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CRUISE REPORT OF THE RESEARCH ON SOUTHERN MINKE WHALES IN 1989/90 UNDER THE JAPANESE PROPOSAL TO THE SCIENTIFIC PERMIT

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ABSTRACT

The research cruise for Japanese proposal of the special permit to take southern minke whales was conducted during the period from December 6, 1989 to March 12, 1990, with using one research base and three sampling vessels. The survey covered the Antarctic Area IV, between longitudes 70°E and 130°E, within a southern part of 55°S.

A total of 1,245 schools (3,378 individuals) of minke whale sightings comprising 767 schools (1,978 ind.) of the primary and 478 schools (1,400 ind.) of the secondary sightings was made by the three sampling vessels during the total searching of 17,094.4 n.miles. Employing the random sampling scheme, a total of 330 individuals including 327 ordinal forms (184 males, 142 females and one unknown) and three dwarf forms (one male, two females) was taken from 323 targeted primary sightings (480 ind.). Searching effort had improved by allocated three persons as top men.

The preliminary analyses suggest: (1), Body length compositions of the samples respective sexes were differed from those by the commercial catches, with indicating of a higher proportion of small individuals. (2), Mature males were dominated through out the research area, while pregnant females were concentrated in around the ice edge. (3), Immature animals tended to be solitary and distributed at the offshore waters. (4), Whale densities tended to be higher in eastern and southern zones of the research area, and these trends were more clear in the later seasons. (5), Seasonal changes were seen in the western zone. No latitudinal changes of biological features were shown in the first half, and it was characterized by dominated mature males and immature females. While in the second half, it was characterized by immature animals in the offshore and mature animals in the ice edge and the Prydz Bay. All mature females in both of the ice edge and Prydz Bay were pregnant.

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1 INTRODUCTION

The Government of Japan proposed a research plan on "The program for the research on the southern hemisphere minke whale (*Balaenoptera acutorostrata* Lacépède, 1807) and for the preliminary research on the marine ecosystem in the Antarctic (SC/39/O4)" to Scientific Committee of the International Whaling Commission (IWC/SC) in 1987 (The Government of Japan, 1987a), and subsequently carried out two cruises of feasibility studies in a part of Area IV in 1987/88 fishing season and in a part of Area V in 1988/89, respectively (The Government of Japan, 1987b, 88; Kato, Hiroyama, Fujise and Ono, 1988; Kato, Fujise, Yoshida, Nakagawa, Ishida and Tanifuji, 1989). These feasibility cruises in 1987/88 and 1988/89 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, Kato, Kasamatsu and Fujise, 1989; Kato, Fujise, Kishino, 1990). The current sampling scheme, which was proposed in the original program, could functionalized in a geographically and oceanographically complex waters such as Area V including the Ross Sea. After the two feasibility studies, Japan reproposed the research plan which modified to the original proposal (The Government of Japan, 1989) with taking 300 minke whales (with 10% of allowance).

This report covers the research cruise in the Antarctic Area IV, which was conducted between November 10 1989 and March 31 1990, 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.

2 AN OUTLINE OF THE CRUISE

2.1 Detail of the research fleet and personnel

Three sampling vessels, *Kyomaru #1* (*KO1*; 812.08GT), *Toshimaru #25* (*T25*; 739.92GT) and *Toshimaru #18* (*T18*; 739.92GT), performed sighting and sampling surveys. *Nisshinmaru #3* (*NO3*; 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, refueling to the sampling vessel and others were dealt with. The collection of biological materials and the processing of whale carcasses were made on *NO3*. The principal specification of each vessel is given in Appendix 1.

Research personnel and their assignments are given in Appendix 2.

2.2 Research area

The research area was established the whole of Antarctic Area IV; east of 70°E and west of 130°E, within a southern part of 55°S. The research area was stratified to three strata; north (55°S-60°S), middle (60°S-45 n.miles from ice edge) and south zone (within 45 n.miles from ice edge). The middle and south zones were, furthermore, longitudinally stratified two sub-strata at 100°E line; western (70°E-100°E) and eastern zone (100°E-130°E). Each zone was surveyed twice. In middle zone, the southern boundary was established after the south zone surveyed, and the northern boundary was latitudinally shift from 60°S to 58°S line, if the latitudinal distance in the middle zone was below 240 n.miles after southern boundary was established. The research in the middle and south zones was conducted the following order; the western south, western middle, eastern south and eastern middle zones.

Fig. 1 shows the geographical locality of the present research area with those of the sighting cruises in lower latitudes.

2.3 Research method

2.3.1 Track line and arrangement of sampling vessels

We established three track lines which are consist of main course and two sub-courses. The main course was randomly established, and two sub-courses were nine miles away from either sides of the main. Two sub-courses located at east (north side in the Prydz Bay) and west side (south side in the Prydz Bay) of the main were named as "sub-course A" and "sub-course B", respectively. Three sampling vessels were allocated to each track line. This arrangement was rotated daily.

Because of the present survey should be covered longitudinally wider waters as a whole of Antarctic Area IV; 70°E-130°E, with limited period, the design of track line in the present research cruise was differed from that of previous two feasibility studies in 1987/88 and 1988/89 cruises, and applied the saw-tooth form track line, which is one of systematic surveys such as adopted by IWC/IDCR southern minke whale assessment cruises, and its modification form.

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

North: The starting point of the main in the first half was randomly chosen from 31 points divided by each 30' between 85°E and 100°E at 55°S. Only one leg between 55°S and 60°S was surveyed along the longitude. In second half the starting point in each vessel was allocated in following three point, 60°S-104°E, 60°S-108°E and 60°S-112°E line. These track lines were set along the longitudes from the selected point, and each vessel was surveyed on these lines between 55°S and 60°S.

Middle: The research was conducted from the starting point on 70°E line eastward in the western part of the research area, and on 130°E westward in the eastern part of the middle zone, respectively. The main course and the

starting point were established by the following procedure.

(1) A line of longitude was randomly chosen from 31 lines divided by each 30' between 70°E and 85°E, and named "standard line". This "standard line" was determined as being at 77°30'E and 77°E lines in the first and second halves, respectively.

(2) Where the turning point set in the northernmost or southernmost point on this "standard line" in the middle zone was randomly chosen. In both first and second halves, the turning position was determined as being at the southernmost point on the standard line.

(3) Lines along the longitude were set between 70°E and 130°E at longitudinal interval of 15° based on above standard line, and named "base line". The turning points were set at the southernmost point on these base lines and at the northernmost point on the mid-lines between these base lines.

(4) The searching course are established by lining in longitudinally order to above turning points, and shaped as zigzag form.

(5) The starting point in the western (or the eastern) middle zone determined as a point of intersection between 70°E (or 130°E) line and a line from the turning point on the standard line to the next turning point on a line which was set 15 longitudinal degree west (or east) away from the standard line. The survey was conducted from this point to eastward (or westward). If this determination need to the southern boundary on the line 15° west (or east) away from the standard line, we used the mean latitude of the 45 n.mile points in the south zone as this boundary.

South: The research was conducted westward from the starting point on 100°E line in the western part of the south zone, and eastward in the eastern part, respectively. The main course and the starting point were established by following procedure.

(1) A line of longitude was randomly chosen from 9 lines divided by each 30' between 96°E and 100°E, and named as "standard line". The standard line was determined as being at 99°E line.

(2) The base lines along the longitude are set at longitudinal intervals of 4° based on above the standard line. Accordingly, these base lines were established as 71°E, 75°E, 79°E, 83°E, 87°E, 91°E, 95°E and 99°E lines in the western south zone, and 103°E, 107°E, 111°E, 115°E, 119°E, 123°E and 127°E lines in the eastern south zone, respectively. These base lines were unchanged throughout the research period.

(3) A position of ice edge on the base line was named as "base point", and a position at 45 n.miles away to the north from this base point was named as "45 n.miles point".

(4) The main course was set from the base point to the next base point via the 45 n.miles point on the present base line, and shaped as saw-tooth form.

(5) As the true position of next base point is unknown until we arrived at this point, the next base point were expected by the best available information such as the position of present base point we arrived, the geographical and weather conditions.

(6) The starting point in the western south zone is a point of intersection between 100°E line and a line from the base point on 99°E to a point which allocated 45 n.miles north and four longitudinal degree east away from this base point. In the eastern south zone, the starting point is a point of intersection between 100°E line and a line from the base point on 103°E to a point which allocated 45 n.miles north and four longitudinal degree west away from this base point.

(7) If the expected base point was located northward from the true base point, we stopped the survey and moved from the expected point to the true point by top-down steaming, then we resumed the survey from this point to the 45 n.miles point with direction (dir.) 360°.

(8) If we met the pack ice until we reached to the expected base point, we also stopped the searching, and moved along the pack ice to the true base point on the next standard line by the top-down steaming. After reached to the true base point, we resumed the survey with dir.360°.

(9) Antarctic Area IV is included the Prydz Bay between 70°E and 80°E. We decided that the southern boundary of the south zone from 70°E to 80°E was limited to 66°S. If we have not met a pack ice until we reached to the base point between 70°E and 80°E, we expected that there was a open sea in the Prydz Bay, and conducted the survey in the Bay by following procedure.

Prydz Bay: As the design of track line used in the south zone was expected to be not functionalized such as the Prydz Bay. The research lines was determined as two west-east legs along the latitude between the eastern wall of the Bay and the western wall (or 70°E line). We conducted the ice edge searching for understanding the shape of the Bay and the position of the bottom of the Bay. First research line along the latitude was randomly chosen from lines divided by each 15' latitude

between 67°30'S to the bottom of the Bay. And Second research line was set to 90 n.miles north away from the first line. The starting point was determined as the point of eastern wall on the first line, the survey started westward with dir.270°. After we reached to the western wall or 70°E line, the fleet moved to the starting point on the second line which was located the western wall of the Bay or at 70°E on the second line. The survey on the second one was conducted eastward with dir.90°.

2.3.2 Sighting manner

The principal sighting manner was similar to that has been adopted in the current IWC/IDCR southern minke whale sighting cruises and previous two feasibility studies in 1987/88 and 1988/1989 cruises, without the setting of the daily advanced distance which the fleet should be gained in a day. This daily advanced distance was not included movements by top-down steaming from the expected base point to the true base point, and from a point of ice edge which we met before reached the expected base point, to the true base point. The daily advanced distance in each zone is predetermined for 150, 170 and 100 n.miles in the north, middle and south zones, respectively.

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. The sampling vessels resumed survey everyday from the point gained the advanced distance from starting 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. Especially, for three species followed as blue, right and humpback whales, extensive confirming and recording by photograph were conducted for study of natural marking with exception of above sighting manner.

After confirming or sampling activities, the vessel returned to the searching line by following method: (1), If position of the vessel at above activities finished was located within three n.miles from the track line, and was ahead of those at whale sighted, the vessel returned to the track line with an angle of 45° from the track line and resumed the searching at same time. (2), If the position was located at over three n.miles away from the track line, and ahead of those at whale sighted, the vessel returned to the position on the searching course vertically corresponded to the position at above activities finished and resumed searching there. (3), If the position was located at behind, the vessel returned to the position of vessels at whales sighted, and resumed the searching.

All activities during the sighting survey and sampling were classified and recorded on the effort data sheet similar to that in IWC/IDCR cruises.

2.3.3 Sampling scheme

As same as the previous feasibility cruises, 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 at the beginning of the survey, we tried to control the sample size in a day after the survey in the western middle zone at the first half by applying several controlling rules (see later section in 2.4.1). It was scheduled to be sampled with a maximum two individuals from each school (school size 2 and over) according to the same random sampling scheme to that in the previous two seasons (see section 4 of Kato *et al.* 1988, 1989), using tables of random sampling digits prepared by different school sizes. This sampling scheme was unchanged throughout the research period with regardless of the controlling of sampling.

2.4 Narrative of the cruise

The fleet left Japan on 10 - 12th of November, 1989 (*N03* from Yokohama on 10th; three sampling vessels from Shimonoseki on 12th). After having a pre-cruise meeting and refueling of sampling vessels on November 23, *N03* cruised to the starting point in the north zone (55°S-97°E, randomly chosen before arrival). *K01* cruised to 64°S-70°E, and then engaged the ice edge searching in the western south zone. Two sampling vessels, *T25* and *T18*, cruised to 30°S-97°E, and then carried out sighting survey from this point to the starting point in the north zone with dir.180° and 12 knot in the daytime (steamed in the night time). The same logistics of sighting survey was also incorporated during the returning cruise from the Antarctic. *N03* and two sampling vessels (*T25* and *T18*) were joined at this starting point at noon on December 6, 1989, and started the survey in the north zone.

The research lasted for 96 days from December 6, 1989 to March 12, 1990. 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 and itinerary are shown in Fig. 2 and Appendix 3, respectively. We described time of this section with using local time advanced 7 hours of GMT (from December 6, 1989 to February 22, 1990), and 8 hours (from February 23 to March 12, 1990), and most of positions used in this section were represent as those for the main course.

2.4.1 The first half (December 6, 1989 - January 19, 1990)

North zone

The fleet commenced searching from 55°S-97°E at noon on December 6. As *K01* was engaged the ice edge searching in the western south zone, two vessels (*T25* and *T18*) were conducted the survey in the north zone. As mentioned above in section 2.3.1, the main course was set on 97°E which was randomly chosen, and the sub-course was set on a line that located nine n.miles eastward away from the main. *T25* and *T18* cruised with dir.180° on these track lines. The initial arrangement of the sampling vessels in the north zone was that *T25* cruised on the main and *T18* on the sub-course, and this arrangement was rotated daily. After about three days searching under the relatively good weather condition, the fleet

reached to 60°S - 97°E where was the ending point of the north zone at 15:00 on December 8. After the fleet finished survey of the north zone, the fleet begun to move the expected starting point of the south zone.

During this period, four whales including three ordinal form minkes and one dwarf form were sampled from four schools (four individuals) of the primary sighting.

Western south zone

On December 8, *T25* searched for the base point (ice edge point) on 99°E, and it was confirmed that the position of this point was 61°51'S. According the procedure in above section 2.3.1, the starting point (61°40'S-100°E) in the western south zone was determined as a point of intersection between 100°E line and a line from 61°51'S-99°E to 61°06'S-103°E. The fleet begun the survey at this point with dir.249° to the base point (61°51'S-99°E). The initial arrangement of the three sampling vessels in the south zone was that *T18* cruised on the main, *T25* on sub-course A, and *KO1* on sub-course B. The fleet reached to the western boundary (63°01'S-70°E) at noon on December 21.

In this south zone, the fleet cruised 100 n.mile (daily advanced distance, mentioned above section in 2.3.2) on the main course in every day with independently of daily searching miles.

During the searching in this zone, the ice edge line was under bias toward north than we expected. Information from the ice edge searching by *KO1* during December 5-9 was available to understand the form of ice edge line in this season, but not available to make an accurate estimate of the base point (the position of pack ice) on the next standard line, because of the position and shape of ice edge line varied every hour with air and sea water temperatures. Satellite information were also not available. The next "base point" are expected by the information such as the position of present base point, the lay of Antarctica, and the past information of ice edge line.

The base point on 81°E was located at 59°40'S by *KO1*'s survey. And past information shown that ice edge was trended to be northward at around 81°E and 85°E than another. Based on these information, we expected that the base points on 83°E and 79°E were located on 61°S, the fleet cruised from the 45 n.mile point on 87°E (60°07'S) to the former expected base point (61°S-83°E) with dir.246 on December 14, and cruised from the 45 n.mile point on 83°E (62°16'S) to the later point (61°S-79°E) with dir.305° on December 16, respectively. On the contrary to our expectation, these true base points on 83°E and 79°E were located southward (63°01'S on the former and 62°52'S on the later), and differences between the expected and true base point on these standard lines were 121 and 112 n.miles at former and later base points, respectively. The fleet must have been moved from the expected point on these standard lines to the true point by the long time top-down steaming. However, with the exception of above two cases, the mean difference between the expected and true base points in this zone was 12.8 n.miles (Table 1).

During this survey, 81 whales were taken from 88 schools (140 individuals) of primary sightings.

Western middle zone

As mean latitude at the 45 n.miles points on the standard lines in the western south zone was 61°42'S, northern boundary of this western middle zone was shifted from 60°S to 58°S. The starting point in the western middle zone was determined as being 58°S-70°E as mentioned above procedure in 2.3.1, and track line was defined as a zigzag formed line which was lined in order to following point; 58°S-70°E, 62°05'S-77°30'E, 58°S-85°E, 61°09'S-92°30'E and 58°S-100°E.

After the survey of south zone was finished, the fleet moved northward 300 n.miles to the starting point of middle zone, and begun the searching in the middle zone with dir.138° at noon on December 22. On December 29, the fleet reached on 100°E line and ended the survey of this zone, and begun to move southward on 100°E.

Under the good weather condition, 51 schools (77 individuals) were sighted as the primary sighting and 41 individuals were taken from these schools.

Eastern south zone

We changed in a part of the setting procedure of the starting point in the eastern south zone for the following two reasons; (1), Distance from the ending point of the middle zone to the starting point of the south zone after the searching of true base point on 103°E was estimated over 300 n.mile. (2). We could easily expected the base point on 103°E, because of we know from our experiences that the shape of the ice edge on January were relatively flatted around in these region.

The changed point of the setting procedure was that the searching the first true base point was changed from on 103°E to on 100°E. We searched the base point on 100°E and expected the base point (64°30'S) on 103°E from the true point on 100°E. The starting point in the eastern south zone was determined as being 63°56'E-100°E, according to the setting rule as mentioned in the previous section. The fleet begun the searching in the south zone at this point with dir.113° at 07:00 on December 31. Distance between the expected and true base points on 103°E was only 10 n.miles (the true base point; 64°20'S).

In this western south zone, 49 schools (132 ind.) and 19 schools (51 ind.) sighted as the primary sightings on December 31, 1989 and January 1, 1990, respectively. Then we controlled the catches of 14 and 12 whales in the days. The whale density was relatively higher than those in the previous western zone. As we easily expected that if we continued the sampling for all primary sightings, the sampling activities would be finished at the early stage of this cruise under the sample size limitation (300 whales with 10% of allowance), and we could not to examine the seasonal changes of biological features on minke whale which were one of the research aim in this cruise. Then we employed the controlling of the catches of whales per day after January 2. Sampling scheme for the targeted school was unchanged. From January 2 to 19 which was the remained period in this south zone, we determined the following sampling rule; the total catch per day was limited up to six individuals, and the number of schools which were sampled by each vessel, was limited up to two. When the total catches per day would be expect-

ed over six, the sampling in the day were immediately stopped and then all sampling vessels engaged the only sighting survey after remained time of the day. On January 4, the weather condition changed to be rough, and the fleet should be top-down steaming, then we could not searched between 111°E and 114°E. And the fleet reached to 119°E on January 7, the base point on this standard line was located in the bottom of a inlet where the ice edge line shaped as a jar, and the 45 n.miles point on this line was located at a mouth of this inlet. The fleet made to be moved from this point to the next base point by top-down steaming. With the exception of 119°E, the track line in this zone was usually located on around 65°S. The fleet cruised eastward with 100 n.miles of daily advanced distance in every day. The fleet reached to the eastern boundary (130°E) at noon on January 10, 1990 with occasional topdown steaming due to strong winds and fogs. Hereafter, the fleet begun to move the starting point of the eastern middle zone.

During 11 days from December 31, 1989 to January 10, 1990 in the survey of this zone, 159 schools (428 ind.) were sighted as a primary sighting, and 72 individuals were sampled from 60 schools (104 ind.) targeted.

In contrast to the mean latitude of the base points in the western south zone was 62°27'S, it was located at 65°12'S in this eastern zone. Mean distance between the expected and true base points were 25.4 n.miles with 25.0 (s.d.), and range were 2 to 68 n.miles (Table 1).

The base point on 100°E was located on 61°45'S and 64°15'S at the beginning of survey in the western (December 9) and eastern south zones (December 31), respectively, and was shifted southward for 150 n.miles during only three weeks.

Eastern middle zone

The fleet cruised northward to 300 n.miles on around 130°E, and reached the starting point of the eastern middle zone (60°S-130°E), then commenced the searching with dir.217° at 13:00 on January 11. From the survey of the south zone, the track line in this zone was determined as a zigzag form was lined in order to following points; 60°S-130°E, 64°40'S-122°30'E, 60°S-115°E, 64°34'S-107°30'E and 60°S-100°E.

As the density of minke whale in offshore region as the middle zone, would be expected relatively small, all primary sightings were targeted for the sampling in this eastern middle zone until on January 17.

When we reached to 64°15'S-108°E at noon on January 17, the number of cumulative catches were reached to 232 whales. Even if the catch limitation would be gained to allowance, the remained sample size were below 100 whales. Then we stopped the sampling in this zone, the sampling vessels were engaged to the only sighting survey during the remained period of this eastern middle zone.

The fleet was arrived at 60°S-100°E on 16:00 January 19, and begun to move the starting point to be expected of the western south zone.

During the survey in this middle zone, the primary sightings were 51 schools (111 ind.), and 50 whales (34 schools) were targeted. 32 ordinary and two dwarf form minke whales were taken from the schools targeted.

2.5.2 The second half (January 21 - March 12, 1990)

Western south zone

By the *T18*'s ice edge survey, the base point on 99°E was located at 64°08'S, and the starting point in the western south zone at second half was determined at 63°57°'S-100°E. This point was shifted southward 137 n.miles from 61°51'S to 64°08'S between the beginning at first and second halves. The fleet commenced the searching in the second half at this point in early morning on January 21.

In this western south zone, we employed again the sampling controlling as followed; (1), The number of samples in the western zones (the middle and south) at first half was 122, and for the examination the seasonal changes of biological feature of minke whale, we tried to take the remained samples in the western zone. (2), To be dispersed the remained samples in the whole of the western zone, the daily catches were limited up to five animals in the south zone and the Prydz Bay. (3), The number of schools to be targeted and taken samples was limited one school on each course in a day, but if the daily mean catches were blow four individuals in this zone, the second school was targeted in each track line after four hour from the beginning to target the first school. (4), To be dispersed sampling, the time of beginning to target the school was randomly chosen from four divided hours and it was changed daily and between three vessels.

The fleet cruised westward under the controlling of the sampling above, and reached to 70°E at noon on February 1.

90 schools (175 ind.) were sighted as the primary sighting, and 49 whales were taken from targeted 38 schools (62 ind.).

Mean latitude of the base points in the western south zone (from 79°E to 99°E) was 64°56'S (Table 1), and the pack ice line was also moved to southward 163 n.miles from that in the first half.

Prydz Bay

In the survey of the western south zone, as there was not pack ice at 66°S-75°E and 66°S-71°E as the base points on 75°E and 71°E, we expected to open in the Prydz Bay, and conducted the survey of this Bay.

For understanding the shape of the Prydz Bay, three vessels (*KO1*, *T25* and *T18*) were conducted the ice edge searching in the Bay. By this survey, the Prydz Bay had no pack ice, and shaped as a plate. After the above procedure in section 2.3.1, the searching line was randomly chosen between 67°15'S and 69°S, and 68°15'S line was chosen. The 66°45'S line was automatically selected as a second track line.

At early morning on February 3, the fleet begun the searching at 68°15'S-78°E with dir.270°, and reached to 70°E line at afternoon on February 4. The fleet moved to the 66°45'S line as the next research line. At early morning on February 5, the fleet resumed searching eastward at 66°45'S-70°E with dir.90°. The fleet met the ice shelf on 78°12'E on February 6, and finished the survey of the Prydz Bay. During 4 days, the primary sightings were 44 schools (77 ind.), and 18 schools (29 ind.) were targeted from the primary sightings, and 23 whales were taken.

Western middle zone

The starting point was determined to 60°20'S-70°E. The track line in this middle zone was determined as a zigzag form which was lined in order to following points; 60°20'S-70°E, 64°45'S-77°E, 60°S-84°30'E, 64°26'S-92°E, 60°S-99°30'E and 60°19'S-100°E.

The fleet finished the searching in the Prydz Bay, and immediately moved 470 n.miles to the starting point of the middle zone. At 07:00 on February 8, the fleet begun the searching at above starting point with dir.144°. In this zone, we determined the following sampling rule; Samples in a day must be taken from only one school in each searching course. If the mean daily catches were below 3.5 animals, until the daily mean catch reached four animals, furthermore one school was targeted in each track line at afternoon.

On February 14, the total catches were reached 330 whales which were the sampling limitation in this cruise, and then we stopped the sampling activity. Hereafter, the fleet commenced only the sighting survey during the remained research period.

The 329th whale taken was lost in the sea during towing to *NO3* by the cutting around the base of flukes.

The fleet reached to 100°E at 09:00 on February 16, and finished the survey in the western middle zone.

During 9 days, 57 schools (75 ind.) were sighted as a primary sighting, and 26 individuals including one whale lost were sampled from 30 schools (37 ind.) targeted under the catch controlling.

Eastern south zone

As the base point on 103°E was located at 64°29'S by *KO1*'s survey, the starting point was determined as 63°55'S-100°E. However, the position of ice edge on 100°E was located northward from this point (63°42'S). The fleet made a detour to pack ice by the topdown steaming, and begun the searching in this zone at 64°02'S-100°35'E with dir.113° at 12:10 on February 17. During the topdown steaming, 505 whales (74 schools) were sighted as the secondary sighting by combined three vessels. The base point at the fleet reached was located at 64°36'S, and the base point was shifted south to seven n.miles in only a day. On February 22, the fleet cruised southward with topdown steaming on 119°E of the standard line as same as those in the first half, this base point on the line was shifted southward, and the fleet was made a topdown steaming for about five hours. Furthermore, as the 45 n.miles point on this line was located at the mouth of this inlet, the fleet was made a detour along ice edge with topdown steaming to the base point of the next standard line (123°E). Except for this steaming, no problem was appeared for the setting rule of the track line was used in this cruise. In this zone, we changed the advanced distance from 100 to 130 n.miles, because of no expended time for the whale sampling.

The fleet reached to 130°E of the eastern boundary of this area at 16:20 on February 24, and finished the survey of the eastern south zone.

As a mean position of the base points in this zone was 65°29'S, it was shifted southward for 17 n.miles between in the first and second halves (Table 1). Mean distance between the expected and

true base points were 24.0 n.miles (range:9-71 n.miles).

Eastern middle zone

The main course in this eastern middle zone was determined as a track line lined in order to following points; 60°21'S-130°E, 60°S-129°30'E, 65°01'S-122°E, 60°S-114°30'E, 64°59'S-107°E and 60°22'S-100°E.

The fleet reached the starting point at evening on February 25. During the period between February 26 and 28, the fleet spent for only drifting because of having rough weather condition. At 09:00 on the March 1, the weather condition was recovered, and the fleet was resumed the searching at 63°32'S-124°21'E with dir.215°.

NO3 cruised together with three sighting vessels after the sampling activities finished. For economical reasons as reduced a charterage of *NO3*, we decided that she would be backed to Tokyo Port until March 31. After the researcher shifted to *NO3* (March 2), sighting data was recorded by research technicians in each vessel. On March 6, *NO3* started to cruise from the research area to Japan. Three sighting vessels (*KO1*, *T25* and *T18*) continued the sighting survey after apart from *NO3*, and reached to 100°E at 15:45 on March 8. Then three sampling vessels begun to move for the starting point of the north zone.

75 primary sightings (137 ind.) and nine secondary sightings (18 ind.) were made in this zone.

North zone

As mentioned above section in 2.3.1, at the beginning of this survey, track line in this north zone was scheduled to be randomly chosen from lines along the longitude between 100°E to 115°E. This setting rule was planned on the assumption that the fleet movement. However, as the sampling activities in this cruise had been finished, we changed the setting rule. Three sampling vessels (*KO1*, *T25* and *T18*) were allocated on 60°S at 104°E, 108°E and 112°E, respectively, and the vessel begun the searching at the point with dir.360° to 55°S.

KO1, *T25* and *T18* started the searching in the north zone at 07:00 on March 9, at 12:20 on March 9, and at 6:35 on March 10, respectively. On March 9, it was conducted the sighting survey under the suitable weather condition. From afternoon on March 10, three vessels should be cruised northward with topdown steaming under the bad weather condition. The vessels reached to 55°S during on March 10 - 12, and we ended researches in the whole area. During the sighting survey, one minke whale was sighted as a primary sighting.

3 SIGHTING AND SAMPLING

3.1 Searching effort

As same as the previous feasibility studies, the present survey collected all items of sighting information which were currently required in the analyses of population size by IWC/SC. We used same data formats which have been adopted in the current IWC/IDCR southern minke whale sighting cruises.

The distribution of searching distance (n.miles) shown in Table 2, by one degree square in each half. A total searching distance of the fleet combined three sampling vessels was 17,094.4 n.miles comprising 728.9, 7,407.0 and 8,958.5 n.miles in the north, the middle and the south zone, respectively. The searching distances in the first half were 8,705.7 n.miles, and 317.0 n.miles longer than that in the second half (8,388.7 n.miles). The searching effort was allocated throughout all latitudes and longitudes in all research period, excepting the topdown steaming due to wrong weather condition and move along the ice-edge in 113°E and 116°E, and from 55°S to 57°S in the second half.

In the first half, the effort was 2,045.5 n.miles longer in the west side than that in the east side of the research area. Especially it was higher at 61°S and 64°S in the western and eastern zone, respectively (1,690.0 n.miles, 1,165.5 n.miles), where the ice edge located on, and 97°E on which the survey in the first north zone was conducted southward (633.1 n.miles).

In the second half, the efforts in the west side was 2,238.7 n.miles longer than that in the east side of the research area. The searching efforts were concentrated on 64°S (1,272.2 and 1,255.5 n.miles in the western and eastern zones, respectively).

3.2 Sighting

3.2.1 Species found

Table 3 indicates lists of whale species with their numbers of schools and individuals which were sighted during the present survey in each zone, with dividing by the type of sighting and the period. Five mysticeti-species and at least five odontoceti-species appeared during the whole period of the research.

Ordinal form minke whale was obviously the dominant species throughout three zones being 767 schools (1,978 individuals) of the primary sighting and 478 schools (1,400 individuals) of the secondary sighting in a total. Most of minke whales were sighted in the south zones. In the first half, the number of schools as the primary sighting was almost equal in both of eastern and western middle zones, while the number of schools in the south was higher in the eastern than that in the western zone. But in the second half, the numbers of minke whale schools were relatively higher in the eastern part of research zone than those in the western part in both of the middle and south zones. This difference discussed in later section.

Four dwarf form minke whales (four schools) were sighted as three primary sightings and one secondary sighting in the north and middle zone. This is described in the later section (3.4).

For larger whales, humpback whales (*Megaptera novaeangliae*) were sighted in all of the research area, especially numbers of whales were sighted in the middle zones as the primary (82 schools, 149 individuals) and secondary sightings (13 schools, 26 individuals). A total of 6 schools of fin whales (*Balaenoptera physalus*) were sighted in the middle and south zones and it was noted that six schools (12 ind.) were sighted at first half in the north zone. Five schools of blue whale (*B. musculus*) were sighted in the first

south zones. Three schools of right whale (*Balaena glacialis*) were sighted in the second middle zones.

Sperm whale (*Physeter catodon*) appeared in the middle and south zones, and mainly in the western zones being 175 schools (185 individuals) of the primary sighting. The most of them were obviously solitary bull. Ziphiids and killer whales (*Orcinus orca*) appeared through three zones and the periods, and were sighted a total of 316 and 73 schools (586 and 992 ind.) as the primary sightings, respectively. Several odontoceti-species including hourglass dolphin (*Lagenorhynchus cruciger*) and pilot whales were sighted in the middle and south zones.

3.2.2 Distribution and density of minke whale

Fig. 3 shows the spatial distribution of the minke whale sightings including both the primary and the secondary sightings.

Table 4 indicates density indices (DI; the number of schools per 100 n.miles searching) and mean school size of the minke whale primary sighting by one degree square in the each half (excluding four dwarf forms).

Higher density indices (DI) were found in a southern and eastern parts of the research area, especially in the second half (6.25 as the whole of the first eastern zone; 7.84 as those of the second eastern). Relatively higher concentrations in the first half appeared at 100°E-104°E in the south zone (DI: 11.59-57.14). In the second half, it was appeared at 100°E-108°E in the middle and south zone (DI: 3.03-125.00), 119°E in the south zone (DI: 68.29) and 76°E in eastern part of the Prydz Bay (DI: 31.88). It was further noted that the relatively higher density of whales was scattered in the middle zone throughout the research period.

3.2.3 Sighting experiment

Experiments about the sighting distances and angles estimations were carried out in each sampling vessel during mid-cruise on February 2 and 17, under the relatively good weather condition (Beaufort wind class 2-3) with the visibility of which minke whale could be found from two to four n.miles apart. As the previous two seasons, we adopted the similar manner to that in IWC/IDCR southern hemisphere minke whale assessment cruises using radio reflector was equipped with the artificial subject which shaped as whales blow. All top man (6 persons) and other personnel who had a chances to engage in the searching had participated this experiment.

A total of 232 experiments combined three sampling vessels were made by a total of 29 testee from their normal place at which they engaged in the searching. The result of this experiment will be reported in the separate paper.

3.2.4 Natural marking

For studies on the natural marking of whales, if we sighted for the schools of humpback, blue and right whales, we tried to approach and take a photograph of these whales without the type of sighting.

In a total of 126 primary and 30 secondary sightings of humpback whales, we tried to approach to the schools for 89 schools

(153 ind.), and could successfully taken a photograph for 65 schools (118 ind.). Six schools (nine ind.) of blue whales were sighted as the primary and secondary sightings, and we approached to four schools (seven ind.), and could taken a photograph for all schools approached (seven ind.). And One school of right whale (one ind.) was taken a photograph.

These photograph will be used for natural marking studies in the feature.

3.3 Sampling

3.3.1 Distribution of samples taken

A total of 330 individuals of minke whale comprising 327 ordinal and three dwarf forms were taken during from the beginning of the survey to the mid-period of the western middle zone survey at second half. Fig. 4 shows the spatial distribution of those animals by sighted position, in each half with different two symbols.

The numbers of samples in each zone were: 4, 41 and 81 for the western part of the north, middle and south zone in the first half; 34 and 72 for the eastern part of the middle and south zone in the first half; 25, 49 and 23 for the middle and south zone, and in the Prydz Bay in the second half.

As a mentioned above section 2.4.1, while we tried the controlling of the samplings for the samples scattered in the whole research area after on January 2, the samplings from the primary minke whale sightings were ended on February 14 in the second western middle zone for the sampling limitation, and samples from the eastern parts of the research area at the second half could not been taken.

Samples tend to be distributed in scattering in the research area where the sampling activity was conducted, without that concentrated in near ice edge as we planned. With reflection of sighting distribution shown in Fig. 3, several concentrations of samples could be observed around the ice edge line as in middle part of the first western south zone (84°E-86°E).

Table 5 indicates the proportion of samples to whales sighted as the primary sighting by latitudes. In this cruise samples were dispersed to the whole of research area with regardless of the abundance of whale. This proportion was relatively higher in 59°S-62°S in the first western zone, 60°S-61°S in the second western, and 61°S-62°S in the first eastern zone.

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

3.3.2 Sampling efficiency

Excluding three dwarf form minke whales, a total of 327 ordinal form minke whales were taken under the sampling scheme mentioned in section 2.3.3. Table 6 indicates the proportion of ordinal form samples taken to the primary sightings and to the sightings targeted in each zone with separately by the survey period. Targeted school for the sampling represents the primary sightings excluding

the primary ones which were nontarget ones for the controlling of the sampling as mentioned in above section 2.4. As in the previous two seasons, samples from a school were scheduled to be randomly taken up to two individuals (as maximum sample size from a school) with regardless of its size.

During the period of the sampling activity were carried out, 320 schools (477 ind.) were targeted from 541 primary sightings (1,084 ind.), and 327 individuals were taken from these targeted schools. The technical sampling efficiency (the proportions of samples taken to the targeted individuals, as defined by Kato *et al.* 1989) was 0.69 with 0.59-0.70 (range).

The true sampling efficiency (the proportion of samples to the primary sightings) was relatively high as being 0.53-0.58 in the first western middle and south zones which all primary sightings were targeted without the limited sampling on December 15. But the true efficiency in the first eastern and second western zones was low as being 0.19-0.35. In these area we tried to the controlling of the sampling. Throughout the surveys in all zones and periods, the true efficiency was only 17% to all whales as the primary sightings.

Table 7 indicates numbers of the primary sighting and the targeted school and sampling efficiencies with school size. The sampling status were classified into three cases as taken none, one and two individuals from a school. The technical efficiency was relatively low being as 0.65-0.67 in the schools of small sizes (school size 1 to 3), while it was increased with increasing school size from 0.80 to 1.00 in school size over 4. The true sampling efficiency was decreased with increasing school sizes. This decreasing was clearly due to sampling size limitation from a school among larger school sizes.

3.3.3 Cause of failure in the sampling

A total of 150 individuals were targeted, and not to be sampled. The causes of those failures by school size summarized in Table 8.

The major causes of the failure in solitary schools were by lost sight of the whale before whale was randomly chosen, and whale behavior such as long diving, fast swimming and quick mobile followed this. In the schools of size over 2, causes of unsampled animals which were primary targeted, were by the whale behavior and weather conditions, while the second targeted whale was not taken by lost of the whale as a result of most of the second whale separated from a school including the first target during the chasing the first, with regardless of the catch of first target.

3.4 Dwarf form minke whale

As previous two feasibility cruises, a total of four dwarf form minke whales were sighted as three primary sightings and ones secondary sighting in the north and eastern middle zones at first half, and three individuals were taken from all primary sightings. Their sighted positions were shown in Figs. 3 and 4, and the information of those animals was summarized in Table 9.

One school of this form was sighted at 55°59'S-97°17'E in the

first north zone, and three schools was sighted between latitudes of 60°09'S-61°30'S and longitudes of 114°52'E-128°06'E, as two primary and one secondary sightings.

By the ovary examination, two female dwarf form minkes (4.3m, 7.1m) were sexually immature and mature animals, and a mature female was pregnant having a foetus (115 cm, male). The reproductive status of a male (5.4m) having a heavier testis of 57g, taken from the middle zone, has not been examined.

The detailed analyses of dwarf form minke whales including six taken in the previous seasons in 1987/88 and 1988/89 seasons, will be reported somewhere in the near future.

4 BIOLOGICAL DATA AND SAMPLE COLLECTION

Biological data and sample collection was made on the deck of *NO3* for 329 whales except with a animal lost. Those animals comprised 185 males including one dwarf form and 144 females including two dwarf forms. The techniques or methods for the present biological survey were principally same as those in the previous season (Kato *et al.*, 1988, 1989b)

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 future.

5 OTHER SURVEYS

5.1 Mark recapture (Discovery tag)

No mark was recaptured throughout the present survey.

5.2 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. Ishikawa and Y. Yamamoto) during 79 days from December 12, 1989 to March 1, 1990. The survey was normally conducted after the ending of sighting and sampling surveys of the day. A total of 78 point was made for the surface and vertical temperature data. The analysis will be reported somewhere by the certain oceanographer.

5.3 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 57.0 hours comprising 23.0 hr., 29.0 hr. and 5.0 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.

5.4 Air and sea water samples for the chemical analysis

The samplings of air and sea water were made on *NO3* for the environmental study. Air and water samplers were set on the upper bridge and boat deck of *NO3*, respectively. Samplings were made during the round cruises.

During the round cruises, a total of 26 air and 26 sea water samples were taken. Those samples were scheduled to be used in the analyses by the Ehime University.

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/area group

6.1.1 Grouping of the samples

As mentioned above section in 2.3.1, the research area was latitudinally divided three strata; north, middle and south zones, and furthermore the middle and south zones were divided longitudinally divided into two parts. The south zone was defined as the region from ice edge to 45 n.miles away north. The research could been conducted within the 45 n.miles zone from ice edge as scheduled. Although the surveys in the middle and south zones were scheduled twice, we could not to conducted the sampling survey in the eastern half of the research area at second half because of the limitation of the sample size.

Through some considerations, we conventionally proposed the following seven time/area groups with the tentative naming for them as based on the research area (Fig. 5):

First western offshore group; 47 individuals taken from off the 45 n.miles zone from the ice edge in the western part of the research area at first half during December 6-29.

First western ice edge group; 78 individuals taken within the 45 n.miles zone from the ice edge in the western part of the area during December 10-28.

Eastern offshore group; 34 individuals taken from off the 45 n.miles zone from the ice edge in the eastern part of the area at first half during January 1-17.

Eastern ice edge group; 70 individuals taken within the 45 n.miles zone from the ice edge in the eastern part of the area during December 31-January 10.

Second western offshore group; 39 individuals taken from off the 45 n.miles zone from the ice edge in the western part of the research area at second half during January 25-February 13.

Second western ice edge group; 35 individuals taken within the 45 n.miles zone from the ice edge in the western part of the area during January 21-February 14.

Prydz Bay group; 23 individuals taken from latitudes between 66°S-69°S during February 3-6.

6.1.2 Sex ratio and reproductive status

The male sex ratios and reproductive structure indicates in Table 11 with dividing by the time/area group. The reproductive status for female was determined by examinations of ovary, uterus and mammary gland. While the reproductive status for male should be determined by the histological examination of testis and epididymis, preparation of testes and epididymides has not been completed by this time. So we tentatively used the traditional weight of testis for the determination of the sexual maturity. If whale have a testis 0.4kg or over in weight, this animal were classified as a sexually mature (Ohsumi, Masaki and Kawamura, 1970; Kato, 1986)

A total of 184 males was obtained throughout the present survey, and the proportion of males to the total samples (male sex ratio) was 0.564. This male sex ratio varied by the group. Its value was higher in the first western offshore ice edge groups (0.723-0.769), and considerably low in the eastern ice edge group and Prydz Bay groups (0.329-0.261).

Mature male was dominant as being 57.1-100% throughout the present survey. In the second western offshore group, immature male was to be relatively higher proportion as occupying 42.9%. In the first western groups, immature female was dominant as 61.5-72.2% in both of the offshore and ice edge. In contrast with that in the first western, immature female was almost even in the eastern and second western offshore groups, while mature female was dominant in the ice edges and Prydz Bay groups (61.1-82.4%). In the Prydz Bay group, mature animals were highly dominated as 100% for male and 88.2% for female, respectively, it was notable that there was no immature male and few immature females there.

It should to be also noted that a total three lactating/pregnant females which was not accompanied by the calf, appeared in the first western ice edge (two ind.) and Prydz Bay groups (one ind.).

6.1.3 Body length composition

Body length compositions with pooling each 20cm interval in each time/area group are given in Fig. 6, separately by sex. Mean body

lengths and their standard deviations by sex and group are given in Table 12.

The length compositions and mean body length were varied with the periods and areas. It was clear that the difference was found in male length between the second western offshore group and the other groups. In the former group, larger males than 8.0m were shown relatively lower proportions to the total, as indicated by mean length 7.3m. On the other hand, length compositions for the other groups were very close each other with mean lengths 8.1-8.5m.

The proportions of larger females than 8.0m were relatively lower in the first western (offshore and ice edge) and second western offshore groups, and mean body lengths of these were 7.3, 7.0 and 8.0m, respectively. In the Prydz Bay, there was no smaller males than 8.0m length, and mean length of those was larger than others (8.5m for male, and 9.0m for female).

If all groups were combined, the mean and mode of length for male were 8.1m and 8.4m, respectively, and it was significantly differed from that for female (8.2m and 8.8-9.0m). 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

Table 13 indicated compositions of reproductive status by school size in each group. The following trends was observed: In the first western groups, mature male was dominant regardless of school size (48.6-100%). Immature female and male were trend to be relatively higher proportion at solitary school (27.0-31.8% for female, 13.6-18.9% for male). In the eastern groups, the proportions of mature male in offshore group were higher throughout all school sizes without school size three (50.0-100%), and it was similar to those of groups above, while in ice edge group those of mature female was also relatively higher at school size two and over (37.5-50.0%). Relatively higher proportion of immature female was found in solitary school of the ice edge group (42.9%), and four immature males was found in school sizes smaller than three individuals.

At second half, relatively higher proportion of immature male to the total was found in the offshore solitary schools (42.1%), while only one immature male was appeared at the solitary class in the ice edge group. No obvious changes of structure with school size was appeared for female because of small sample sizes.

When all groups were combined, higher proportions of mature male were found throughout the all school sizes (38.9-62.5%), and no trends with school size was appeared. Immature animals were relatively higher proportions in the solitary schools in both of sexes (19.4% for male, 24.1% for female), and few immature animals were found in school size four and over. Relatively higher proportions of mature female were found in school size two and over (16.7-33.3%).

6.2.2 Body length composition

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

Fig. 7 shows body length compositions in each school size class with values of mean lengths and their standard deviations, separately by sex.

Mean body length in the solitary school was 7.6m and 7.4m for male and female, respectively, it was significantly differed from that of school size two and over (8.3-8.5m for male, 8.2-8.7m for female). In the solitary school, there was two mode of body length class in both of sexes. Modes of length frequencies in solitary school were 8.4 and 5.6m for male, and 9.4 and 5.6m for female, respectively, while there was one mode of length frequencies in larger school sizes (two and over), and few animals smaller than 7.0m occupied in the larger schools.

7 DISCUSSIONS

The present survey had lasted 97 days from December 6, 1989 to March 12, 1990 for Antarctic Area IV by three sampling vessels and one research base. The research area was latitudinally divided to north, middle and south zones, and for the middle and south zones, there were further longitudinally divided to eastern and western zones.

This section discussed major three points including the periodical changes of density and biological structure, full analyses and consideration is expected to be made in the future study.

7.1 Periodical changes of whale density and biological structure of minke whale.

The present survey was conducted twice for the middle and south zones as following order; western south, western middle, eastern south and eastern middle zones. Although all primary sightings of minke whales were targeted at the beginning of the survey, we tried to control the sample size in a day from the survey in the eastern south zone at the first half. While we tried to control the sampling, the sampling activities were finished on February 14 for the limitation of the sample size. By this reason, we could not take samples from the eastern parts of the research area at second half.

In this section, periodical changes of whale density and biological structure were chiefly discussed for the western zones.

Table 14 shows whale density indices (DI) and mean school sizes (MSS) in each research zone by separately two halves (data based on Table 2 and 4). The density index was higher in southern zone than in middle zone, and those in eastern zone was higher than that in western zone (DI:10.87-11.63). The whale densities in each zones were higher in the second half with exception of the eastern south zone. No changes of whale density were appeared in the eastern south zone between two halves (DI:11.63-10.87), while mean school size in this zone was higher in the second half than those in the first half as about 1.9 fold (MSS:2.69-5.04). In contrast with this zone, the mean school sizes in the middle zones were not changed

(2.22-1.83 for eastern, 1.51-1.00 for western). As a mentioned above section 3.2.2, it should be noted that relatively higher density area was scattered in the middle zone. Comparing with the previous feasibility study in 1987/88 which was conducted in a part of Area IV (105°E-115°E)(Kato *et al.*, 1988), it was shown that the whale density and mean school size in the second eastern south zone of the present cruise were similar to those of area between 63°S-65°S in the second period (February 6 - March 1) of the previous study (DI:20.57, MSS:3.90), which was almost same area and period to this cruise.

Biological structure was also changed with these changes of the whale density and mean school size. In the first half, no regional changes on biological structure between the western offshore and ice edge groups, and it was characterized dominated mature males and immature females, and few mature females (see Table 11 and Fig. 6). In the second half, it was characterized that immature animals in the offshore group and mature animals in the ice edge group, especially in the Prydz Bay group which the proportion of immature animals to the total was only 8.7% (2 ind.). All mature females in the ice edge group were pregnant. These regional changes of biological structure in the second half were similar that those of offshore groups (*NG*, *COG* and *EOG*) and ice edge groups (*WIG* and *EIG*) in the previous feasibility study (Kato *et al.*, 1988). In previous survey, however, few pregnant females appeared in the offshore groups, and these animals were concentrated near ice edge zone. In the present survey, throughout the period of sampling activities, several mature females were found in the offshore regions. This would be suggested that the samples in the present survey had been taken before the peak of southward migrating of minke whale. As mentioned above section 6.2.1, male mature was dominated throughout all school sizes in both of offshore and ice edge groups in the first half, while at the second half mature male was dominated in the school size 2 and over, and immature animals were relatively dominated in solitary school of the offshore group. No obvious changes of structure with school size was appeared for female in each zone and between two halves.

While whale density and mean school size were relatively higher in the second eastern zones, we could not take samples from this zone. Further samples from the second eastern zones, will be require for the future studies on the seasonal changes of biological structure.

7.2 Different feature of the samples from the commercial one

Fig. 8 shows length composition in the present survey with those by the commercial whaling in Area IV in 1986-87, and those of the previous feasibility study in 1987/88. Mean body length and standard deviations of these indicates in Table 15.

Mean body length in the present survey was 8.1m for male, 8.2m for female, respectively. Those values were significantly differed in both of sexes from those by commercial catches (8.5m for male, 9.0m for female; t-test, $p<0.001$). It was clear that no differences were observed between those of the present survey and the previous feasibility study in 1987/88 (Kato *et al.*, 1988). The difference

between the research and commercial were the relatively higher proportion of smaller whale to the total and higher standard deviation with wider ranges for both sexes in the research. The proportion of animals smaller than 7.0m to the total were 12.0% for male, 21.1% for female in the present survey, respectively.

7.3 Sampling biases

Table 16 shows the comparison of the mean estimated body lengths of the samples taken and those of whales targeted but lost in middle and south zones with separately school size classes (one, two and three or over). The estimation of length was carried out before taking or chasing by the sampling vessels. No difference was shown between the estimated body lengths of taken and untaken individuals targeted.

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Table 1. Latitudinal difference (n.miles) of the expected and true base points on standard lines in each half.

Western south zone

Standard line	First half			Second half		
	Expected base point	True base point	Distance (n.miles)	Expected base point	True base point	Distance (n.miles)
71°E	63°30'S	63°30'S	0	(66°00'S)	——	-
75°E	62°50'S	62°46'S	4	(66°00'S)	——	-
79°E	61°00'S	62°52'S	112	65°30'S	64°59'S	31
83°E	61°00'S	63°01'S	121	65°30'S	64°59'S	31
87°E	61°07'S	60°52'S	15	65°10'S	65°34'S	24
91°E	62°00'S	62°43'S	43	65°10'S	65°23'S	13
95°E	62°00'S	61°58'S	2	64°30'S	64°33'S	3
99°E	——	61°51'S	-	——	64°08'S	-
Mean	61°55'S	62°27'S	42	65°10'S	64°56'S	20

Eastern south zone

Standard line	First half			Second half		
	Expected base point	True base point	Distance (n.miles)	Expected base point	True base point	Distance (n.miles)
103°E	64°30'S	64°20'S	10	——	64°36'S	-
107°E	64°30'S	65°22'S	52	65°30'S	65°44'S	14
111°E	65°10'S	64°57'S	13	65°30'S	65°22'S	8
115°E	65°00'S	64°58'S	2	65°20'S	65°11'S	9
119°E	65°10'S	66°18'S	68	65°20'S	66°31'S	71
123°E	65°42'S	65°17'S	25	65°55'S	65°31'S	24
127°E	65°20'S	65°12'S	8	65°10'S	65°26'S	16
Mean	65°03'S	65°12'S	25	65°28'S	65°29'S	24

Table 2. Searching distances (n.miles) by one degree square, with combining the three sampling vessels in each half.

First half (6/DEC/'89 - 19/JAN/'90)

Latitude	Longitude																												Total
	70°E	71°E	72°E	73°E	74°E	75°E	76°E	77°E	78°E	79°E	80°E	81°E	82°E	83°E	84°E	85°E	86°E	87°E	88°E	89°S	90°E	91°E	92°E	93°E	94°E	95°E	96°E	97°E	98°E	99°E	
North zone																															
55°S																		9.3										109.5			117.8
56°S																												112.5			112.5
57°S																												110.0			110.0
58°S																												95.0			95.0
59°S																												97.6			97.6
Middle zone																															
58°S	47.5														60.5	113.5	115.0	97.0	18.5									23.0	79.5		554.5
59°S		13.5	68.0	45.0								73.0	100.0	11.0				1.0	43.5	25.5	65.5	6.0					9.0	3.0	1.5		470.5
60°S				44.5	32.5						30.0	127.5	49.0								38.5	66.0	11.5	41.5	89.5	53.5	8.0				652.0
61°S						29.5	103.5	29.0	16.0	37.5	9.5												10.5	47.5	14.5						298.0
62°S							4.5	6.5																							11.0
South zone																															
60°S										7.5			7.0	71.0	61.0	11.5	37.0	107.0	29.5	28.0	23.5	7.0									390.0
61°S									11.0	84.0	102.0	64.5	17.5	15.0				52.0	57.5	54.0	96.5	113.5	67.0	66.0	110.5	125.0	79.0	87.5	115.5	35.0	1402.0
62°S	10.5	32.5	57.0	44.0	97.5	91.5	70.3	75.5	101.5	19.7		25.0	30.0	42.0							7.0	59.5									980.2
63°S	60.0	37.5	37.7																												134.5
Total	198.0	133.5	162.0	133.5	198.0	121.0	178.3	111.0	128.5	177.7	130.0	211.5	212.5	139.5	174.5	126.5	135.5	259.3	112.5	186.0	199.0	282.0	155.5	170.0	164.0	133.0	97.5	633.1	196.5	95.0	5375.6

Latitude	Longitude																												Total
	100°E	101°E	102°E	103°E	104°E	105°E	106°E	107°E	108°E	109°E	110°E	111°E	112°E	113°E	114°E	115°E	116°E	117°E	118°E	119°E	120°E	121°E	122°E	123°E	124°E	125°E	126°E	127°E	128°E	129°E	
Middle zone																															
60°S	111.5	68.5												8.5	1.0	67.5	58.5												40.0	64.5	420.0
61°S		59.5	41.0									14.5	121.5	63.0			62.0	22.0									25.5	71.5	40.5		521.0
62°S				22.0	53.0	9.5						26.0	10.5						14.0	75.0	7.0					22.0	66.0	15.0				320.0
63°S					37.0	106.0	14.0		59.5	102.5	11.0									33.0	66.0	14.5		16.5	10.5						470.5
64°S								12.0	45.0													41.0	104.5	25.5	4.0						232.0
South zone																															
63°S	14.0	6.5	20.0	59.0	28.6																										128.1
64°S	31.5	41.0	37.5	2.0	7.0		31.0	58.0	51.0	16.5	20.0			3.5	49.5	38.5	69.5	69.0	37.5				21.0	68.5	43.5	2.0	32.5	78.5		17.5	933.5
65°S							12.0	40.5	7.0	5.0	4.0				3.5			12.5	52.0	115.5	18.5				13.0		4.0	4.0		3.5	295.0
66°S																			4.0	6.0											10.0
Total	157.0	175.5	98.5	83.0	125.6	115.5	117.0	110.5	162.5	124.0	35.0	40.5	132.0	72.0	54.0	106.0	190.0	103.5	107.5	229.5	91.5	95.5	125.5	110.5	71.5	24.0	129.0	169.0	90.5	35.5	3339.1

Table 2. (continued)

Second half (21/JAN - 12/MAR/'90)

Latitude	Longitude																												Total
	70°E	71°E	72°E	73°E	74°E	75°E	76°E	77°E	78°E	79°E	80°E	81°E	82°E	83°E	84°E	85°E	86°E	87°E	88°E	89°E	90°E	91°E	92°E	93°E	94°E	95°E	96°E	97°E	98°E	99°E	
Middle zone																															
60°S	112.5	19.0											1.0	4.0	52.0	91.0	17.5												14.5	44.5	355.0
61°S	19.5	107.0	52.5									63.0	109.0	17.0		13.5	68.5	6.5										10.0	4.0		480.5
62°S			49.0	56.5	12.0					16.5	12.5	46.5						4.5	79.0	48.0					18.0						342.5
63°S				14.5	45.0	80.5	7.0	6.5	64.0	77.0	15.0									45.0	3.5		29.0	109.0	46.0						542.0
64°S						31.0	75.5	73.0	34.5													5.5	42.0								259.5
South zone																															
63°S																								4.5	51.0	40.5	19.0	50.0	99.0	101.0	365.0
64°S							7.0	39.5	27.5	20.5	0.5	19.5	62.0	19.5		19.2	13.0	50.5	44.5	57.0	96.0	93.5	91.0	77.5	71.5	100.5	43.0	14.0	9.0	38.5	1013.7
65°S	92.5	110.5	91.0	62.5	122.0	175.0	93.0	38.5							49.5	48.0	20.0	90.5	25.0	8.0	26.5	43.0									1111.5
66°S	49.5	66.5	62.0	49.5	28.5	63.0	64.5	69.5	28.0																						481.0
67°S																															0.0
68°S	40.5	57.0	58.0	49.0	35.0	52.0	34.5	47.0																							364.0
Total	314.5	359.0	312.5	223.5	242.5	401.5	281.5	271.0	154.0	124.0	28.0	129.0	172.0	40.5	101.5	171.7	137.0	150.0	148.5	148.0	116.5	142.0	152.5	191.0	196.5	141.5	92.5	74.0	135.5	194.0	5313.7

Latitude	Longitude																												Total
	100°E	101°E	102°E	103°E	104°E	105°E	106°E	107°E	108°E	109°E	110°E	111°E	112°E	113°E	114°E	115°E	116°E	117°E	118°E	119°E	120°E	121°E	122°E	123°E	124°E	125°E	126°E	127°E	128°E	129°E	
North zone																															
55°S																															3.0
56°S																															3.0
57°S																															0.0
58°S									39.0				25.0																		64.0
59°S					37.0				46.0				59.0																		142.0
Middle zone																															
60°S	110.0	10.0																													120.0
61°S	23.5	108.0	5.0									53.5	99.0																		289.0
62°S			42.5	106.5	12.0							23.0	1.0																		185.0
63°S				32.5	115.0	45.0													6.0	27.5	50.0			56.0	25.0						357.0
64°S						4.5	50.5	73.5													75.0	123.5	113.5	72.5	2.0						515.0
65°S																						22.0	1.0								23.0
South zone																															
63°S	9.0	9.0	13.5	33.0																											59.5
64°S	14.0	41.5	64.0	56.5	26.5	40.5	10.0	14.3	9.5						41.0	58.5		10.5	6.0				19.5	63.5	2.5		50.5	93.0	48.5	21.5	740.5
65°S						28.0	92.5	39.0	28.0	10.0	1.0				8.0	15.0		26.5	49.5	10.0			2.0	4.0	5.0	23.0	37.5	43.0	25.0	38.5	537.5
66°S																			22.0	20.5											42.5
Total	155.5	167.5	125.0	228.5	140.5	118.0	143.0	126.5	122.5	30.0	1.0	76.5	184.0	1.0	49.0	73.5	0.0	37.0	93.5	58.0	125.0	145.5	136.0	134.0	34.5	23.0	98.0	136.0	73.5	60.0	3075.3

Table 3. Lists of number of sighting (no. individuals-no. schools) combined three sampling vessels by species, type of sighting in each zone with separately by two halves.

First Half (6/DEC/'89-19/JAN/'90)

Species	Western		Eastern		Total	
	primary	secondary	primary	secondary	primary	secondary
North zone						
Minke whale (ordinal)	3/3	—	—	—	3/3	—
Minke whale (dwarf)	1/1	—	—	—	1/1	—
Humpback whale	10/5	—	—	—	10/5	—
Fin whale	12/6	—	—	—	12/6	—
Ziphiids	23/10	—	—	—	23/10	—
Killer whale	2/1	—	—	—	2/1	—
Middle zone						
Minke whale (ordinal)	77/51	68/39	109/49	23/17	186/100	91/56
Minke whale (dwarf)	—	—	2/2	1/1	2/2	1/1
Humpback whale	44/25	6/3	35/20	2/1	79/45	8/4
Fin whale	2/2	2/1	1/1	—	3/3	2/1
Sperm whale	13/8	3/3	19/19	5/4	32/27	8/7
Ziphiids	82/39	12/5	21/15	2/1	103/54	14/6
Killer whale	170/7	—	—	10/1	170/7	10/1
Pilot whale	151/4	15/1	70/1	160/4	221/5	175/5
South zone						
Minke whale (ordinal)	140/88	44/38	428/159	258/104	568/247	302/142
Humpback whale	35/23	11/6	1/1	2/1	36/24	13/7
Blue whale	2/1	—	7/4	1/1	9/5	1/1
Sperm whale	42/40	51/43	9/8	2/2	51/48	53/45
Ziphiids	131/66	43/23	50/22	9/6	181/88	52/29
Killer whale	163/11	41/5	124/11	34/3	287/22	75/8
mbined						
Minke whale (ordinal)	220/142	112/77	537/208	281/121	757/350	393/198
Minke whale (dwarf)	1/1	—	2/2	1/1	3/3	1/1
Humpback whale	89/53	17/9	36/21	4/2	125/74	21/11
Fin whale	14/8	2/1	1/1	—	15/9	2/1
Blue whale	2/1	—	7/4	1/1	9/5	1/1
Sperm whale	55/48	54/46	28/27	7/6	83/75	61/52
Ziphiids	236/115	55/28	71/37	11/7	307/152	66/35
Killer whale	335/19	41/5	124/11	44/4	459/30	85/9
Pilot whale	151/4	15/1	70/1	160/4	221/5	175/5

Table 3. (continued)

Second Half (21/JAN-12/MAR/'90)

Species	Western		Eastern		Total	
	primary	secondary	primary	secondary	primary	secondary
North Zone						
Minke whale (ordinal)	—	—	1/1	—	1/1	—
Sperm whale	—	—	1/1	—	1/1	—
Pilot whale	—	—	—	40/1	—	40/1
Middle Zone						
Minke whale (ordinal)	75/57	20/17	137/75	19/10	212/132	39/27
Humpback whale	43/22	12/6	27/15	6/3	70/37	18/9
Fin whale	—	—	12/1	—	12/1	—
Right whale	1/1	2/1	1/1	—	2/2	2/1
Sperm whale	88/86	17/15	1/1	2/2	89/87	19/17
Ziphiids	55/37	4/4	84/46	1/1	139/83	5/5
Killer whale	54/9	10/1	66/4	3/1	120/13	13/2
Pilot whale	505/2	194/4	—	—	505/2	194/4
Hourglass dolphin	4/1	9/2	16/2	16/4	20/3	25/6
Unidentified dolphin	10/1	43/1	21/2	—	31/3	43/1
South Zone						
Minke whale (ordinal)	175/90	73/52	756/150	848/164	931/240	921/216
Humpback whale	18/11	4/2	3/2	15/8	21/13	19/10
Fin whale	5/1	—	—	—	5/1	—
Sperm whale	41/40	6/6	2/2	3/2	43/42	9/8
Ziphiids	69/45	15/9	67/34	27/6	136/79	42/15
Killer whale	94/11	115/5	232/11	115/2	326/22	230/7
Pilot whale	—	—	—	30/1	—	30/1
Hourglass dolphin	—	—	—	2/1	—	2/1
Unidentified dolphin	—	—	10/1	—	10/1	—
Prize Bay						
Minke whale (ordinal)	77/44	47/37			77/44	47/37
Humpback whale	3/2	—			3/2	—
Sperm whale	1/1	—			1/1	—
Ziphiids	4/2	—			4/2	—
Killer whale	87/8	48/5			87/8	48/5
Combined						
Minke whale (ordinal)	327/191	140/106	894/226	867/174	1221/417	1007/280
Humpback whale	64/35	16/8	30/17	21/11	94/52	37/19
Fin whale	5/1	—	12/1	—	17/2	—
Right whale	1/1	2/1	1/1	—	2/2	2/1
Sperm whale	130/127	23/21	4/4	5/4	134/131	28/25
Ziphiids	128/84	19/13	151/80	28/7	279/164	47/20
Killer whale	235/28	173/11	298/15	118/3	533/43	291/14
Pilot whale	505/2	194/4	—	70/2	505/2	264/6
Hourglass dolphin	4/1	9/2	16/2	18/5	20/3	27/7
Unidentified dolphin	10/1	43/1	31/3	—	41/4	43/1

Table 3. (continued)

Combined throughout the research period

Species	primary	secondary
Minke whale (ordinal)	1978/767	1400/478
Minke whale (dwarf)	3/3	1/1
Humpback whale	219/126	58/30
Fin whale	32/11	2/1
Blue whale	9/5	1/1
Right whale	2/2	2/1
Sperm whale	216/205	89/77
Ziphiids	586/316	113/55
Killer whale	992/73	376/23
Pilot whale	726/7	439/11
Hourglass dolphin	20/3	27/7
Unidentified dolphin	41/4	43/1

Table 4 Density indices (no. schools/100 searching miles) and mean school size by one degree square, with combining the three sampling vessels in each half.

First half (6/DEC/'89 - 19/JAN/'90)

Latitude	Longitude																															Total
	70°E	71°E	72°E	73°E	74°E	75°E	76°E	77°E	78°E	79°E	80°E	81°E	82°E	83°E	84°E	85°E	86°E	87°E	88°E	89°E	90°E	91°E	92°E	93°E	94°E	95°E	96°E	97°E	98°E	99°E	
North zone																																
55°S																		0.00										0.91			0.85
																		(0.00)										(1.00)			(1.00)
56°S																												0.00			0.00
																												(0.00)			(0.00)
57°S																												0.00			0.00
																												(0.00)			(0.00)
58°S																												1.18			1.18
																												(1.00)			(1.00)
59°S																												1.02			1.02
																												(1.00)			(1.00)
Middle zone																																
58°S	23.16													0.00	2.64	0.00	0.00	0.00										4.35	3.77		3.25
	(2.18)													(0.00)	(1.00)	(0.00)	(0.00)	(0.00)										(1.00)	(1.33)		(1.78)
59°S		0.00	2.94	0.00								2.74	0.00	9.09			0.00	0.00	0.00	0.00	0.00						0.00	12.50	133.33		1.70
		(0.00)	(1.00)	(0.00)								(1.00)	(0.00)	(1.00)			(0.00)	(0.00)	(0.00)	(0.00)	(0.00)						(0.00)	(1.00)	(1.50)		(1.13)
60°S				2.25	4.32					3.33	1.57	0.00								0.00	1.52	17.39	2.41	0.00	13.08	0.00						2.91
				(1.00)	1.50)					(1.00)	(1.50)	0.00)								(0.00)	(1.00)	1.50)	(1.00)	(0.00)	(1.86)	(0.00)						(1.53)
61°S						3.39	2.90	3.45	0.00	0.00	0.00											0.00	2.13	0.00								2.08
						(2.00)	(1.00)	(1.00)	(0.00)	(0.00)	(0.00)											(0.00)	(1.00)	(0.00)								(1.17)
62°S							0.00	0.00																							0.00
							(0.00)	(0.00)																							(0.00)
South zone																																
60°S										0.00			0.00	0.00	14.75	36.78	0.00	0.93	0.00	0.00	0.00	0.00										3.59
										(0.00)			(0.00)	(0.00)	(1.78)	(1.75)	(0.00)	(1.00)	(0.00)	(0.00)	(0.00)	(0.00)										(1.71)
61°S									0.00	0.00	0.00	3.10	0.00	0.00				3.85	0.00	5.56	0.00	4.41	1.49	3.03	0.90	6.40	2.56	1.14	0.87	0.00		2.00
									(0.00)	(0.00)	(0.00)	(2.50)	(0.00)	(0.00)				(1.00)	(0.00)	(1.00)	(0.00)	(1.00)	(1.00)	(2.00)	(2.00)	(1.25)	(1.00)	(1.00)	(1.00)	(0.00)		(1.29)
62°S	0.00	0.00	1.75	11.36	4.10	4.37	2.86	1.32	4.93	10.70		0.00	3.41	0.00							28.57	13.45										4.11
	(0.00)	(0.00)	(1.00)	(1.60)	(2.50)	(1.75)	(1.50)	(2.00)	(1.60)	(1.50)		(0.00)	(1.00)	(0.00)							(2.00)	(1.25)										(1.59)
63°S	1.67	4.57	10.81																													4.88
	(1.00)	(2.50)	(1.75)																													(2.33)
Total	6.06	3.00	4.32	4.49	4.21	4.13	2.81	1.80	3.85	1.69	0.87	1.89	1.41	0.50	6.88	3.16	0.00	1.31	0.00	1.61	1.51	7.43	1.93	1.18	4.88	6.02	2.38	0.70	3.05	0.08	2.64
	(2.33)	(2.50)	(1.43)	(1.50)	(2.00)	(1.80)	(1.20)	(1.50)	(1.60)	(1.33)	(1.50)	(1.75)	(1.00)	(1.00)	(1.58)	(1.75)	(0.00)	(1.00)	(0.00)	(1.00)	(1.67)	(1.20)	(1.00)	(2.00)	(1.98)	(1.25)	(1.00)	(1.00)	(1.33)	(0.00)	(1.55)

	Longitude																															Total
	100°E	101°E	102°E	103°E	104°E	105°E	106°E	107°E	108°E	109°E	110°E	111°E	112°E	113°E	114°E	115°E	116°E	117°E	118°E	119°E	120°E	121°E	122°E	123°E	124°E	125°E	126°E	127°E	128°E	129°E	
Middle zone																																
60°S	1.79	0.00												11.76	0.00	1.48	0.00												0.00	0.00	0.95
	(1.00)	(0.00)												(4.00)	(0.00)	(1.00)	(0.00)												(0.00)	(0.00)	(1.75)
61°S		1.48	0.00									13.79	0.82	0.00			1.61	0.00										0.00	0.00	0.00		0.96
		(1.00)	(0.00)									(2.00)	(5.00)	(0.00)			(1.00)	(0.00)										(0.00)	(0.00)	(0.00)		(2.20)
62°S				0.00	0.00	0.00						3.85	0.00						14.29	2.67	0.00						10.10	0.00	6.67			3.13
				(0.00)	(0.00)	(0.00)						(1.00)	(0.00)						(1.50)	(1.00)	(0.00)						(1.75)	(0.00)	(1.00)			(1.40)
63°S				2.70	2.83	7.14			5.04	11.71	0.00									3.03	7.58	0.00		0.00	9.52							5.74
				(1.00)	(1.67)	(2.00)			(2.33)	(3.50)	(0.00)									(1.00)	(2.60)	(0.00)		(0.00)	(1.00)							(2.67)
64°S								8.33	0.00													0.00	0.00	7.84	0.00							1.29
								(1.00)	(0.00)													(0.00)	(0.00)	(2.00)	(0.00)							(1.67)
South zone																																
63°S	57.14	15.38	25.00	11.59	32.26																											21.76
	(2.75)	(2.00)	(2.00)	(2.88)	(3.00)																											(2.70)
64°S	53.97	19.51	37.33	0.00	0.00		2.20	15.52	0.00	12.12	20.00			200.00	14.14	6.78	2.88	1.45	0.00				0.00	1.46	6.90	0.80	3.08	5.10		11.43	7.23
	(2.76)	(3.38)	(2.29)	(0.00)	(0.00)		(1.50)	(4.11)	(0.00)	(1.00)	(1.75)			(4.00)	(4.57)	(2.33)	(2.00)	(1.00)	(0.00)				(0.00)	(1.00)	(3.33)	(0.00)	(1.00)	(1.50)		(2.50)	(2.85)
65°S							16.67	9.88	0.00	60.00	75.00				114.29			0.00	7.69	14.72	0.00				0.00			100.00	50.00		28.57	14.92
							(2.00)	(2.25)	(0.00)	(2.33)	(1.33)				(4.50)			(0.00)	(2.00)	(2.53)	(0.00)				(0.00)			(4.00)	(2.00)		(2.00)	(2.61)
66°S																			0.00	50.00												30.00
																			(0.00)	(1.67)												(1.67)
Total	17.20	5.70	19.29	8.60	6.06	2.60	4.27	12.67	1.85	13.71	20.00	7.41	0.76	2.78	20.37	4.49	1.58	0.97	5.58	10.02	5.46	0.00	0.00	2.71	5.63	16.67	3.91	4.14	8.00	3.51	6.25
	(2.63)	(3.00)	(2.21)	(2.88)	(2.71)	(1.67)	(1.80)	(3.36)	(2.33)	(3.00)	(1.57)	(1.67)	(5.00)	(4.00)	(4.55)	(2.14)	(1.67)	(1.00)	(1.83)	(2.22)	(2.60)	(0.00)	(0.00)	(1.67)	(2.75)	(1.75)	(3.40)	(1.57)	(0.00)	(2.33)	(2.58)

Table 4 (continued)

Second half (21/JAN - 12/MAR/'90)

Latitude	Longitude																														Total
	70°E	71°E	72°E	73°E	74°E	75°E	76°E	77°E	78°E	79°E	80°E	81°E	82°E	83°E	84°E	85°E	86°E	87°E	88°E	89°E	90°E	91°E	92°E	93°E	94°E	95°E	96°E	97°E	98°E	99°E	
Middle zone																															
60°S	0.00	0.00											100.00	0.00	1.92	7.69	5.71												0.00	0.00	2.82
	(0.00)	(0.00)											(1.00)	(0.00)	(1.00)	(1.00)	(1.00)												(0.00)	(0.00)	(1.00)
61°S	0.00	0.00	0.00									3.17	2.75	5.88		0.00	1.46	15.38										0.00	0.00		1.66
	(0.00)	(0.00)	(0.00)									(1.00)	(1.00)	(1.00)		(0.00)	(1.00)	(2.00)										(0.00)	(0.00)		(1.13)
62°S			2.04	1.77	0.00					0.00	0.00	6.45						22.22	5.06	8.33					0.00						4.09
			(1.00)	(1.00)	(0.00)					(0.00)	(0.00)	(1.67)						(2.00)	(1.50)	(1.50)					(0.00)						(1.50)
63°S				6.90	4.44	0.00	0.00	0.00	3.13	0.00	0.00									6.67	0.00		0.00	6.42	2.17						2.95
				(1.00)	(1.50)	(0.00)	(0.00)	(0.00)	(1.50)	(0.00)	(0.00)									(1.00)	(0.00)		(0.00)	(1.57)	(4.00)						(1.56)
64°S						0.00	0.00	2.86	0.00													18.18	14.29								3.48
						(0.00)	(0.00)	(1.00)	(0.00)													(2.00)	(1.00)								(1.11)
South zone																															
63°S																								0.00	0.00	0.00	5.26	4.00	1.01	1.98	1.64
																								(0.00)	(0.00)	(0.00)	(1.00)	(1.00)	(2.00)	(4.50)	(2.33)
64°S							14.29	7.59	0.00	0.00	0.00	5.13	1.61	5.13		0.00	0.00	5.94	4.49	1.49	1.16	2.14	3.70	5.16	1.40	3.98	2.33	0.00	12.50	5.19	3.16
							(1.00)	(2.67)	(0.00)	(0.00)	(0.00)	(3.00)	(1.00)	(1.00)		(0.00)	(0.00)	(2.33)	(1.00)	(1.00)	(1.00)	(1.50)	(2.00)	(1.50)	(3.00)	(1.50)	(2.00)	(0.00)	(3.00)	(2.00)	(1.81)
65°S	4.32	5.43	0.00	1.60	2.46	4.00	2.15	0.00							0.08	2.08	10.53	8.12	16.00	25.00	7.55	6.98	0.00								4.68
	(1.75)	(2.00)	(0.00)	(1.00)	(2.33)	(2.00)	(2.50)	(0.00)							(1.25)	(2.00)	(3.50)	(2.63)	(1.00)	(1.00)	(1.50)	(1.67)	(1.00)								(1.90)
66°S	6.06	1.50	4.84	2.02	7.02	3.17	0.00	4.32	0.00																						3.12
	(1.33)	(2.00)	(3.67)	(2.00)	(4.00)	(2.50)	(0.00)	(2.00)	(0.00)																						(0.00)
67°S																															0.00
																															(0.00)
68°S	2.47	3.51	3.45	2.50	8.57	7.69	31.88	10.64																							7.97
	(2.00)	(1.00)	(1.00)	(2.00)	(1.00)	(1.25)	(1.45)	(1.40)																							(1.34)
Total	2.54	2.51	1.92	2.24	4.12	3.24	4.97	4.80	1.30	0.00	0.00	4.65	2.91	4.94	4.93	4.66	4.38	8.13	6.73	5.95	2.59	4.23	6.58	5.76	1.07	2.84	3.23	2.78	1.59	2.17	3.59
	(1.63)	(1.78)	(2.33)	(1.40)	(2.10)	(1.95)	(1.57)	(1.77)	(1.50)	(0.00)	(0.00)	(1.67)	(1.00)	(1.00)	(1.20)	(1.13)	(2.67)	(2.46)	(1.20)	(1.20)	(1.33)	(1.67)	(1.30)	(1.55)	(3.50)	(1.50)	(1.50)	(1.00)	(2.50)	(3.25)	(1.51)

Latitude	Longitude																														Total
	100°E	101°E	102°E	103°E	104°E	105°E	106°E	107°E	108°E	109°E	110°E	111°E	112°E	113°E	114°E	115°E	116°E	117°E	118°E	119°E	120°E	121°E	122°E	123°E	124°E	125°E	126°E	127°E	128°E	129°E	
North zone																															
55°S					0.00				0.00				0.00																		0.00
					(0.00)				(0.00)				(0.00)																		(0.00)
56°S					0.00				0.00				0.00																		0.00
					(0.00)				(0.00)				(0.00)																		(0.00)
57°S					0.00				0.00				0.00																		0.00
					(0.00)				(0.00)				(0.00)																		(0.00)
58°S					0.00				0.00				0.00																		0.00
					(0.00)				(0.00)				(0.00)																		(0.00)
59°S					2.70				0.00				0.00																		0.00
					(1.00)				(0.00)				(0.00)																		(0.00)
Middle zone																															
60°S	0.00	0.00																													0.00
	(0.00)	(0.00)																													(0.00)
61°S	4.26	3.70	0.00									3.74	4.04																		3.81
	(1.00)	(1.50)	(0.00)									(2.00)	(1.00)																		(1.36)
62°S			0.00	1.88	8.33							0.00	0.00																		1.62
			(0.00)	(1.00)	(1.00)							(0.00)	(0.00)																		(1.00)
63°S				3.08	9.57	20.00													16.67	3.64	0.00			3.57	0.00						7.00
				(2.00)	(1.27)	(2.44)													(5.00)	(1.00)	(0.00)			(1.50)	(0.00)						(1.88)
64°S						66.67	7.92	17.69													0.00	3.24	3.52	8.28	50.00						6.80
						(2.00)	(2.50)	(1.92)													(0.00)	1.00)	(2.75)	(1.50)	(1.00)						(1.89)
65°S																						4.55	0.00								4.35
																						(6.00)	(0.00)								(6.00)
South zone																															
63°S	125.00	50.00	19.05	3.03																											28.57
	(5.00)	(2.50)	(1.00)	(2.00)																											3.76)
64°S	7.14	19.28	17.19	14.16	7.84	12.35	10.00	0.00	0.00						0.00	1.71		0.00	0.00				0.00	0.00	0.00		3.96	6.45	2.06	4.65	6.89
	(2.00)	(1.13)	(1.64)	(3.25)	(3.50)	(1.80)	(1.00)	(0.00)	(0.00)						(0.00)	(1.00)		(0.00)	(0.00)				(0.00)	(0.00)	(0.00)		(1.00)	(3.17)	(0.00)	(1.00)	(2.29)
65°S						10.00	7.27	28.09	35.71	3.33	0.00				0.00	6.67		11.32	12.12	0.00			0.00	0.00	0.00	26.09	5.33	2.33	0.00	5.19	12.09
						(1.00)	(2.17)	(4.16)	(4.40)	(2.00)	(0.00)				(0.00)	(2.00)		(4.00)	(16.67)	(0.00)			(0.00)	(0.00)	(0.00)	(1.33)	(2.00)	(3.00)	(0.00)	(2.00)	(4.50)
66°S																			13.64	68.29											40.00
																			(16.67)	(16.21)											(0.00)
Total	7.72	9.55	10.66	5.25	8.95	17.27	7.69	21.53	27.40	3.33	0.00	2.61	4.00	0.00	0.00	2.72	0.00	8.11	11.98	25.86	0.00	3.44	2.94	4.08	2.90	26.09	4.55	5.15	1.36	5.00	7.84
	(4.42)	(1.56)	(1.54)	(2.67)	(2.00)	(2.05)	(2.18)	(3.39)	(4.40)	(2.00)	(0.00)	(2.00)	(1.00)	(0.00)	(0.00)	(1.50)	(0.00)	(4.00)	(15.50)	(15.20)	(0.00)	(2.00)	(2.75)	(1.50)	(1.00)	(1.33)	(1.50)	(3.14)	(0.00)	(1.67)	(2.74)

Table 5. Number of individuals sighted as primary sighting and taken by latitude in each half with separately by the western and eastern zones, excluding dwarf form minke whales.

Latitude (°S)	The first half (6/DEC/'89-19/JAN/'90)			The second half (21/JAN-12/MAR/'90)		
	Sighted ind. (A)	Samples taken (B)	Ratio (B/A)	Sighted ind. (A)	Samples taken (B)	Ratio (B/A)
Western zones (70°E-100°E)						
55	1	1	1.00	—	—	——
56	0	0	0.00	—	—	——
57	0	0	0.00	—	—	——
58	33	15	0.45	—	—	——
59	10	7	0.70	—	—	——
60	53	35	0.66	10	5	0.50
61	43	22	0.51	9	7	0.78
62	59	39	0.66	21	7	0.33
63	21	6	0.29	39	8	0.21
64	—	—	——	68	24	0.35
65	—	—	——	103	24	0.23
66	—	—	——	38	11	0.29
67	—	—	——	0	0	0.00
68	—	—	——	39	12	0.31
Eastern zones (100°E-130°E)						
60	7	2	0.29	0	—	——
61	11	5	0.45	15	—	——
62	14	7	0.50	3	—	——
63	147	36	0.24	111	—	——
64	238	28	0.12	183	—	——
65	115	23	0.20	304	—	——
66	5	3	0.60	277	—	——

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

	The first half (6/DEC/'89-19/JAN/'90)					The second half (21/JAN - 9/MAR/'90)					Whole period (12/JAN - 31/MAR/'90)				
	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	3 - 3	3 - 3	3	1.00	1.00	1 - 1	———	–	——	——	4 - 4	3 - 3	3	1.00	0.75
Middle															
western	51 - 77	51 - 69	41	0.59	0.53	57 - 75	30 - 37	26	0.70	0.35	108 - 152	81 - 106	67	0.63	0.44
eastern	49 - 109	32 - 48	32	0.67	0.29	75 - 137	———	–	——	——	124 - 246	32 - 48	32	0.67	0.13
combined	100 - 186	83 - 117	73	0.62	0.39	132 - 212	30 - 37	26	0.70	0.12	232 - 398	113 - 154	99	0.64	0.25
South															
western	88 - 140	88 - 125	81	0.65	0.58	134 - 252	56 - 91	72	0.79	0.29	222 - 392	144 - 216	153	0.71	0.39
eastern	139 - 378	60 - 104	72	0.69	0.19	150 - 756	———	–	——	——	289 -1134	60 - 104	72	0.69	0.06
combined	227 - 518	148 - 229	153	0.67	0.30	284 -1008	56 - 91	72	0.79	0.07	511 -1526	204 - 320	225	0.70	0.15
Total	330 - 707	234 - 349	229	0.66	0.32	417 -1221	86 - 128	98	0.77	0.08	747 -1928	320 - 477	327	0.69	0.17

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 and over.

Table 7. Sampling efficiencies to number of primary sighting and to number of whales targeted by school size, excluding dwarf form minke whale.

School size (A)	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	274	163	163	54	109	-	0.67	0.40	1.00
2	137	81	162	11	34	36	0.65	0.39	1.00
3	69	50	100	6	21	23	0.67	0.32	0.67
4	28	15	30	2	2	11	0.80	0.21	0.50
5	15	6	12	-	1	5	0.92	0.15	0.40
6	9	3	6	-	-	3	1.00	0.11	0.33
7	2	1	2	-	-	1	1.00	0.14	0.29
> 8	7	1	2	-	-	1	1.00	0.03	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.

	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	identi-fication	others	unknown	Total
No sample obtained	1	3	10	4	12	3	1	2	19	–	–	54
	2	3	4	1	3	–	4	1	3	1	1	22
	3	–	2	–	–	2	2	1	3	1	–	12
	4	–	–	1	–	2	–	–	1	–	–	4
	Total	6	16	6	15	7	7	4	26	2	1	92
Only one sample obtained	2	–	2	2	4	1	4	–	19	2	–	34
	3	1	2	1	2	2	2	–	11	–	–	21
	4	–	–	–	–	–	–	–	2	–	–	2
	5	–	–	–	–	–	1	–	–	–	–	1
	7	–	–	–	–	–	–	–	–	–	–	0
	Total	1	4	3	6	3	7	–	32	2	–	58

Table 9. Information of dwarf form minke whales taken during the present survey.

Sample no.	Date	Position sighted	School size	Position taken	B.L. (m)	Sex	Reproductive information	
2	6.Dec.'89	55°59'S 97°17'E	1	55°59'S 97°18'E	4.3	F	immature	
199	12.Jan.'90	61°30'S 128°06'E	1	61°36'S 128°19'E	5.4	M	(under the examination)	testis weight; 57g, 53g
215	15.Jan.'90	60°59'S 116°06'E	1	60°58'S 116°06'E	7.1	F	pregnant,	Foetus; 115cm, male

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	185	144	329
External body proportion	185	144	329
Photographic records of external character	185	144	329
Diatom film record and sampling	185	144	329
Standard measurements of blubber thickness (Three point on each whale)	185	144	329
Body weight	185	144	329
Body weight by parts and detailed measurements of blubber thickness	32	27	59
Earplug for age determination**)	185	144	329
Tympanic bulla for age determination	179	135	314
Largest baleen plate for age determination	42	55	97
Vertebral epiphyses sample	181	138	319
Skull measurement (length and breadth)	183	143	326
Mammary grand; lactation status, measurements and histology sample	—	144	144
Milk sample for chemical analysis	—	3	3
Ovary collection	—	144	144
Corpora number, counting	—	144	144
Uterine horn; measurement and endometrium sample	—	144	144
Uterine fluid for sperm detection	—	140	140
Foetal number	—	82	82
(Foetal length	49	32	81)
(Foetal sex	49	32	81)
(Foetal weight	49	32	81)
(Foetus body proportion	39	31	70)
Collection of foetus	—	15	15
Testis and epididymis weight and tissue collection	185	—	185
Smear sample from testis and epididymis tissues	185	—	185
Blood sample for gonadal hormone assay	183	137	320
Tissue sample for hormone assay	—	60	60
Muscle, liver and heart samples for electrophoretic study	185	144	329
Foetus samples for electrophoretic study	—	65	65
Skin, muscle and kidney samples for DNA study	185	144	329
Foetus samples for DNA study	—	65	65
Tissue samples for heavy metal analyses	135	112	247
Tissue samples for organochlorine analyses	135	110	245
Stomach content, conventional record	185	144	329
Stomach content weight	182	140	322
Collection of stomach contents for the food and feeding study	34	22	56
Collection of intestine contents for the food and feeding study	1	1	2
Tissue samples of various parts the body for the lipid analyses	32	26	58
Stomach contents for the lipid analyses	4	2	6
Collection of whole skeleton	3	5	8
Checking external parasite including its sampling	71	48	119
Sampling of parasite in viscera	4	4	8

*) including three individuals of dwarf form.

**) principally both earplugs were collected from both side and were preserved in formalin solution, while six earplugs of one of the pair were freezed for the chemical analysis.

Table 11. Male sex ratio and biological structure of minke whales taken in the present survey by time/area group (excluding dwarf forms).

Time/area group	Male			Female							Male sex ratio
	Imm.	Mat.	Total	Imm.	Mat.					Total	
					Preg.	P&L	Lact.	Ovu.	Rest.		
First western offshore	3 (8.8)	31 (91.2)	34	8 (61.5)	5 (38.5)	-	-	-	-	13	0.723
First western ice edge	8 (13.3)	52 (86.7)	60	13 (72.2)	3 (16.7)	2 (11.1)	-	-	-	18	0.769
Eastern offshore	3 (13.0)	20 (87.0)	23	5 (45.5)	6 (54.5)	-	-	-	-	11	0.676
Eastern ice edge	1 (4.3)	22 (95.7)	23	13 (27.7)	32 (68.1)	-	-	2 (4.3)	-	47	0.329
Second western offshore	9 (42.9)	12 (57.1)	21	9 (50.0)	6 (33.3)	-	-	1 (5.6)	2 (11.1)	18	0.538
Second western ice edge	1 (5.9)	16 (94.1)	17	7 (38.9)	11 (61.1)	-	-	-	-	18	0.486
Prydz Bay	-	6 (100)	6	2 (11.8)	14 (82.4)	1 (5.9)	-	-	-	17	0.261
Total	25 (13.6)	159 (86.4)	184	57 (40.1)	77 (54.2)	3 (2.1)	0	3 (2.1)	2 (1.4)	142	0.564

Table 12. Mean body length (m) and its standard deviation of samples by sex and the time/area group.

Time/area group	Male			Female		
	Mean (S.D.)	Range	n	Mean (S.D.)	Range	n
First western offshore	8.2 (0.72)	5.8-9.0	34	7.3 (1.36)	5.5-9.7	13
First western ice edge	8.1 (0.83)	5.4-9.0	60	7.0 (1.26)	4.8-9.2	18
Eastern offshore	8.4 (0.54)	6.4-9.0	23	8.3 (1.00)	6.7- 9.8	11
Eastern ice edge	8.1 (0.64)	5.5-8.8	23	8.5 (0.85)	5.4-10.1	47
Second western offshore	7.3 (1.37)	5.2-9.4	21	8.0 (1.27)	5.4- 9.6	18
Second westrn ice edge	8.2 (0.43)	7.4-9.3	17	8.2 (0.86)	6.3- 9.6	18
Prydz Bay	8.5 (0.38)	8.0-9.0	6	9.0 (0.69)	6.9- 9.9	17
Combined	8.1 (0.86)	5.2-9.4	184	8.2 (1.19)	4.8-10.1	142

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

Time/area group	School size	Male				Female						Total	Male sex ratio
		Imm.		Mat.		Imm.		Preg.		Other Mat.			
First western offshore	1	3	(13.6)	10	(45.5)	7	(31.8)	2	(9.1)	-		22	0.59
	2	-		12	(75.0)	1	(6.3)	3	(18.8)	-		16	0.75
	3	-		5	(100.0)	-		-		-		5	1.00
	4	-		4	(100.0)	-		-		-		4	1.00
First western ice edge	1	7	(18.9)	18	(48.6)	10	(27.0)	2	(5.4)	-		37	0.68
	2	1	(3.6)	22	(78.6)	2	(7.1)	1	(3.6)	2	(7.1)	28	0.82
	3	-		12	(92.3)	1	(7.7)	-		-		13	0.92
Eastern offshore	1	1	(12.5)	6	(75.0)	-		1	(12.5)	-		8	0.88
	2	1	(10.0)	5	(50.0)	2	(20.0)	2	(20.0)	-		10	0.60
	3	1	(12.5)	3	(37.5)	2	(25.0)	2	(25.0)	-		8	0.50
	4	-		2	(50.0)	1	(25.0)	1	(25.0)	-		4	0.50
	>=5	-		4	(100.0)	-		-		-		4	1.00
Eastern ice edge	1	1	(14.3)	-		3	(42.9)	2	(28.6)	1	(14.3)	7	0.14
	2	-		7	(35.0)	2	(10.0)	10	(50.0)	1	(5.0)	20	0.35
	3	-		8	(33.3)	5	(20.8)	11	(45.8)	-		24	0.33
	4	-		4	(50.0)	1	(12.5)	3	(37.5)	-		8	0.50
	>=5	-		3	(27.3)	2	(18.2)	6	(54.5)	-		11	0.27
Second western offshore	1	8	(42.1)	3	(15.8)	4	(21.1)	2	(10.5)	2	(10.5)	19	0.58
	2	1	(7.1)	6	(42.9)	3	(21.4)	4	(28.6)	-		14	0.50
	3	-		3	(75.0)	-		-		1	(25.0)	4	0.75
	4	-		-		2	(100.0)	-		-		2	0.00
Second western ice edge	1	1	(11.1)	5	(55.6)	2	(22.2)	1	(11.1)	-		9	0.67
	2	-		1	(10.0)	2	(20.0)	7	(70.0)	-		10	0.10
	3	-		4	(50.0)	1	(12.5)	3	(37.5)	-		8	0.50
	4	-		4	(100.0)	-		-		-		4	1.00
	>=5	-		2	(50.0)	2	(50.0)	-		-		4	0.50
Prize Bay	1	-		-		-		6	(100.0)	-		6	0.00
	2	-		2	(25.0)	-		5	(62.5)	1	(12.5)	8	0.25
	3	-		2	(40.0)	1	(20.0)	2	(40.0)	-		5	0.40
	4	-		1	(50.0)	1	(50.0)	-		-		2	0.50
	5	-		1	(50.0)	-		1	(50.0)	-		2	0.50
Combined	1	21	(19.4)	42	(38.9)	26	(24.1)	16	(14.8)	3	(2.8)	108	0.58
	2	3	(2.8)	55	(51.9)	12	(11.3)	32	(30.2)	4	(3.8)	106	0.55
	3	1	(1.5)	37	(55.2)	10	(14.9)	18	(26.9)	1	(1.5)	67	0.57
	4	-		15	(62.5)	5	(20.8)	4	(16.7)	-		24	0.63
	>=5	-		10	(47.6)	4	(19.0)	7	(33.3)	-		21	0.48
	Total	25	(7.7)	159	(48.8)	57	(17.5)	77	(23.6)	8	(2.5)	326	0.56

Table 14. Density indices (no. schools/100 searching miles) and mean school size by each zone in separately two halves.

Area	First half			Second half		
	Density index (DI)	Mean school size (MSS)	(DI)*(MSS)	Density index (DI)	Mean school size (MSS)	(DI)*(MSS)
Western						
North	0.57	1.00	0.57	—	—	—
Middle (M)	2.58	1.51	3.90	2.88	1.00	3.79
South (S)	3.06	1.59	4.87	3.60	1.94	6.98
Prydz Bay (P)	—	—	—	5.25	1.75	9.19
M + S + P	2.86	1.56	4.47	3.59	1.71	6.15
Eastern						
North	—	—	—	0.49	1.32	0.49
Middle (M)	2.50	2.22	5.55	5.04	1.83	9.20
South (S)	11.63	2.69	31.32	10.87	5.04	54.78
M + S	6.25	2.58	16.13	7.84	3.97	31.13

Table 15. Comparison of mean body length between samples by the present and previous surveys, and the Japanese commercial whaling in Area IV.

Sex	Samples	Mean	SD	Range (min.- max.)	n	Difference to the present study		
						df	t-value	p
Male	present survey	8.09	0.862	5.2 - 9.4	184	—	—	—
	previous survey[1)]	7.98	0.926	5.2 - 9.3	153	335.0	1.109	$0.2<p<0.3$ *
	commercial whaling[2)]	8.52	0.337	7.2 - 9.2	193	235.6	6.361	$p<0.001$ **
Female	present survey	8.15	1.20	4.8 -10.1	142	—	—	—
	previous survey[1)]	7.93	1.18	5.4 - 9.9	119	259.0	1.506	$0.1<p<0.2$ *
	commercial whaling[2)]	8.99	0.436	7.3 -10.3	321	157.8	8.099	$p<0.001$ **

1) the previous research cruise in 1987/88 (Kato et al. 1988)
2) commercial whaling in 1986/87
* ordinary t-test
** Welch's t-test

Table 16. Comparison of estimated body lengths which were made before chasing between of whales taken and lost by school size with separately two research zones.

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[1)]			
1	7.4	(1.32)	4.0-10.0	46	8.0	(0.53)	6.7-8.6	12	45.62	2.516[2)]	0.01<p<0.02
2	8.1	(0.50)	6.2-8.7	31	8.2	(0.45)	6.5-8.7	21	50.00	0.802[3)]	0.4<p<0.5
>=3	8.4	(0.23)	8.2-8.7	10	8.3	(0.47)	7.5-8.7	5	4.44	0.464[2)]	0.6<p<0.7
Total	7.8	(1.03)	4.0-10.0	99	8.1	(0.48)	6.5-8.7	38	130.67	2.405[2)]	0.01<p<0.02

South zone

School size	Estimated length (m) at sea								df	t-value	p
	Taken				Lost						
	Mean	(S.D.)	Range	n	Mean	(S.D.)	Range	n[1)]			
1	7.6	(0.85)	5.3-8.6	54	7.5	(0.95)	5.0-8.6	20	30.77	0.564[2)]	0.5<p<0.6
2	8.0	(0.55)	6.3-8.9	67	8.1	(0.54)	6.0-8.6	31	96.00	0.478[3)]	0.6<p<0.7
3	8.2	(0.32)	6.8-8.7	52	8.2	(0.28)	7.6-8.5	12	62.00	0.417[3)]	0.6<p<0.7
>=4	8.3	(0.38)	7.0-8.7	29	8.6	(0.27)	8.4-8.9	3	30.00	1.491[3)]	0.1<p<0.2
Total	8.0	(0.64)	5.3-8.9	202	7.9	(0.73)	5.0-8.9	66	99.65	0.651[2)]	0.5<p<0.6

1): Data presents for only chased animals among the targeted.
2): Welch's t-test
3): Ordinary t-test

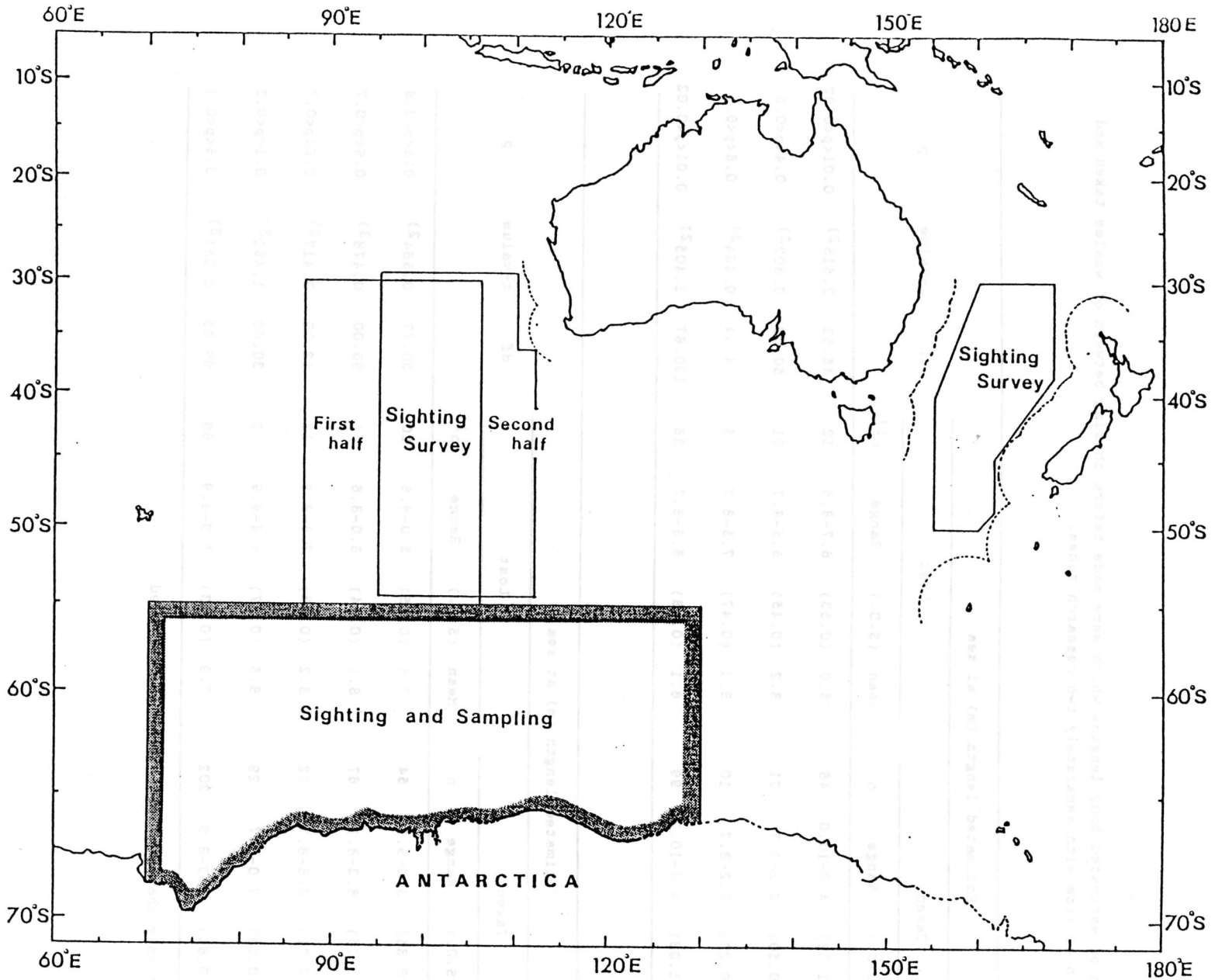

Fig. 1. Research areas of the Antarctic sampling survey and the low and middle latitudinal sighting surveys in 1989/90 seasons.

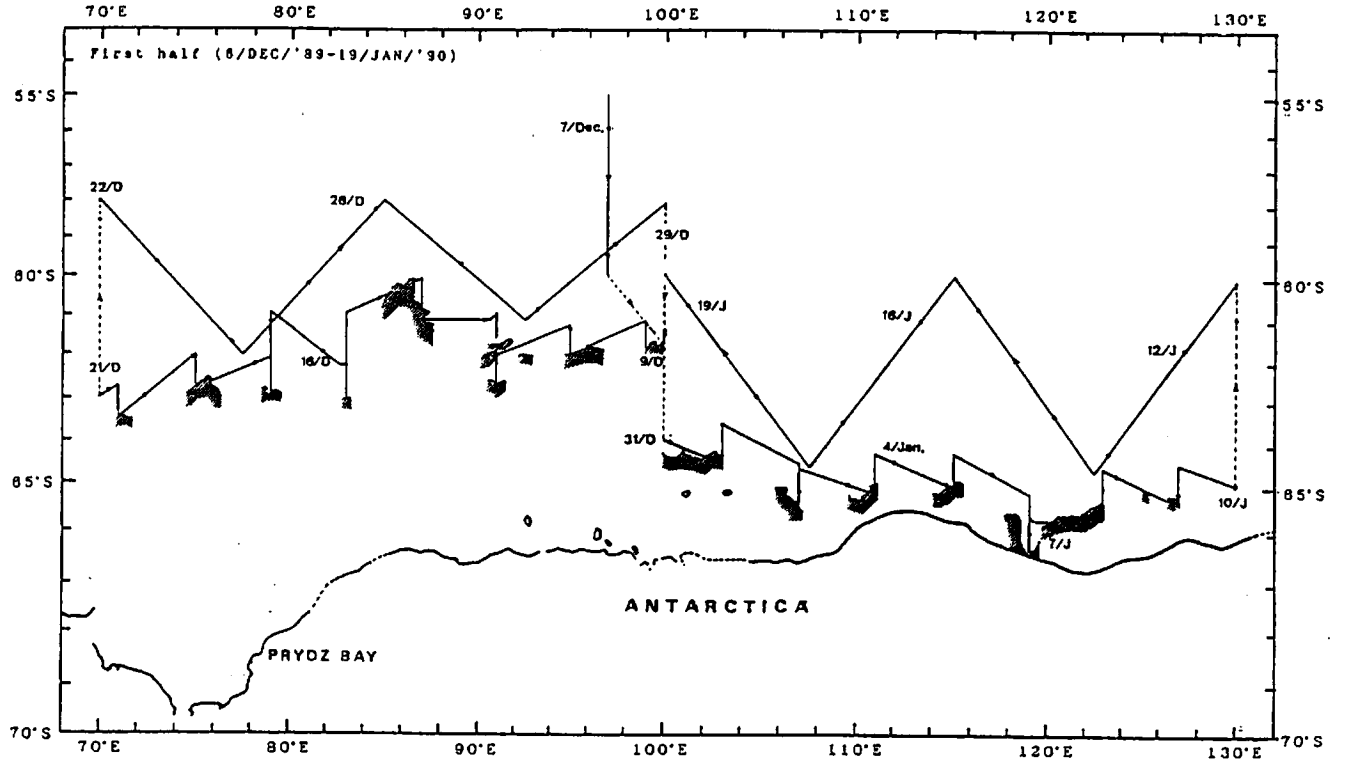

Fig. 2. Cruise tracks of the present survey with separately by the two halves. The solid line and the broken line represent the main course of the searching, the moving between research zone, respectively.

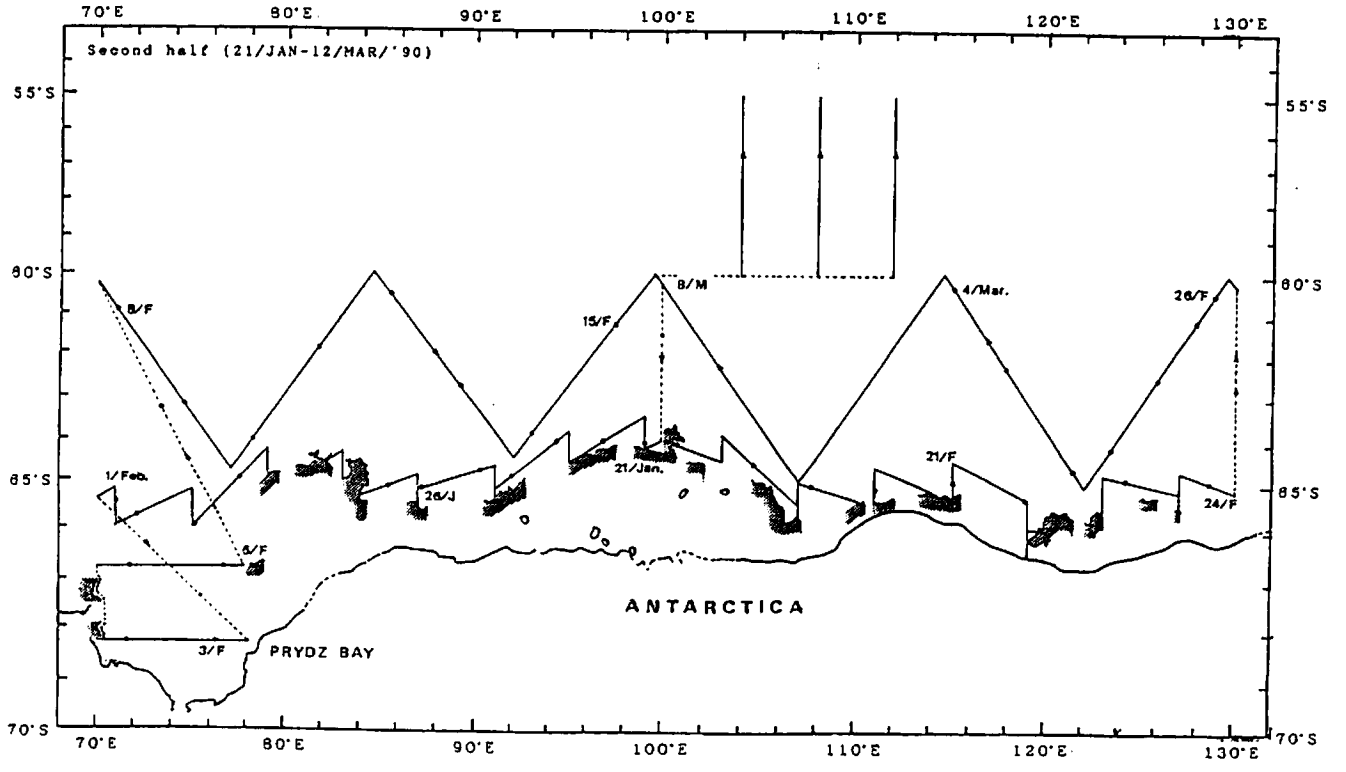

Fig. 2. (continued)

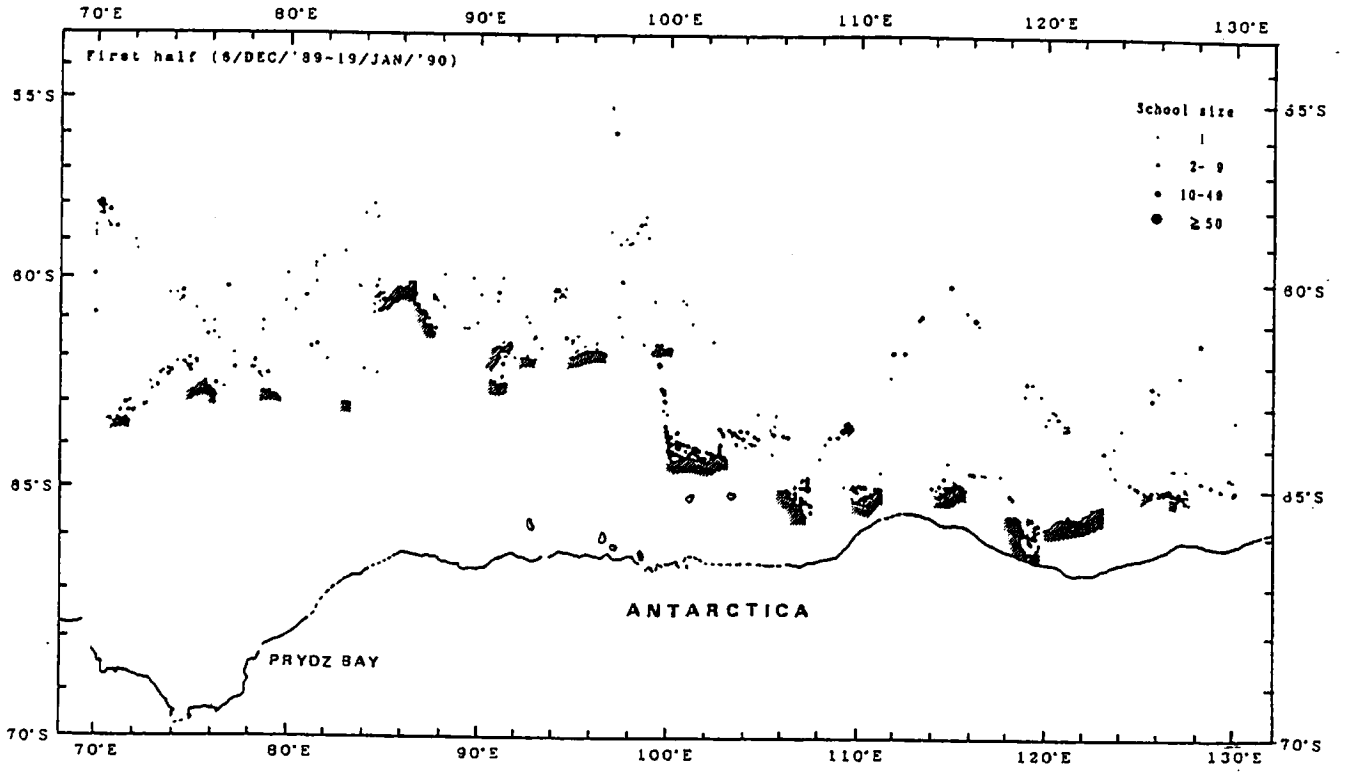

Fig. 3. Distribution of minke whale sightings including both primary and secondary sightings in each half. Closed circles indicate ordinal forms and asterisks dwarf forms.

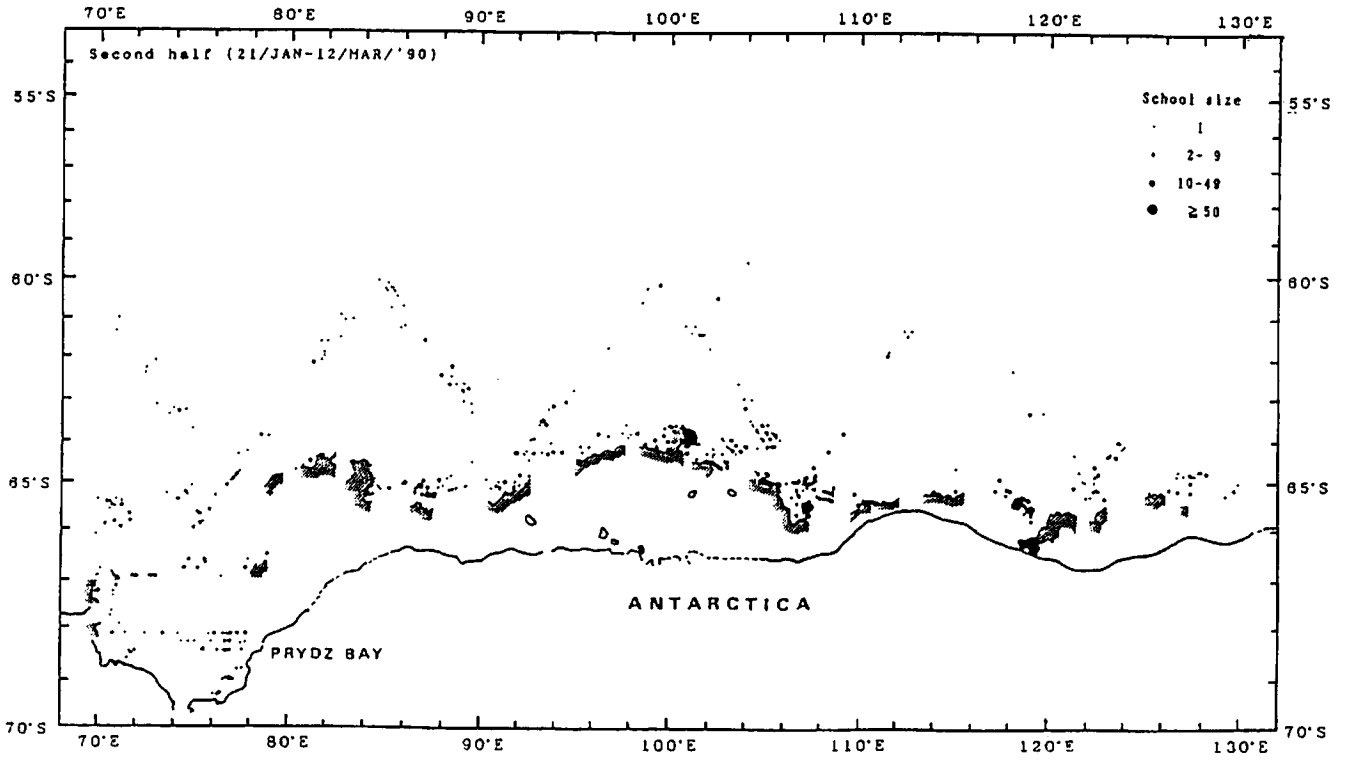

Fig. 3. (continued)

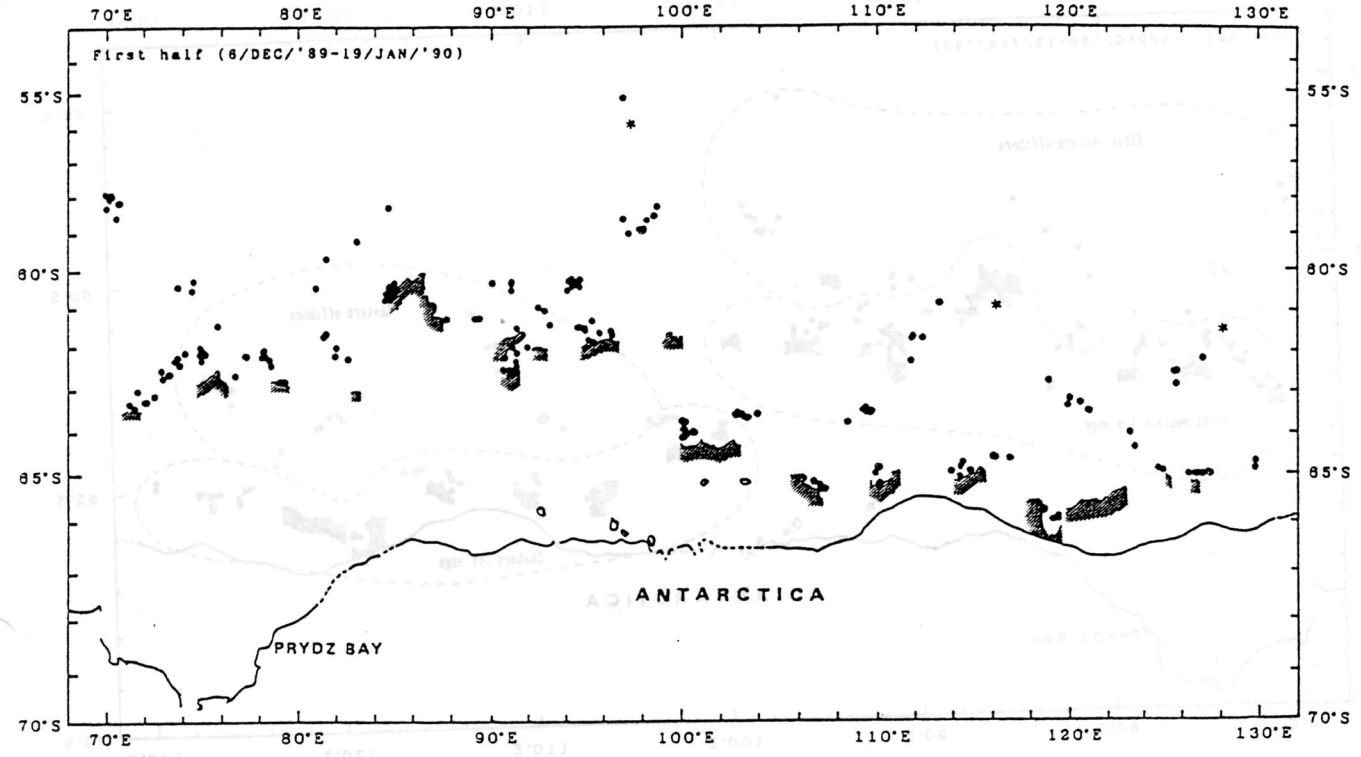

Fig. 4. Distribution of minke whales sampled based on their sighted position in each half. Closed circles represent ordinal forms and asterisks dwarf forms.

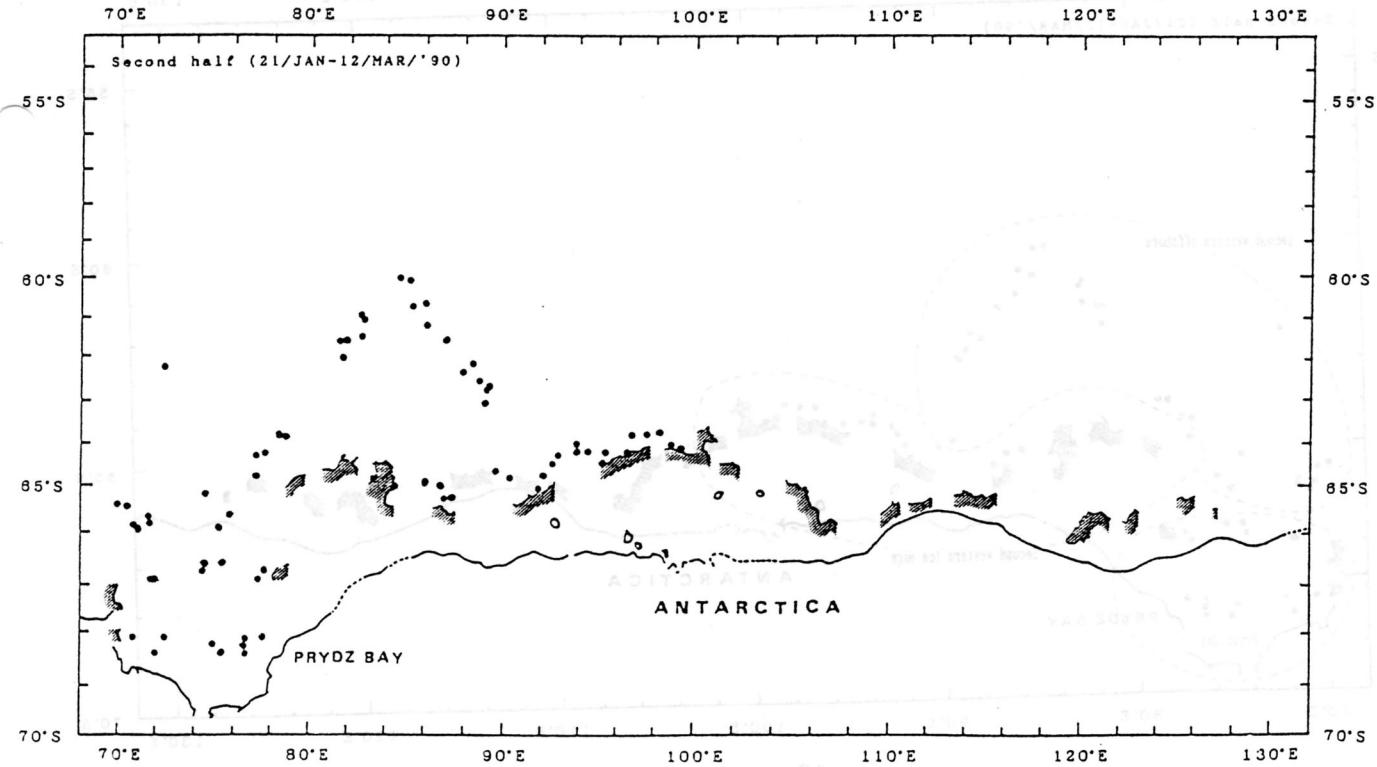

Fig. 4. (continued)

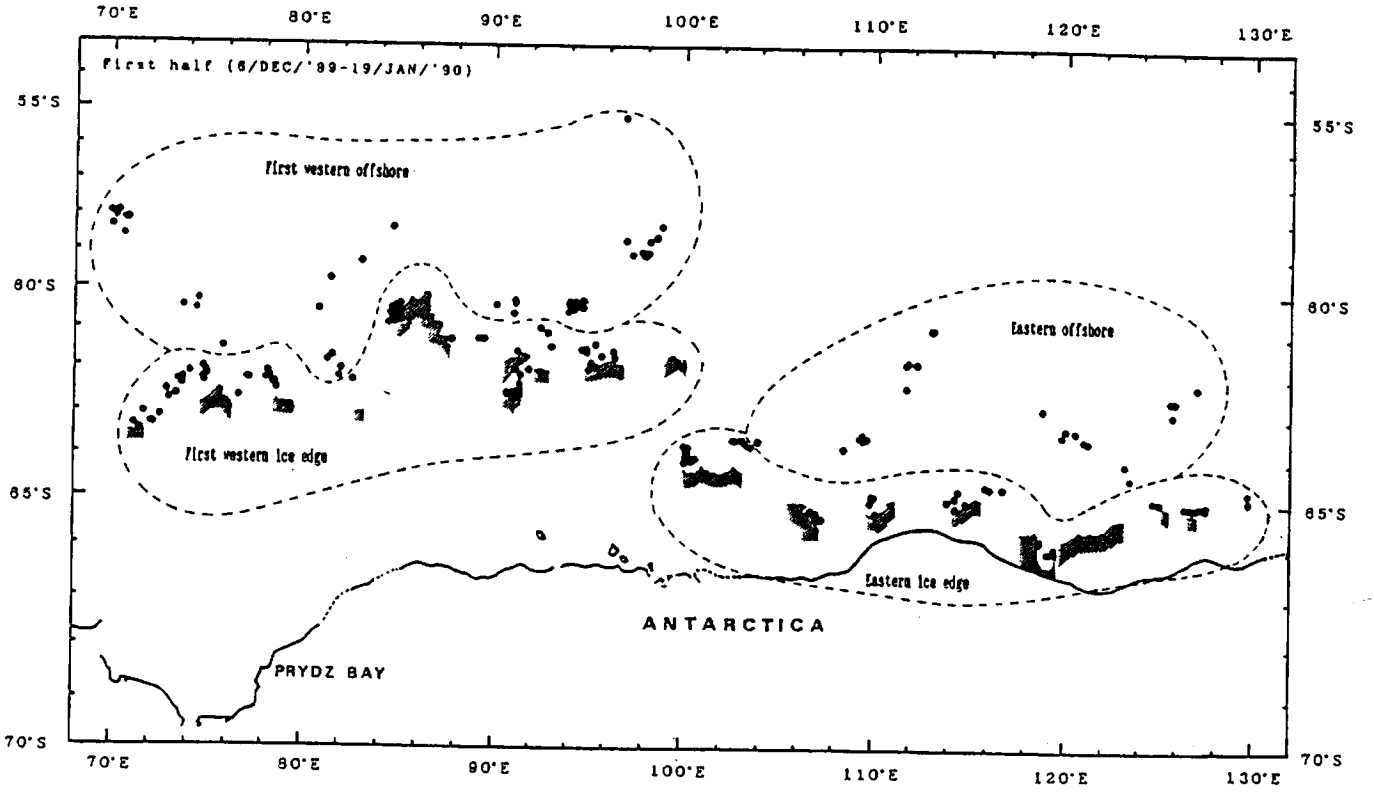

Fig. 5. Time/area group of whale sampled for the preliminary analyses in the present study.

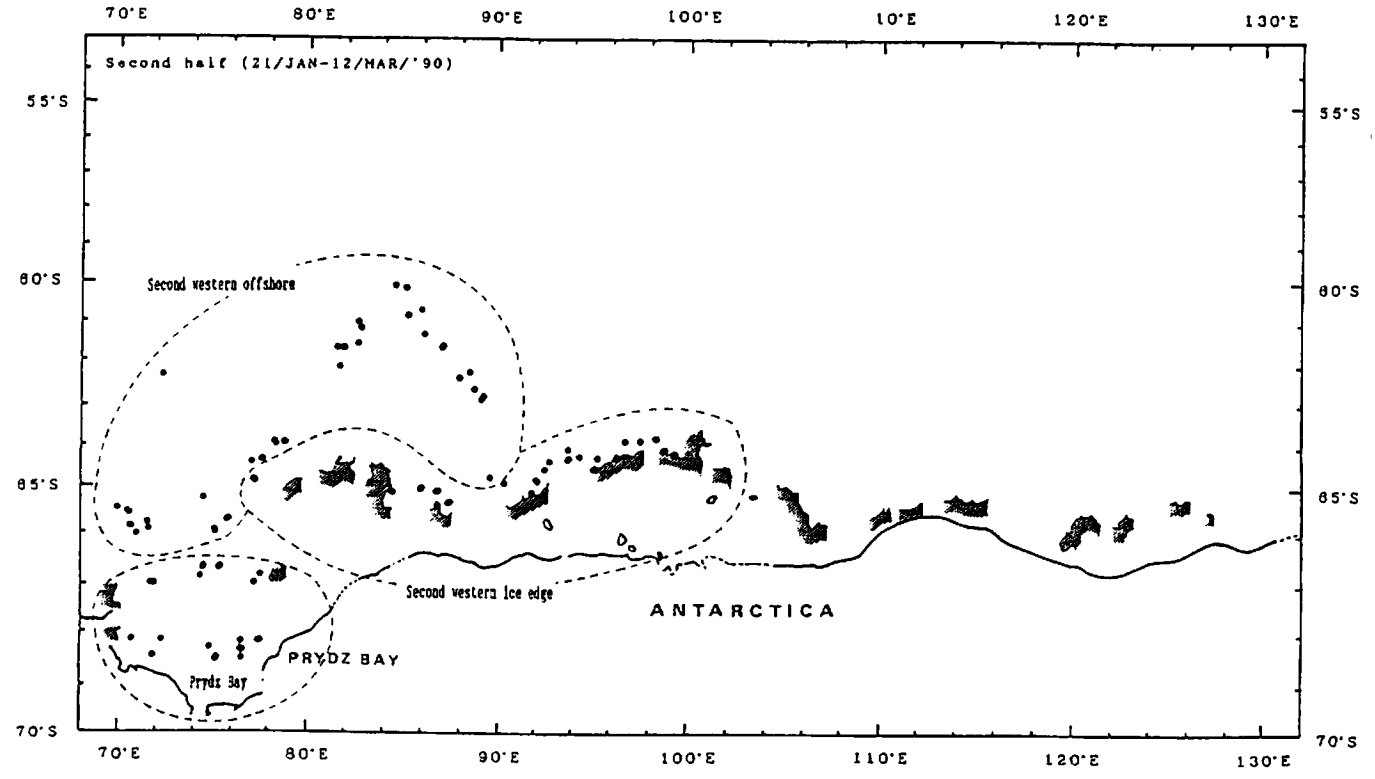

Fig. 5. (Continued)

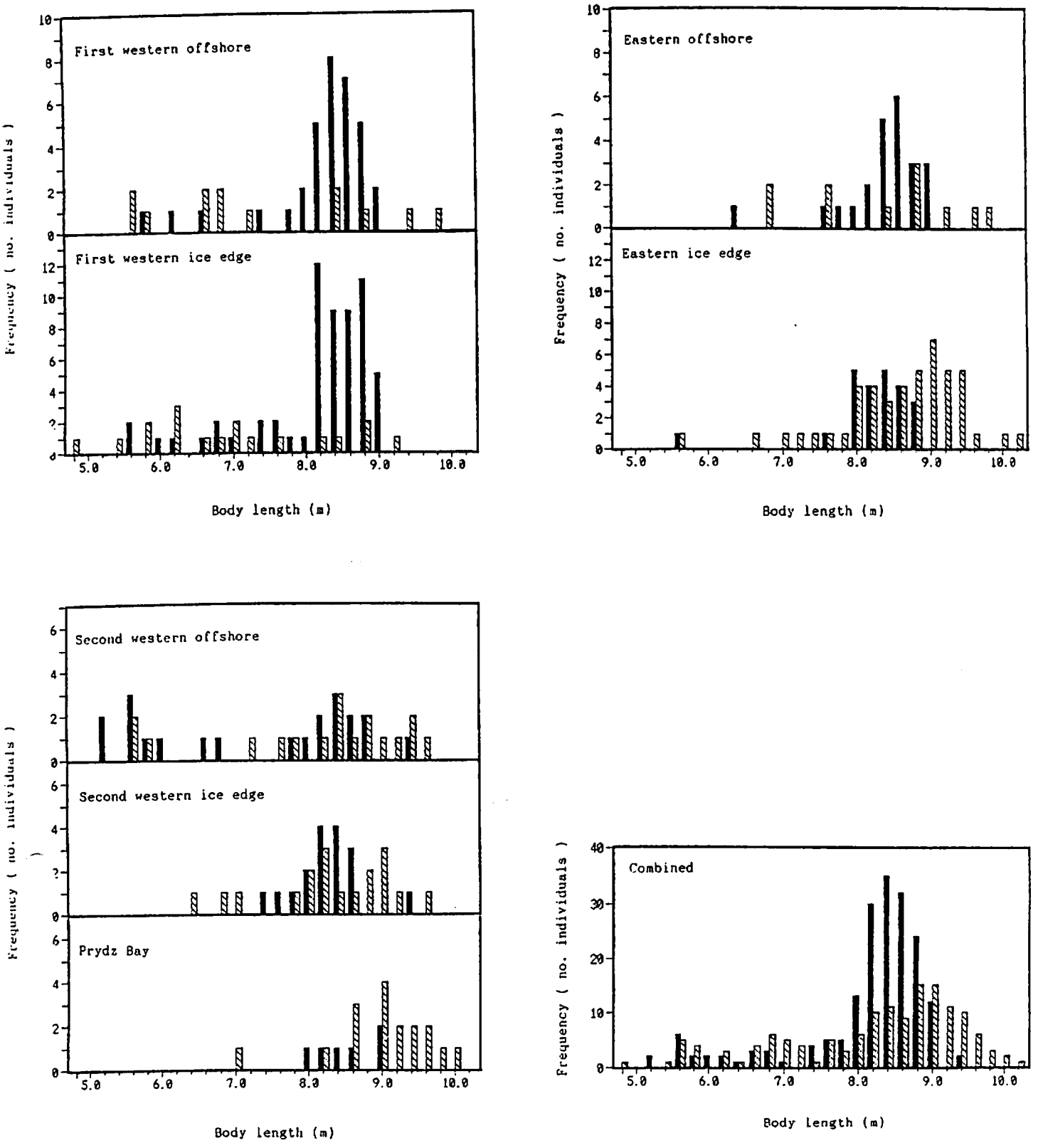

Fig. 6. Body length compositions (m) with pooling each 20 cm interval by sex and the time/area group. Solid and hatched lines represent male and female, respectively.

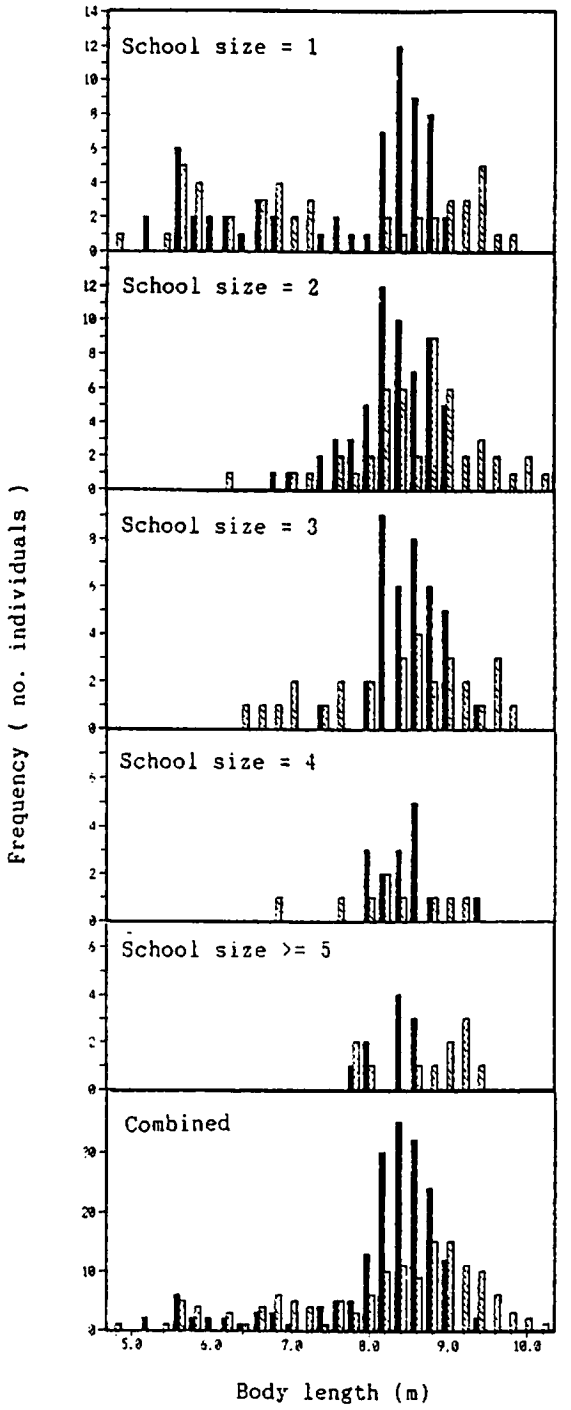

Fig. 7. Body length compositions (m) with pooling each 20 cm interval, mean body lengths and their standard deviations (SD) by sex and school size. The data were combined by all time/area groups.

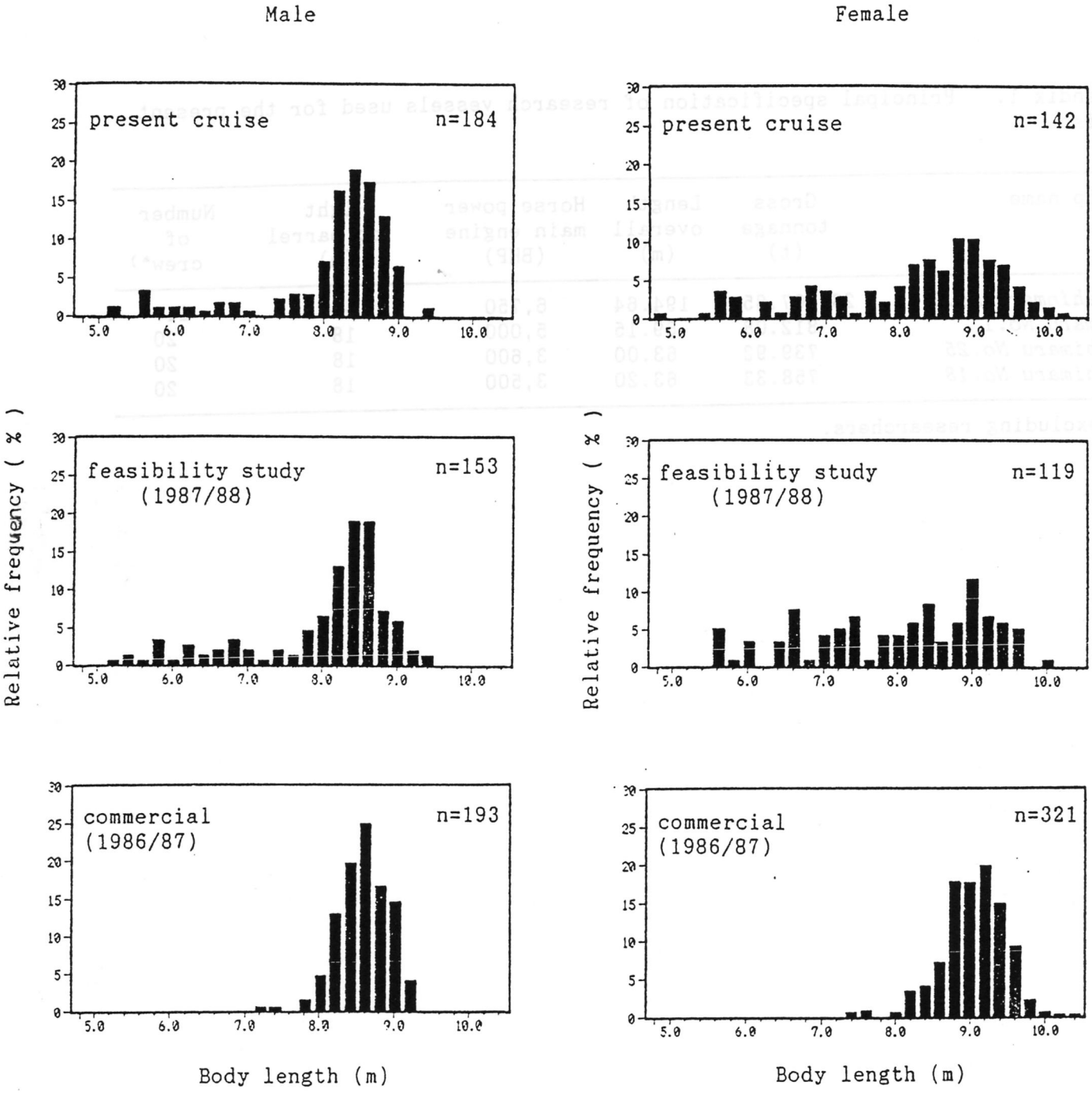

Fig. 8. Comparison of body length composition (m) of samples with pooling each 20 cm interval, by the present cruise in 1989/90 (upper) with those by the previous feasibility study cruise in 1987/88 (middle, Kato *et al.* 1988), and by the Japanese commercial whaling in Area IV in 1986/87 season (bottom).

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*)
Nisshinmaru No.3	23,107.85	194.64	6,750	—	117
Kyomaru No.1	812.08	69.15	5,000	18	20
Toshimaru No.25	739.92	63.00	3,600	18	20
Toshimaru No.18	758.33	63.20	3,500	18	20

*) excluding researchers.

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

Personnel	Situation	Ship*)	Assignment
Kazuo YAMAMURA	Cruise leader	*NO3*	General management of the scientific researches
Yoshihiro FUJISE	Chief researcher (vice leader)	*NO3*	Manegement of the scientific researches and biological data and sample collection
Shigeru TANIFUJI	General manager (vice leader)	*NO3*	General management of the fleet including security of the vessels and health maintenance of the crew
Syuichi KAWASHIMA	Supporting staff	*NO3*	Management of sampling vessels
Hiroshi MIYAKOSHI	Supporting staff	*NO3*	Support of biological research and Management of the by-products
Ryoko ZENITANI	Researcher	*NO3*	Biological data and sample collection
Yoshiyuki YAMAMOTO	Researcher	*NO3*	Biological data and sample collection (6/DEC/'89-10/JAN/'90)
		KO1	Determination of target whale Collection of sighting and sampling data Oceanographical research (10/JAN/'90-)
Hajime ISHIKAWA	Researcher	*KO1*	Determination of target whale Collection of sighting and sampling data Oceanographical research (6/DEC/'89-13/JAN/'90)
		NO3	Biological data and sample collection (13/JAN/'90-)
Koji Kimura	Researcher	*T25*	Determination of target whale Collection of sighting and sampling data
Masayuki KOMABA	Researcher	*T18*	Determination of target whale Collection of sighting and sampling data
Yukihiro MAIYA	Research technician	*KO1*	Recording effort and weather data
Isamu KIMURA	Research technician	*T25*	Recording effort and weather data
Masamitsu YAMADA	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

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

Appendix 3. Itinerary of the fleet in 1989/90 research cruise.

Event	Date	Latitude	Longitude
Nisshinmaru No.3 left Yokohama	Nov. 10, '89	35°26'N	139°40'E
Kyomaru No.1 and *Toshimaru Nos.25* and *18* left Shimonoseki	12, '89	33°58'N	130°57'E
Pre-cruise meeting and refueling	23, '89	12°27'S	114°27'E
Start of *First period* and survey in the north zone	Dec. 6, '89	55°00'S	97°00'E
End of the north zone	8, '89	60°00'S	97°00'E
Start of survey in the western south zone	9, '89	61°40'S	100°00'E
Mid-cruise meeting and refueling (*Kyomaru No.1*)	10, '89	61°48'S	94°58'E
Mid-cruise meeting and refueling (*Toshimaru Nos.25* and *18*)	11, '89	61°30'S	92°52'E
End of the western south zone	21, '89	63°01'S	70°00'E
Start of survey in the western middle zone	22, '89	58°00'S	70°00'E
End of the western middle zone	29, '89	58°38'S	98°46'E
Start of survey in the eastern south zone	31, '89	63°56'S	100°00'E
Mid-cruise meeting and refueling (*Kyomaru No.1*)	Jan. 5, '90	64°22'S	115°38'E
Mid-cruise meeting and refueling (*Toshimaru No.18*)	6, '90	65°51'S	119°00'E
Mid-cruise meeting and refueling (*Toshimaru No.25*)	7, '90	65°35'S	120°29'E
End of the eastern south zone	10, '90	64°52'S	130°00'E
Start of survey in the eastern middle zone	11, '90	60°00'S	130°00'E
End of the eastern middle zone and *First period*	19, '90	60°00'S	100°00'E
Start of *Second period* and survey in the western south zone	Jan. 21, '90	63°58'S	99°58'E
Mid-cruise meeting and refueling (*Kyomaru No.1*)	29, '90	65°40'S	75°38'E
Mid-cruise meeting and refueling (*Toshimaru Nos.25* and *18*)	30, '90	65°31'S	74°15'E
Start of survey in the Pridz Bay	Feb. 3, '90	68°15'S	77°59'E
End of the western south zone	6, '90	66°42'S	78°12'E
Start of survey in the western middle zone	8, '90	60°20'S	70°00'E
End of the western middle zone	16, '90	60°19'S	100°00'E
Start of survey in the eastern south zone	17, '90	64°02'S	100°35'E
Mid-cruise meeting and refueling (*Kyomaru No.1*)	21, '90	64°32'S	114°48'E
Mid-cruise meeting and refueling (*Toshimaru Nos.25* and *18*)	24, '90	65°06'S	129°24'E
End of the eastern south zone	24, '90	65°10'S	130°00'E
Start of survey in the eastern middle zone	26, '90	60°21'S	130°00'E
End of the eastern middle zone	Mar. 8, '90	60°22'S	100°00'E
Start of survey in the north zone	9, '90	60°00'S	104°00'E
End of the north zone and *Second period*	Mar. 12, '90	55°00'S	112°00'E
Kyomaru No. 1 and *Toshimaru Nos. 25* and *18* arrived at Shimonoseki	31, '90	33°58'N	130°57'E
Nisshinmaru No. 3 arrived at Tokyo	31, '90	35°38'N	139°45'E