.00 (0.00) | — | — | — | 2.05 (1.00) |
| 76° S - | — | — | — | — | — | — | — | 7.79 (1.00) | 6.33 (1.20) | — | — | — | 7.05 (1.09) |
| 77° S - | — | — | — | — | — | — | — | — | 5.56 (2.00) | 7.81 (1.20) | 0.00 (0.00) | — | 5.47 (1.43) |
| Total | 2.21 (1.00) | 1.99 (1.25) | 4.76 (1.11) | 6.34 (2.94) | 12.40 (3.38) | 8.20 (3.35) | 7.34 (1.51) | 4.52 (1.60) | 2.76 (1.33) | 0.95 (1.18) | 1.30 (1.18) | 0.66 (1.00) | 3.81 (2.11) |

Table 3. (cont.)

The second half (23/FEB - 31/MAR/'89)

| Latitude | Longitude (E) | | | | | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 168° - | 169° - | 170° - | 171° - | 172° - | 173° - | 174° - | 175° - | 176° - | 177° - | 178° - | 179° - | |
| North zone | | | | | | | | | | | | | |
| 53° S - | — | — | — | — | — | — | — | — | — | — | — | — | — |
| 54° S - | — | — | — | — | — | — | — | — | — | — | — | — | — |
| 55° S - | — | — | — | — | — | — | — | — | — | — | — | — | — |
| 56° S - | — | 0.00 (0.00) | — | — | — | — | — | — | — | — | — | — | 0.00 (0.00) |
| 57° S - | — | 0.00 (0.00) | — | — | — | — | — | — | — | — | — | — | 0.00 (0.00) |
| 58° S - | — | 0.00 (0.00) | — | — | — | — | — | — | — | — | — | — | 0.00 (0.00) |
| 59° S - | — | 0.00 (0.00) | — | — | — | — | — | — | — | — | — | — | 0.00 (0.00) |
| Middle zone | | | | | | | | | | | | | |
| 60° S - | — | — | — | — | — | — | — | 0.00 (0.00) | 0.00 (0.00) | 0.00 (0.00) | — | — | 0.00 (0.00) |
| 61° S - | — | — | — | — | — | — | — | — | 0.00 (0.00) | 0.00 (0.00) | — | — | 0.00 (0.00) |
| 62° S - | — | — | — | — | — | — | — | — | — | 3.13 (1.00) | 0.85 (1.00) | — | 1.34 (1.00) |
| 63° S - | — | — | — | — | — | — | — | — | — | — | 0.00 (0.00) | 0.00 (0.00) | 0.00 (0.00) |
| 64° S - | 0.81 (1.00) | 1.61 (1.00) | 1.37 (1.00) | 6.35 (2.75) | 0.00 (0.00) | 0.00 (0.00) | 3.95 (2.00) | 3.08 (1.00) | 0.00 (0.00) | 0.00 (0.00) | 1.49 (1.00) | 0.00 (0.00) | 1.33 (1.77) |
| 65° S - | 4.29 (2.00) | 7.89 (1.67) | — | — | — | — | — | — | — | — | — | — | 5.06 (1.89) |
| 66° S - | — | — | — | — | — | — | — | — | — | — | — | — | — |
| 67° S - | — | — | — | — | — | — | — | — | — | — | — | — | — |
| 68° S - | — | — | — | — | — | — | — | — | — | — | — | — | — |
| South zone | | | | | | | | | | | | | |
| 69° S - | — | — | — | — | — | — | — | — | — | — | — | — | — |
| 70° S - | 8.14 (1.29) | 2.00 (1.00) | 0.00 (0.00) | — | — | — | — | — | — | — | — | — | 4.27 (1.22) |
| 71° S - | — | 33.33 (2.00) | 7.89 (2.33) | 9.73 (1.89) | 11.45 (3.00) | 0.00 (0.00) | — | — | — | — | — | — | 9.71 (2.19) |
| 72° S - | — | — | — | — | 40.46 (3.86) | 28.50 (3.18) | 11.03 (4.00) | 7.69 (2.00) | 58.82 (4.88) | 250.00 (5.00) | — | — | 22.05 (3.78) |
| 73° S - | — | — | — | — | — | — | — | — | 63.64 (4.86) | 1.64 (2.00) | 1.06 (1.00) | 1.33 (1.00) | 4.15 (3.80) |
| 74° S - | — | — | — | — | — | 4.55 (1.00) | 3.77 (1.00) | 11.54 (1.00) | 0.00 (0.00) | 2.08 (2.00) | 0.00 (0.00) | 0.00 (0.00) | 3.62 (1.10) |
| 75° S - | — | — | 5.71 (1.00) | 2.17 (1.00) | 2.04 (1.00) | 9.52 (1.00) | 0.00 (0.00) | — | — | — | — | — | 3.87 (1.00) |
| 76° S - | — | — | — | — | 0.00 (0.00) | 8.16 (1.50) | 5.00 (1.00) | 9.09 (1.00) | 12.50 (1.00) | 10.81 (1.00) | 3.70 (1.00) | 0.00 (0.00) | 8.04 (1.06) |
| 77° S - | — | — | — | — | — | — | — | — | — | — | 3.23 (4.00) | 4.17 (1.00) | 3.80 (2.00) |
| Total | 4.00 (1.57) | 0.76 (1.43) | 3.51 (1.67) | 6.95 (2.07) | 6.43 (3.36) | 8.79 (2.56) | 5.72 (2.62) | 5.63 (1.20) | 4.78 (3.90) | 1.94 (1.75) | 1.08 (1.60) | 0.82 (1.00) | 3.18 (2.30) |

Table 4. Information of the duplicate and the same-time sightings*) which were made by the paired vessels throughout the present survey.

| Date | Time | Position | Vessels | Sighting no. | Sighting Angle | Sighting Dist.(n.miles) | Species | School size |
|---|---|---|---|---|---|---|---|---|
| (Duplicate sighting) | | | | | | | | |
| 31/JAN/'89 | 09:58 | 65°06'S | *T18* | 8001 | S-007 | 0.7 | Mi | 2 |
| | | 174°59'E | *KOI* | 1004 | 000 | 1.0 | | |
| 17/FEB/'89 | 14:29 | 72°12'S | *T18* | 8007 | P-015 | 1.1 | Mi | 4 |
| | | 172°58'E | *KOI* | 1003 | P-040 | 1.0 | | |
| 1/MAR/'89 | 18:50 | 72°50'S | *T18* | 8011 | P-100 | 0.8 | Mi | 4 |
| | | 176°26'E | *KOI* | 1005 | P-090 | 0.7 | | |
| (Same-time sighting)*) | | | | | | | | |
| 18/FEB/'89 | 12:07 | 72°19'S | *T18* | 8007 | S-040 | 1.5 | Mi | 4 |
| | | 173°43'E | *T25* | 5012 | P-005 | 3.0 | Mi | 16 |

*) different schools were sighted at the same instance by the different vessels.

Table 5. Numbers of individuals sighted (by primary sighting) and taken by latitude in the each half, excluding dwarf form minke whales.

| Latitude | The first half (12/JAN - 22/FEB/'89) | | | The second half (23/FEB - 31/MAR/'89) | | | Total (12/JAN - 31/MAR/'89) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Sighted (S) | Taken (T) | Ratio (T/S) | Sighted (S) | Taken (T) | Ratio (T/S) | Sighted (S) | Taken (T) | Ratio (T/S) |
| North zone | | | | | | | | | |
| 53°S - | 3 | 3 | 1.00 | — | — | — | 3 | 3 | 1.00 |
| 54°S - | 1 | 1 | 1.00 | — | — | — | 1 | 1 | 1.00 |
| 55°S - | 5 | 5 | 1.00 | — | — | — | 5 | 5 | 1.00 |
| 56°S - | 2 | 2 | 1.00 | 0 | 0 | — | 2 | 2 | 1.00 |
| 57°S - | 1 | 0 | 0.00 | 0 | 0 | — | 1 | 0 | 0.00 |
| 58°S - | 2 | 0 | 0.00 | 0 | 0 | — | 2 | 0 | 0.00 |
| 59°S - | 0 | 0 | — | 0 | 0 | — | — | — | — |
| Middle zone | | | | | | | | | |
| 60°S - | 0 | 0 | — | 0 | 0 | — | 0 | 0 | — |
| 61°S - | 0 | 0 | — | 0 | 0 | — | 0 | 0 | — |
| 62°S - | 10 | 1 | 0.10 | 2 | 1 | 0.50 | 12 | 2 | 0.17 |
| 63°S - | 17 | 0 | 0.00 | 0 | 0 | — | 17 | 0 | 0.00 |
| 64°S - | 9 | 1 | 0.11 | 23 | 6 | 0.26 | 32 | 7 | 0.22 |
| 65°S - | 7 | 2 | 0.29 | 17 | 7 | 0.41 | 24 | 9 | 0.38 |
| 66°S - | 10 | 5 | 0.50 | — | — | — | 10 | 5 | 0.50 |
| 67°S - | 37 | 16 | 0.43 | — | — | — | 37 | 16 | 0.43 |
| 68°S - | 71 | 30 | 0.43 | — | — | — | 71 | 30 | 0.43 |
| South zone | | | | | | | | | |
| 69°S - | 99 | 30 | 0.30 | — | — | — | 99 | 30 | 0.30 |
| 70°S - | 6 | 0 | 0.00 | 11 | 6 | 0.55 | 17 | 6 | 0.35 |
| 71°S - | 24 | 5 | 0.21 | 35 | 16 | 0.46 | 59 | 21 | 0.36 |
| 72°S - | 90 | 23 | 0.26 | 138 | 34 | 0.25 | 228 | 57 | 0.25 |
| 73°S - | 2 | 0 | 0.00 | 38 | 17 | 0.45 | 40 | 17 | 0.43 |
| 74°S - | 15 | 6 | 0.40 | 11 | 3 | 0.27 | 26 | 9 | 0.35 |
| 75°S - | 3 | 0 | 0.00 | 6 | 0 | 0.00 | 9 | 0 | 0.00 |
| 76°S - | 12 | 4 | 0.33 | 19 | 4 | 0.21 | 31 | 8 | 0.26 |
| 77°S - | 10 | 7 | 0.70 | 6 | 1 | 0.17 | 16 | 8 | 0.50 |
| Total | 436 | 141 | 0.32 | 306 | 95 | 0.31 | 742 | 236 | 0.32 |

Table 6. Sampling efficiencies to number of primary sighting and to number of whales targeted by the status of the arrangement of sampling vessels in each zone and the period, excluding dwarf form minke whales.

| | The first half (12/JAN - 22/FEB/'89) | | | | | The second half (22/FEB - 31/MAR/'89) | | | | | Whole period (12/JAN - 31/MAR/'89) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Sighted[1] | Targeted[2] | Samples | Efficiency | | | | | | | | | | | |
| | school- ind. (A) - (B) | school- ind. (C) - (D) | taken (E) | tech. (E/D) | true (E/B) | (A)-(B) | (C)-(D) | (E) | (E/D) | (E/B) | (A)-(B) | (C)-(D) | (E) | (E/D) | (E/B) |
| North | | | | | | | | | | | | | | | |
| by single | 4 - 4 | 4 - 4 | 4 | 1.00 | 1.00 | —— | —— | – | —— | —— | 4 - 4 | 4 - 4 | 4 | 1.00 | 1.00 |
| by pair | 9 - 10 | 9 - 10 | 7 | 0.70 | 0.70 | —— | —— | – | —— | —— | 9 - 10 | 9 - 10 | 7 | 0.70 | 0.70 |
| combined | 13 - 14 | 13 - 14 | 11 | 0.79 | 0.79 | —— | —— | – | —— | —— | 13 - 14 | 13 - 14 | 11 | 0.79 | 0.79 |
| Middle | | | | | | | | | | | | | | | |
| by single | 40 - 61 | 25 - 37 | 24 | 0.65 | 0.39 | 12 - 19 | 12 - 16 | 7 | 0.44 | 0.37 | 52 - 80 | 37 - 53 | 31 | 0.58 | 0.39 |
| by pair | 60 - 103 | 28 - 45 | 31 | 0.69 | 0.30 | 12 - 23 | 12 - 18 | 7 | 0.39 | 0.30 | 72 - 126 | 40 - 63 | 38 | 0.60 | 0.30 |
| combined | 100 - 164 | 53 - 82 | 55 | 0.67 | 0.34 | 24 - 42 | 24 - 34 | 14 | 0.41 | 0.33 | 124 - 206 | 77 - 116 | 69 | 0.59 | 0.33 |
| South | | | | | | | | | | | | | | | |
| by single | 41 - 115 | 41 - 62 | 28 | 0.45 | 0.24 | 49 - 125 | 49 - 72 | 35 | 0.49 | 0.28 | 90 - 240 | 90 - 134 | 63 | 0.47 | 0.26 |
| by pair | 54 - 146 | 52 - 78 | 47 | 0.60 | 0.32 | 59 - 137 | 58 - 86 | 46 | 0.53 | 0.34 | 113 - 283 | 110 - 164 | 93 | 0.57 | 0.33 |
| combined | 95 - 261 | 93 - 140 | 75 | 0.54 | 0.29 | 108 - 262 | 107 - 158 | 81 | 0.51 | 0.31 | 203 - 523 | 200 - 298 | 156 | 0.52 | 0.30 |
| Total | | | | | | | | | | | | | | | |
| by single | 85 - 180 | 70 - 103 | 56 | 0.54 | 0.35 | 61 - 144 | 61 - 88 | 42 | 0.48 | 0.29 | 146 - 324 | 131 - 191 | 98 | 0.51 | 0.30 |
| by pair | 123 - 259 | 89 - 133 | 85 | 0.64 | 0.33 | 71 - 160 | 70 - 104 | 53 | 0.51 | 0.33 | 194 - 419 | 159 - 237 | 138 | 0.58 | 0.33 |
| combined | 208 - 439 | 159 - 236 | 141 | 0.60 | 0.32 | 132 - 304 | 131 - 192 | 95 | 0.49 | 0.31 | 340 - 743 | 290 - 428 | 236 | 0.55 | 0.32 |

1) primary sighting

2) no. of schools targeted; the primary sightings excluding the primary ones which were made during the period engaged in the only sighting survey and/or were nontarget ones for the sample size control in the first middle.
no. of individuals targeted; it was scheduled to take up to two individuals among schools size ≥ 2.

arrangement of sampling vessels and by school size.

| School size (A) | Status | no. school sighted (B) | no. school targeted (C) | no. animals targeted (D) | Sampling taken (E) | | | Efficiency | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | none | one | two | (E/D)[1] | (E/A-B)[2] | Tech.Max. |
| 1 | by single | 84 | 71 | 71 | 49 | 22 | – | 0.31 | 0.26 | |
| | by pair | 107 | 81 | 81 | 49 | 32 | – | 0.40 | 0.30 | |
| | combined | 191 | 152 | 152 | 98 | 54 | – | 0.35 | 0.28 | 1.00 |
| 2 | s | 23 | 22 | 44 | 9 | 9 | 4 | 0.39 | 0.37 | |
| | p | 28 | 23 | 46 | 7 | 6 | 10 | 0.57 | 0.46 | |
| | c | 51 | 45 | 90 | 16 | 15 | 14 | 0.48 | 0.42 | 1.00 |
| 3 | s | 10 | 9 | 18 | 1 | 3 | 5 | 0.72 | 0.43 | |
| | p | 25 | 23 | 46 | 3 | 8 | 12 | 0.70 | 0.43 | |
| | c | 35 | 32 | 64 | 4 | 11 | 17 | 0.76 | 0.43 | 0.67 |
| 4 | s | 10 | 10 | 20 | – | 3 | 7 | 0.85 | 0.43 | |
| | p | 17 | 15 | 30 | 2 | 7 | 6 | 0.63 | 0.28 | |
| | c | 27 | 25 | 50 | 2 | 10 | 13 | 0.72 | 0.33 | 0.50 |
| 5 | s | 8 | 8 | 16 | 1 | 2 | 5 | 0.75 | 0.30 | |
| | p | 8 | 8 | 16 | – | 3 | 5 | 0.81 | 0.33 | |
| | c | 16 | 16 | 32 | 1 | 5 | 10 | 0.78 | 0.31 | 0.40 |
| 6 | s | 4 | 4 | 8 | – | 3 | 1 | 0.63 | 0.21 | |
| | p | 4 | 4 | 8 | 1 | – | 3 | 0.75 | 0.25 | |
| | c | 8 | 8 | 16 | 1 | 3 | 4 | 0.69 | 0.23 | 0.33 |
| 7 | s | 2 | 2 | 4 | – | – | 2 | 1.00 | 0.29 | |
| | p | 1 | 1 | 2 | – | – | 1 | 1.00 | 0.29 | |
| | c | 3 | 3 | 6 | – | – | 3 | 1.00 | 0.29 | 0.29 |
| 8 | s | 2 | 2 | 4 | 1 | – | 1 | 0.50 | 0.13 | |
| | p | 2 | 2 | 4 | – | – | 2 | 1.00 | 0.25 | |
| | c | 4 | 4 | 8 | 1 | – | 3 | 0.75 | 0.19 | 0.25 |
| ≥9 | s | 3 | 3 | 6 | – | – | 3 | 1.00 | 0.20 | |
| | p | 2 | 2 | 4 | – | – | 2 | 1.00 | 0.15 | |
| | c | 5 | 5 | 10 | – | – | 5 | 1.00 | 0.18 | <0.25 |

1) Technical sampling efficiency.
2) True sampling efficiency.

Table 8. A summary of causes of failures in the insufficient sampling by school size and the status of the arrangement of sampling vessels.

| School size | no. of individuals unable to be sampled due to | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | quick mobile | long diving | fast swimming | sea condition | pack ice | time limitation | technical problem | others | unknown | Total |
| by single | | | | | | | | | | |
| 1 | 21 | 4 | 3 | 20 | – | 1 | – | – | – | 49 |
| 2 | 15 | – | 1 | 10 | – | – | 1 | – | – | 27 |
| 3 | 2 | – | – | 2 | – | – | – | – | 1 | 5 |
| 4 | 1 | – | – | 1 | – | 1 | – | – | – | 3 |
| 5 | – | – | 2 | 1 | 1 | – | – | – | – | 4 |
| 6 | – | – | – | – | – | 1 | 2 | – | – | 3 |
| 7 | – | – | – | – | – | – | – | – | – | – |
| 8 | – | – | – | – | – | 1 | 1 | – | – | 2 |
| Total | 39 | 4 | 6 | 34 | 1 | 4 | 4 | – | 1 | 93 |
| by pair | | | | | | | | | | |
| 1 | 18 | – | 3 | 26 | 1 | – | – | 1 | – | 49 |
| 2 | 4 | 1 | 3 | 9 | 1 | 2 | – | – | – | 20 |
| 3 | 3 | – | 2 | 4 | 1 | 3 | 1 | – | – | 14 |
| 4 | 4 | – | 1 | 2 | 1 | 1 | 1 | 1 | – | 11 |
| 5 | – | 1 | – | 2 | – | – | – | – | – | 3 |
| 6 | – | – | – | – | – | 1 | 1 | – | – | 2 |
| Total | 29 | 2 | 9 | 43 | 4 | 7 | 3 | 2 | – | 99 |
| combined | | | | | | | | | | |
| 1 | 39 | 4 | 6 | 46 | 1 | 1 | – | 1 | – | 98 |
| 2 | 19 | 1 | 4 | 19 | 1 | 2 | 1 | – | – | 47 |
| 3 | 5 | – | 2 | 6 | 1 | 3 | 1 | – | 1 | 19 |
| 4 | 5 | – | 1 | 3 | 1 | 2 | 1 | 1 | – | 14 |
| 5 | – | 1 | 2 | 3 | 1 | – | – | – | – | 7 |
| 6 | – | – | – | – | – | 2 | 3 | – | – | 5 |
| 7 | – | – | – | – | – | – | – | – | – | – |
| 8 | – | – | – | – | – | 1 | 1 | – | – | 2 |
| Total | 68 | 6 | 15 | 77 | 5 | 11 | 7 | 2 | 1 | 192 |

| Sample no. | Date | Position sighted | School size | Position taken | B.L. (m) | Sex | Reproductive information | |
|---|---|---|---|---|---|---|---|---|
| 5 | 13.Jan.'89 | 55°22'S 178°10'E | 1 | 55°22'S 178°08'E | 4.5 | F | immature | |
| 13 | 17.Jan.'89 | 62°04'S 177°28'E | 1 | 62°05'S 177°26'E | 7.0 | F | pregnant, | Foetus; 119cm, male |
| 14 | 17.Jan.'89 | 62°07'S 177°02'E | 1 | 62°07'S 176°58'E | 6.0 | M | (under the examination) | testis weight; 195g, 182g |
| 70 | 4.Feb.'89 | 60°38'S 175°07'E | 1 | 60°37'S 175°06'E | 5.9 | F | immature | |
| 227 | 19.Mar.'89 | 61°54'S 177°55'E | 1 | 61°56'S 177°55'E | 7.0 | F | mature (possibly pregnant judging from strech mark), uterus damaged by harpoon | |

Table 10. Summary of research items of the biological data and sample collection and number of whales survey in each item.

| Samples and data | Number of whales | | |
|---|---|---|---|
| | Male | Female | Total*) |
| Body length and sex | 86 | 155 | 241 |
| External body proportion | 86 | 155 | 241 |
| Photographic records of external character | 86 | 155 | 241 |
| Diatom film record and sampling | 86 | 155 | 241 |
| Standard measurements of blubber thickness (Three point on each whale) | 72 | 122 | 194 |
| Body weight | 86 | 154 | 240 |
| Body weight by parts and detailed measurements of blubber thickness | 14 | 33 | 47 |
| Earplug for age determination**) | 86 | 155 | 241 |
| Tympanic bulla for age determination | 28 | 30 | 58 |
| Largest baleen plate for age determination | 23 | 25 | 48 |
| Vertebral epiphyses sample | 85 | 152 | 237 |
| Skull measurement (length and breadth) | 85 | 153 | 238 |
| Mammary grand; lactation status, measurements and histology sample | — | 155 | 155 |
| Milk sample for chemical analysis | — | 1 | 1 |
| Ovary collection | — | 155 | 155 |
| Corpora number, counting | — | 155 | 155 |
| Uterine horn; measurement and endometrium sample | — | 155 | 155 |
| Uterine fluid for sperm detection | — | 122 | 122 |
| Foetal number | — | 98 | 98 |
| (Foetal length | 51 | 46 | 97) |
| (Foetal sex | 51 | 46 | 97) |
| (Foetal weight | 51 | 46 | 97) |
| (Foetus body proportion | 43 | 40 | 83) |
| Collection of foetus | — | 12 | 12 |
| Testis and epididymis weight and tissue collection | 86 | — | 86 |
| Smear sample from testis and epididymis tissues | 86 | — | 86 |
| Blood sample for gonadal hormone assay | 65 | 140 | 205 |
| Tissue sample for hormone assay | 0 | 64 | 64 |
| Muscle, liver and heart samples for electrophoretic study | 86 | 155 | 241 |
| Skin, muscle and kidney samples for DNA study | 86 | 155 | 241 |
| Tissue samples for heavy metal analyses | 68 | 74 | 142 |
| Tissue samples for organochlorine analyses | 45 | 71 | 116 |
| Foetus samples for organochlorine analyses | — | 80 | 80 |
| Stomach content, conventional record | 86 | 155 | 241 |
| Stomach content weight | 85 | 153 | 238 |
| Collection of stomach contents for the food and feeding study | 23 | 48 | 71 |
| Collection of intestine contents for the food and feeding study | 0 | 3 | 3 |
| Intestine samples for bacteriological study | 1 | 4 | 5 |
| Tissue samples of various parts the body for the lipid analyses | 14 | 33 | 47 |
| Stomach contents for the lipid analyses | 3 | 3 | 6 |
| Tissue samples for digestive enzyme analyses | 1 | 4 | 5 |
| Collection of whole skeleton | 1 | 3 | 4 |
| Collection of skull | 1 | 1 | 2 |
| Checking external parasite including its sampling | 86 | 155 | 241 |
| Checking internal parasite in viscera including its sampling | 9 | 12 | 21 |

*) including five individuals of dwarf form.
**) principally both earplugs were collected from both side and were preserved in formalin solution, while seven earplugs of one of the pair were freezed for the chemical analysis.

Table 11. Summary of biopsy dart experiments on the deck of *NO3* using minke whale carcase of 8.5m in body length (male) on January 14 '99.

| Trial no. | Head[1] type | Shooting distance (m) | Aspect (°) | Incidence (°) | Result | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Dart release | Hit or not | Tissue sampling | Dart recovery |
| 1 | D | 15 | 20 | 30 | Yes | Yes | Yes | No |
| 2 | D | 15 | 20 | 30 | Yes | Yes | Yes | Yes |
| 3 | D | 15 | 20 | 30 | Yes | Yes | Yes | Yes |
| 4 | D | 15 | 20 | 30 | Yes | Yes | Yes | Yes |
| 5 | E | 15 | 20 | 30 | No | Yes | No | Yes |
| 6 | E | 15 | 20 | 30 | No | Yes | Yes | Yes |
| 7 | F | 15 | 20 | 30 | Yes | Yes | No | Yes |
| 8 | F | 15 | 20 | 30 | Yes | Yes | Yes | Yes |
| 9 | F | 15 | 20 | 30 | Yes | Yes | Yes | Yes |
| 10 | B2 | 15 | 20 | 30 | Yes | No | No | Yes |
| 11 | B2 | 15 | 20 | 30 | Yes | Yes | No | Yes |
| 12 | B2 | 15 | 20 | 30 | Yes | Yes | No | Yes |

[1] see Fig. 5.

Table 12. Male sex ratio and biological structure of minke whales taken in the present survey by the time-areal group (excluding dwarf forms).

| Time-areal group[*] (Latitude) | Male | | | Female | | | | | | | | Male sex ratio |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Imm. | Mat. | Total | Imm. | Mat. | | | | | | Total | |
| | | | | | Preg. | P&L | Lact. | Ovu. | Rest. | Unknown | | |
| North (53°S-56°S) | 1 (16.7) | 5 (83.3) | 6 | 4 (80.0) | 0 | 1 (20.0) | 0 | 0 | 0 | 0 | 5 | 0.545 |
| Middle (62°S-67°S) | 6 (31.6) | 13 (68.4) | 19 | 3 (42.9) | 3 (42.9) | 0 | 0 | 1 (14.3) | 0 | 0 | 7 | 0.731 |
| Ice berg (67°S-69°S) | 8 (27.6) | 21 (72.4) | 29 | 16 (36.4) | 26 (59.1) | 0 | 0 | 0 | 2 (4.5) | 0 | 44 | 0.408 |
| Adere (70°S-73°S) | 6 (23.1) | 20 (76.9) | 26 | 21 (28.4) | 50 (67.6) | 0 | 0 | 1 (1.4) | 1 (1.4) | 1[**] (1.4) | 74 | 0.268 |
| Ross Sea (73°-77°S) | 0 | 5 (100) | 5 | 0 | 19 (90.5) | 0 | 0 | 0 | 1 (4.8) | 1[**] (4.8) | 21 | 0.192 |
| Total | 21 (24.7) | 64 (75.3) | 85 | 44 (29.1) | 98 (64.9) | 1 (0.7) | 0 (0.0) | 2 (1.3) | 4 (2.6) | 2 (1.3) | 151 | 0.360 |

[*] See Fig. 8.
[**] Uterine horn was damaged by the harpoon but both ovaries with corpus luteum and/or corpora ablicans remained.

Table 13. Biological structure and male sex ratio by school size in each group (excluding dwarf form minke whales).

| Group | School size | Male | | Female | | | Total | Male sex ratio |
|---|---|---|---|---|---|---|---|---|
| | | Imm. | Mat. | Imm. | Preg. | Other Mat. | | |
| North and Middle (53°S-67°S) | 1 | 4 (17.1) | 6 (25.7) | 7 (30.0) | 1 ( 4.3) | 1 ( 4.3) | 19 | 0.53 |
| | 2 | 1 (11.1) | 6 (66.7) | - ( — ) | 1 (11.1) | 1 (11.1) | 9 | 0.78 |
| | 3 | - ( — ) | 5 (83.3) | - ( — ) | 1 (16.7) | - ( — ) | 6 | 0.83 |
| | 4 | 2 (66.7) | 1 (33.0) | - ( — ) | - ( — ) | - ( — ) | 3 | 1.00 |
| Iceberg and Adare (67°S-73°S) | 1 | 3 (15.8) | 9 (47.4) | 3 (15.8) | 4 (21.1) | - ( — ) | 19 | 0.63 |
| | 2 | 4 (14.2) | 3 (10.7) | 5 (17.8) | 12 (42.6) | 1 ( 4.2) | 25 | 0.28 |
| | 3 | 1 ( 2.5) | 7 (17.2) | 12 (29.5) | 18 (44.3) | 1 ( 2.6) | 39 | 0.21 |
| | 4 | - ( — ) | 10 (29.2) | 6 (17.5) | 14 (40.9) | 2 ( 6.4) | 32 | 0.31 |
| | ≧5 | 6 (10.0) | 12 (20.1) | 11 (18.4) | 28 (46.9) | 1 ( 1.7) | 58 | 0.31 |
| Ross sea (73°S-77°S) | 1 | - ( — ) | 2 ( 9.2) | - ( — ) | 12 (55.4) | 2 (13.4) | 16 | 0.13 |
| | 2 | - ( — ) | 3 (33.3) | - ( — ) | 6 (66.7) | - ( — ) | 9 | 0.33 |
| | 4 | - ( — ) | - ( — ) | - ( — ) | 1 (100.0) | - ( — ) | 1 | 0.00 |

Table 14. Comparison of minke whale density and biological structure between the period.

| Period | DI[1] | School[2] size | n | Male | | Female | | | Male sex ratio |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Imm. | Mat. | Imm. | Mat. | Other Mat. | |
| Adare group | | | | | | | | | |
| First half (16-18/FEB/'89) | 88.9 | 5.6 | 28 | 1 (3.5) | 1 (17.9) | 7 (25.0) | 15 (53.6) | — (—) | 0.21 |
| Second half (27/FEB-14/MAR/'89) | 32.2 | 3.4 | 72 | 5 (6.9) | 15 (20.8) | 14 (19.4) | 35 (48.6) | 3 (4.2) | 0.28 |
| Middle group | | | | | | | | | |
| First half (17-31/JAN/'89) | 2.4 | 1.5 | 12 | 1 (8.3) | 5 (41.7) | 2 (16.7) | 3 (25.0) | 1 (8.3) | 0.50 |
| Second half (19-27/MAR/'89) | 1.7 | 1.8 | 14 | 5 (35.7) | 8 (57.2) | 1 (7.1) | — (—) | — (—) | 0.93 |

1) Density index; number of schools per 100 miles searching distance based on the data given in Tables 1 and 3.
2) mean school size; based on the data given in Tables 1 and 3.

Table 15. Comparison of estimated body lengths which were made before chasing between of whales taken and of lost by school size.

*Middle zone*

| School size | Estimated length (m) at sea | | | | | | | | df | t-value | p |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Taken | | | | Lost | | | | | | |
| | Mean | (S.D.) | Range | n | Mean | (S.D.) | Range | n[2] | | | |
| 1 | 7.2 | (0.96) | 5.3-8.5 | 21 | 7.2 | (0.91) | 5.4-8.3 | 6 | 25 | — | — |
| 2 | 8.0 | (0.68) | 6.0-8.7 | 18 | 7.5 | (1.09) | 5.5-8.5 | 7 | 23 | 1.320 | 0.1<p<0.2 |
| 3 | 7.8 | (0.56) | 6.5-8.7 | 20 | 8.1 | (0.30) | 7.8-8.4 | 2 | 20 | 0.712 | 0.2<p<0.5 |
| >4 | 7.7 | (0.63) | 6.2-8.5 | 10 | 7.6 | (0.57) | 6.8-8.0 | 3 | 11 | 0.227 | 0.8<p |
| Total | 7.6 | (0.80) | 5.3-8.7 | 69 | 7.5 | (0.94) | 5.4-8.5 | 18 | 85 | 0.449 | 0.5<p<0.8 |

*South zone*

| School size | Estimated length (m) at sea | | | | | | | | df | t-value | p |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Taken | | | | Lost | | | | | | |
| | Mean | (S.D.) | Range | n[1] | Mean | (S.D.) | Range | n[2] | | | |
| 1 | 8.3 | (0.58) | 6.2-8.7 | 24 | 8.4 | (0.42) | 6.5-9.2 | 33 | 55 | 0.742 | 0.2<p<0.5 |
| 2 | 8.5 | (0.27) | 7.5-8.9 | 23 | 8.3 | (0.35) | 7.6-9.0 | 9 | 30 | 1.671 | 0.1<p<0.2 |
| 3 | 8.4 | (0.42) | 7.0-9.7 | 25 | 8.5 | (0.28) | 8.0-9.0 | 8 | 31 | 0.611 | 0.5<p<0.8 |
| >4 | 8.3 | (0.35) | 6.3-8.8 | 83 | 8.5 | (0.21) | 8.0-8.8 | 12 | 93 | 1.909 | 0.05<p<0.1 |
| Total | 8.3 | (0.40) | 6.2-9.7 | 155 | 8.4 | (0.37) | 6.5-9.2 | 62 | 215 | 1.691 | 0.05<p<0.1 |

1) no data of estimated length on one whale.
2) data presents for only chased animals among the targeted.

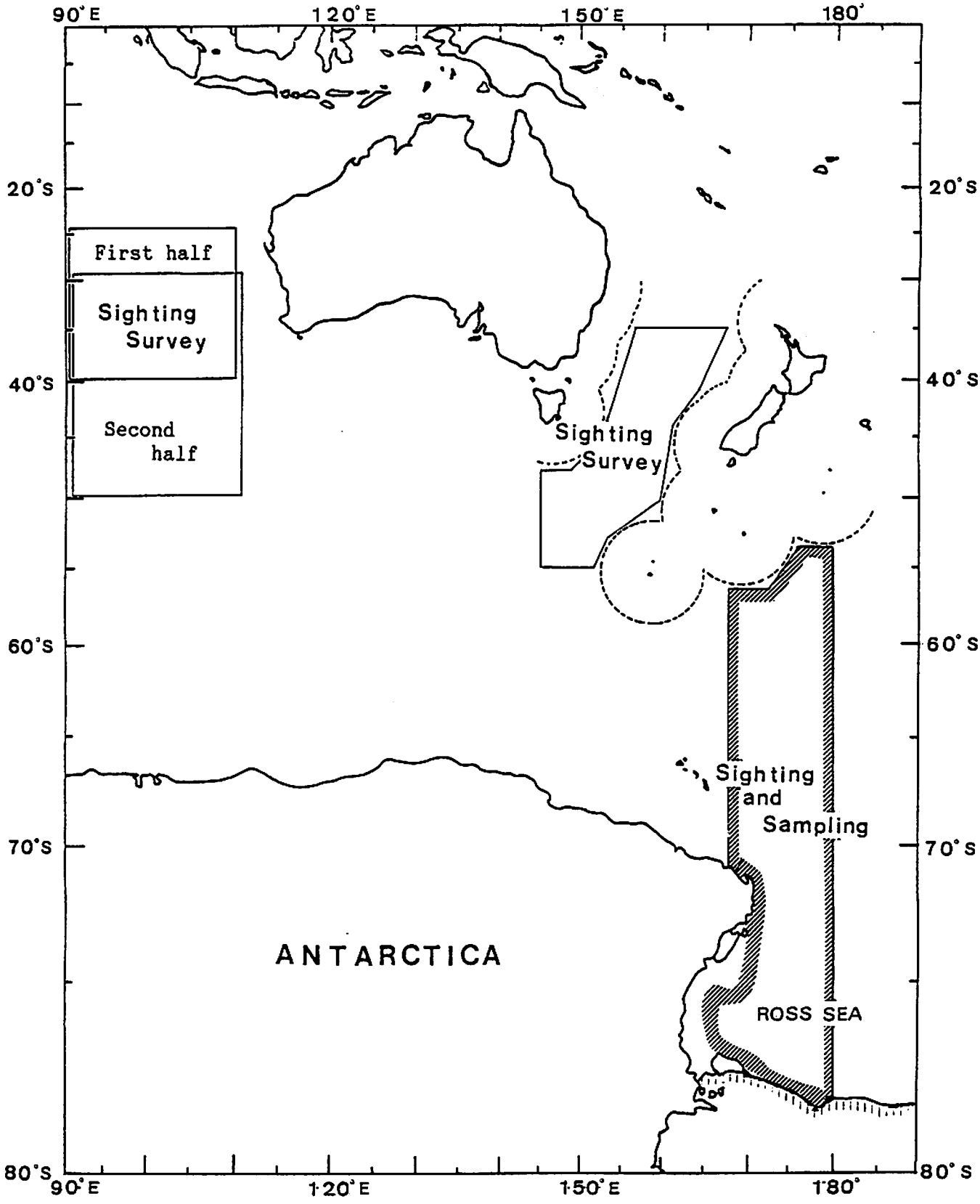



Fig. 1. Research areas of the Antarctic sampling survey and the low and middle latitudinal sighting surveys.

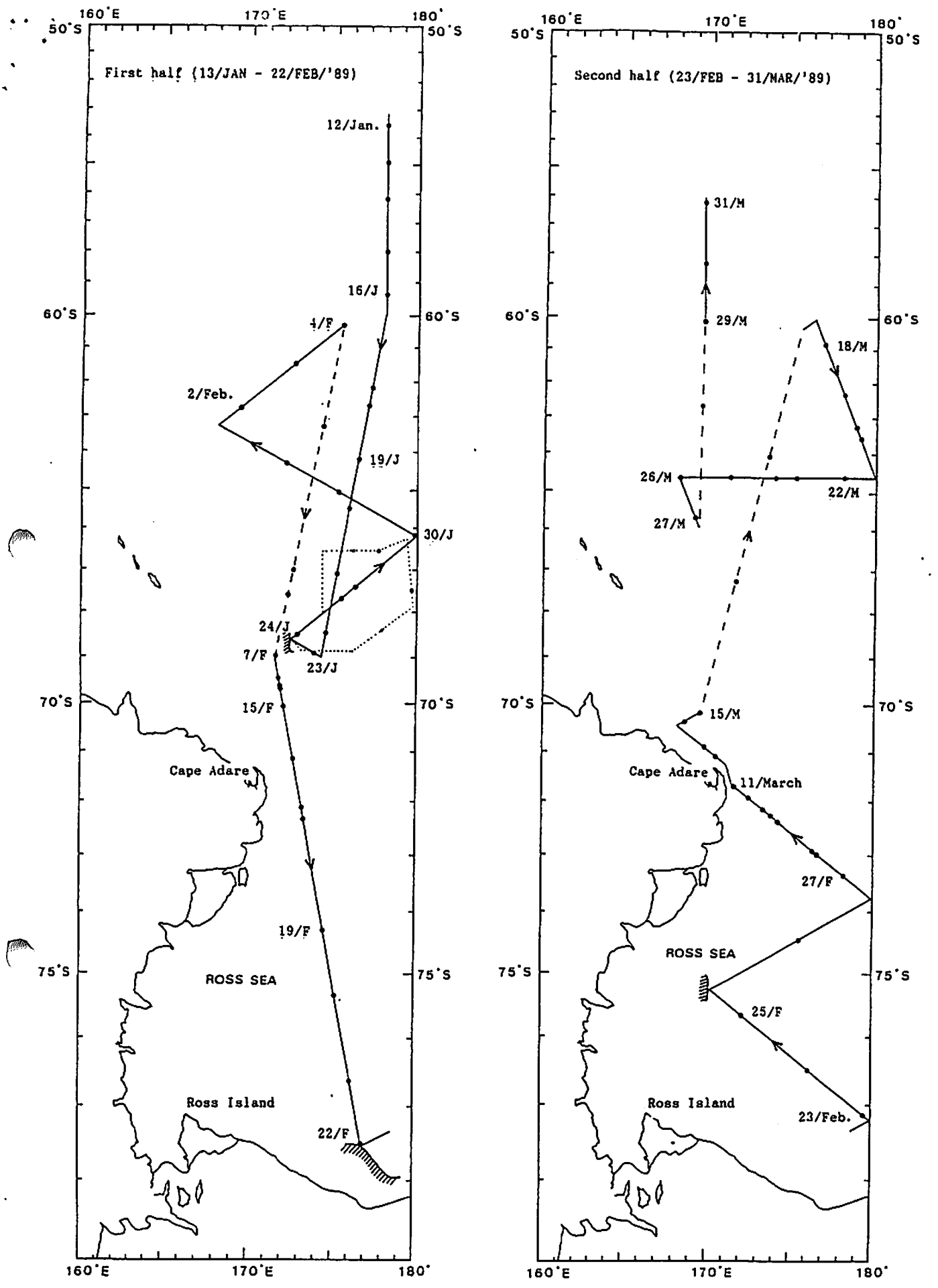



Fig. 2. Cruise tracks of the present survey with separately by the two halves. The solid line and the broken line represent the main course of the searching, the moving between research zones, respectively, the dotted line is steaming course of *NO3* during January 24 - 28.

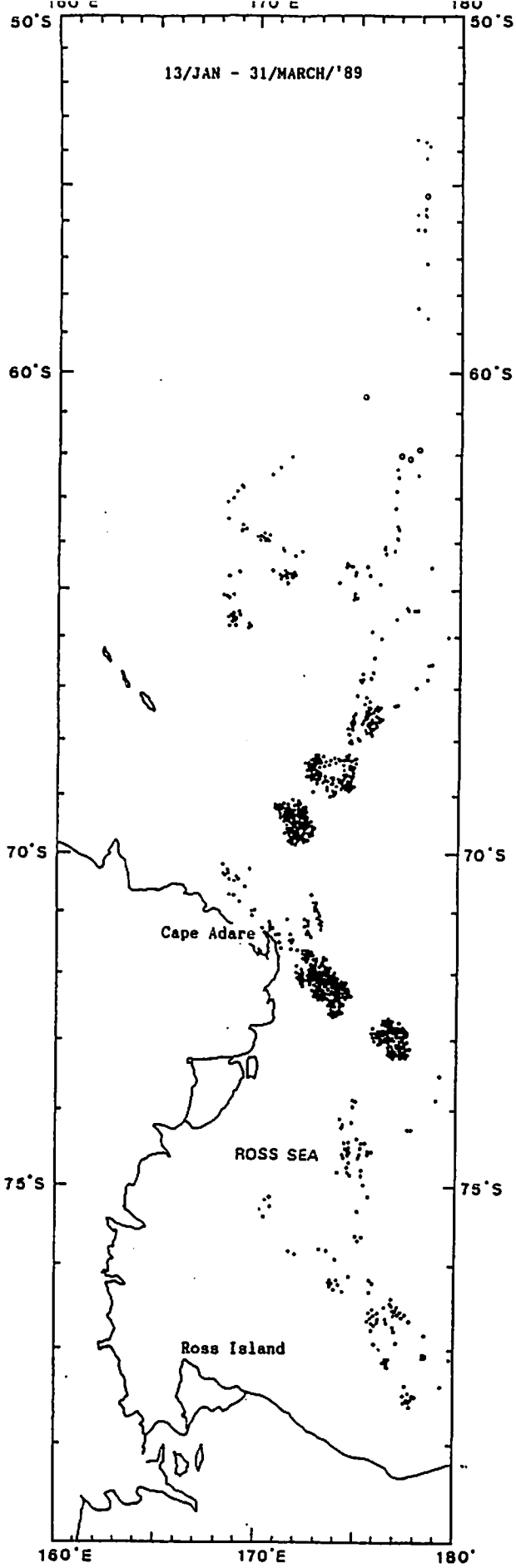



Fig. 3. Distribution of minke whale sightings including both primary and secondary sightings. Closed circles indicate ordinal forms and open circle dwarf forms.

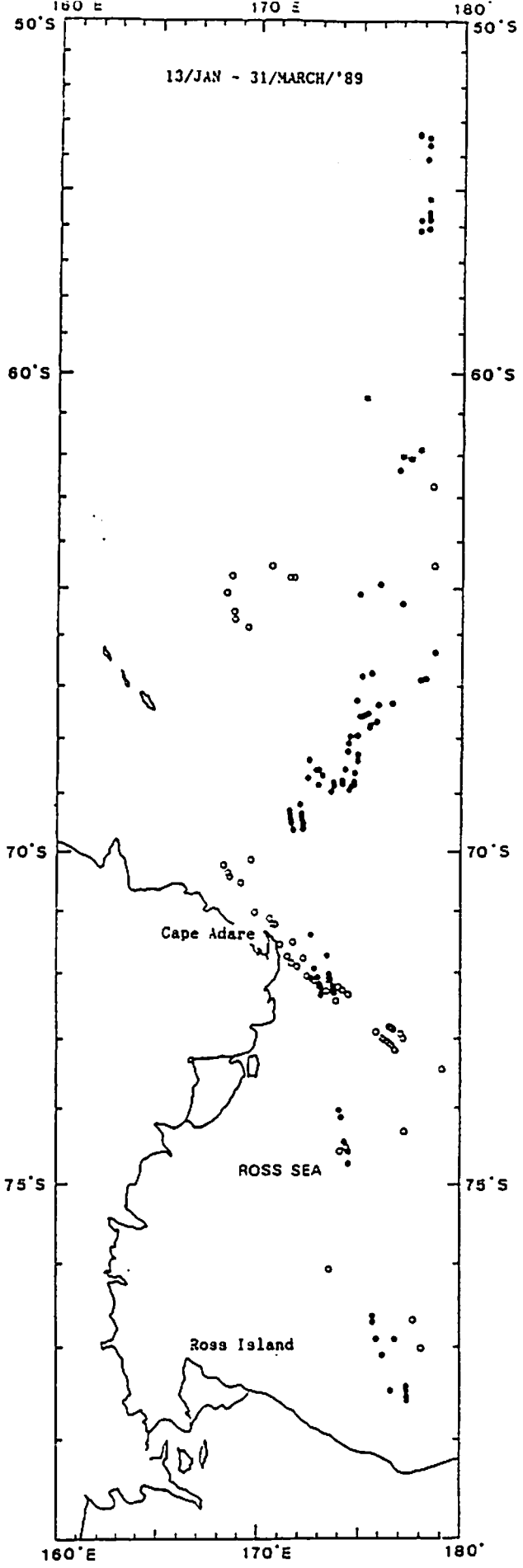
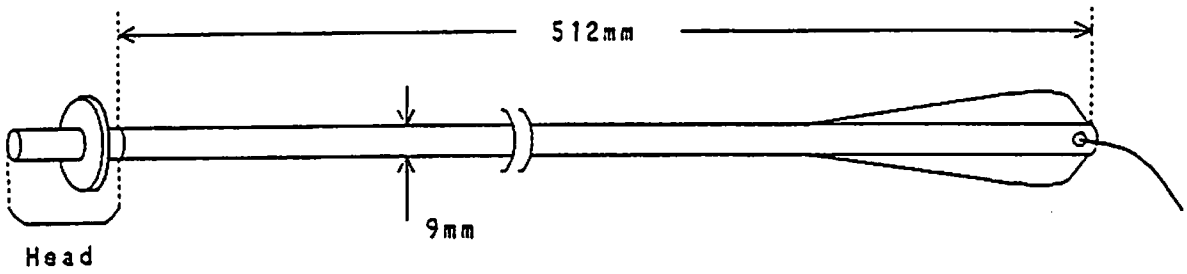



Fig. 4. Distribution of minke whale samples taken based on their sighted position. Closed circle represents samples taken in the first half (12/Jan. - 22/Feb./'89) and open circle in the second half (23/Feb. - 31/March/'89). Asterisks represent positions of dwarf form minke whales taken.




Section of head type

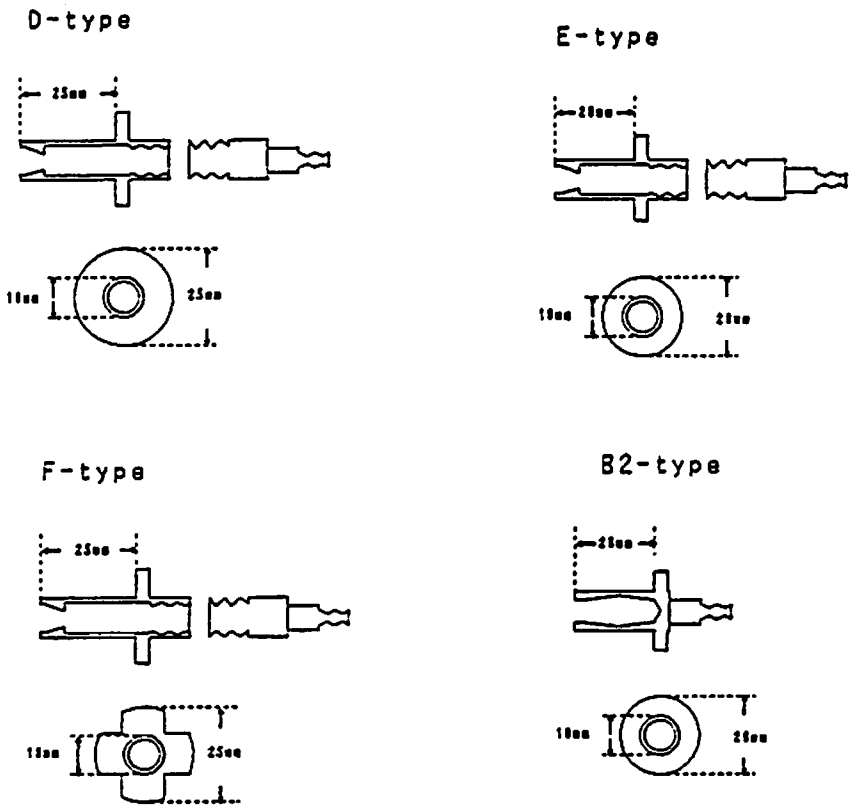



Fig. 5. Heads and dart body used in the experiment for the development of effective dart head in 1988/89. D - F types are developed by the Institute of Cetacean Research for the present season. B2 type is that used in the previous season.

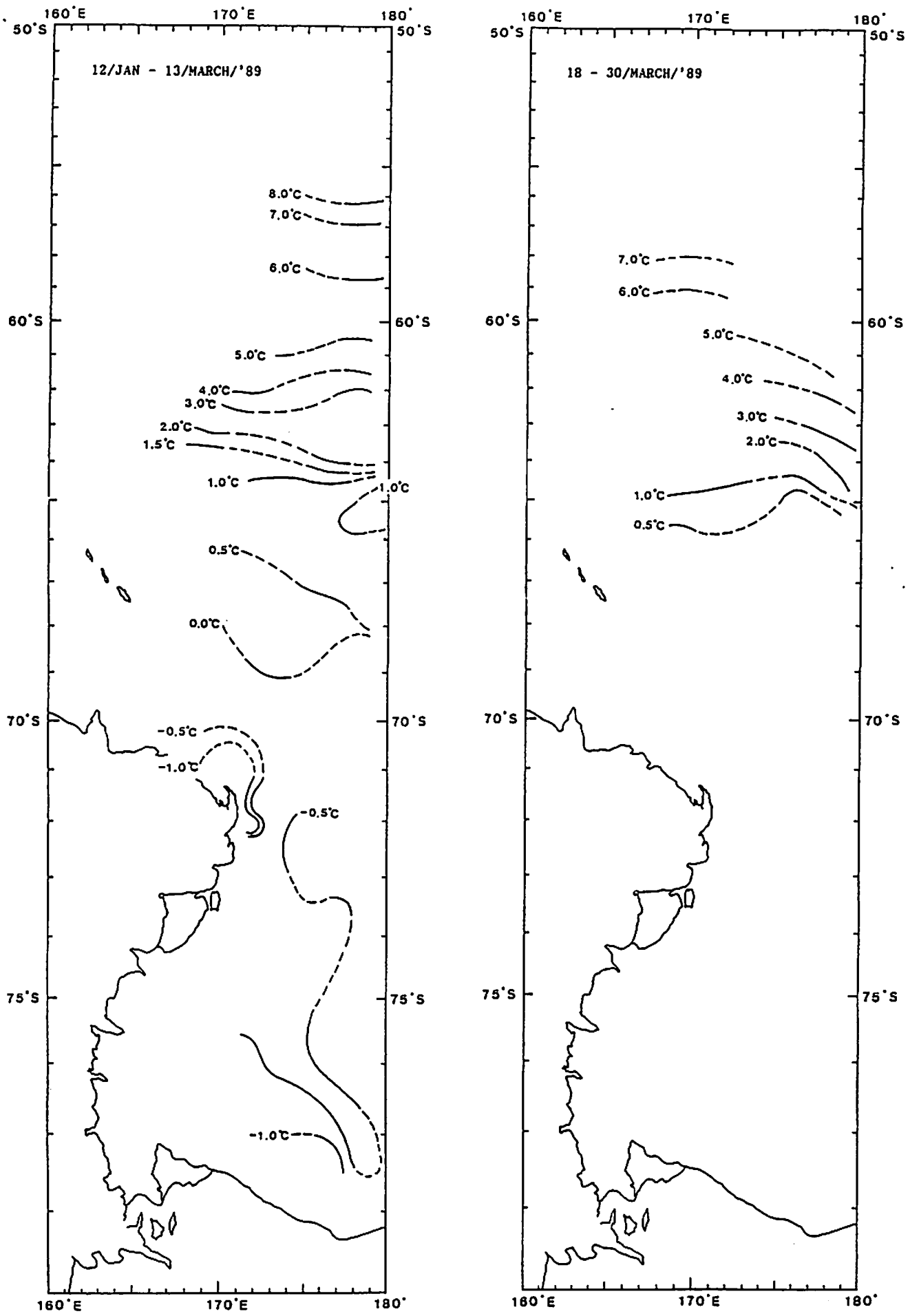



Fig. 6. Surface water isotherms divided into two conventional two periods, based on the data taken by sampled water.

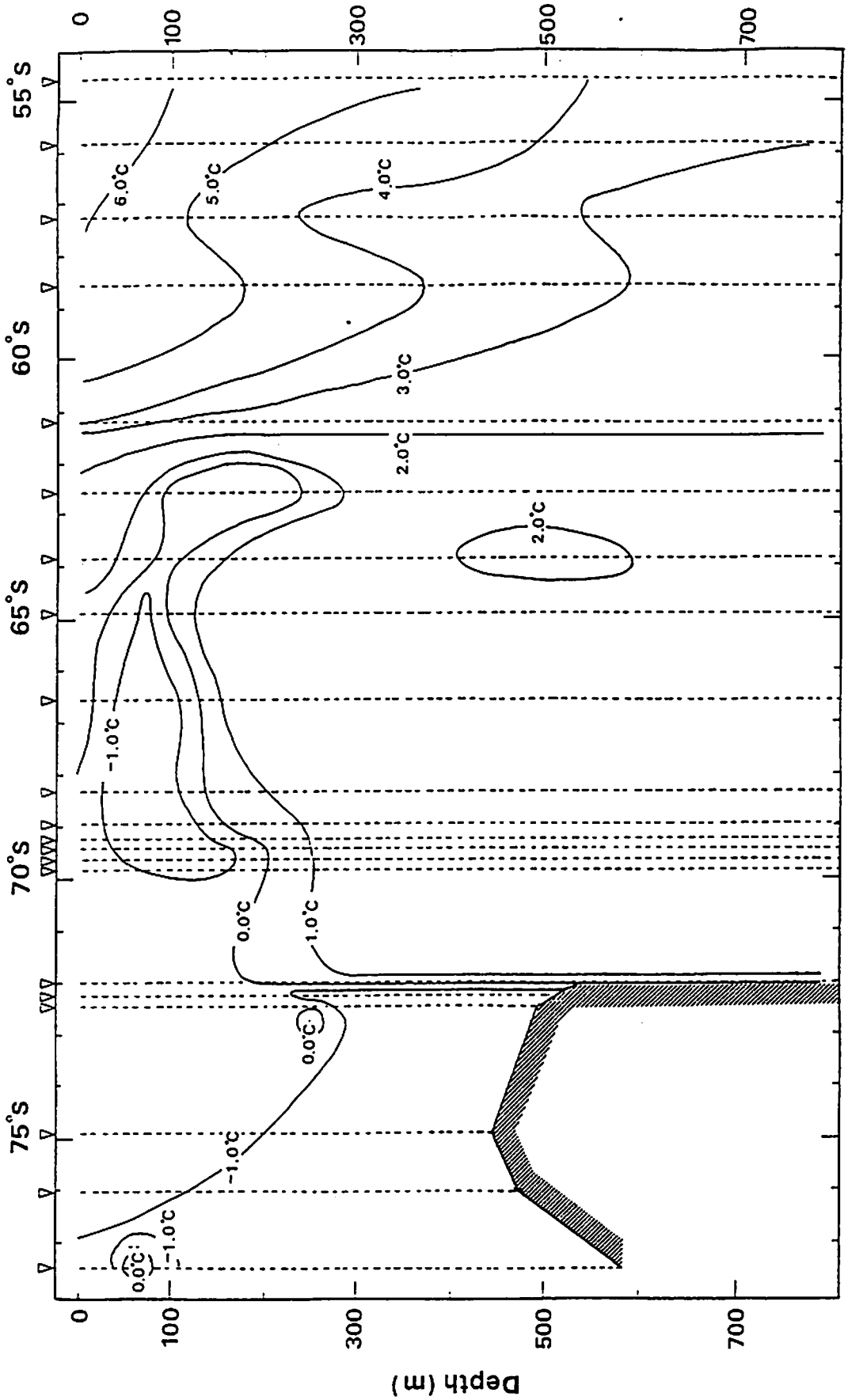



Fig. 7. Vertical isotherm along the approximate strait line from 54° S-178° E to 77° S-173° E based on the XBT surveys of 21 points (open triangles) during January 12 and February 21.

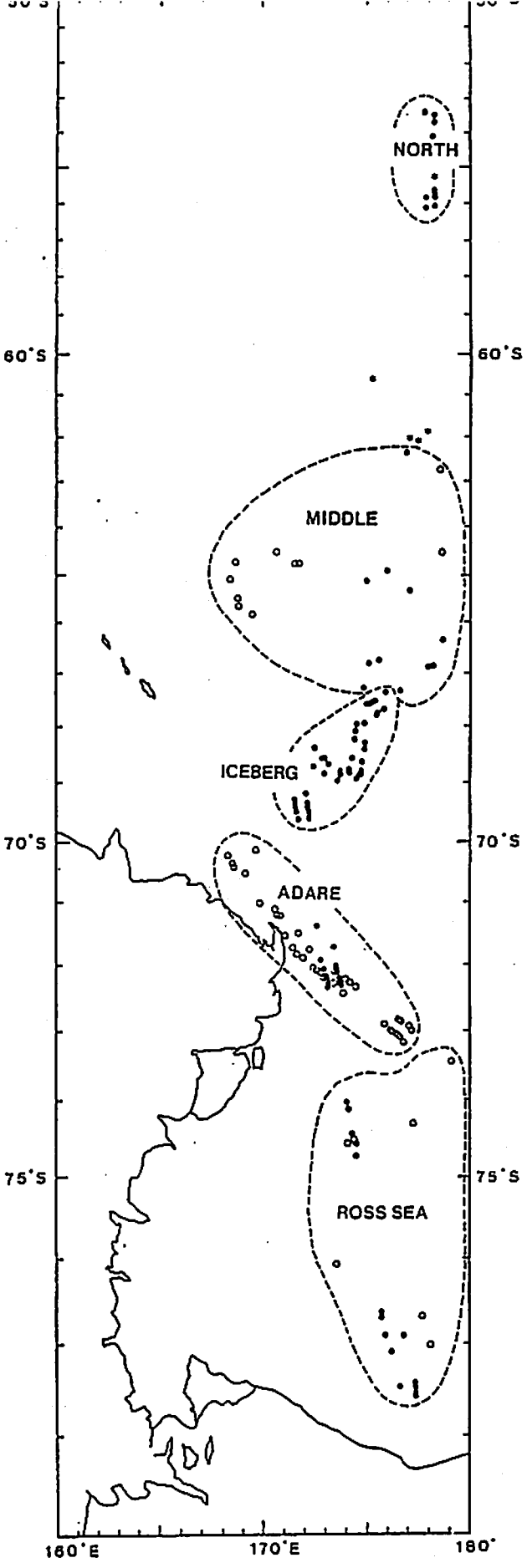



Fig. 8. Grouping of samples by the time-areal groups for the present preliminary analyses.

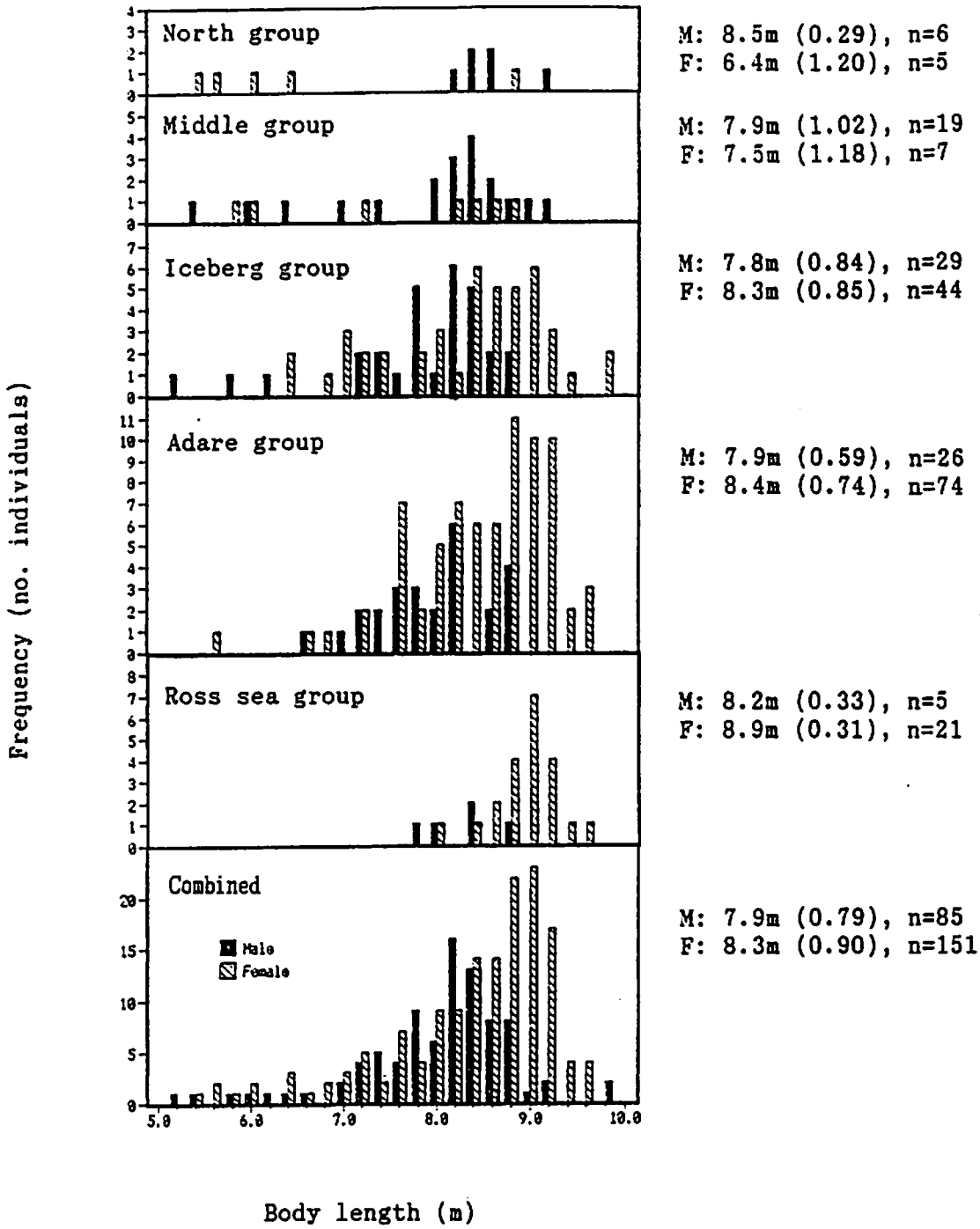



Fig. 9. Body length compositions (m) with pooling each 20cm interval, mean body lengths and their standard deviations (s.d.) for respective sexes by the time-areal groups.

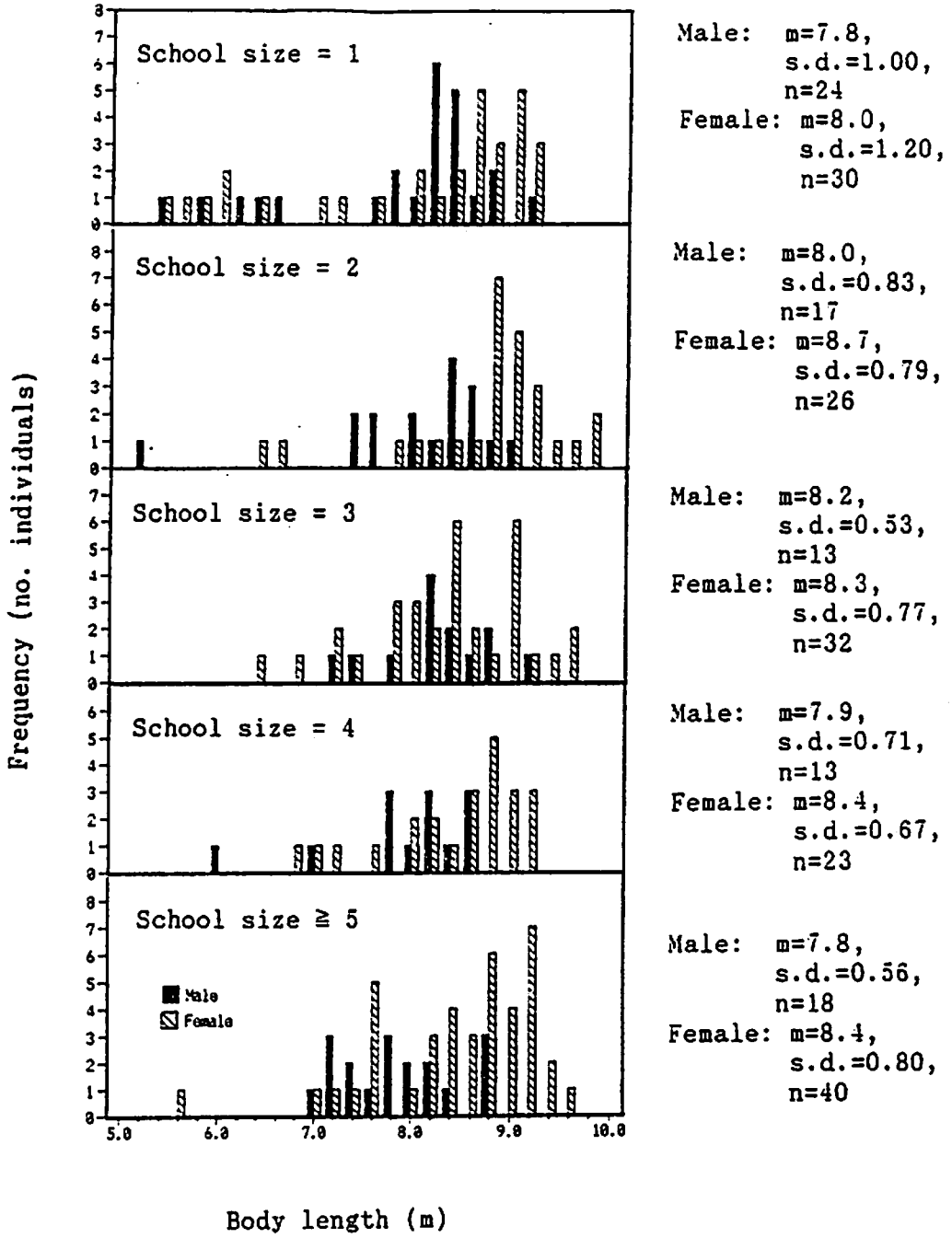



Fig. 10. Body length compositions (m) with pooling each 20cm interval, mean body lengths and their standard deviations (s.d.) for respective sexes by school size. The data were combined by all time-areal groups.

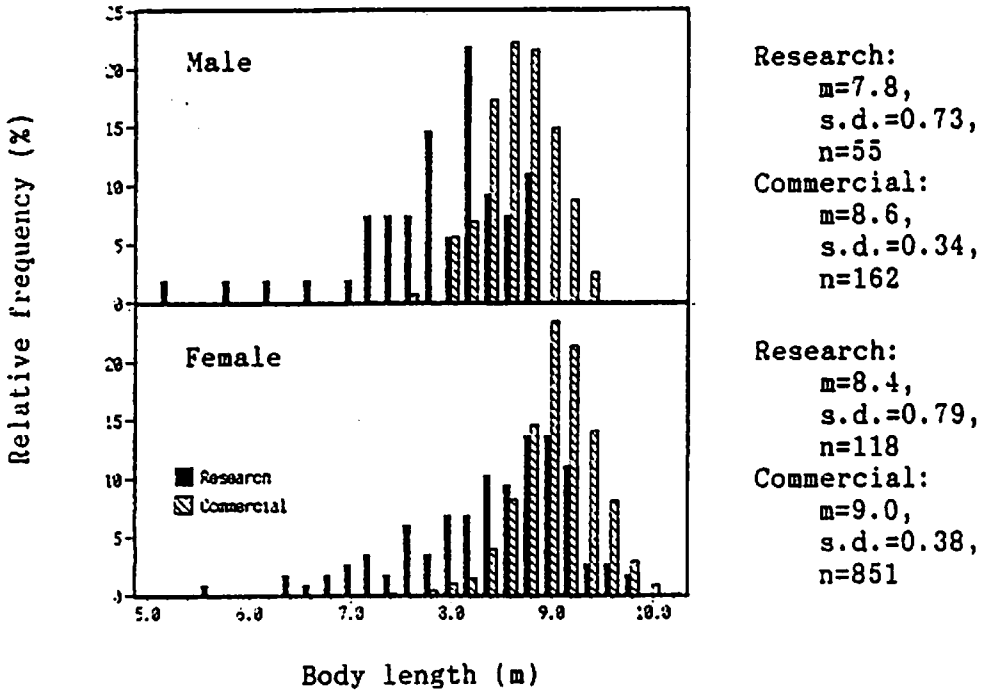



Fig. 11. Comparison of body length compositions of samples by the present survey in 1988/89 (Adare+Iceberg groups) with those by the Japanese commercial whaling in Area V in 1986/87 season. Solid and hatched lines represent the research and the commercial samples, respectively. The localities of both samples taken were almost coincided.

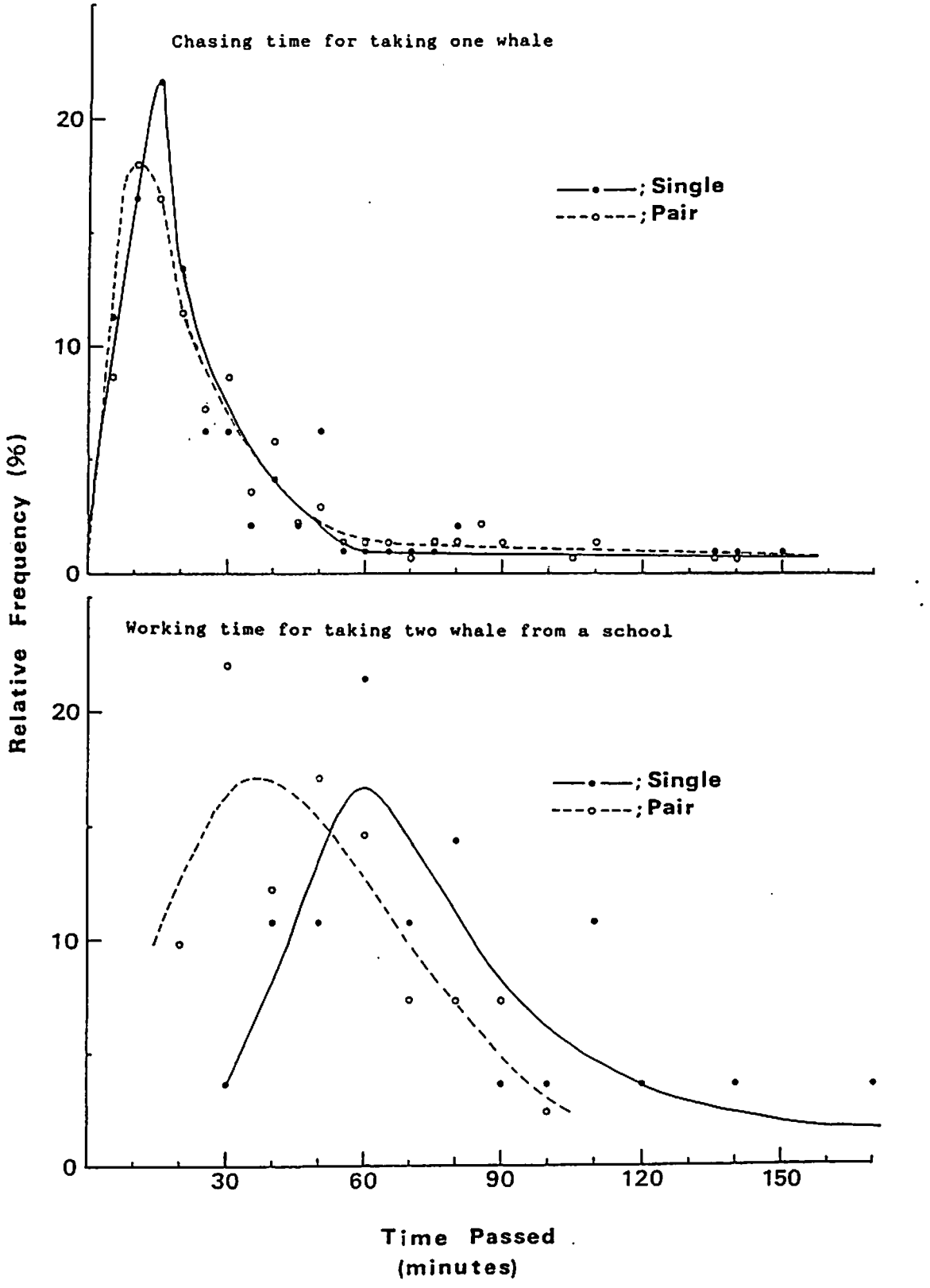



Fig. 12. Comparison of the working times between the different status of sampling vessels, on the chasing time for taking one whale (upper) and the working time (from the beginning of chase the first target to hit the second target) for taking two whales from a school (bottom).

Appendix 1. Principal specification of research vessels used for the present cruise.

| Ship name | Gross tonnage (t) | Length overall (m) | Horse power main engine (BHP) | Hight top barrel (m) | Number of crew*) |
|---|---|---|---|---|---|
| *Kyomaru No. 1* | 812.08 | 69.15 | 5,000 | 18 | 18 |
| *Toshimaru No. 25* | 739.92 | 63.00 | 3,600 | 18 | 19 |
| *Toshimaru No. 18* | 758.33 | 63.20 | 3,500 | 18 | 19 |
| *Nisshinmaru No. 3* | 23,107.85 | 194.64 | 6,750 | — | 117 |

*) excluding researchers.

Appendix 2. Details of research personnel and their assignment in the present cruise.

| Personnel | Situation | Ship*) | Assignment |
|---|---|---|---|
| Hidehiro KATO | Cruise leader | *NO3* | General management of the scientific researches |
| Shigeru TANIFUJI | General manager (vice leader) | *NO3* | General management of the fleet including security of the vessels and health maintenance of the crew |
| Yoshihiro FUJISE | Chief researcher (vice leader) | *NO3* | Biological data and sample collection |
| Syuichi KAWASHIMA | Chief researcher | *NO3* | Management of sampling vessels |
| Hiroshi OKAMOTO | Researcher | *NO3* | Biological data and sample collection |
| Hideyoshi YOSHIDA | Researcher | *KO1* | Determination of target whale<br>Collection of sighting and sampling data<br>Oceanographical research |
| Susumu NAKAGAWA | Researcher | *T25* | Determination of target whale<br>Collection of sighting and sampling data |
| Mitsuhiro ISHIDA | Researcher | *T18* | Determination of target whale<br>Collection of sighting and sampling data |
| Tameo RYONO | Research technician | *KO1* | Recording effort and weather data |
| Katsuji GOMI | Research technician | *T25* | Recording effort and weather data |
| Tomiya YAMASHITA | Research technician | *T18* | Recording effort and weather data |
| Shigeo TABATA | Research technician | *NO3* | Biological data and sample collection |
| Yutaka EGUCHI | Research technician | *NO3* | Biological data and sample collection |
| Hiroshi MIYAKOSHI | Manager | *NO3* | Management of the by-products |

*) *NO3, Nisshinmaru #3; KO1, Kyomaru #1; T25, Toshimaru #25; T18, Toshimaru #18.*

Appendix 3. Daily arrangement of the sampling vessels[1] in the present survey, (see text, section 2.4.1). The number in parenthesis represents daily searching distance in n.miles.

| Date | Sub-course A[2] | Sub-course B[2] | Date | Sub-course A | Sub-course B |
|---|---|---|---|---|---|
| Jan. 12,'89 | *T25-T18* (40) | *K01* (89) | 21 | *K01* (53) | *T18-T25* (35) |
| 13 | *T18* (116) | *K01-T25* (76) | 22 | *T25-K01* (28) | *T18* (40) |
| 14 | *T18-K01* (76) | *T25* (101) | 23 | *T25* (58) | *K01-T18* (48) |
| 15 | *K01* (81) | *T25-T18* (45) | 24 | *T25-T18* (50) | *K01* (51) |
| 16 | *K01-T25* (151) | *T18* (162) | 25 | *T18* (61) | *K01-T25* (46) |
| 17 | *T25* (110) | *T18-K01* (77) | 26 | *T18-K01* (101) | *T25* (99) |
| 18 | *T18-T25* (45) | *K01* (75) | 27 | *K01* (78) | *T25-T18* (68) |
| 19 | *T18* (54) | *T25-K01* (28) | 28 | *K01-T25* (3) | *T18* (4) |
| 20 | *K01-T18* (101) | *T25* (118) | Mar. 1 | *T25* (18) | *T18-K01* (0.5) |
| 21 | *K01* (106) | *T18-T25* (46) | 2 | *T18-T25* (20) | *K01* (37) |
| 22 | *T25-K01* (22) | *T18* (39) | 3 | (drifting through a day) | |
| 23 | *T25* (40) | *K01-T18* (39) | 4 | *T18* (11) | *T25-K01* (5) |
| 24 | *T25-T18* (11) | *K01* (12) | 5 | *K01-T18* (13) | *T25* (31) |
| 25 | (drifting through a day) | | 6 | (drifting through a day) | |
| 26 | (drifting through a day) | | 7 | (drifting through a day) | |
| 27 | *T18* (43) | *K01-T25* (36) | 8 | (drifting through a day) | |
| 28 | *T18-K01* (28) | *T25* (57) | 9 | *K01* (3) | *T18-T25* (4) |
| 29 | *K01* (96) | *T25-T18* (39) | 10 | (drifting through a day) | |
| 30 | *K01-T25* (114) | *T18* (152) | 11 | *T25-K01* (31) | *T18* (28) |
| 31 | *T25* (86) | *T18-K01* (52) | 12 | *T25* (15) | *K01-T18* (20) |
| Feb. 1 | *T18* (157) | *T25-K01* (147) | 13 | *T25-T18* (16) | *K01* (16) |
| 2 | *K01-T18* (156) | *T25* (163) | 14 | *T18* (61) | *K01-T25* (46) |
| 3 | (drifting through a day) | | 15 | (drifting through a day) | |
| 4 | *K01* (45) | *T18-T25* (22) | 16 | (moving to the Middle zone) | |
| 5 | (moving to the South zone) | | 17 | (moving to the Middle zone) | |
| 6 | (moving to the South zone) | | 18 | *T25-K01* (120) | *T18* (130) |
| 7 | (drifting through a day) | | 19 | *T25* (110) | *K01-T18* (75) |
| 8 | (drifting through a day) | | 20 | (drifting through a day) | |
| 9 | (drifting through a day) | | 21 | *T25-T18* (78) | *K01* (72) |
| 10 | *T25-T18* (18) | *K01* (16) | 22 | *T18* (105) | *K01-T25* (94) |
| 11 | *T18* (4) | *K01-T25* (8) | 23 | *T18-K01* (9) | *T25* (9) |
| 12 | *T18-K01* (2) | *T25* (1) | 24 | *K01* (79) | *T25-T18* (95) |
| 13 | *K01* (1) | *T25-T18* (0.6) | 25 | *K01-T25* (38) | *T18* (48) |
| 14 | (drifting through a day) | | 26 | *T25* (59) | *T18-K01* (90) |
| 15 | (drifting through a day) | | 27 | *T18-T25* (46) | *K01* (15) |
| 16 | *K01-T25* (56) | *T18* (63) | 28 | (moving to the North zone) | |
| 17 | *T25* (7) | *T18-K01* (7) | 29 | *T25* (56) | *T18-K01* (47) |
| 18 | *T18-T25* (3) | *K01* (1) | 30 | *T18-T25* (125) | *K01* (124) |
| 19 | *T18* (55) | *T25-K01* (39) | 31 | *T18* (59) | *T25-K01* (67) |
| 20 | *K01-T18* (67) | *T25* (94) | | | |

1) *K01*, *Kyomaru #1*; *T25*, *Toshimaru #25*; *T18*, *Toshimaru #18*

2) Two sub-courses located at left and right side of the main course were named as sub-course A and B at the beginning of the survey in each zone.