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PRELIMINARY REPORT OF THE FEASIBILITY STUDY ON SOUTHERN MINKE WHALE UNDER THE JAPANESE PROPOSAL TO THE SPECIAL PERMIT

Hidehiro KATO*, Hisashi HIROYAMA**, Yoshihiro FUJISE*
and Kiyoshi ONO***

ABSTRACT

The research cruise for feasibility study of Japanese proposal of the special permit to take southern minke whales was conducted during the period from January 17 to March 26, 1988. The survey covered latitudinally wider area from 55° S to ice edge line between longitudes of 105° E and 115° E than those in the commercial whaling. The research cruise employed systematic sighting survey and the sampling of minke whales based on the random sampling scheme. A total of 421 minke whale schools (1,350 ind.) comprising of 227 primary and 194 secondary sightings was sighted during the searching of 8,482.4 n.miles, which was evenly allocated between the northern and southern strata. The sampling was conducted solely to take whales of the primary sightings. Employing this sampling manner, 273 whales (154 males, 119 females) were collected. The body length composition of them was considerably different from that in commercial whaling, finding a higher proportion of smaller animals. Preliminary analyses suggested: 1) minke whale density and school size were abruptly increased in the waters close to pack ice; 2) sexually mature females tended to concentrate in the pack ice area, immature animals distributed in the offshore waters and sexually mature male appeared in both areas; 3) the small or immature were apt to be solitary, while the larger or mature males usually make larger school associating with a similar sized females. Details of analyses on data including sighting, sampling, biological and oceanographical surveys obtained from the present cruise will be presented in future studies.

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*) Institute of Cetacean Research, 3-32-11, Ohjima, Koto-ku, Tokyo 136
**) Fisheries Agency, 1-2-1, Kasumigaseki, Chiyoda-ku, Tokyo 100
***)Faculty of Fisheries, Nagasaki University, 1-2 Bunkyo-cho, Nagasaki city, Nagasaki 852

1 INTRODUCTION

The Government of Japan proposed a research plan on the feasibility study (Government of Japan, 1987a; SC/D87/1) on "the program for research on the southern hemisphere minke whale and for preliminary research on the marine ecosystem in the Antarctic (Government of Japan, 1987b; presented to Scientific Committee of the International Whaling Commission (IWC/SC) at 39th annual meeting as SC/39/04)" to the IWC at October 1987 and gave a permission to enforce this research plan with taking of 300 minke whales (*Balaenoptera acutorostrata* (Lacépède, 1804)) as a maximum sample size to the Institute of Cetacean Research which was newly established in Tokyo.

Three specific topics can be identified in this plan as:

(1) The research plan adopted the stochastic sampling from the whale schools sighted by systematic sighting survey such as adopted by IWC/IDCR southern minke whale assessment cruises.

(2) Since the beginning of the full exploitation of southern minke whale in 1971/72 season their operation area had limited within waters close to the pack ice edge zone (Shimadzu and Kasamatsu, 1981; 1983; 1984). Whereas the research plan was made to cover latitudinally wider waters from by 55°S to ice edge line the commercial ones.
(3) The scientific informations were scheduled to be collected as much as possible from each sample whale in the present plan.

This report outlined the Antarctic cruise which was conducted during December 23 1987 and April 20 1988 under the research plan above and presented some preliminary analyses on the data obtained from the present cruise.

The research plan also proposed the sighting survey of minke whales in lower latitudes between 100° - 110°E, the cruise report of that sighting survey is separately provided from the present cruise by Kasamatsu (1988). Geographical locations of research areas including both Antarctic and low latitudinal surveys are given in Fig. 1.

2 AN OUTLINE OF THE CRUISE

2.1 Details of the research fleet

Two sampling vessels, *Kyomaru #1* (*KO1*; 812.08GT.) and *Toshimaru #25* (*T25*; 739.92GT.), engaged in sighting and sampling works. *Nisshinmaru #3* (*NO3*; 23,107.85GT.) bore a research base in which general matters including consideration of research strategy, weather forecasting, receiving of ice informations and others were dealt with. The processing of whale carcass, biological samples and data collections were made on the deck of *NO3*. Table 1 summarizes principal specifications of each vessel.

2.2 Research personnel

Research personnel and their assignments were (see also Table 2): H. Kato, cruise leader, engaged in general management of the research and biological works on *NO3*. Y. Fujise, researcher, engaged in biological works on *NO3*. H. Hiroyama (*KO1*) and K. Ono (*T25*), researchers, engaged in recording of sighting informations and determination of the target whales to be sampled according to stochastic sampling scheme in each sampling vessel. Kato and Hiroyama swapped their assignments and vessels during two weeks in the mid-cruise.

Two research technicians, S. Tabata and Y. Eguchi, assisted biological collection works on *NO3*. Records of searching effort, weather condition and catching were completed by research assistants, who were chief officers in each sampling vessel, M. Yamada (*KO1*) and T. Ryono (*T25*).

2.3 Research area and principal of the cruising course.

In the area of 105° - 115°E, the southern stratum (from pack ice edge to 60°S) and the northern stratum (55° - 60°S) had been designated as research area. As described in the instruction note (Anon., 1987; SC/D87/35) submitted to the special meeting of IWC/SC held at Cambridge in 1987, the searching course consisted of the main track and two sub-track lines, located six miles vertically away from either sides of the main, at which sampling vessels were designated to cruise. The main track was controlled under the different rules in each stratum such as; in the northern stratum the fleet should cruise on the pre-determined eight north/south leg (northern legs) systematically arranged along the longitudes, whereas the track was randomly established (so called "reflection course") in the southern stratum.

Although the principal of the cruising rule including details has been given in the instruction note mentioned above, several determinative points to control the track line were:

(1) The starting point of the cruise in the research area was randomly chosen from one of the northern ends of eight northern legs at 55°S by the method as follows: After giving serial number to small balls corresponding these legs and putting them in a closed box, we chose starting point by reading the number on the first falling ball from a small hole (but slightly larger than a ball) of well shaken box. By adopting this procedure, starting point was determined as being at 55°S - 108°18'E.

(2) Compass direction of 230 degree (co.230°) had been randomly chosen prior to the start of this cruise as an initial penetration direction of the cruise from the south end of selected northern leg above to the southern stratum.

(3) An angle of reflection at boundaries of the research area in the southern stratum such as pack ice edge, 60°S, 105°E and 115°E lines had been selected to be 70° prior to the present cruise. When the fleet can have two reflection courses with an angle of 70° to either sides at the boundary, choice of direction was randomly selected by the same procedure as in (1).

(4) The timing of penetration to the northern stratum from the southern stratum were determined by the weather condition in the northern stratum with regardless of location of the fleet in the southern stratum. The fleet once suspends the research and moves to the south end of the nearest un-surveyed northern leg and cruises to north on this leg. After reaching north end of the leg (we set this point to be at 55°09'S in order to avoid to sample whales distributed in north of 55°S), the fleet cruises to the north end of the nearest un-surveyed leg, and hereafter takes to south. The fleet should returned to the suspended position in the southern stratum after arriving at the south end of the northern leg (60°S).

Technical points of the present research cruise can be summarized as follows: The searching was made with 12 knot during

the day time either between 0600 and 2000 or between the hours 30 minutes after sunrise and before sunset. The fleet principally stopped during the night time at the ending position of the day, and resumed searching from the same position in the next morning. The sampling vessels cruised on the sub-track lines as mentioned previously, but their allocated sub-tracks were occasionally swapped each other. The samplings of whales were made at the only primary sightings appeared within three miles (vertical distance) from the sub-track line. When it is unsuitable weather and sea condition for the searching, the fleet principally suspended the searching and drifted for waiting for its improvement. After confirming, sampling and towing etc., the sampling vessels returned to original position on the sub-track line at which they left to confirm the sighted whales and resumed the searching there. Any activities during sighting and sampling works were classified and recorded on the effort data sheet similar to that has been adopted in IWC/IDCR southern hemisphere minke whale assessment cruises.

2.4 Narrative of the cruise

The fleet left Japan on the 23rd - 25th Dec. 1987 (*NO3* from Yokohama, Kanagawa prefecture on the 23rd; *KO1* and *T25* from Shimonoseki, Yamaguchi prefecture on the 25th). After refueling of sampling vessels from *NO3* and having a pre-cruise meeting at 13°52'S - 114°32'E on the 5th Jan. 1988, the fleet cruised to southward and arrived at the starting point of the research area (55°S - 108°18'E, randomly chosen before arrival) in the early morning of 17th Jan. during the southward cruising, sampling vessels carried out sighting survey with 12 knot in the day time defined as in previous section and steamed in the night time. During these pre-research sightings, the sub-track lines of the vessels were set outside of Australian 200 nautical miles zone. These logistics were also adopted in the post-research sighting survey from ending point of the research area to 200 n.miles south of the Lombok Strait.

The research lasted for 70 days from the 17th Jan. to the 26th March 1988. We described briefly an outline of the cruise as below. The period of cruise was divided into three based on the nature of the research. The cruise track and itinerary are shown in Fig. 2 and Table 3, respectively.

First period (Jan. 17 - Feb. 6)

The fleet commenced research with co.180° at 55°S-108°18'E from 0600 on Jan. 17 arranging as follows; *KO1* on the sub-track of east side and *T25* on the west side of the main. The first sighting of minke whale was made by *KO1* at 56°45'S-108°28'E on Jan. 17 and this whale was sampled. Hereafter, the fleet continued cruise southward and reached at 60°S in the afternoon on 18th Jan. Three minke whale schools were sighted between site at 59°30' and 60°S and four samples were collected from them.

The direction of the main track was taken to co.230° at 60°S-108°18'E according to the rule in the afternoon Jan. 18,

hereafter the fleet cruised on this track and met at the western boundary of 105° E at 61° 22'S on 20th Jan., subsequently changed course direction with an angle of 70° (namely, direction of the main track was co.120°). After three days searching, the fleet reached to the eastern boundary (64° 02'S-115° E) in the early morning on Jan. 23 with occasional topdown steaming and drifting due to strong wind and poor visibility on the 20th and with night steaming on the 22th to avoid stormy weather, at which the direction of the main track was taken to co.230°. During these period, 12 whales were sampled from areas along the track line between 60° S-108° 18'E and 60° 45'S-106° 45'E and six from between the position 62° 40'S-109° 35'E and 63° 25'S-112° 30'E.

After waiting for a weather recovery through a day (Jan. 23), the fleet resumed searching with co.230° , frequency of minke whale sighting was increasing with its advances, and a total of 11 whales was sampled until ending works of 25th. We met at the ice edge line at 65° 37'S-110° 32'E before noon on of the 28th Jan., at which the direction of the fleet was taken to co.340°. A total of 33 whales was sampled during the days from 26th to 28th, 30 samples of them were obtained from the waters within 20 miles from the ice edge line. Hereafter, the fleet cruised toward to north (co.340°) with occasional drifting due to poor visibility and reached to 60° S of the northern boundary of the southern stratum at 106° 03'E before noon on Feb. 1, at which the fleet suspended the research in the southern stratum. During this northward cruising 15 whales were sampled.

The fleet moved to 60° S-106° 06'E where it is south end of the nearest un-surveyed northern leg and commenced searchings toward to north in the afternoon on Feb. 1, and two whales were sampled 59° 44'S and 58° 55'S near the track line. However, on Feb. 2, the fleet was hove due to storm suddenly generated, and slowly moved to north-west (wind direction). We had resumed searchings from 58° S on the main track in the morning on Feb. 3, after turning north corner *via* 55° 09'S-106° 06'E and 55° 09'S-107° 12'E the fleet cruised toward to south on Feb. 4 and reached to south end of this northern leg in the morning of Feb. 6. No minke whale was sighted between the days from 2nd to 6th Feb. A mid-cruise meeting was held at *NO3* during the refueling to the sampling vessels after end of the research work of the day on 5th Feb.

Second period (Feb. 6 - March 1)

The fleet returned to the suspended position (60° S-106° 03'E) of the previous research in the southern stratum and resumed searching from there with co.230° in the afternoon on the 6th Feb., subsequently took cruising direction to co.120° within a day because of arriving at western boundary (60° 26'S-105° E). With repeating searching and drifting due to poor visibility, we continued to cruise along this track and obtained six samples between 61° 05'S-107° 28'E and 62° 10'S-111° 05'E. The fleet met at an eastern boundary (63° 10'S-115° E) and turned to co.230° on 9th Feb. 11 minke whale schools were sighted around the turning position and 12 whales were sampled from them.

After turning from the eastern boundary, the weather

condition gradually tended to be better for searching. A total of 15 whales were sampled from area between positions from 64°20'S- 112°10'E to 65°20'S-109°10'E on Feb. 11-12. Minke whale sightings including secondary ones were getting frequently and their school sizes became bigger from the evening of 12th Feb., subsequently we entered into the high density area of minke whales at 65°15'S -109°18E from the morning of 13th Feb. Since the number of sampled whale per day sometimes reached 14 which was nearly maximum capacity for processing on *NO3*, the catch controlling was sometimes employed. Consequently a total of 127 whales were sampled from this high density area during the days from 13th to 22nd Feb. An average searching distance per day was only 10.4 n.miles due to high concentration of whales there. During this period, the fleet met at ice edge line at 65°46'S - 107°52'E and turned to co.340° on Feb. 16.

Since the weather condition in the northern stratum was thought to be recovered, the fleet once suspended the research in the southern stratum at 65°23'S-107°32'E on Feb. 22 and moved to the south end of the nearest un-surveyed northern leg (60°S - 109°24'E) so as to carry out the research in the northern stratum. During this movement the sampling vessels were engaged in sighting survey with passing mode in the day times.

We commenced the searching to north from the point above in the morning of 24th Feb., but the fleet had to be hove at just before arrival at 58°S through two days (the 25th and 26th) due to the storm which was suddenly generated. The searching was resumed from the interrupted position where we met the storm on Feb. 27. The fleet reached to the north corner of this leg (55°09'S-109°24'E), subsequently turned to west toward the north end of the nearest un-surveyed leg and turned again to south at 55°09S-110°30'E, where the sampling vessels swapped their sub-track lines on Feb. 28. The fleet continued to cruise southward with occasional drifting or topdown steaming due to strong winds and reached to the south end of this leg (60°S-110°30'E) on March 1. No minke whale was sighted through this north excursion.

Third period (March 1 - 26)

Until the end of the second period of the cruise, the number of sampleed whale had summed to be 245 individuals and samples collected in waters south of 65°S occupied 67.4% of those. If we resumed sampling at the suspended position in the southern stratum (65°20'S-107°30'S), the magnitude of occupation above should have clearly increased under the sample size limitation of this cruise (300 whales). In order to avoid such concentrated sampling in a particular waters, we steamed to 62°19'S-105°E, where it is a cross point of the main track line and the western boundary when we would have continued to cruise with co.340° from the suspended position. Then we resumed searching in the southern stratum from the cross point above with the reversal direction of co.340° (= co.160°) in the afternoon of the 2nd March.

The fleet cruised southward with co.160°, but no minke whale was sighted between the latitudes of 62°S and 63°S. The first minke whale sighting on this track was made at 64°37'S-106°38'E in the afternoon on 3rd March, and two whales were

sampled from this sighting. After sampling on five whales from waters near the 65° S on the 4 - 5th, the fleet had arrived at the suspended position of the previous highly concentrated area in the southern stratum (65° 23'S-107° 32'E) before noon on March 5. Such dramatic density change of minke whale within two weeks may be explained by ice movement, because the ice edge line was retreated to far south comparing with that in Feb. 22.

Therefore, the fleet returned to 62° 19'S-105° E with topdown steaming and resumed searching from there with co.90° in the morning on March 6. With adopting drifting occasionally due to poor visibility, the fleet reached to the eastern boundary at 62° 19'S-115° E on March 8. During this eastward cruising, in spite of sightings of two minke whale schools it was difficult to sample because of erosive behavior and long time diving. The next direction at the boundary was randomly chosen as to be co.200° the day before one day to meet the boundary by the cruising rule described in previous chapter.

No minke whale was sighted during the southward cruise with co.200° from the east boundary to area in front of the ice edge line where we met in the morning March 10 (64° 58'S-112° 49'E). Because the ice edge was developed along line from WNW to ESE, we had had a choice of direction either co.310° or co.90° as searching course after meeting ice line. Consequently, co.90° was chosen by the random procedures as mentioned in previous chapter.

After taking the cruising direction to east, several minke whales appeared and four whales were sampled. Since the most of sightings were made by *T25* which cruised on the southern sub-track of the main, *KO1* (cruising on the northern sub-track) advanced 15 n.miles miles to east consequently and her advance was estimated to be more. Moreover, during the handling of the first sample, company whales which should be sampled next escaped often inside of the pack ice area. To solve these problems, we employed the method of cooperative sampling between *KO1* and *T25* on March 11 as follows: While searching was made by only *T25* on her sub-track line, *KO1* suspended once her research and followed to *T25*. After the first whale was sampled by *T25*, *KO1* started to sample the next whale from the same school with keeping random sampling scheme (see chapter 4). Six of ten individuals sampled on the 11th were obtained through this procedure.

During eastward cruising on March 12, the fleet shifted their position slightly two times to north according to the cruising rule of the instruction note because unexpected ice edge line appeared in front of the sub-track line of *T25*. The fleet met at the eastern boundary at 64° 41'S-115° E in the afternoon on 12th March, subsequently the fleet employed the direction to co.340°. A total of six whales was sampled around the turning point.

After waiting for the weather recovery through a day on March 13, the fleet cruised northward (co.340°) with occasional drifting due to poor visibility. On March 15, we once finished the research in the southern stratum at 61° 11'S-112° 13'E, subsequently the fleet moved to the southern end of the nearest un-surveyed northern leg by the night steaming.

The fleet commenced the searching in the northern stratum

at 60°S-112°44'E in the morning on March 16. With repeating heaving, drifting and topdown steaming due to unsuitable weather conditions, the fleet continued to cruise *via* 55°09'S - 112°44'E and 55°09'S-113°50'E (the north end of the nearest northern leg; randomly chosen from two legs) on the 20th, and reached to 59°34'S in the evening on March 22. For saving time to be spent for the movement during the day time and for the time limitation of the present cruise, we ended the searching of this leg (113°50'E) at that point and moved to the southern end of the final leg (111°38'E) in the northern stratum by night steaming. During this north excursion no minke was whale sighted.

We commenced the searching on the final northern leg from 60°S-111°38'E on March 23. In the afternoon on the 23rd, one minke whale school (dwarf form) was sighted at 58°23'S-111°26'E by *T25* and one sample was obtained from that school. No minke whale appeared after the sighting mentioned above. By reaching to 55°S of this leg at noon on March 26, we ended researches in the whole area.

3 SIGHTING

Sighting survey of the present cruise was conducted under the similar scheme which has been adopted in IWC/IDCR southern hemisphere minke whale assessment cruise. Items of the informations to be collected in the present cruise covered those which were currently required in the analyses of sighting data by the IWC/SC. And we adopted same data formats including sighting, effort and weather as those in current IWC/IDCR cruises. Preliminary results of sightings survey in the present cruise were described in this section. The population estimate and details of analyses on data obtained from the present cruise will be made in future studies.

3.1 Species found

Table 4 indicates a list of species found by the vessels, sighting type and the stratum. Five species of mysticeti and at least six species of odontoceti were sighted during the cruise. Fig. 3 shows geographical distribution of large sized whales sighted during the three periods classified in the previous chapter (including primary and secondary sightings).

The minke whale was obviously dominant species with sightings of 421 school (1,350 individuals) comprising of 227 primaries and 194 secondaries (including three third-sightings). Most of minke whales were sighted in the southern stratum, whereas only seven schools were confirmed in the northern stratum. It was noteworthy that a school comprising two minke whales of dwarf form occurred in the northern stratum (in the third period).

The humpback whale (*Megaptera novaeangliae*) followed the minke whale, and a total of 56 schools (123 individuals) was sighted and its distribution overlapped with that of minke whales

in both strata, but main ground was slightly north. Few fin (*Balaenoptera physalus*) and sei whales (*Balaenoptera borealis*) were sighted, on the contrary a special attention should be paid on two sightings of the right whale (*Balanea glacialis*) in the southern stratum.

Among odontoceti whales, Ziphiidae, at least including southern bottlenose whale (*Hyperoodon planifrons*), were frequently sighted as 100 schools throughout the both strata. Especially 29 sightings in the northern stratum where weather conditions were not so suitable were worth to note. The killer whales (*Orcinus orca*) followed to Ziphiidae and sometimes were found in both strata, The sighting of the sperm whale (*Physeter catodon*) was not frequent, but they were all solitary bull. Several other odontoceti whales including the long-finned pilot whale (*Globicephala melaena*), hour-glass dolphin (*Lageonorhynchus cruciger*) and southern right whale dolphin (*Lissodelphis peroni*) were sighted in the research area but they were not frequent.

3.2 Searching effort (distance)

As mentioned previously, the activities related to the sighting and sampling surveys were classified and recorded on effort data format. Although the present plan was partly introduced indirect closure to the sighted school (closing commenced at which sighting angle is positioned an angle of 60° or more from the sub-track), we defined, in this report, searching effort as the distance between positions at beginning of searching and at finding whale school on each sub-track line.

A total searching distance of the fleet (*KO1 + T25*) was 8,482.4 n.miles comprising 4,327.3 and 4,155.1 n.miles in the northern and the southern strata, respectively. The ratio of searching distance (n.m.) to the size of research area ($n.m.^2$) to be covered in the present cruise was about 2.8 - 4 folds of those in the resent IWC/IDCR Antarctic minke whale assessment cruises (Table 5). Table 6 indicates spatial distribution of the searching distance combined with two sampling vessels by one degree square. Although 11 grids out of 110 were not surveyed throughout the cruise (especially western grids in latitudes of 60°S), the present cruise covered 90% to the total grids. More effort was spent on grids between 63° - 64°S and 113° - 114°E where the main tracks were crossed within a grid. Effort was expected to be evenly allocated throughout latitudes, it seems that actual effort was relatively concentrated in 55°S and 62°S where eastward cruising had been made, while the efforts were relatively short in 60°S, 61°S and 65°S.

3.3 Distribution, school size and density of minke whales

Table 6 indicates not only searching effort but also corresponded density indices of minke whale including the number of sightings and mean school sizes by one degree square. Density index (DI) used in this table was calculated by the solely primary sightings as;

DI = ((no. of individual)/(searching miles)) X 100

therefore, this represents the number of whales per 100 n.miles searching.

Minke whales distributed in relatively wider longitudes from 56°S to ice edge zone (65°30'S) in the first period (Jan. 17 - Feb. 6). And some whale concentrations were recognized not only in the waters close to the ice edge (65°S-110°, 111°, 112°E) with DI 30.8 - 70.5 but also off-shores such as 64°S-114°E with DI 31.8 and 60°S-107°E with DI 16.5. Mean school sizes were generally large in the high density area such as 3.25 - 3.50 in the ice edge grids, but it tended to be small in the off-shore concentrations to be 1.38 - 2.00.

On the other hand, in the second period (Feb. 6 - March 1), no minke whale was sighted in north of 60°S. Distinctive high densities were recognized in the southern latitudes. Especially extreme high densities (DI, 301.5 - 490.4) were recorded in the ice bay between 65°S and 107° - 108°E. Mean school sizes were as large as 3.97 - 4.86.

It seems that the magnitude of the concentration of whales in the southern latitudes was much distinctive in the third period (March 1 - 26), though sightings of minke whale was not so frequent in high latitudes because we did not meet the pack ice edge where high density could be expected. Another attention would be paid to the density change between periods in the waters of 65°S-107°E, decreasing DI from 490.4 in the second to 2.3 in the third period. This may be due to ice edge movement to further south as mentioned in the previous chapter.

A school associated with two dwarf form minke whales was sighted at 58°23'S-111°26'E in the third period, when ordinal minke whales were thought to be concentrated in the waters close to pack ice. Although dwarf form minke whales sometimes occur in the tropical and temperate latitudes (Best, 1985; Arnold, Marsh and Heinson, 1986), the present sighting must be first record in the Antarctic region.

Throughout the three periods, as shown in Fig. 4, density of minke whale inclined from the southern to the northern latitudes. Furthermore even by rough calculation, DI of 65°S suggested that over 70% of the total whales concentrated in this latitudes even in terms of one second square of this latitudes comparing to other latitudes. Fig. 4 also shows latitudinal changes in mean school size in each period and in throughout entire periods. Although the trend was not clearly elucidate in the third period because of small sample size, schools were getting larger in size with latitudes from north to south in the first and second periods as showing mean values to be 3.31 - 4.46 in 65°S. Thus schools were abruptly increased in density and size in near waters close to the pack ice edge line.

3.4 Experiment about the sighting distance and an angle estimation

Experiments about the sighting distance and an angle estimation were carried out in each sampling vessel during mid-cruise on

13th - 14th Feb., under the good weather condition for visibility (a minke whale school 4 n.miles apart could be detected) with gentle breeze (wind force 2 - 3 Beaufort classes). We adopted similar procedure to the experiment in the IWC/IDCR southern hemisphere minke whale assessment cruises. All topmen (five persons in each vessel) and other personnel who had a chances to engage in searching participated in this experiment.

A total of 17 persons was tested for eight different combinations of distance and angle (eventually a total of 136 experiments). Every testee on a sighting board by using normal binocular estimated sighting distance and angle for a artificial subject equipped with radio reflector in each experiment. At the same instance, accurate distance and an angle from the vessel to the subject was measured by the radar. After comparison of estimated and radar data, accuracy of each testee in sighting distance and angle estimation can be examined.

Since data processing of this experiment has not been completed, this will be shown and examined in the future study.

4 SAMPLING

In the present cruise, all the minke whale sightings identified as primary sighting were scheduled to be sampled with a maximum of two whales from a each school under the stochastic sampling scheme as mentioned below. A total of 273 whales were sampled by adopting this procedure during the period between January 17 and March 23 1988. This section outlines the sampling scheme adopted in the present cruise as described below.

4.1 Sampling scheme

For the determination of whales to be sampled, we prepared various tables of random sampling digits according to school sizes (TRS; Fig. 5 shows an example of them).

4.1.1 Numbering of individual whales within a school

After close enough to count the individuals, we sketchily recorded their position in a school and gave serial number to those individuals from left to right.

4.1.2 Choice of individuals to be sampled

Sampling scheme varied in school size and whale behavior as described below:

a) Solitary whale

A whale was to be sampled.

b) School size = 2

First target whale was determined according to the unused top number in TRS (school size = 2); if the unused top number in TRS was "2" , the whale numbered as "2" was the first target. After the first target whale was sampled, sampling of the other was commenced.

C) School size ≧ 3

The first target whale was chosen by the unused top number in TRS specific to school size by the same procedure as *B)*. After sampling the first whale, individuals remained in the school were re-numbered according to the positions by sketching again. The second target whale was chosen among the remained members by its re-numbered "number" according to the unused top number in TRS for a new school size (ordinarily, (original size) - (1)).

D) Choice when a school separates

When a school had separated into several sub-groups, we adopted the determination weighted by sub-group size as follows: When a school associated with 7 whales had separated into tow sub-groups of five (sub A) and two animals (sub B), target sub-group was initially determined as follows; If the unused top number in TRS (school size = 7) was 1 - 5 (serial numbers were given from larger sub-group to smaller for this purpose), larger sub-group (sub-group A) became the target sub-group (if the unused top number was 6 or 7, sub-group B became the target sub-group), subsequently first target whale was chosen from sub-group A by the same procedure for determination of the first target as in *C)* under the condition of school size = 5. The second target was determined by repeating this procedure under the condition of school sizes of sub-group A = 4 (5-1) and B = 2.

E) Give up time for the chasing

Give up time for the chasing to the one target whale was set to be one hour regardless school size.

4.2 The feature of sampling

A total of 273 whales were sampled during the present cruise according to the sampling scheme described above. It can be said that the present scheme was successfully adopted without any significant problems to the sampling work at the field.

As being scheduled, we had surely sampled minke whales of the primary sighting. Table 7 indicates the proportion of the successfully sampled school in the total primary sightings by school size. Causes of failures in samplings were classified into five categories as summarized in Table 8.

The number of primary sightings for solitary whale was 83 sightings and 53 samples were obtained from them. 30 whales were lost in spite of effort of sampling. The dominant cause of these failures came to the losing sight of whale by the reasons such as quick mobiles or long time diving, 19 whales were lost because of this cause. Unsuitable weather conditions including poor visibility and strong wind caused in failures in seven whales.

Fig. 6 compares the (estimated) length compositions between of sampled and of unsampled whales based on the data estimated before the taking at sampling vessels. Mean values were calculated to be 22.9 ft (SD. = 3.59, n = 48) and 23.9 ft (SD.=3.77, n=17) for sampled and unsampled whales, respectively, and difference between them was statistically insignificant (t-test, $0.3<P<0.4$).

As mentioned previously, two whales could be sampled as its maximum from a school in the present cruise. The number of primary sightings counted with two or more whales in a school were 144 schools. The scheme two whales to take sampling from a school (hereafter two-whales-sampling) succeeded in 86 schools. Especially, failures of two-whales-sampling were only four times out of 39 chances among schools having five or more individuals. In contrast, the successes of two-whale-sampling were 24 of the 71 chances among school sizes 2 and 3.

Fig. 7 plotted the relationships in body lengths between the first and the second samples obtained from a same school by the two-whale-sampling. Mean of differences of body lengths in pairs ((B.L. the first)-(B.L. the second)) was 0.51 ft (SD., 3.35) and no specific trend could be detected (t-test, $0.3<P<0.4$).

On the other hand, we could not sample as much as one whale on 10 schools by the cause of the whale behavior (5 schools) and of escape into pack ice (5 schools) among schools having two or more animals. These failures happened often in a smaller size of school such as 2. The one sampling of the first target with a failure of the second (hereafter one-whale-sampling) were 48 (there was no *vice versa*). The major causes for this situation were; whale behavior (26), escape into pack ice (11) and technical problem (6). Such one-whale-samplings were frequently found in smaller schools as 2-4. One case, in one-whale-sampling, was due to the trouble in identification of the target whale as follows: After sampling the first target from a primary school (n=4), we ceased sampling by the reason that another school (secondary sighting, n=2) joined to the primary sighting resulted to the inability of identification.

As mentioned above, two-whales-sampling under the present sampling scheme was relatively easier on schools with larger whales, and more samples could be obtained under the present scheme without any problems to our experiences. On the other hand, two-whales-sampling was not easy on schools associated with smaller size. For this reason, cooperative samplings between two sampling vessels with keeping the principal of the sampling scheme (see chapter 2) was so effective to the avoidance failure when two whales sampling was employed.

4.3 Spatial distribution of samples and sampling rate

Fig. 8 shows spatial distribution of samples obtained throughout the cruise. Only eight samples were obtained from the northern stratum. The rest of 265 were from the southern stratum. The sampling distribution was almost reflected by the sighting. For example, 63.4% of the total were obtained from southern waters of 65° S, especially 76.8% of them concentrated in the high density

area in the second period (65°S - 107°, 108°E).

Table 9 indicates the number of samples by latitude (based on the first sighted position of each sample) and its proportion to the number of the primary sightings within the same latitudes as samples (hereafter sampling rate). Throughout three periods, the sampling rate was higher in the northern latitudes, especially as showing above as 0.7 in the north latitudes of 62°S. While, in the southern latitudes (64° - 65°S), sampling rates were as lower as 0.36 - 0.50. This is clearly due to the sample size limitation from a school.

As mentioned previous chapters, a school associated with two dwarf form minke whales was sighted (58°23'S-111°26'E) and one sample obtained from them (58°22'S-111°30'E). This type of minke whale has firstly obtained from the Antarctic region since the start of taking minke whale. This may be resulted from latitudinally wider coverage in the present cruise than those in the commercial whaling.

4.4 Time budget

In the present cruise, effort in each sampling trial was recorded on the data format with following items such as confirming, chasing, handling, towing and other actions related to the sampling work. Since those data have not been fully processing yet, it will be presented somewhere.

5 BIOLOGICAL DATA AND SAMPLE COLLECTION

5.1 Biological data and sample collection

Biological data and sample collection were made on all of 273 whales sampled comprising 154 males (including 153 ordinal and one dwarf forms) and 119 females on the deck of *NO3*. This sub-section outlines those works. Details of analyses of the data and samples will be examined somewhere (a part of preliminary analyses have been shown in chapter 7).

Every whale sampled in the present cruise was numbered serially after checking flukes number, which was engraved in the sampling vessel so as to identify catching and sighting number. Subsequently we commenced biological works on samples as described below. Table 10 summarizes research items and their efforts.

5.1.1 Sex and morphometrics including body weight

After photographic recording of the lateral side of carcass, we measured not only body length (straight line between tip of snout and notch of tail flukes; by the order of nearest 10 cm) but also their body proportion of all whales sampled (17 points; in nearest 1cm) including half girths at anus and umbilicus. Sex

identification and recording relative stage of diatom infection of animals were also made at this stage. Body weight measurement by parts was carried out once a day (normally first whale of the day; 39 individuals), whole weights were occasionally weighed for only smaller whales than 6.1m in body length before flensing (11 individuals). By this measurement, we obtained both informations of body weights before and after flensing in six whales.

Standard measurement on thickness of blubber in nearest 0.1 cm at three points on the lateral side of the body (below dorsal fin, above umbilicus and position at ear). Skull measurements (length and the greatest breadth; in nearest 1cm) were made in all of whales sampled using a pair of large sized vernier calipers.

5.1.2 Reproduction

Female

After skinning blubber, the measurement of the greatest breadth and thickness of mammary gland in nearest 0.1 cm and tissue collection (preserved in 10% formalin solution) were made in all females sampled. Ovary collection, measurement on width of uterine horn as well as endometrium tissue collection (preserved in 10% formalin solution) were also made in all females. Collection of uterine fluid for sperm detection was conducted from the vagina or uterus of all sexually mature female and all females to be considered as puberty, and we made this experiment in 70 females. The counting of corpora number, weighing ovaries and measurement of three dimensional diameter of corpus luteum, corpora albicans and graafian follicle largest three of all ovaries collected were completed during the cruise after research.

If foetus present in uterus, the number of foetus, sex, length (in nearest 1cm) and weight were recorded. Identification of foetus sex was based on not only the shape of sexual organ but also the distance between anus and center of sexual organ. In the present cruise, 57 foetus were found from 57 females. Among them 55 were measured and 54 were sexed. Body proportion was to be measured in foetus having over 200cm in body length, in such a case it was only one foetus in the present cruise.

Male

Both testes and epididymides were separately weighed in nearest 10g on all males. Tissue samples of those organs were collected from the center of the right side with size of 1.0cm cubic and 1.0cm length respectively, and those were preserved in 10% formalin solution. Smear samples obtained from both tissues in center of testis and epididymis among 129 males.

5.1.3 Age character

In the present cruise, we attempted to collect earplugs from both sides of all whales sampled; as a result, this trial was succeeded in 256 whales (one earplug missing in 15 and both

missing in two whales). Those earplugs were partly prepared during the returning cruise after research. As a supplement of an age determination, tympanic bullae were principally collected from whales smaller than body lengths 7.1m and 7.4m in male and females respectively or whales missing both earplugs. The largest baleen plates were also principally collected from whales smaller than 6.1 m of body length either sexes for a supplemental age character. In the present cruise tympanic bullae and the largest baleen plates were collected from 73 and 45 individuals respectively.

The sections of vertebra between epiphyses and centrum were cut out from the 6th dorsal and 3rd lumber vertebra of all whales sampled with a size of about 4.5 X 7.0 X 0.7cm and those were preserved in 10% formalin solution.

5.1.4 Tissue and blood sample collection

Blood (serum) sampling for gonadal hormone assay were scheduled to collect from all whales sampled; as a result, those were obtained from 238 whales (134 male and 104 females) and were stored in freezing after centrifuging for serum separation. The tissues including skin and muscle for DNA study and muscle, liver and heart for electrophoretic study were collected from all whales sampled with 50g for each, and those were stored in freezing of about -20°C soon after the collection.

Several tissues for the pollution study including, muscle, liver, kidney and pancreas were collected from three sexually mature animals for either sexes and stored in freezing. Serum samples for the pollution study were obtained from 43 pregnant females and their foetus.

For the lipid analysis, we collected following tissues with 500g - 5kg from weighed whales; muscle (just below dorsal fin), blubber (from two portions), ventral groove, vertebrae (7th lumber), liver, fore stomach, heart, kidney and small intestine.

5.1.5 Stomach contents

Conventional stomach content records including food species with rough classification and relative richness were completed in all whales sampled. If euphausiid was present, its condition was also kept in record with three classification. In addition, we attempted to weigh stomach contents (principally by the part of stomach) from all whales except individuals its relative richness below 25%; finally this measurement was succeeded on 85 individuals.

Stomach contents were occasionally collected from the whales having relatively fresh foods in their stomachs. We collected stomach contents including euphausiids and fishes from 134 individuals.

5.1.6 Mark recapture

No mark was returned throughout the present cruise.

5.1.7 Miscellaneous

Four whole skeletons were collected for the purpose of the classification study and the social educations: their body lengths were; 8.9m - male; 8.1m - male; 8.5m - male; 7.0m - male (dwarf form).

5.2 Biopsy experiment

For development of biopsy dart, some experiment were carried out on the deck of *NO3* using whale carcass of 6.6m male on Feb. 1. In the present experiment was used following crossbow and dart as the sampling equipments:

crossbow; Barnett Thunderbolt, 71cm(L) X 81cm(W)
dart; Barnett fiber arrow, 53cm(L) X 0.9cm(ϕ)

End of dart was linked with a line (#200 and #8) in a fishing reel attached to the gripe of crossbow. We developed several different types of dart head for sampling tissue of the target in this experiment (Fig. 9).

Ten trials were conducted with distances of 25m and 30m to the target whale lying on its belly on a deck. Table 11 summarized conditions of trials and their results. Throughout trials, the head of type B was resulted most effective for sampling tissue, although this type with smaller stopper occasionally penetrated into the carcass. But it might be often difficult to recover sampled tissue. We met some troubles in dart release regardless head type. This may come from unsuitable fishing reel for this purpose.

Unfortunately, we could not find a chance to try this biopsy experiment on alive whale in sea.

6 OCEANOGRAPHICAL RESEARCH

In addition to routine recording of weather and sea conditions, oceanographical surveys including surface temperature in sampled waters and vertical thermal distribution by XBT were carried out on board of *T25* by one of the researchers (Ono) during the research period. This chapter outlines those works and presents the preliminary result. Details of analyses including its relation to the whale distribution will be made by the oceanographer in the near future.

Surveys were normally conducted after the finishing of sampling and sighting works in each a day (17th Jan. - 25th March, 17:00 - 21:00; 26th March, 10:50), therefore, observing points (67 points) were almost same as with the ending point of searching of the day.

6.1 Surface temperature

Surface temperature was measured using sampled water from surface and the standard thermometer. Isotherms within a research area were given in Fig. 10 by the three periods.

An isothermal line of 3°C was located near the 56°S throughout the three periods. However, other isothermal lines moved with periods as follows: line of 2°C was located at 60°-61°S in the first period while it was at 62°S in the second and third period; line of 1°C positioned between 64° - 65°S in the first and second period while it was at 63°S; line of 0°C was in near 65°S in the first and second period but it was in between 64° - 65°S in the third period. Near the pack ice line, thermal incline was generally steeply from 0°C to -1.5°C. However, isothermal lines of 0°C and -0.5°C were diffused in eastern ice edge line (third period) where whale density was relatively low.

6.2 XBT survey

For this survey, we used XBT recorder (TURUMI XBT, MK2S) and probes (TURUMI T-6A) which could scan vertical water temperatures from 0 to 460m of depth. Vertical isotherms obtained from those data were given in Fig. 11.

The thermocline could be differentiated between the depth of 50m and 80m - 100m in latitudes from 55°S to 64°S, but it was not so clear in waters south of 65°S. It was observed throughout the periods that the warm water (1° - 3°C) formed above the thermocline and the cold waters (0° - -1°C) formed below the thermocline (expanded until about 200m).

From the vertical distributions obtained from the present cruise, it was suggested that the cold water came from melting of pack ice migrated under the surface warm waters from pack ice area to the offshore by diffusing between 50m and 200m of depth.

6.3 Marine debris

The survey of marine debris have been made from at the wheel house of *NOJ* (height 21m from sea level). A total searching hour was 422.75 hours comprising 176.0 hr. (first period, 17th Jan. - 6th Feb.), 95.0 hr. (second period, 6th Feb. - 1st March) and 151.75 hr. (third period, 2nd - 26th March). One plastic bottle and one box made with expanded polystyrene were sighted in the first period, while nothing was found in the second and the third periods.

Same surveys were also made during the cruise between the research and adjacent waters of Japan. Those data will be analyzed by a certain authority in the future.

A plastic bag (55cm X 38cm) was found from the stomach of a whale sampled in the southern stratum.

7 PRELIMINARY ANALYSES

This chapter provided a part of preliminary analyses of biological structures on samples which was made just after the cruise. Details of analyses will be completed in the further study.

Body length of all samples were measured in nearest 10cm, however, for the present analyses we examined body length data in nearest one foot.

7.1 Sex, length and reproductive structure of samples

7.1.1 Grouping of samples

In order to examine biological characteristics of samples, we conventionally proposed several time-areal groups. In this grouping of samples, following factors were taken account;

(1) Spatial distribution of samples,
(2) Spatial distribution of whale concentrations based on sighting data,
(3) Possible seasonal movement of whales,
(4) Distance from the pack ice line,
(5) Discontinuity of sighting.

As shown in Fig. 12 following five time-areal groups could be proposed:

Northern group (NG); 28 individuals; Jan./17-19, Feb./1-8, March/23
Offshore center group (COG); 33 ind.; Jan./22, 28-31, Feb./11-12
Eastern offshore group (EOG); 12 ind.; Feb./8-9
Western pack ice group (WIG);139 ind.; Feb./12 - March/5
Eastern pack ice group (EIG); 61 ind.; Jan./24-28, March/10-12

7.1.2 Sex and length composition

A total of 273 whales sampled was composed of 154 males and 119 females. Male sex ratios by the group were; NG - 0.821, COG - 0.515, EOG - 0.833, WIG - 0.482, EIG - 0.607. From these values, it could be noted that males are dominant in northern and offshore groups. Among the ice side groups, on the other hand, the sex ratio was almost even in WIG while male was slightly dominant in EIG.

Fig. 13 shows length compositions by sex and group. In both northern and offshore groups, body length was shown to be relatively larger in males, ranging from 17 to 30ft. In females of these groups, on the other hand, it was smaller, 18 to 24ft except one large female of 28ft. It might be another characteristic feature that difference of body length in males was not prominent among five groups, though there was slightly high proportions of smaller animals in northern and offshore

groups. Difference of female composition among groups was distinct, that is, a large female was absent in northern and offshore groups.

Mean body lengths and their standard deviations by sex and group are given in Table 12 by sex and group. Reflecting of the differences in body length, mean values were statistically different among northern - offshore groups and pack ice groups as being 24.5 - 25.1 to 26.9 - 27.0ft and 20.2 - 21.2 to 25.8 - 27.7ft in males and females respectively (t-test, $p<0.05$ - 0.001).

Both in the pack ice groups, mean length of female in WIG was statistically larger than that of EIG (t-test, $0.005<p<0.01$) though males mean length was not.

7.1.3 Reproductive status

Reproductive status of females were interpreted by the presences of corpus luteum or albicans in the ovary, foetus in uterus and milk in the mammary gland. Male reproductive status should be examined by histological evidences. Since preparation of testes and epididymides tissues has not been completed by this time, we took conventional value of testis weight (over 0.3 kg in heavier side; originally provided by Ohsumi, Masaki and Kawamura (1970) and reconfirmed by Kato (1986)) as a tentative criterion of sexual maturity. Table 13 indicates reproductive status by group based on those criteria. It is noteworthy that, throughout sampling, no lactating female was found.

In the offshore groups, all females except one pregnant individual were identified as sexually immature, and proportions of sexually immature in males were also relatively high. On the other hand, in the pack ice groups, the proportion of sexually immature animals decreased to 36.1 - 50.0% and 11.9 - 13.5% in females and males respectively. In the pack ice groups, it was noted that the proportion of pregnant female in WIG was higher than that in EIG.

7.2 Biological characteristics by the school size

7.2.1 Mean length and reproductive status by school size

Table 14 indicates mean body length with its standard deviation and range by the school size. Mean body length in solitary class was statistically smaller than those of other school size classes in both sexes as being 22.9 ft and 21.8 ft in male and females respectively (t-test, $p<0.001$). Among classes of school size larger than two, mean values of length could not show any specific trend as being 26.9 - 27.3ft in male and around 27ft in females. However, in a class of school size six or more, they were slightly higher in female. School size two in mean value of length took the position between the solitary and larger school in either sex.

The reproductive status by school size showed that sexually immature animals were dominant in solitary classes in both sexes

(Table 15).

From above analyses, it was found that smaller immature animals were apt to be solitary in offshores whereas larger sexually mature animals tend to make larger school in the high latitudes.

7.2.2 Combination of animals by the school size

As mentioned in chapter 5, it was attempted to sample two whales at its maximum from a school by primary sighting. As a result, 172 individuals in 86 pairs were obtained during the cruise.

Table 16 indicates combinations of those pairs with respects to sex and reproductive status by school size. As whole trends among school sizes, there was no combination of both immature males and a few combination of immature and mature males. On the other hand, the most frequent combination was male and female in both mature being 23 pairs. Combinations of both mature males (16 pairs), and of mature male and immature female (15 pairs) was also frequent.

Within a class of school size 2, combination of different sexes was relatively dominant regardless of reproductive status. Among larger sized schools (>3), combination of male in mature and females both in mature and immature were frequently observed.

Combinations of body length of pairs were also partly analyzed (Table 17). Following trends were suggested that although combinations of both smaller lengths or different sizes such as smaller and larger lengths were dominant in school size 2, combination of animals with similar length (also both larger) were getting higher in frequently with increasing school size.

7.3 Foetus frequency

Out of 59 sexually mature females, 57 females were pregnant. Since no multiple foetus was found, mean litter size was 1.0.

Body length of foetus was considerably varied ranging from smaller than 5.0cm to 207cm, suggesting untimely migration to higher latitudes or variation of the timing of the conception. However, foetal length was gradually increased by day as shown in Fig 14, which plots foetal length to the date setting 1 for Jan. 1 1988. Fitted liner regression produced following equation:

$$L = 47.61 + 0.76\ t \quad (r = 0.208;\ n = 55)$$

where, L = foetal length (cm) and t = date.

7.1 Thickness of blubber

Thickness of blubber was measured at three point of lateral side in each whale. This section dealt with from only data measure at the point below dorsal fin.

Table 18 indicates means of thickness of blubber by the

groups with their standard deviations and ranges of data as well. Blubber of female in mean value were thicker than that of male. It seems that blubber thickness in WIG and EOG were slightly thicker than those in the others. Relatively wider range of thickness might come from different timing of migration. But other information may be required for this point.

Fig. 15 plots thickness of blubber of each individual to the date setting 1 for Jan. 1 1988. Although several variations were present, minimum and maximum value clearly increased by day. Fitted liner regression produced following equation:

$$T = 3.07 + 0.023\ t \quad (r = 0.393;\ n = 273)$$

where, T = thickness of blubber (cm) and t = date. Slope is significantly different from 0 (t-test; $p<0.001$).

7.5 Stomach contents

7.5.1 Food species

We observed stomach contents in all whales sampled. Except 13 whose stomachs were damaged by the harpoon, 211 individuals contained foods in their stomachs and 49 individuals were apparently empty.

Table 19 summarized food species found in the stomachs with rough classification in the present cruise. Euphausiids was exclusively dominant in food item as found in 210 individuals (99.5% of the total). Among them, some fishes including *Notothenia* sp. were mixed with Euphausiids in stomachs of three individuals. An another fish, *Myctophid* sp. was found from a stomach of whale (dwarf form) sampled in the northern stratum on March 23, whose stomach content was composed of only this fish. Details of sorting for stomach contents will be reported in near future.

7.5.2 Relative richness

Table 20 indicates the proportion of relative richness of stomach content by classifying four categories as mentioned in 5.1.5 by the groups. In northern and offshore groups, near full stomach (75 - 100%) was not found and stomachs of which richness was less than 50% and empty occupied 84 - 92% to the total. On the other hand, the proportion of stomachs in richness over 49% were relatively high as being 17.5% (including 5 near full stomach) and 15.3% in WIG and EIG, respectively.

Daily changes in the proportion of relative richness of stomach contents were given in Table 21. In the pack ice groups, the proportion of empty stomach increased with time progress, while higher richness decreased with time. This suggested the peak of feeding is in the morning or earlier time. This pattern was obscure among the data of the offshore and northern groups.

7.6 Different feature from commercial whaling

Fig. 16 shows body length compositions by sex. Data were compared with those in commercial whaling in Area IV (the Japanese fleet in 1986/87 season). The ranges of compositions in the present research were 17 - 30ft and 18 - 33ft in males and females respectively, while corresponded value of those in the commercial were 24 - 30ft and 24 - 34ft. And proportions of smaller animals to the total were higher in both sexes, especially among females in the research. Mean values indicated statistical difference between the research(R) and the commercial(C) as; 26.2ft(R) to 28.0ft(C) and 26.0ft(R) to 29.5ft(C) in males and females, respectively (t-test, $p<0.001$).

The proportion of sexually mature animals to the total samples were 78.6% (121 in 154 inds.) and 49.6% (59 in 119 inds.) in males and females respectively. These occupations were considerably lower than that in the commercial era based on the same criteria of sexual maturation by Masaki (1979) and Kato (1982).

Table 22 indicates the number of sexually immature and mature animals by sex and body length class. Except dwarf form, body lengths for sexually mature male was 23ft at its minimum and sexually immature was 26ft at its maximum. Since length at 50% of sexual maturation should exist between these length, this value could be higher that the previous estimates by Masaki (1979) and Kato (1982) with same method using testicle weight as described somewhere above. On the other hand, for females, length at 50% of sexual maturation existed between 26ft and 27ft and this value was almost similar to the previous estimate of 26.5ft by Kato (1987). Mean body length of soon after the attainment of sexual maturity (the first ovulation), which is another measure of length at sexual maturation, was 27.2ft (SD=0.34, n=8). This was the same value as a proposed mean length at sexual maturation for the total population by Kato (1987).

8 DISCUSSION

The present research plan has firstly in corporated systematic sighting survey and random sampling concurrently since the beginning of the population study of the whale researches, and it may be said that research plan of the present feasibility study was successfully realized by the present cruise.

The purposes of the present cruise which were described in the research plan (Government of Japan, 1987a; SC/D87/1) can be quoted as following four points: 1), the feasibility study of the newly refined sampling scheme designed for stochastic sampling in the original program (e.g. whether the required number of samples can be collected by the designated method within the given period); 2), the feasibility study on the technical problems encountered in the survey for the sampling vessels whether the can collect sighting data and samples concurrently; 3), Investigation on the extent of segregation by age, sex,

reproductive condition; 4), investigation on the uniformity or non-uniformity of the biological character specific to school size.

This chapter discussed mainly some aspects as described below regarding whether the present cruise could obtain all the information about these purposes cited above.

8.1 *The feasibility study of the newly refined sampling scheme designed for stochastic sampling in the original program (e.g. whether the required number of samples can be collected by the designated method within the given period)*

As mentioned in chapter 4, it may be said that newly refined sampling scheme was successfully adopted without any problems throughout the present cruise, consequently we could obtained 273 samples under the sampling scheme within a limited research period (70 days).

Although a total searching distances of about 9,600 n.miles was expected in the research plan, actual distance in the cruise (8,482.4 n.miles) was about 12% shorter than expected one due to mainly considerable proportions of the unsuitable weather and sea conditions for the searching. About 10% lower of sample size (273 individuals) in this cruise than expected one (300 individuals) may have resulted from the shortage of the searching distance mentioned above. The weather condition, therefore, is one of the determinative factors in the planning of future cruise. This aspect is desired to be fully examined by the validated time budget and other related data.

8.2 *The feasibility study on the technical problems encountered in the survey by the sampling vessels which collect sighting data and samples concurrently*

There was no such case that systematic sighting was hindered by the presence of sampling work or *vice versa* in the present cruise. Therefore, we believe that systematic sighting and sampling work could be conducted concurrently. One of major factors for this success that most of crew on the sampling vessels had experiences in IDCR southern minke whale assessment cruise. In addition the good relation between researchers and crew for sighting, and sampling and collecting information especially regard to school formations.

The number of researchers and assistants seems to be slightly insufficient for the amount of their allocated works the sighting vessels.

There were no any problems in the biological data and sample collection on the deck of *NO3*, thanks to the cooperation of the experienced flensing staffs and to the contributions of experienced researchers and technicians. However, there are several insufficient equipments to be improved.

8.3 *Investigation on the extent of segregation by age, sex,*

reproductive condition

As preliminarily analyzed in chapter 7, some aspects of the nature of sexual and reproductive segregation, which had been suggested by the data from commercial whaling (Ohsumi and Masaki, 1975; IWC, 1979; Best, 1982; Kato, 1987 etc.) has been clarified by showing differences in sex and length composition including sexual status among the groups. The characteristic feature in segregation will be analyzed further using the present randomized data obtained from longitudinally wider waters.

8.1 *Investigation on the uniformity or non-uniformity of the biological characteristics according to school size*

All whale samples were obtained under the sampling scheme which were designed to enable to examine school structure. We have had preliminary results as follows (see chapter 7); smaller immature animals were apt to be solitary whereas larger sexually mature animals tend to make larger school in the high latitudes. In addition, from the analyses of 86 pairs obtained, combination of male in mature and females both in mature and immature were frequently observed in larger sized school. Therefore, it is suggested that biological characters may be depend on school size examined.

This feature will be examined fully by both the present and future data.

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

Ship name	Gross tonnage (t)	Length overall (m)	Horse power main engine (BHP)	Hight top barrel (m)	Number of crew*)
Kyomaru No. 1	812.08	69.15	5,000	18	18
Toshimaru No. 25	739.92	68.37	3,600	18	19
Nisshinmaru No. 3	23,107.85	194.64	6,750	—	117

*) excluding researchers.

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

Personnel	Situation	Ship	Assignment
Hidehiro KATO	Cruise leader	*NO3*	General management of overall researches Biological data and sample collection
Yoshihiro FUJISE	Researcher	*NO3*	Biological data and sample collection
Hisashi HIROYAMA	Researcher*)	*KO1*	Determination of target whale Collection of sighting and sampling data
Kiyoshi ONO	Researcher	*T25*	Determination of target whale Collection of sighting and sampling data Oceanographical research
Masamitsu YAMADA	Research assistant	*KO1*	Recording effort and weather data
Tameo RYONO	Research assistant	*T25*	Recording effort and weather data
Shigeo TABATA	Research assistant	*NO3*	Biological data and sample collection
Yutaka EGUCHI	Research assistant	*NO3*	Biological data and sample collection

*) held concurrently governmental inspector

Table 3. Itinerary of the fleet in 1987/88 research cruise.

Event	Date	Latitude	Longitude
Nisshinmaru No.3 left Yokohama	Dec. 23, '87	35° 26'N	139° 40'E
Kyomaru No.1 and Toshimaru No.25 left Shimonoseki	25, '87	33° 58'N	130° 57'E
Pre-cruise meeting and refueling	Jan. 5, '88	13° 52'S	114° 32'E
Start of *First period*	17, '88	55° 00'S	108° 18'E
Suspended survey in the southern stratum	Feb. 1, '88	60° 00'S	106° 03'E
Start of survey in the northern stratum	1, '88	60° 00'S	106° 06'E
Mid-cruise meeting and refueling	5, '88	59° 21'S	107° 12'E
End of *First period*	6, '88	60° 00'S	107° 12'E
Start of *Second period*	6, '88	60° 00'S	106° 03'E
Suspended survey in the southern stratum	22, '88	65° 23'S	107° 32'E
Start of northern stratum	24, '88	60° 00'S	109° 24'E
End of *Second period*	Mar. 1, '88	60° 00'S	110° 30'E
Start of *Third period*	2, '88	62° 19'S	105° 00'E
Mid-cruise meeting and refueling	3, '88	64° 49'S	107° 01'E
End of survey in the southern stratum	15, '88	61° 11'S	112° 13'E
Start of survey in the northern stratum	16, '88	60° 00'S	112° 44'E
End of *Third period*	26, '88	55° 00'S	111° 38'E
Post-cruise meeting and refueling	26, '88	54° 58'S	111° 49'E
Kyomaru No. 1 and Toshimaru No. 25 arrived at Shiogama	Apr. 18, '88	38° 19'N	141° 04'E
Nisshinmaru No. 3 arrived at Tokyo	20, '88	35° 38'N	139° 45'E

Table 4. A list of number of sightings (no. individual/ no. school) by species, vessel, type of sighting in the present cruise.

Species	Primary sighting						Secondary sighting						Grand total		
	KOI		*T25*		Total		*KOI*		*T25*		Total				
	S[2]	N[3]	S	N	S	N	S	N	S	N	S	N	S	N	Total
Minke whale (ordinal form)	259/92	7/4	395/129	2/2	654/220	9/6	416/97	0	269/97	0	685/194	0	1339/414	9/6	1348/420
Minke whale (dwarf form)	0	0	0	2/1	0	2/1	0	0	0	0	0	0	0	2/1	2/1
Humpback whale	47/19	2/2	28/15	0	75/38	2/2	31/14	0	15/6	0	46/20	0	121/54	2/2	123/56
Fin whale	1/1	0	0	2/2	1/1	2/2	0	0	0	2/2	0	2/2	1/1	4/4	5/5
Right whale	2/2	0	0	0	2/2	0	0	0	0	0	0	0	2/2	0	2/2
Sei whale	0	0	0	1/1	0	1/1	0	0	0	0	0	0	0	1/1	1/1
Sperm whale	4/4	0	0	2/2	4/4	2/2	0	0	1/1	0	1/1	0	5/5	2/2	7/7
Ziphiidae[1]	77/32	30/15	82/30	29/14	159/62	59/29	8/5	0	8/4	0	16/9	0	175/71	59/29	234/100
Killer whale	110/10	5/1	72/7	0	182/17	5/1	45/7	0	32/4	0	77/11	0	259/28	5/1	264/29
Pilot whale	0	85/3	0	0	0	85/3	0	0	0	0	0	0	0	85/3	85/3
Hourglass dolphin	3/1	0	5/1	3/1	8/2	3/1	8/1	0	0	4/1	8/1	4/1	16/3	7/2	23/5
S. right whale dolphin	0	15/1	0	0	0	15/1	0	0	0	0	0	0	0	15/1	15/1
Other dolphin	0	0	49/7	11/4	49/7	11/4	8/1	0	3/1	0	11/2	0	60/9	11/4	71/13

1) at least including southern bottlenose whale.
2) southern stratum
3) northern stratum

Table 5. Searching distances (n. miles), sizes of research area (n. m.^{2}) in the present cruise and recent IWC/IDCR southern hemisphere minke whale assessment cruises.[1]

Cruise	Area	Searching distance (n. miles) -- a	Size of research area (n. m.^{2}) -- b	Ratio (a/b)
Present cruise	55°S-Ice edge 105°-115°E	8,482.4	190,300	0.045
IDCR, 82/83	I	4,855.8	451,000	0.011
IDCR, 81/82	II[2]	2,999.1	213,007	0.014
IDCR, 79/80	III	7,205.2	569,000	0.013
IDCR, 78/79	IV	7,945.0	507,100	0.016
IDCR, 80/81	V	7,170.0	575,072	0.013

1) data from Butterworth, Hammond and Mizroch (1984)
2) east half (0 - 30°W) of Area II

Table 6. Searching distance of two vessels (nautical miles), primary minke whale sightings (no. individuals/ no. schools), mean school sizes and density indices (no. whales/ searching distance) by one degree square in each period.

First period (January 17 - February 6)

Latitude	Longitude										Total
	105° E	106° E	107° E	108° E	109° E	110° E	111° E	112° E	113° E	114° E	
55° S											
Density Index	0	0	0	0							0
Minke whales											
School size											
Distance (n. miles)	9.0	89.6	116.2	120.0							333.4
56° S	0	0	0	0.84							0.29
				1/1							1/1
				1.00							1.00
	60.0	60.0	109.0	119.0							348.0
57° S	0	0	0	0							0
	60.0	60.0	33.0	89.0							242.0
58° S	0	0	0	0							0
	6.0	4.0	92.0	120.0							222.0
59° S	1.67	1.82	0	6.12							2.68
	1/1	1/1		6/3							8/5
	1.00	1.00		2.00							1.60
	60.0	55.0	85.0	98.1							298.1
60° S	0	4.56	16.42	66.67							8.38
		6/4	11/8	1/1							18/13
		1.50	1.38	1.00							1.39
	14.0	131.6	67.0	1.5							214.9
61° S		0	0								0
		36.3	90.9								127.2
62° S			0.94	6.08	4.41	23.2	0				5.43
			1/1	7/5	2/2	7/2					17/10
			1.00	1.40	1.00	3.50					1.70
			106.5	115.2	45.2	30.2	15.6				312.9
63° S				13.92	5.16	0	2.12	26.09			8.43
				7/5	1/1		1/1	3/1			12/8
				1.40	1.00		1.00	3.00			1.50
				50.3	19.4	14.1	47.1	11.5			142.4
64° S				0	21.33	14.85		20.64	6.36	31.79	17.65
					16/8	3/1		9/2	4/3	11/6	43/20
					2.00	3.00		4.50	1.33	1.83	2.15
				7.3	75.0	20.2		43.6	62.9	34.6	243.6
65° S					0	70.46	64.13	30.84			55.78
						52/16	37/11	7/2			96/29
						3.25	3.36	3.50			3.31
					17.9	73.8	5.7	22.7			172.1

Table 6. (cont.)

Second period (February 6 - March 1)

Latitude	Longitude										Total
	105° E	106° E	107° E	108° E	109° E	110° E	111° E	112° E	113° E	114° E	
55° S											
Density index					0	0					0
Minke whales											
School size											
Distance (n. miles)					143.2	136.3					279.5
56° S					0	0					0
					120.0	120.0					240.0
57° S					0	0					0
					120.0	58.0					178.0
58° S					0	0					0
					120.0	116.0					236.0
59° S					0	0					0
					115.0	120.0					235.0
60° S	0	1.51	0								0.47
		1/1									1/1
		1.00									1.00
	135.7	66.2	11.9								213.8
61° S		0	1.89	3.41	1.51	10.14	0				3.12
			1/1	2/2	1/1	3/2					7/6
			1.00	2.00	1.00	1.50					1.17
		15.4	52.9	58.7	66.2	29.6	1.5				224.3
62° S						4.24	0	0	1.77	8.30	1.73
						1/1			1/1	2/2	4/4
						1.00			1.00	1.00	1.00
						23.6	63.2	64.1	56.4	24.1	231.4
63° S								0	1.51	18.39	10.55
									1/1	19/7	20/8
									1.00	2.71	2.50
								20.0	66.2	103.3	189.5
64° S					8.40	3.85	22.69	6.26	0		11.26
					1/1	2/2	14/8	3/3			20/14
					1.00	1.00	1.75	1.00			1.43
					11.9	52.0	61.7	47.9	4.2		177.7
65° S			490.39	301.52	60.61	7.87					258.20
			204/42	139/35	26/5	1/1					370/83
			4.86	3.97	5.20	1.00					4.46
			41.6	46.1	42.9	12.7					143.3

Table 6. (cont.)

Third period (March 1 - 26)

Latitude	Longitude										Total
	105° E	106° E	107° E	108° E	109° E	110° E	111° E	112° E	113° E	114° E	
55° S											
Density Index							0	0	0	0	0
Minke whales											
School size											
Distance (n. miles)							120.0	118.1	102.8	57.0	397.9
56° S							0	0	0	0	0
							107.0	120.0	60.0	56.0	343.0
57° S							0	0	0	0	0
							83.0	120.0	42.0	60.0	305.0
58° S							1.67*)	0	0	0	0.56
							2/1				2/1
							2.00				2.00
							120.0	120.0	60.0	60.0	360.0
59° S							0	0	0	0	0
							120.0	120.0	34.0	34.0	308.0
60° S											
61° S								0	0		0
								99.8	4.8		104.6
62° S	0	0	0	0	0	0	1.79	2.30	0	0	0.39
							1/1	2/1			3/2
							1.00	2.00			1.50
	109.0	54.4	55.8	54.3	54.8	55.7	55.8	86.8	109.0	130.6	766.2
63° S	0	0							0	0	0
	72.9	52.1							115.9	139.6	380.5
64° S		4.22	9.01					2.83	5.32	11.25	7.09
		4/2	3/1					1/1	7/2	16/10	31/16
		2.00	3.00					1.00	3.50	1.60	1.94
		94.8	33.3					35.4	131.6	142.2	437.3
65° S		0	2.29						41.51		16.17
			1/1						11/5		12/6
			1.00						2.20		2.00
		4.1	43.6						26.5		74.2

*) dwarf form

Table 7. Sampling rate to number of primary sighting and whales to be sampled by school size.

School size (A)	No. primary sightings (B)	Whales to be sampled[1] (C)	Whales actuary sampled (D)			Sampling rate	
			0	One	Two	(D/C)	(D/A*B)
1	83	83	30	53	-	0.64	0.64
2	41	82	7	21	13[2]	0.57	0.57
3	30	60	0	19	11	0.68	0.46
4	30	60	2	5	23[2]	0.85	0.43
5	21	42	0	2	19[2]	0.95	0.38
6	8	16	1	0	7	0.88	0.29
7	5	10	0	0	5	1.00	0.29
8	4	8	0	1	3	0.88	0.22
9	1	2	0	0	1	1.00	0.22
≧10	4	8	0	0	4	1.00	0.13

1) School size 1, no. school size×1; school size≧2, no. school size×2.
2) including one school by cooperative sampling in each school size.

Table 8. A list of causes of failure in applying two-whale-sampling.

Status	School size	no. incidences						
		Identifications[1]	lost sight of whale		Pack ice[4]	Technical	Unknown	Total
			by behavior[2]	by weather[3]				
No sample obtained	1		19	7	1	2	1	30
	2		4		3			7
	3							0
	4				2			2
	5							0
	6		1					1
	Total	0	24	7	6	2	1	40
Only one sample obtained	2		16	1	3	1		21
	3		8	2	4	5		19
	4	1	2		1		1	5
	5				2			2
	6							0
	7							0
	8				1			1
	Total	1	26	3	11	6	1	48

1) could not identify target whale
2) quick mobile or long time diving
3) strong wind, poor visibility or sunset
4) escaped into inside of pack ice

Table 9. Sampling rate (no. whales sampled / no. whales sighted in primary sightings) by latitude and the period.

Latitude (°S)	First period (Jan. 17 - Feb. 6)			Second period (Feb. 6 - March 1)			Third period (March 1 - 26)			Total		
	Sighted (S)	Sampled (C)	Ratio (C/S)	Sighted (S)	Sampled (C)	Ratio (C/S)	Sighted (S)	Sampled (C)	Ratio (C/S)	Sighted (S)	Sampled (C)	Ratio (C/S)
55												
56	1	1	1.00							1	1	1.00
57												
58							2	1	0.50	2	1	0.50
59	8	6	0.75							8	6	0.75
60	18	14	0.78	1	0	0.00				19	14	0.74
61				7	5	0.71				7	5	0.71
62	17	8	0.47	4	4	1.00	3	0	0.00	24	12	0.50
63	12	5	0.42	20	9	0.45				32	14	0.44
64	43	17	0.40	20	9	0.45	31	21	0.68	94	47	0.50
65	96	34	0.35	370	133	0.36	12	6	0.50	478	173	0.36
Total	195	85	0.44	422	160	0.38	48	28	0.58	665	273	0.41

Table 10. Check list of biological data and samples collected during the present cruise.

Samples and data	Number of whales		
	Male	Female	Total
Body length and sex	154	119	273
External proportion	154	119	273
Photographic records of carcases	154	119	273
Diatom film record and sampling	154	119	273
Standard measurements of blubber thickness (Three point on each whale)	154	119	273
Body weight and detailed measurements of blubber thickness	27	18	45
Mammary grand, lactation status measurements and histology sample	—	119	119
Milk sample for chemical analysis	—	0	0
Ovary collection	—	119	119
Corpora number, counting	—	119	119
Uterine horn measurement and endometrium sample	—	119	119
Uterine fluid for sperm detection	—	70	70
Foetal number	—	57	57
Foetal length	—	55	55
Foetal sex	—	54	54
Foetal weight	—	55	55
Foetus body proportion	—	1	1
Collection of foetus	—	19	19
Testis and epididymis weight and tissue collection	154	—	154
Smear sample from testis tissue	129	—	129
Blood sample for gonadal hormone assay	134	104	238
Muscle, liver and heart samples for electrophoretic study	154	119	273
Skin and muscle samples for DNA study	154	119	273
Tissue samples for pollution study	3	3	6
Blood samples for pollution study	0	43	43
Foetus samples for pollution study	0	10	10
Stomach content, conventional record	154	119	273
Stomach content weight	51	34	85
Collection of stomach contents for the food study	80	54	134*)
Earplug for age determination	153	118	271
Earplug for chemical analysis	5	7	12
Tympanic bulla for age determination	31	42	73
Largest baleen plate for age determination	20	25	45
Vertebral epiphyses sample	150	119	269
Skull measurement (length and breadth)	154	119	273
Tissue sampling of various parts the body for the lipid analyses	23	14	37
Collection of whole skeleton	4	0	4

*) including 30 individuals whose foods were collected separately from 1st to 4th stomach.

Table 11. Result of biopsy dart experiment on whale carcases.

Trial no.	Head[1] type	Shooting distance (m)	Result		
			Dart release	Dart recovery	Tissue sampling
1	A	35	Yes	-	No
2	C	35	Yes	-	No
3	A	25	No	-	-
4	B1	25	Yes	No[2]	Yes
5	B2	25	Yes	Yes	Yes
6	B3	25	Yes	-	No
7	B2	25	Yes	No[3]	Yes
8	B2	25	No	-	-
9[4]	B2	ca.50	-	-	-
10[4]	B2	ca.40	-	-	-

1) see Fig. 9.
2) due to deep penetration of the head (8cm from surface).
3) a line was snapped at recovering of the sample.
4) experiment for the only purpose of the observation on the trajectory of a dart.

Table 12. Mean body length (ft) and its standard deviation of samples by sex and the time-areal group.

Time-areal group*)	Male			Female		
	Mean (S.D.)	Range	n	Mean (S.D.)	Range	n
NG (56-62°S)	24.5 (4.1)	17.1-29.8	23	21.1 (1.8)	19.0-23.9	5
COG (62-65°S)	24.5 (3.9)	17.4-30.5	17	21.2 (2.6)	17.7-27.6	16
EOG (62-63°S)	25.1 (3.3)	19.7-30.5	10	20.2 (0.5)	19.7-20.7	2
WIG (64-65°S)	26.9 (1.9)	20.3-29.8	67	27.7 (2.6)	21.3-31.5	72
EIG (64-65°S)	27.0 (2.6)	19.0-30.2	37	25.8 (4.0)	18.4-32.5	24
Total	26.2 (3.0)	17.1-30.5	154	26.0 (3.8)	17.7-32.5	119

*) NG; northern, COG; offshore central, EOG; eastern offshore, WIG; western pack ice, EIG; eastern pack ice, see Fig. 12.

Table 13. Reproductive status of samples by sex and the time-areal group.

Time-areal group[1]	Male		Female				
	Imm.	Mat.	Imm.	Mat.			
				Preg.	Rest.	Lact.	Unknown
NG (56-62°S)	9 (39.1)	14 (60.9)	5 (100)	0	0	0	0
COG (62-65°S)	8 (47.1)	9 (52.9)	15 (93.8)	1 (6.2)	0	0	0
EOG (62-63°S)	3 (30.0)	7 (70.0)	2 (100)	0	0	0	0
WIG (64-65°S)	8 (11.9)	59 (88.1)	26 (36.1)	44 (61.1)	1 (1.4)	0	1[2] (1.4)
EIG (64-65°S)	5 (13.5)	32 (86.5)	12 (50.0)	12 (50.0)	0	0	0
Total	33 (21.4)	121 (78.6)	60 (50.4)	57 (47.9)	1 (0.8)	0 (0.0)	1 (0.8)

[1] NG; northern, COG; offshore central, EOG; eastern offshore, WIG; western pack ice, EIG; eastern pack ice, see Fig. 12.
[2] Uterine horn was damaged by the harpoon but both ovaries with one corpus luteum remained.

Table 14. Mean body length and its standard deviation (S.D.) of samples by sex and school size.

School size	Male			Female		
	Mean (S.D.)	Range	n	Mean (S.D.)	Range	n
1	22.9 (3.8)	17.4-28.5	30	21.8 (2.7)	18.0-29.8	22
2	25.8 (3.3)	17.1-30.5	27	25.5 (4.5)	17.7-31.2	20
3	27.3 (1.5)	21.6-29.2	29	26.9 (3.9)	18.4-32.5	11
4	27.6 (1.1)	25.9-29.8	28	27.1 (2.8)	20.7-31.2	23
5	26.9 (2.0)	20.3-29.2	16	27.4 (2.4)	22.3-30.8	24
≥6	27.0 (1.9)	23.0-30.5	24	27.9 (2.8)	21.3-31.5	19

Table 15. Sexual maturity by sex and school size.

School size	Male		Female	
	Imm.	Mat.	Imm.	Mat.
1	17 (56.7)	13 (43.3)	21 (95.5)	1 (4.5)
2	8 (29.6)	19 (70.4)	10 (50.0)	10 (50.0)
3	1 (3.4)	28 (96.6)	4 (36.4)	7 (63.6)
4	0 (——)	28 (100)	9 (39.1)	14 (60.9)
5	2 (12.5)	14 (87.5)	11 (45.8)	13 (54.1)
≥6	5 (20.8)	19 (79.2)	5 (26.3)	14 (73.7)
Total	33 (21.4)	121 (78.5)	60 (50.4)	59 (49.6)

Table 16. Combinations of two individuals collected from a same school with respect to sex and reproductive status by the school size.

School size		2				3				4			
		Male		Female		Male		Female		Male		Female	
		Imm.	Mat.	Imm.	Mat.	Imm.	Mat.	Imm.	Mat.	Imm.	Mat.	Imm.	Mat.
Male	Imm.	0	0	3	2	0	1	0	0	0	0	0	0
	Mat.	—	2	2	3	—	3	2	2	—	6	5	6
Female	Imm.	—	—	1	0	—	—	0	1	—	—	1	2
	Mat.	—	—	—	0	—	—	—	1	—	—	—	3

School size		5				≥6				Total			
		Male		Female		Male		Female		Male		Female	
		Imm.	Mat.	Imm.	Mat.	Imm.	Mat.	Imm.	Mat.	Imm.	Mat.	Imm.	Mat.
Male	Imm.	0	1	1	0	0	3	1	1	0	5	5	3
	Mat.	—	1	4	6	—	4	2	6	—	16	15	23
Female	Imm.	—	—	2	2	—	—	0	1	—	—	4	6
	Mat.	—	—	—	2	—	—	—	3	—	—	—	9

Table 17. Combinations of two individuals collected from a same school with respect to body length (ft) by the school size.

Smaller whale (ft)	School size 2 Larger whale (ft)										School size 3 Larger whale (ft)								School size 4 Larger whale (ft)						
	22	23	24	25	26	27	28	29	30	31	25	26	27	28	29	30	31	32	25	26	27	28	29	30	31
17	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
20	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
21	-	-	-	-	-	-	2	-	-	1	-	-	-	1	-	-	-	-	-	-	-	1	-	-	-	-
22	-	1	1	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
23		-	-	-	-	-	-	-	-	-	1	-	-	-	-	1	-	-	-	2	1	-	-	-	-	-
24			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
25				-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	1	-	1	-	-	-	-	-
26					-	-	1	-	-	-		-	1	1	-	-	-	-		-	2	1	2	1	-	
27						-	2	1	1	-			1	1	-	-	-	-			1	2	2	-	-	
28							-	-	-	-				-	-	-	-	-				1	1	-	1	
29								-	-	-					-	-	-	1					1	1	-	

Smaller whale (ft)	School size 5 Larger whale (ft)							School size ≥6 Larger whale (ft)									Total Larger whale (ft)										
	24	25	26	27	28	29	30	23	24	25	26	27	28	29	30	31	22	23	24	25	26	27	28	29	30	31	32
17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
20	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	-	1	-	-	-	-	-	-
21	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1	-	-	-	-	4	-	-	1	-
22	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	1	-	-	1	-	-
23	-	-	-	1	-	-	-	-	-	-	1	1	1	2	-	-	-	-	-	1	3	3	1	2	1	-	-
24	-	-	-	1	-	-	1		-	-	-	-	-	-	-	-		-	-	-	-	1	-	-	1	-	-
25		1	1	2	1	-	-			-	-	2	-	-	-	-			-	2	3	5	1	-	-	-	-
26			-	2	-	-	-				-	1	-	2	1	1				-	-	6	3	4	2	1	-
27				-	1	1	1					2	1	1	-	1					-	4	7	5	2	1	-
28					-	-	1						-	1	-	-						-	1	2	1	1	-
29						2	1							1	-	-							-	4	2	-	1
30							-								-	1								-	-	1	-

Table 18. Blubber thickness of samples by sex and the time-areal group.

Time-areal group*)	Male				Female			
	Mean	(S.D.)	Range	n	Mean	(S.D.)	Range	n
NG (56-62° S)	3.4	(0.8)	2.1-4.6	23	4.4	(0.8)	2.9-5.3	5
COG (56-62° S)	3.9	(0.6)	3.0-5.1	17	4.0	(0.5)	3.2-5.2	16
EOG (56-62° S)	4.2	(0.7)	2.7-5.0	10	5.0	(0.3)	4.7-5.3	2
WIG (56-62° S)	4.1	(0.7)	2.7-5.5	67	4.4	(0.8)	2.9-7.0	72
EIG (56-62° S)	3.6	(0.8)	2.2-5.5	37	4.3	(0.9)	2.7-6.1	24
Total	3.9	(0.8)	2.1-5.5	154	4.3	(0.8)	2.7-7.0	119

*) NG; northern, COG; offshore central, EOG; eastern offshore, WIG; western pack ice, EIG; eastern pack ice, see Fig. 12.

Table 19. A list of food item with rough classification and their frequency of occurrence to the total whales sampled.

Stomach content	Occurence	%
Euphausiids only	207	(75.8)
Euphausiids & Fishes	3	(1.1)
Fishes only	1	(0.4)
Empty	49	(17.9)
Lost	13	(4.8)
Total	273	(100.0)

Table 20. Composition of relative richness of stomach contents based on conventional classification by the subarea.

Relative richness (%)	Incidence (%)[1] Time-areal group[2]									
	NG		COG		EOG		WIG		EIG	
75 - 100	0	(0.0)	0	(0.0)	0	(0.0)	5	(3.8)	1	(1.7)
50 - 74	4	(16.0)	4	(13.3)	1	(8.3)	18	(13.7)	8	(13.8)
25 - 49	6	(24.0)	9	(30.0)	6	(50.0)	30	(22.9)	14	(24.1)
< 25	8	(32.0)	13	(43.3)	2	(16.7)	61	(46.6)	17	(29.3)
Empty	7	(28.0)	4	(13.3)	3	(25.0)	17	(13.0)	18	(31.0)
Unknown	3		3		0		8		3	
Total	28		33		12		139		61	

1) percentage to the total excluding stomach status unknown.
2) NG; northern, COG; offshore central, EOG; eastern offshore, WIG; western pack ice, EIG; eastern pack ice, see Fig. 12.

Table 21. Daily changes in the relative richness of stomach contents by the time-areal group (NG, COG and EOG were combined as offshore).

Relative richness (%)	Incidence (%)							
	6:00-9:00		9:00-12:00		12:00-15:00		15:00-Sunset	
WIG								
75 - 100	4	(8.3%)	0	(0.0%)	0	(0.0%)	1	(5.0%)
50 - 74	8	(16.7%)	6	(15.4%)	3	(12.5%)	1	(5.0%)
25 - 49	19	(39.6%)	7	(17.9%)	0	(0.0%)	4	(20.6%)
< 25	15	(31.3%)	20	(51.3%)	17	(70.8%)	9	(45.0%)
Empty	2	(4.2%)	6	(15.4%)	4	(16.7%)	5	(25.0%)
Unknown*)	3		4		0		1	
Total	51	(100%)	43	(100%)	24	(100%)	21	(100%)
EIG								
75 - 100	1	(6.3%)	0	(0.0%)	0	(0.0%)	0	(0.0%)
50 - 74	3	(18.8%)	2	(18.2%)	2	(13.3%)	1	(6.3%)
25 - 49	5	(31.3%)	3	(27.3%)	5	(33.3%)	1	(6.3%)
< 25	5	(31.3%)	2	(18.2%)	3	(20.0%)	7	(43.8%)
Empty	2	(12.5%)	4	(36.4%)	5	(33.3%)	7	(43.8%)
Unknown	1		1		1		0	
Total	17	(100%)	12	(100%)	16	(100%)	16	(100%)
Offshore								
75 - 100	0	(0.0%)	0	(0.0%)	0	(0.0%)	0	(0.0%)
50 - 74	3	(21.4%)	1	(5.9%)	2	(18.2%)	3	(12.0%)
25 - 49	5	(35.7%)	7	(41.2%)	3	(27.3%)	6	(24.0%)
< 25	3	(21.4%)	8	(47.1%)	4	(36.4%)	8	(32.0%)
Empty	3	(21.4%)	1	(5.9%)	2	(18.2%)	8	(32.0%)
Unknown	0		1		4		1	
Total	14	(100%)	18	(100%)	15	(100%)	26	(100%)

*) including samples stomach lost

Table 22. Sexual maturity by sex and body length (ft) of samples the present cruise.

Body Length (ft)	Male			Female		
	Imm.	Mat.	Total	Imm.	Mat.	Total
17.0-17.9	3 (100)	0	3	1 (100)	0	1
18.0-18.9	3 (100)	0	3	5 (100)	0	5
19.0-19.9	4 (100)	0	4	5 (100)	0	5
20.0-20.9	6 (100)	0	6	4 (100)	0	4
21.0-21.9	7 (100)	0	7	9 (100)	0	9
22.0-22.9	4 (80.0)	1 (20.0)*)	5	6 (100)	0	6
23.0-23.9	3 (75.0)	1 (25.0)	4	11 (100)	0	11
24.0-24.9	1 (50.0)	1 (50.0)	2	4 (100)	0	4
25.0-25.9	1 (7.3)	12 (92.3)	13	6 (100)	0	6
26.0-26.9	1 (4.2)	23 (95.8)	24	4 (36.4)	7 (63.6)	11
27.0-27.9	0	44 (100)	44	5 (41.7)	7 (58.3)	12
28.0-28.9	0	25 (100)	25	0	9 (100)	9
29.0-29.9	0	11 (100)	11	0	17 (100)	17
30.0-30.9	0	3 (100)	3	0	12 (100)	12
31.0-31.9	-	-	-	0	6 (100)	6
32.0-32.9	-	-	-	0	1 (100)	1

*) dwarf form

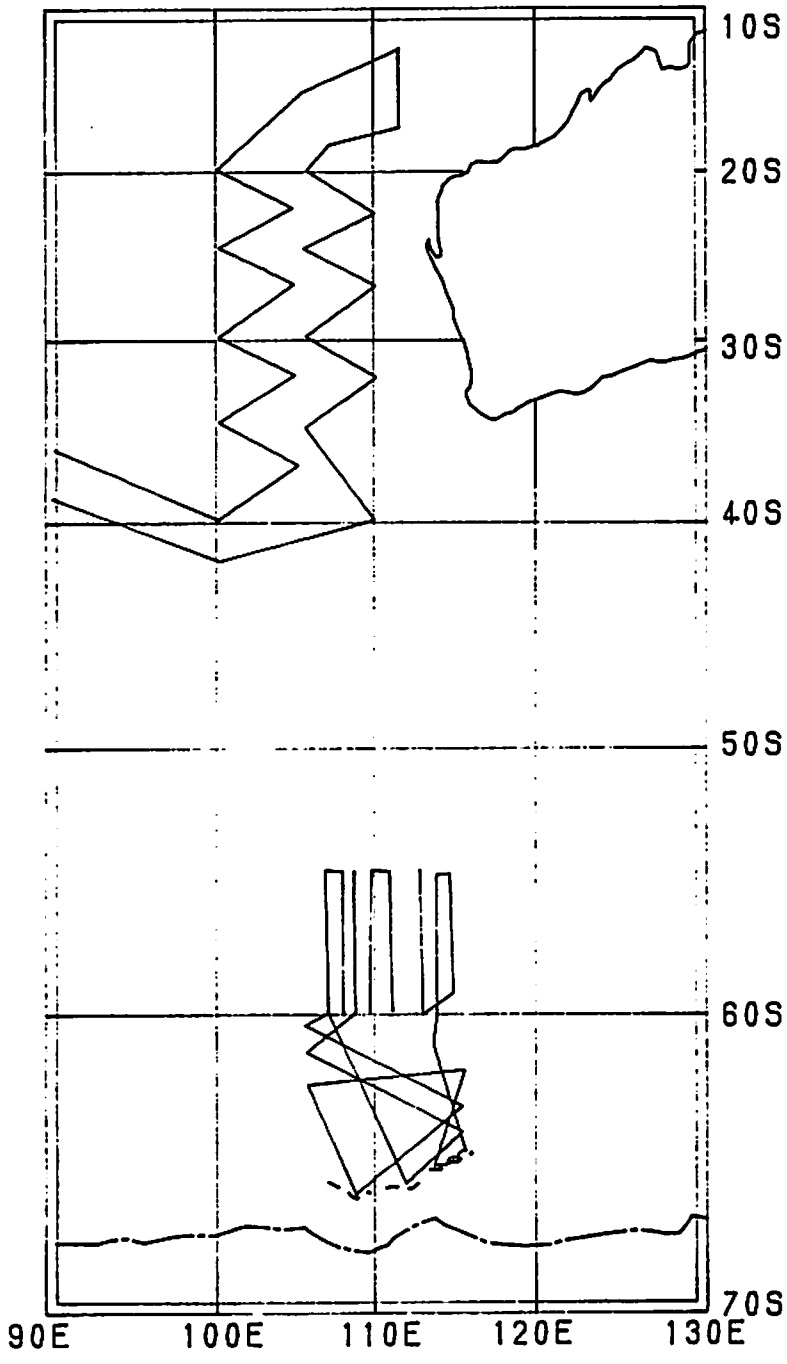

Fig. 1. Both cruise tracks of Antarctic (sighting and sampling), and low latitudinal surveys (only sighting) in 1987/88 season.

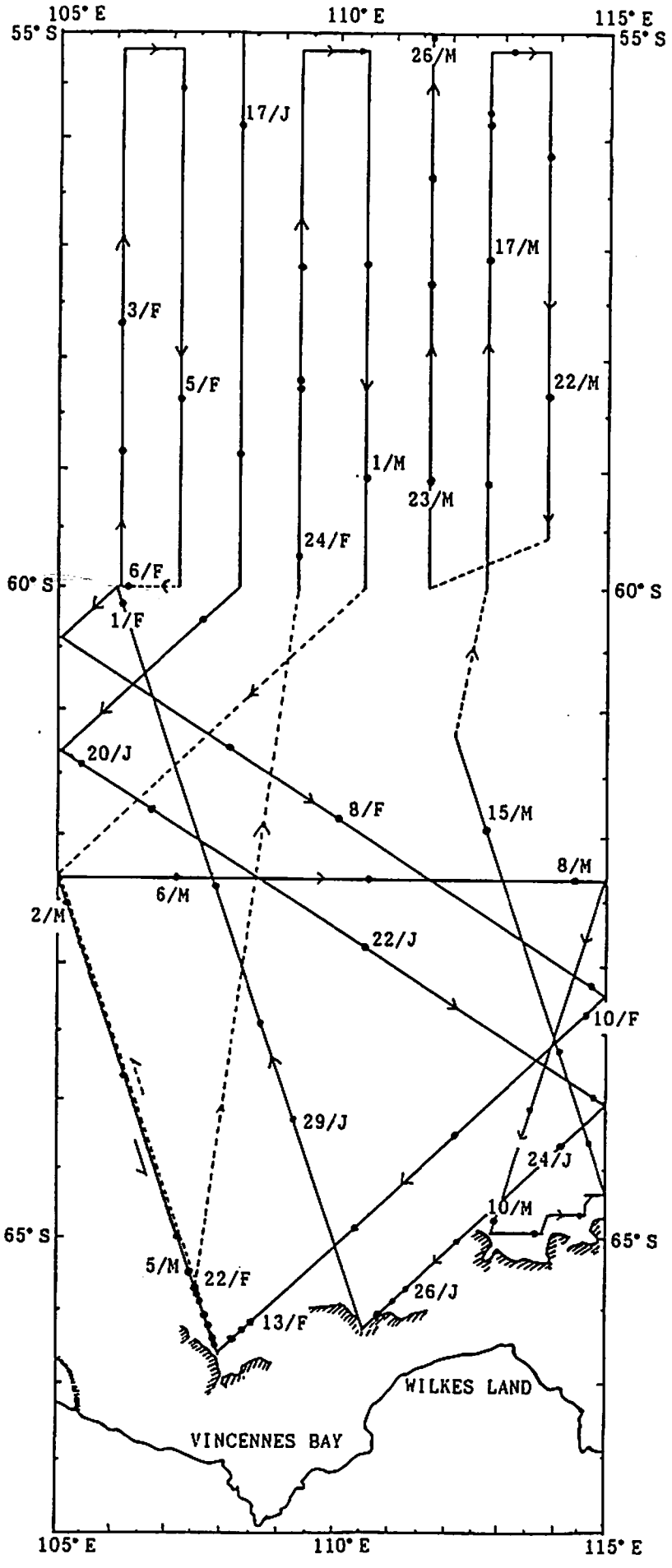

Fig. 2. Cruise track of the present cruise during days from January 17 and March 26, the northern and southern stratam were defined as north and south waters of 60° S.

First period (Jan. 17-Feb. 6)

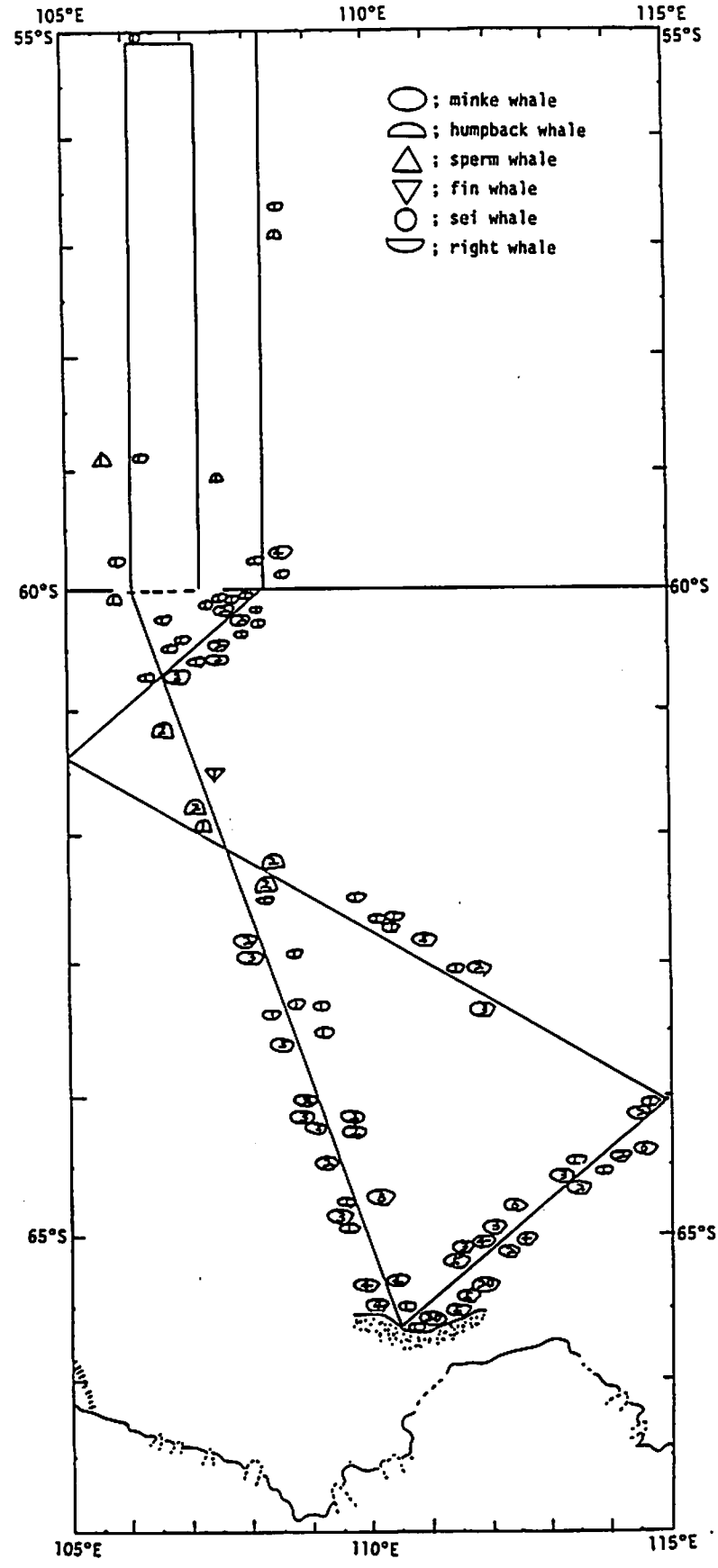

Fig. 3. Distribution of sighting of large sized whale including primary and secondary sightings by the three period. Number in a symbol principally indicates number of individuals in a school but several neighboring sightings are combined for minke whale in the high density areas.

Second period (Feb. 6-March 1)

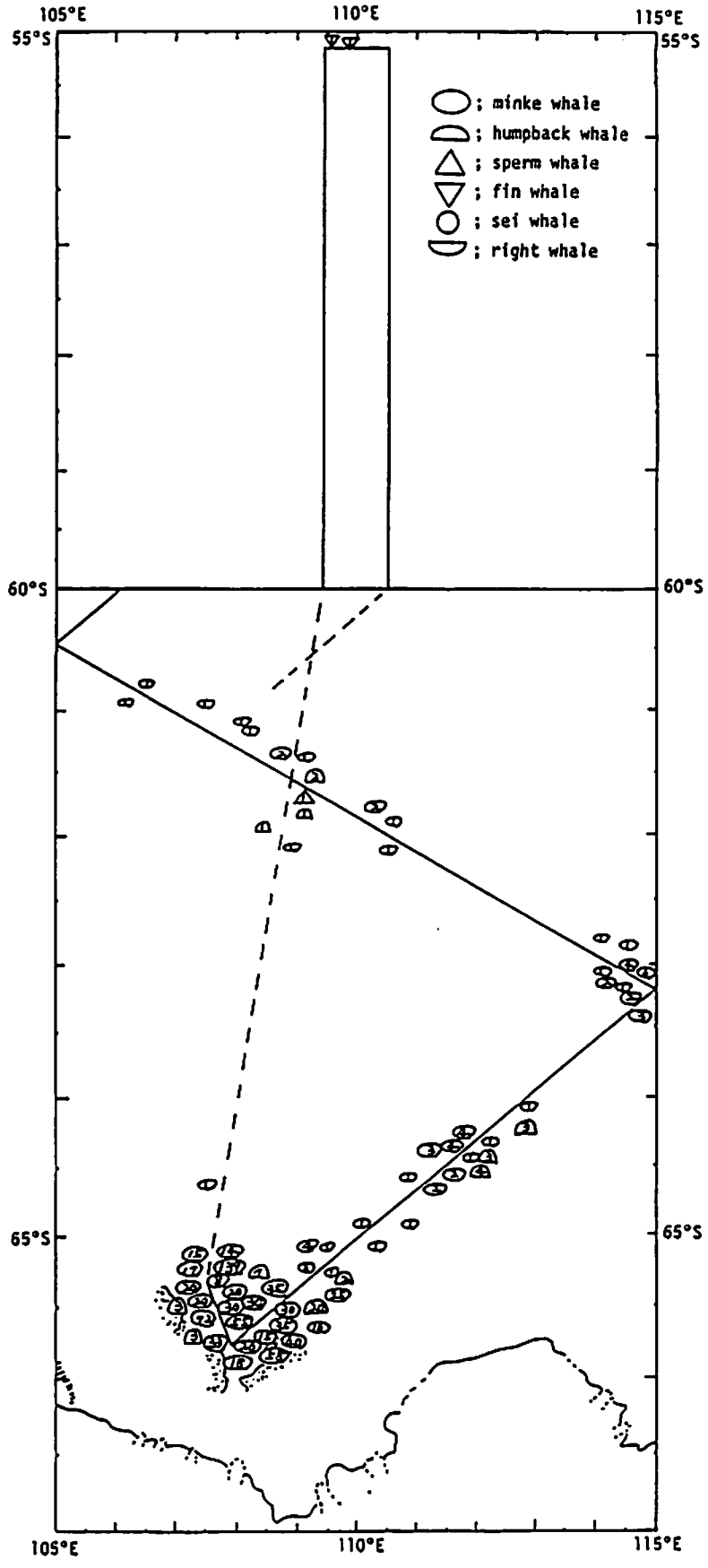

Fig. 3. (cont.)

Third period (March 1-26)

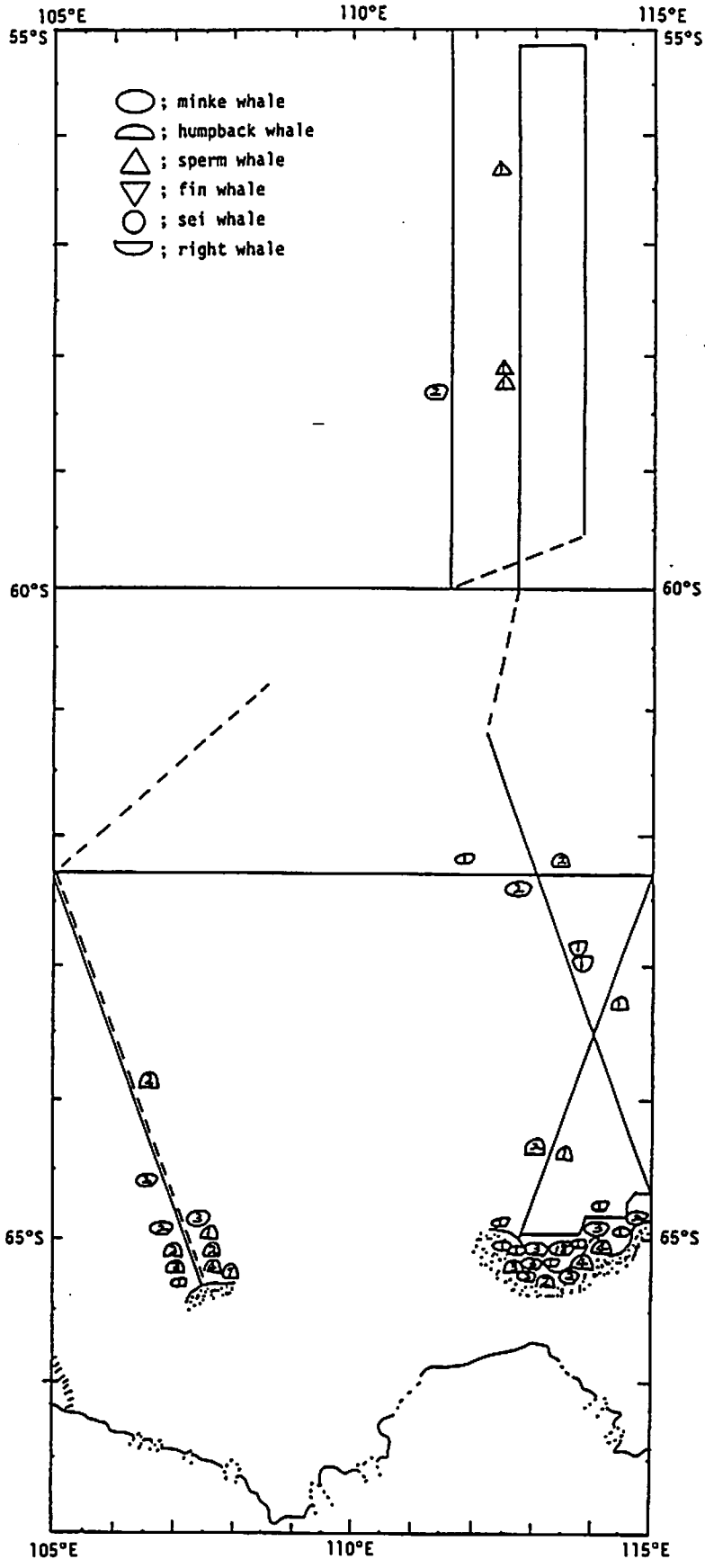

Fig. 3. (cont.)

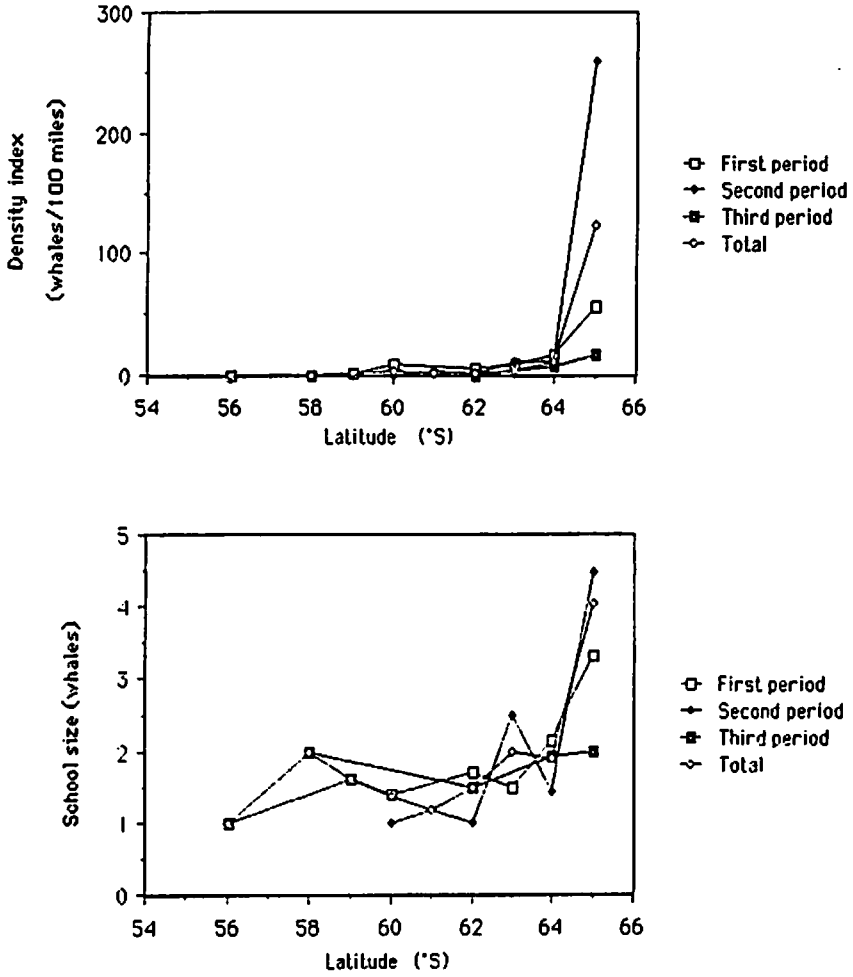

Fig. 4. Latitudinal changes in density index (upper) and mean school size (bottom) of the minke whale based on primary sighting by the period.

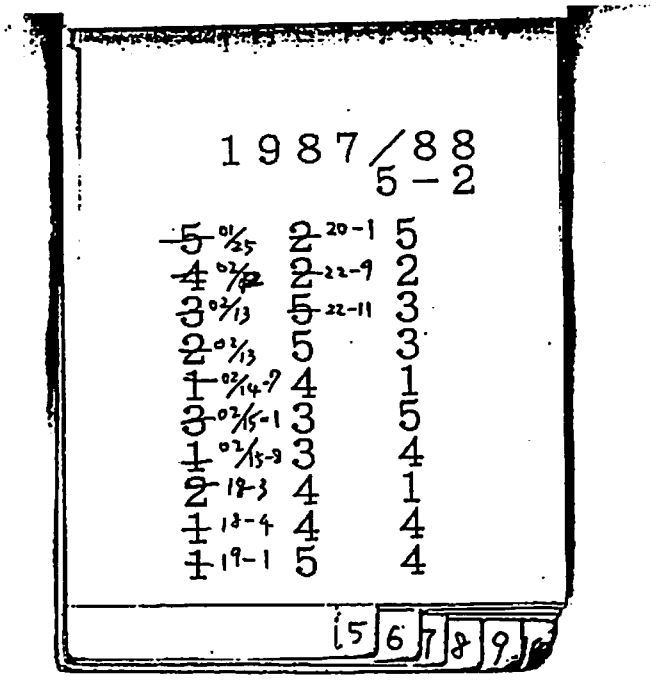

Fig. 5. An example of table of random sampling digits used the target whale within a school, an example shows that for school size 5.

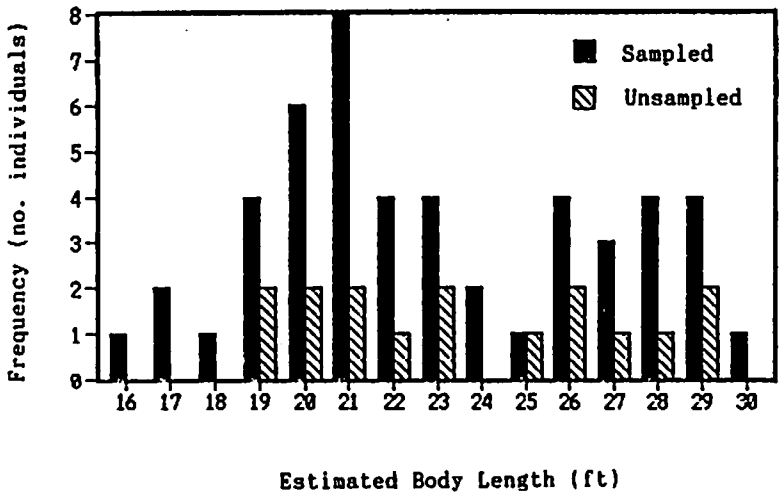

Fig. 6. Comparison of body lengths which were estimated at the sampling vessels before taking between sampled and unsampled individuals among solitaly whale.

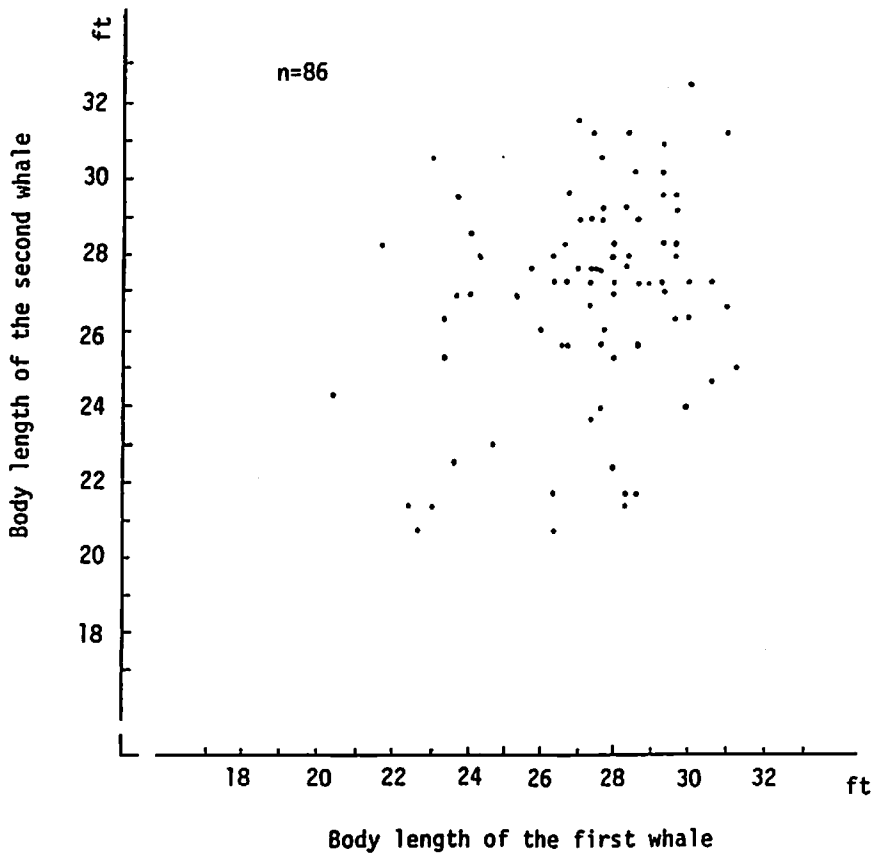

Fig. 7. Relationship in body length between of the first and the second samples obtained from a same school.

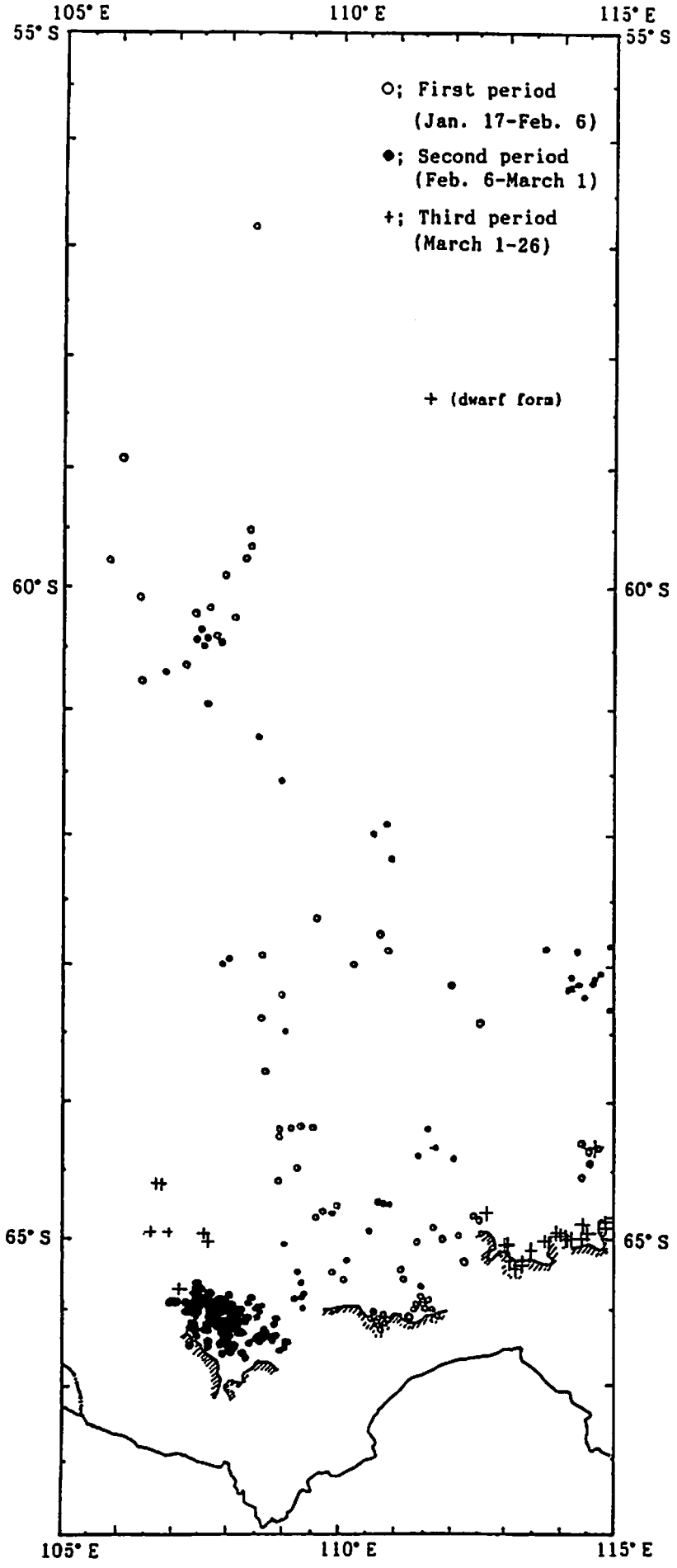

Fig. 8. Distribution of whale sampled from the present cruise by the period.

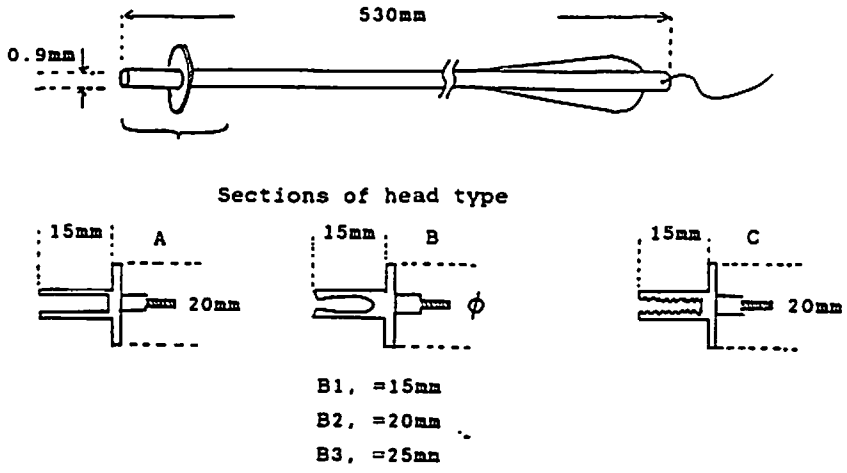

Fig. 9. Head of biopsy darts used in the experiment for dart development in the present cruise.

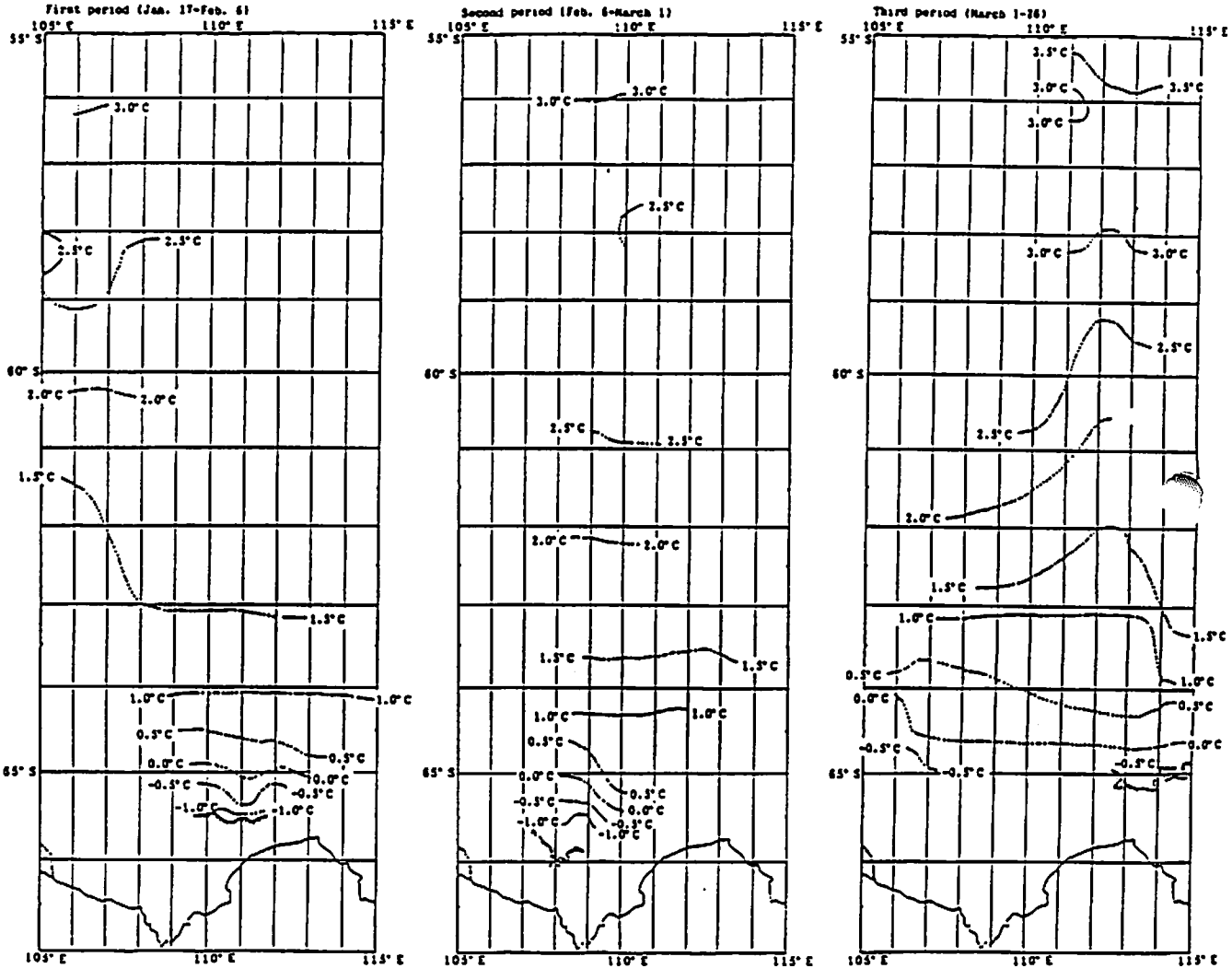

Fig. 10. Surface water isothermals based on the data by sampled water in each period.

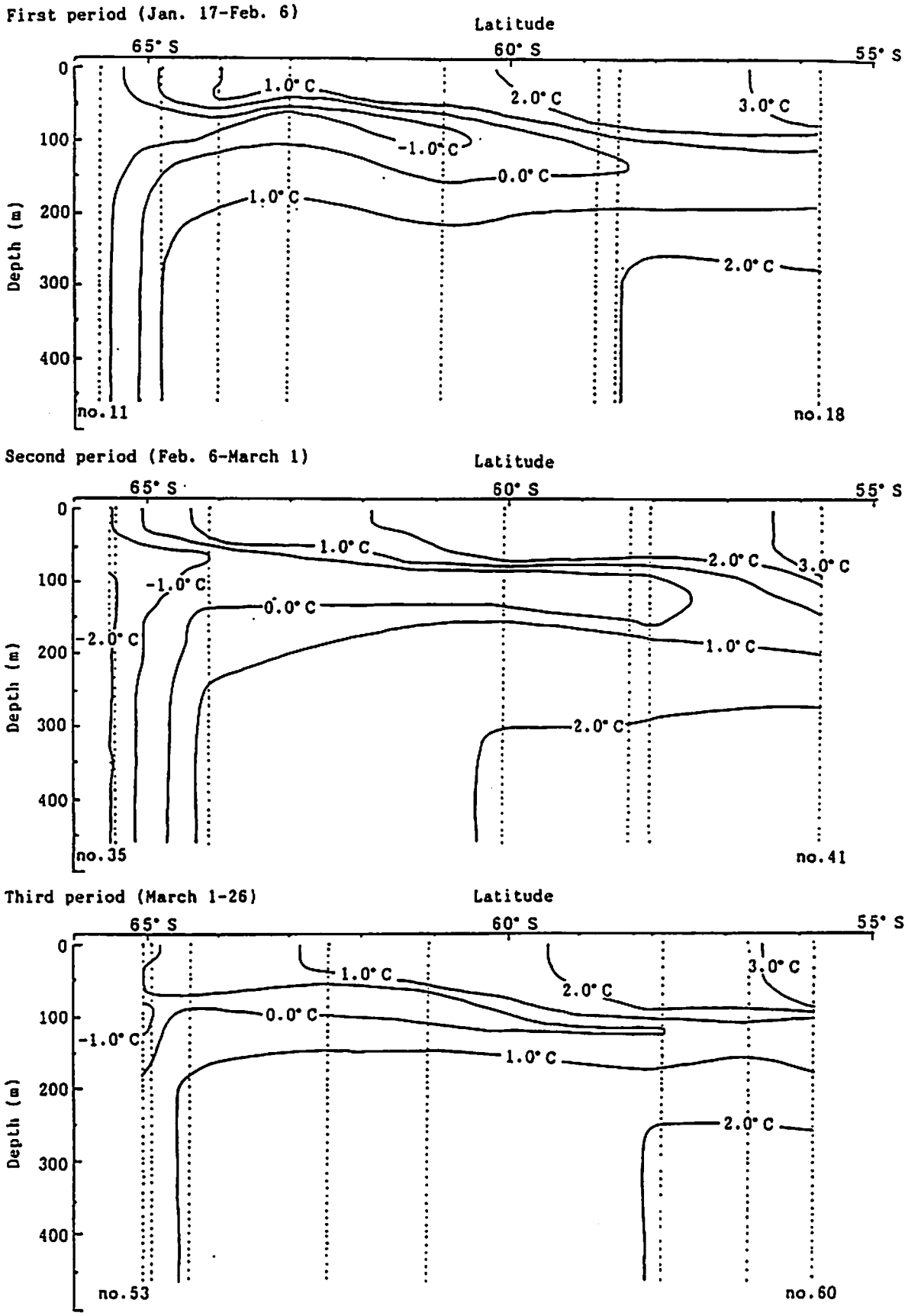

Fig. 11. Vertical isothermals by XBT survey. Sections are made by following sampling points; no. 11 (65°39'S 110°49'E) to no. 18 (55°46'S 105°54'E) in the first period, no. 35 (65°29'S 107°40'E) to no. 41 (55°44'S 109°00'E) in the second, no. 53 (65°05'S 113°36'E) to no. 60 (55°48'S 112°26'E) in the third period.

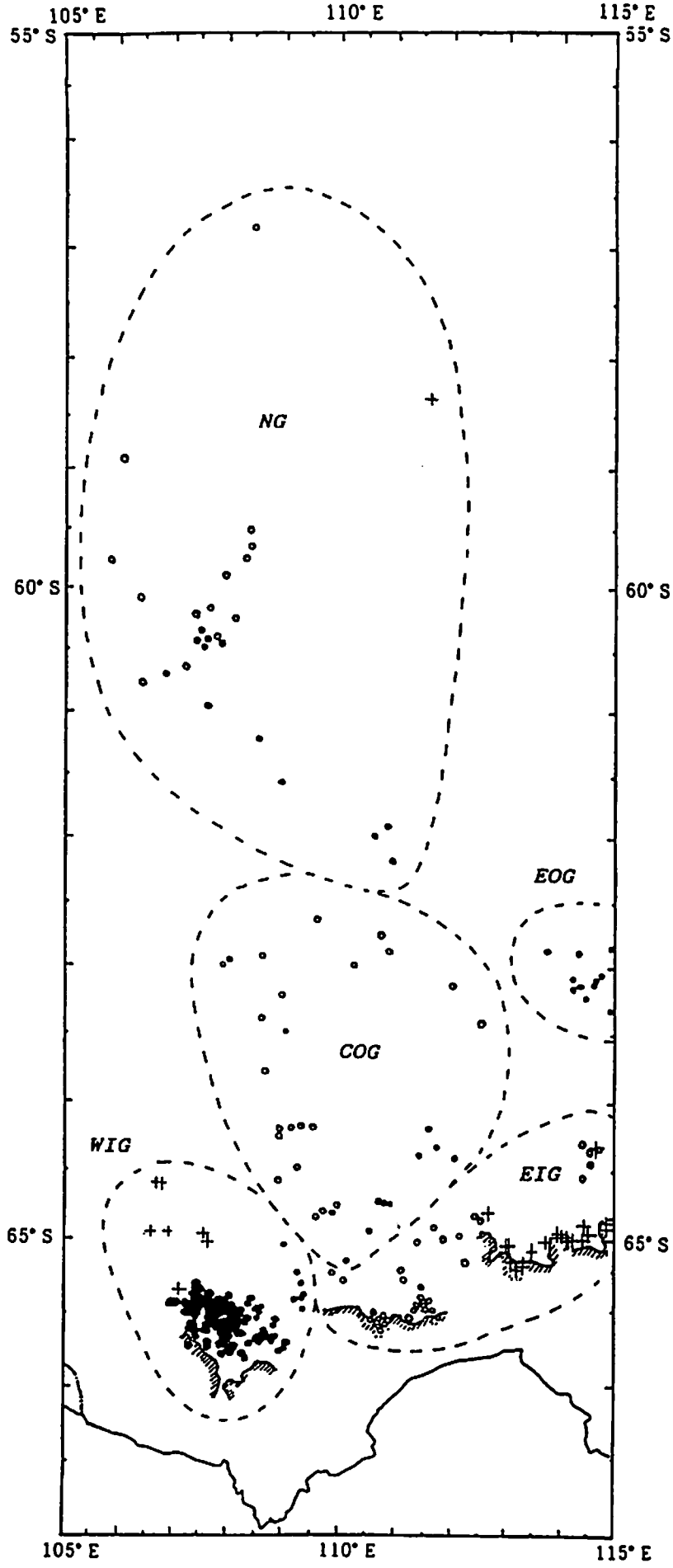

Fig. 12. Time-areal group of whale sampled for the present preliminary analyses: NG; northern, COG; offshore center, EOG; eastern offshore, WIG; western pack ice, EIG; eastern pack ice.

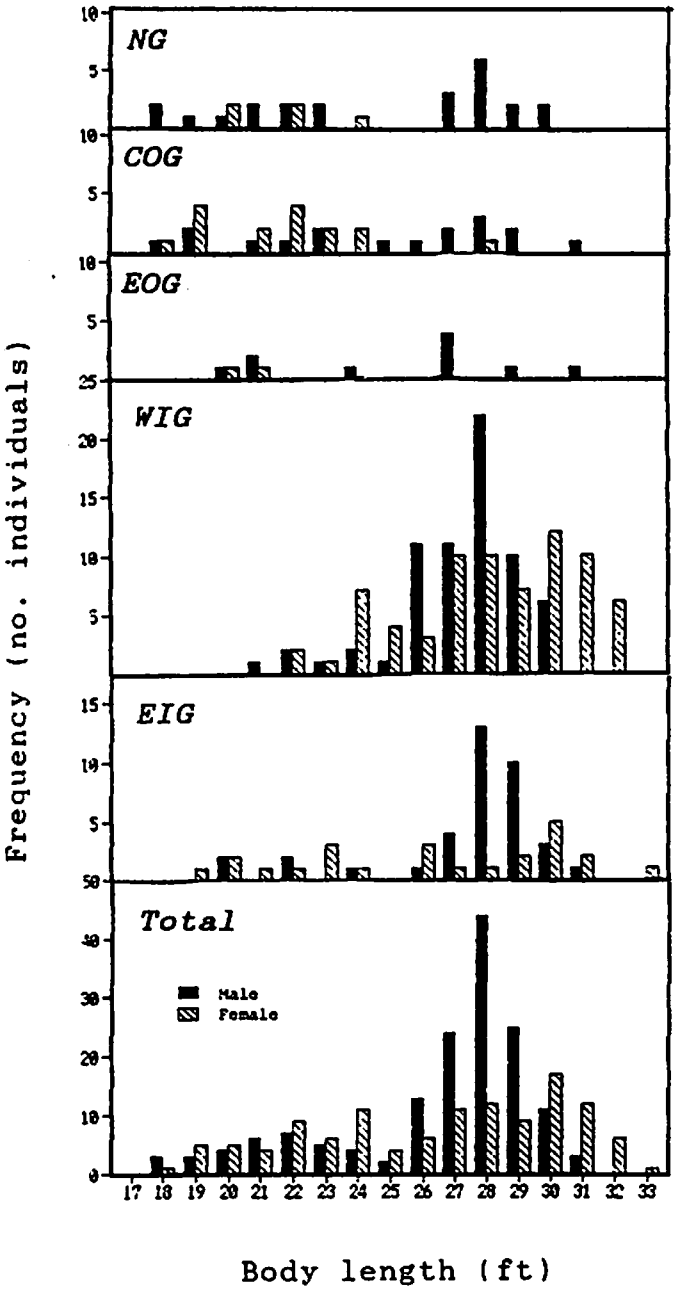

Fig. 13. Body length composition (ft) by sex and the time-areal group. NG; northern group, COG; offshore center, EOG; eastern offshore, WIG; western pack ice, EIG; eastern pack ice.

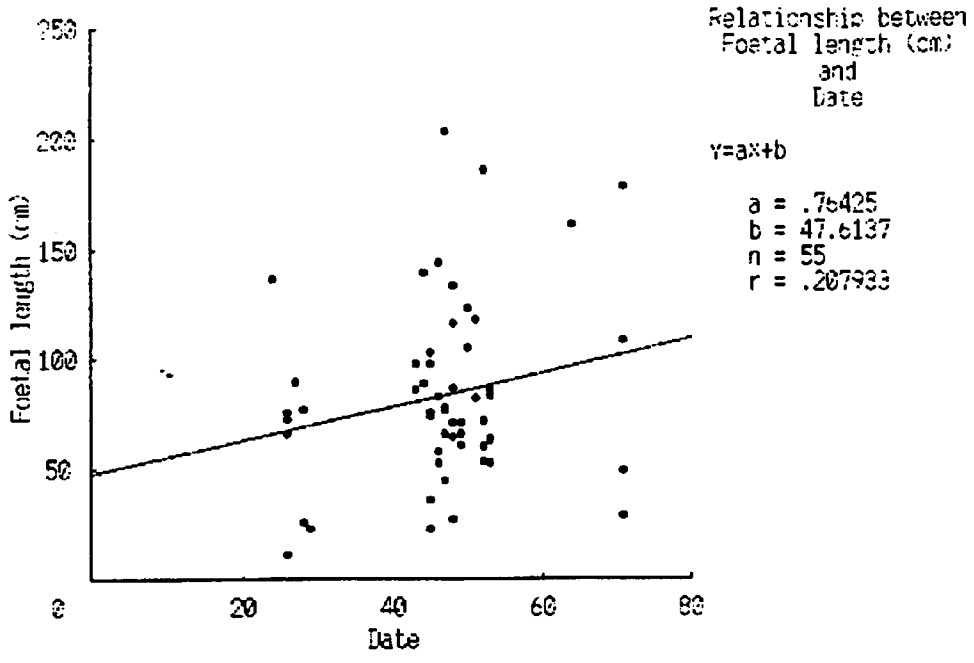

Fig. 14. Size distribution of foetuses collected in the present cruise, date setting 1 for Jan. 1 1988.

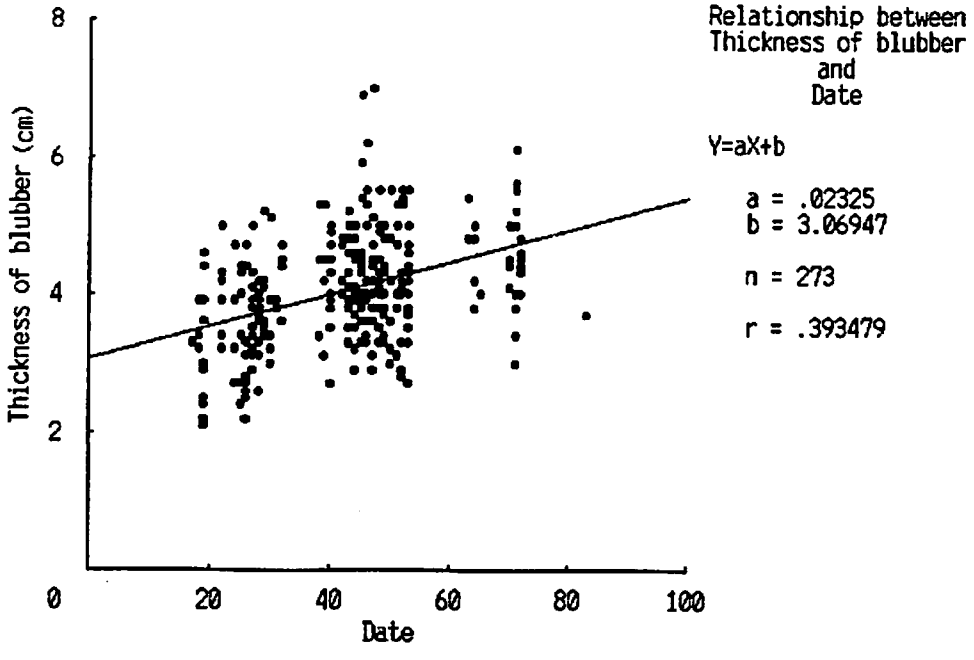

Fig. 15. Distribution of the thickness of blubber on mid lateral at below of dorsal fin, the date setting 1 for Jan. 1 1988.

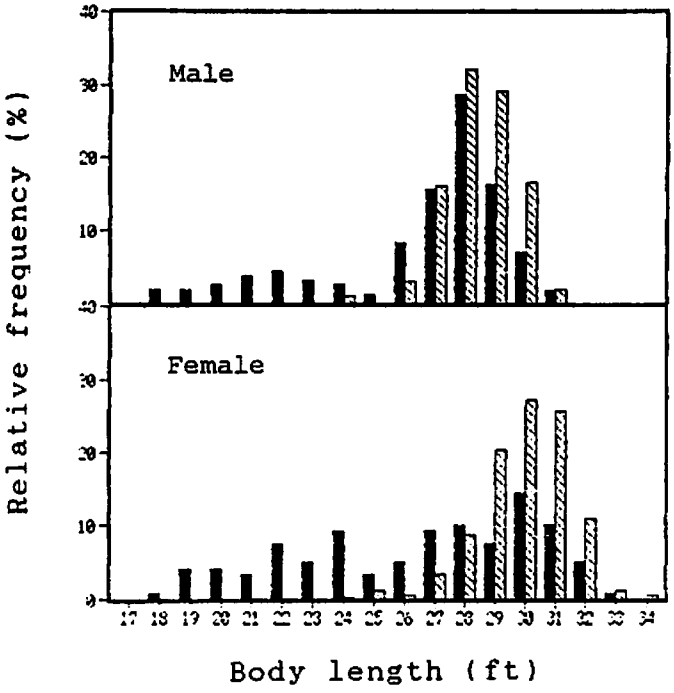

Fig. 16. Comparison of body length compositions in the present cruise (solid line) with those by the Japanese commercial whaling in Area IV in 1986/1987 season (hatched line).