SC/43/Mi11

REPORT OF THE 1990/91 SOUTHERN MINKE WHALE RESEARCH CRUISE UNDER SCIENTIFIC PERMIT IN AREA V

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ABSTRACT

Three sighting/sampling vessels undertook a systematic sighting and sampling survey for southern minke whales under Japanese special permit in Area V (south of 55°S 130°E-170°W), including that part of the Ross Sea east of 170°W, from Dec. 19, 1990 to Mar. 22, 1991. The sighting/sampling vessels surveyed a total of 14,759.9 n.miles and made 750 primary sightings (1,725 individuals, including six schools of six individuals of diminutive form) and 468 secondary sightings (1,269 individuals) of southern minke whales. A total of 327 minke whales was sampled from the primary sightings, including 323 of the ordinal form (164 males, 159 females) and four of the diminutive form (all female). Fifty-two percent of the targeted animals were successfully sampled. Efficiency of sampling increased with school size. Preliminary analyses of the samples suggested:(1) mean body lengths (8.2 m for males, 8.5 m for females) are significantly shorter than in the last commercial catch (t-test, $p<0.001$) and the proportion of smaller animals is greater; (2) mature males predominated away from the ice edge, while both mature males and pregnant females were strongly represented near the ice edge in the western part of the research area; (3) pregnant females predominated in the Ross Sea, and the presence of non-pregnant mature females (13.8% resting, 3.8% ovulating), was notable, especially among solitary animals (giving a ratio of pregnant females to resting mature females of 3:1); (4) reproductive status did not varied greatly with school size, but the proportion of mature animals was slightly higher in schools of five or more; (5) the male sex ratio was higher in the second half than in the first half. Four experiments, including an experiment to monitor the reaction of minke whales in the vicinity of a chasing vessel, were conducted during the cruise.

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INTRODUCTION

In 1987/88 and 1988/89, Japan conducted a feasibility study based on a revised version of the "Program for the Research on the Southern Hemisphere Minke Whale and for the Preliminary Research on the Marine Ecosystem in the Antarctic" submitted to the IWC in 1987. Previous cruises have been described by Kato, Hiroyama, Fujise and Ono (1989), and by Kato, Fujise, Yoshida, Nakagawa, Ishida and Tanifuji (1990), and analyses of results presented by Kishino, Kato, Kasamatsu and Fujise (1988), Kato, Kishino and Fujise (1990), Kasamatsu, Kishino and Hiroyama (1990), Kato, Fujise and Kishino (1990), Kasamatsu, Kishino and Taga (1990), and Fujise, Kato and Kishino (1990). Following completion of the feasibility study, the research program commenced in 1989/90, in Area IV (see Fujise, Yamamura, Zenitani, Ishikawa, Yamamoto, Kimura and Komaba, 1990). In 1990, Japan submitted to the IWC/SC the plan for the second year of the research program, to cover Area V (Government of Japan, 1990). The plan was reviewed by the IWC/SC prior to the 42nd Annual Meeting of the IWC. In consideration of comments from the IWC/SC and a resolution adopted by the IWC with regard to the program, Japan submitted modifications to the plan to the IWC (Anon., 1990). The principal modifications concerned the means of determining the cruise track and the starting point. The following additions were also made: (1) experiments to observe the reaction of minke whales in the vicinity of a chase; (2) a feasibility study to see whether both skin and muscle tissue samples can be collected by biopsy dart; and (3) the actual collection of skin samples by biopsy dart from southern minke whales in low latitudinal waters. This report describes the cruise and the methods used for the collection of data, and presents preliminary results.

PLANNING AND OUTLINE OF CRUISE

A meeting was held in Tokyo, Nov. 19-20, to finalize plans for the research cruise, with the participation of scientists, the researchers who would join the cruise, and representatives of the ships' crews. In summary, the meeting concluded the following:

Sighting/Sampling Research in the Antarctic

Research Area Divisions

Area V would be divided into three sectors: Northern (55-60°S latitude, 130°E-170°W longitude), Western (south of 60°S, 130-165°E longitude), and Eastern (south of 60°S, 165°E-170°W; south of 70°S, eastern boundary of 160°W). The Western and Eastern Sectors would be further divided into two strata, a southern stratum extending from the pack ice edge to a locus 45 n.miles from the ice edge, and a middle stratum extending from the northern boundary of the southern stratum to the southern boundary of the Northern Sector (60°S). The southern stratum, Eastern Sector, in the second half would also divided into two parts: western (west of 180°) and eastern (east of 180°).

The one exception to the above was the northern boundary of the southern stratum, Eastern Sector, in the second half (Ross Sea). This boundary would be set at 69°S instead of 45 n.miles from the pack ice edge.

Fleet

A total of four vessels would be used: the mother ship and research base

Nisshin Maru No.3 (NM3, 23,107.85 g/t), and three sighting/sampling vessels, the Kyo Maru No.1 (K01, 812.08 g/t), the Toshi Maru No. 25 (T25, 739.92 g/t), and the Toshi Maru No. 18 (T18, 758.33 g/t).

Construction of Trackline and Research Schedule

Cruise tracks in the Northern Sector would be north-south transects between points of fixed latitude and longitude. There were two points to be considered when designing the trackline: (1) there should be an equal probability that any point within the research area would be covered, and (2) the selection of the number of starting points should not be too rough (Anon., 1990). Cruise tracks in the southern strata in 1990/91 would be designed not as in 1989/90 but in the same manner as for IWC/IDCR Southern Hemisphere Minke Whale Assessment Cruises (Anon., 1984).Starting points would be selected based on the 1 n.mile intervals instead of 10 n.mile intervals in 1989/90.

All sectors would be surveyed twice each during the cruise. Specifically, in the first half sectors and strata would be surveyed in the following order: i) Northern Sector; ii) Eastern Sector (southern stratum, middle stratum); iii) Western Sector (southern stratum, middle stratum). Research in the second half would follow the same pattern except that the Northern Sector would be surveyed last.

It was decided that the fleet would depart Japan on Nov. 24, 1990, and return in mid-April, 1991. Research days would be allocated as follows: Northern Sector - two days in the first half and two in the second; Eastern Sector - 17 days in the first half, 23 in second; Western Sector - 21 days in the first half, 22 in the second.

Sighting and Sampling

The sighting/sampling vessels would operate using the closing mode on predetermined tracklines. Searching would begin each day from a point a predetermined distance from the previous day's starting point. The three vessels would follow parallel tracklines 9 n.miles apart, at a standard speed of 11.5 knots. A constant watch would be kept for 14 hrs per day (0600-2000) or from 30 minutes after sunrise to 30 minutes before sunset. While searching, three men would be in the barrel. These would normally be assisted by a further four (captain, gunner, quartermaster and researcher) on the upper bridge, and two or three (chief engineer, radio operator and oiler) on the platform above the asdic hut. Sightings obtained from this cruise would be divided into two categories: primary sightings (i.e. those when full searching is being applied) and others. Closing for confirmation or sampling would be conducted only for primary sightings of minke whales, and only when those sightings were no further than 3 n.miles from the trackline. (In addition, closing would be made regardless of distance to photograph natural markings of blue, humpback and right whales.) After completion of confirming or sampling, the vessel would normally return to the trackline at an angle of 45°. If, however, the vessel found itself more than 3 n.miles from the trackline after the completion of confirming or sampling, it would return at an angle of 90°. In this case, the vessel would go into topman-down steaming (no search effort) until it had returned to the trackline.

Samples would be taken from primary sightings within 3 n.miles of the trackline. All solitary animals and animals in schools of two would be taken. From schools of three or more, two whales would be sampled at random, selection being made according to the same random sampling

scheme used on the previous cruise (Kato et al., 1989, 1990b; Fujise et al., 1990b).

Because of the extent of the research area and the limited time available, sighting/sampling vessels would need to cover a certain distance per day. Specifically, the following distances were designated: southern strata - 100 n.miles/day; middle strata - 160 n.miles/day; Northern Sector - 150 n.miles/day. An exception was made in the case of the southern stratum, Eastern Sector, in the second half (Ross Sea), where the distance to be covered daily was fixed at 140 n.miles.

One researcher would be aboard each sighting/sampling vessel, while three researchers responsible for biological sampling would travel aboard the NM3. Researchers aboard the sighting/sampling vessels would be responsible for the random selection of whales to be sampled. They would also be responsible for keeping records of sightings and experiments, while records of search effort and weather conditions would be kept by the officer on watch.

Experiments and Other Research

Four experiments were planned for the 1990/91 cruise: (1) an experiment to evaluate the accuracy of estimates of distance and angle made by observers; (2) a series of experiments to monitor the reaction of minke whales in the vicinity of a chasing vessel; (3) testing of a newly developed air gun and darts as a means of taking biopsy samples of both skin and muscle tissue; and (4) a series of preliminary experiments to test a newly developed delivery system and related apparatus for satellite tagging.

Natural marking studies would be conducted on an opportunistic basis for blue, humpback and right whales. Biopsy skin sampling for humpback whales was planned. Oceanographical research using an XBT would be conducted by one of the sighting/sampling vessels (T25) in the research area. Any marine debris observed during the transit between the research area and Japan would be recorded by an officer aboard the NM3.

Sighting Surveys in Low Latitudinal Waters

Systematic sighting surveys in 1990/91 would be conducted by the vessels Shonan Maru and Shonan Maru No.2. The main research areas for these sighting surveys would be in the South Pacific (see Fig. 1). In the first half (late November to late December, 1990), the area between 30-45°S and 125-170°W would be surveyed. In the second half, after completion of the 14th IWC/IDCR Southern Hemisphere Minke Whale Assessment Cruise in Area VI, surveys would be conducted between 25-30°S and 173-177°E, and between 55-49°S and 178°E-172°W. Surveys would not be conducted in the 200-n.mile exclusive zone of any nation. During the cruises, biopsy skin sampling of minke whales in lower latitudinal waters was also planned.

This report does not cover these cruises. Findings will be reported in the near future.

CRUISE NARRATIVE

Transit to Northern Sector

On the morning of Nov. 24, the NM3 departed Yokohama Port, and the KO1, T25 and T18 departed Shimonoseki Port. From Dec. 8-18, the KO1, T25 and T18 conducted sighting surveys in waters from 25°S (Tasman Sea) to 55°S. The effort applied to research by all vessels was limited due to bad

weather. Terminating sighting earlier than the other two vessels, the T25 steamed to 66°07S 180°, and on Dec. 18 commenced mapping of the ice edge in a westward direction.

FIRST HALF (Dec. 19, 1990 - Jan. 31, 1991)
Cruise tracks in the first half are shown in Fig. 2a.

Northern Sector
On the morning of Dec. 19, at 55°20S 165°E (20 n.miles from the 200 n.mile zone of N. Zealand), the NM3, K01 and T18 commenced sighting and sampling research in the Northern Sector. Research was completed on the evening of Dec. 20 at 60°S 165°E. Research effort was limited due to poor visibility.

Eastern Sector
Southern stratum
The T25 completed ice mapping between 180° and 165°E on 21 Dec. Based on this information, a locus 45 n.miles from the pack ice edge was constructed between these longitudes. No information on sightings was received until all waypoints had been decided. Based on the length of the locus and allocated research days, the distance between waypoints on the locus was calculated by the same method as used for recent IWC/IDCR cruises (Anon., 1984). The first waypoint on the locus was randomly selected from candidate for starting points with 1 n.mile intervals, as was the starting point of 63°31S 165°E. Subsequent waypoints on the locus and on the ice edge were decided by the same methods adopted for IDCR cruises. For the first two days of research, Dec. 22-23, sighting surveys were conducted by all three sighting/sampling vessels. For the next two days, at about 65°20S 172°40E, the experiment to monitor the reaction of minke whales in the vicinity of a chase was conducted. The location was chosen after sighting on the previous days had revealed a suitably high density of minke whales. Sighting and sampling research was suspended on Dec. 26 due to zero visibility, but resumed on Dec. 27 at 65°17S 172°42E. The locus between 180° and 170°W was drawn by estimating the ice edge line from satellite images from NOAA 10 and 11. At mid-day on Dec. 31, an unexpected bulge to the northeast was encountered in the ice edge, and all sighting/sampling vessels had to steam topman-down throughout the day. Research in the southern stratum of the Eastern Sector was completed on the evening of Dec. 31, at 65°30 170°45W. Search effort and the number of samples were limited due to poor visibility and the very low number of minke whale sightings.

Middle stratum
Research started on Jan. 1, at 63°40S 170°W, after celebration of the New Year. Strong winds prevailed from Jan. 4-7. However, good sighting conditions returned on the last two days in this stratum. Research was completed on the evening of Jan. 9, at 62°08S 165°E.

Western Sector
Southern stratum
The T25 left the middle stratum in the Eastern Sector on Jan. 8, one day earlier than the K01 and T18, in order to map the ice edge in the eastern part of the southern stratum, Western Sector (150-162°E). On Jan. 10, after completion of the research in the middle stratum, Eastern

Sector, the K01 and T18 also conducted ice mapping between 161-165°E. The locus and first six waypoints were decided based on this information, prior to starting research. The starting point was randomly decided at 64°23S 165°E, and the fleet moved in a westward direction. Strong winds and poor visibility prevailed for the first four days, but from Jan. 15 until the last day of research in this stratum the weather was far better. As direct observation of the ice edge had not been made from 150-130°E, the locus was drawn based on the estimated ice edge line from satellite images from NOAA 10 and 11. On Jan. 17, at about 143-144°E, the ice edge was encountered further north than had been expected. Topman-down steaming thus had to be made through the night along the pack ice edge to reach the starting point of the next leg (see Fig. 2a). Research in this stratum was completed on the afternoon of Jan. 20, at 64°22S 130°E. The fleet immediately commenced the transit to the starting point in the middle stratum, Western Sector.

Middle stratum

The starting point was randomly selected at 61°45S 130°E and research commenced on the morning of Jan. 21. Weather was bad from Jan. 24-26, but favorable on the remaining days. The sample allocation in this stratum was filled by Jan. 29, and so the remaining two days were spent sighting only. Research was completed on the afternoon of Jan. 31 at 63°34S 165°E.

SECOND HALF (Feb. 2, 1991 - Mar. 22)

Cruise tracks in the second half are shown in Fig. 2b.

Eastern Sector

Southern stratum

The waypoints and cruise tracks in this stratum were constructed based on the estimated ice edge line from satellite images by the same means used for the middle stratum. The starting point was selected at 69°S 170°15E. A severe gale was encountered from the afternoon of Feb. 1 (just one day before the scheduled start of research) to Feb. 5, and all vessels were obliged to "heave to" towards the southeast. No research activities were conducted in this period. Sighting and sampling finally started on the morning of Feb. 6 at 71°31S 175°22E. Due to the gale, a total of 210 n.miles on the predetermined trackline went completely unsurveyed. Research in the western part (west of 180°) of the southern stratum finished on the evening of Feb. 9. The fleet then headed toward the starting point in the eastern part of the southern stratum. On Feb. 10, during the transit between the western and eastern parts, sighting was conducted while not on the predetermined tracklines. Research in the eastern part started at 0600 hrs on Feb. 11 at 78°13S 166°40W, just north of the continental Ross ice shelf. Favorable weather prevailed throughout the period. On the afternoon of Feb. 14, at about 71°S 176°W, the pack ice edge was encountered and subsequently found to extend as far west as 179°15W. Since the remainder of the cruise trackline (between 71°S and 69°S) was thought to be almost entirely covered by the pack ice, the fleet began the transit at 0040 hrs on Feb. 15 to the starting point in the middle stratum. The cruise track north of 71°S was, therefore, unsurveyed.

Middle stratum

Research in this stratum started on Feb. 16 at 65°01S 170°W. Only one waypoint on the northern boundary (60°S) and two waypoints on the southern boundary (69°S) were located in this stratum (total four legs) because of the limited number of days available for this extensive area. Strong winds and poor visibility prevailed throughout the research in this stratum. The T18 left the research area on the evening of Feb. 25 to map the ice edge in the eastern part of the Western Sector. The other sighting/sampling vessels encountered very strong wind on the morning of the last day in this stratum (Feb. 26), obliging them to halt research at 0900 hrs. They thus began to transit to the Western Sector. Due to this strong wind, therefore, a small part (71 n.miles) of the final leg of the trackline was unsurveyed.

Western Sector

Southern stratum

On Feb. 26-27, the T18 conducted ice mapping over an area bounded by 65-68°S and 157-159°E. The locus and first two waypoints were decided using both information from the T18 and from satellite images (south of 68°S and west of 157°E). The starting point was also selected randomly. A further eight waypoints were decided based on the estimated ice edge line from satellite images. On the morning of Mar. 3, at 65°15S 158°E, the ice edge was encountered extending northward. It was subsequently found to extend as far north as 63°40S 157°30E, some 65-80 n.miles north of its estimated position. The fleet had to navigate along the ice edge through the night. Due to the unexpected extent of the pack ice, the waypoints and tracklines had to be shifted 85 n.miles to the north (see Fig. 2b). The vessels reached their revised waypoints on the revised estimate of the ice edge position early in the morning of Mar 4, but the actual ice edge was found to be 20 n.miles south. Tracklines and waypoints were thus shifted once again, by 20 n.miles. Research was completed on the afternoon of Mar. 9, at 64°56S 130°E.

Middle stratum

Research in this stratum started on the morning of Mar. 10, at 64°07S 130°E. The waypoints and starting point were decided by the same method used for previous middle strata. Strong winds or poor visibility were encountered on Mar. 11-13, but on Mar. 10 and Mar. 14 weather conditions were favorable. Sampling was completed on the afternoon of Mar. 14 and the NM3 left the research area at mid-day on Mar. 15. The sighting/sampling vessels continued sighting in the remaining area, but encountered poor weather from Mar. 15-19. All three vessels completed their surveys in the middle stratum on Mar. 20 at 165°E and immediately headed for their starting points in the Northern Sector.

Northern Sector

Research began in the Northern Sector on the morning of Mar. 21, the KO1 from 60°S 165°E, the T25 from 60°S 162°30E, and the T18 from 60°S 160°E. All three vessels encountered strong winds. The T18 had to terminate research on the evening of Mar. 21, at 59°16S 159°55E, due to a very high swell. The survey was finished by the KO1 on the evening of Mar. 22 at 55°36S 165°o2E, and by the T25 on the evening of Mar. 21 at 58°S 163°30E. On Mar. 22, all three sighting/sampling vessels headed northward. Search effort in this sector was extremely limited due to bad weather and poor sightability.

Transit from Research Area to Japan

Sighting surveys were conducted in the waters between 49°30S and 30°S (exclusive of 200-n.mile zones) from Mar. 24 during the transit from the research area to Japan. All three sighting/sampling vessels completed research for 1990/91 on the evening of Mar. 26, and headed for Japan. The NM3 entered Tokyo Port on the morning of Apr. 9 and the sighting/sampling vessels arrived at Shimonoseki Port on the morning of Apr. 11.

RESULTS

Sightings and Sampling

Search Efforts

Search effort is expressed as "searching distance", that is the distance covered by all three sighting/sampling vessels while in full searching mode. It is calculated from the time spent searching and the speed of the vessels.

In the Northern Sector, searching distances in the first and second halves were 205.1 and 7.0 n.miles, respectively. The extremely short searching distance in the second half was due to persistent bad weather.

In the Eastern Sector in the first half, searching distances were 1,516.5 and 1,868.6 n,miles in the southern and middle strata, respectively. Those in the second half were 1,622.8 and 2,469.4 n.miles, respectively. The greater searching distance in the second half in the middle stratum was due to more days being allocated for research and to better weather conditions than in the first half.

In the Western Sector in the first half, searching distances were 1,632.9 and 2,720.7 n.miles in the southern and middle strata, respectively. Those in the second half were 1,051.4 and 1,665.5 n,miles, respectively. The shorter searching distances in the second half in both the southern and middle strata were due to bad weather, and in particular poor visibility.

The total searching distance for the cruise south of 55°S was 14,759.9 n.miles (7,943.8 in the first half and 6,816.1 in the second). Combined searching distances for all three sighting/sampling vessels are summarized in Table 1.

Number of Sightings

Sightings are classified as primary and secondary. Primary sightings are those made when a vessel is in searching mode while on the trackline. Secondary sightings are those made in all other modes, e.g. closing, chasing, or topman-down steaming.

A total of 6,194 cetaceans (11 species identified) was sighted during the cruise, of which 48% were minke whales. Numbers of sightings by stratum are shown in Table 1. The sites of all primary sightings of minke whales are shown in Fig. 3.

In the first half, primary sightings were made of 327 schools of minke whales containing 688 individuals (incl. five schools of the diminutive form containing a total of five individuals). In the second half, primary sightings were made of 423 schools containing 1,037 individuals (incl. one school of one animal of diminutive form). The sighting rate of minke whales (no. of primary schools per n.mile) ranged from 0.014-0.146 in the southern strata and from 0.017-0.057 in the middle strata. The highest rate occurred in the southern stratum, Eastern Sector, in the second half (Ross Sea), and the lowest occurred in the Northern Sector in the first half (0.010). Secondary sightings totaled 468

schools containing 1,269 individuals, accounting for 39% of all minke whale sightings.

It is interesting to note that eight blue whales were observed in the southern Ross Sea (south of 75°S). On two previous IDCR cruises, approximately the same searching effort was expended in the same area, and yet in 1980/81 no sightings were made (Butterworth and Best, 1982), and in 1985/86 just two whales were sighted (Anon., 1986). Also noteworthy were the frequencies with which humpback and fin whales were observed. Humpback whales were encountered frequently in the first half in both the Eastern and Western Sectors, but far less so in the second half. Conversely, fin whales were more frequently observed in the second half than in the first.

Number of Samples Taken and Catch Sites

A total of 327 minke whales (323 ordinal forms, four diminutive forms) was sampled. Sample sizes by stratum are shown in Table 2, and catch sites in Fig. 4. To obtain representative samples from all areas covered and avoid concentration of catches in small areas, a ceiling was placed on the number of samples which could be taken in any one stratum, and, if necessary, on the number of samples which could be taken in any one day. The latter ceiling was enforced in all the southern strata (except the southern stratum, Eastern Sector, in the first half), and in the middle stratum, Western Sector, in the first half. In the eastern part of the middle stratum, Western Sector, in both halves, only sighting was conducted (east of 160°E in the first half and east of 150°E in the second half) as the sample allocations for this stratum had already been filled in the western part. The highest numbers of samples by area were taken in the Western Sector in the first half (January) and in the Eastern Sector in the second half (February). These two months span the period when southern minke whales are considered to be most abundant in the Antarctic (Ohsumi, 1979; IWC, 1983; Kasamatsu and Nishiwaki, 1990).

Sampling Efficiency

Two indices of sampling efficiency have been calculated, the "technical sampling efficiency" (the ratio of whales taken to whales targeted), and the "true sampling efficiency" (the ratio of whales taken to individuals classified as primary sightings)(see Table 2). The highest technical efficiency (0.66) was achieved in the southern stratum, Eastern Sector (Ross Sea), in the second half (in the same stratum in the first half, efficiency was actually higher, but is discounted here due to the small sample size). The lowest value (0.33) was recorded in the Northern Sector in the first half. The true sampling efficiencies varied from 0.14-0.26 in the southern strata and from 0.14-0.45 in the middle strata, respectively. Overall technical efficiency was higher in the southern strata (0.57) than in the middle strata (0.46), a fact considered attributable in particular to more favorable sea conditions but also to weather conditions and school size (see below). On the other hand, the overall true sampling efficiency was lower in the southern strata (0.19) than in the middle strata (0.22) due to the fact that more sightings were made in the southern strata but a ceiling was imposed on sample size. The overall technical and true sampling efficiencies for the entire cruise were 0.52 and 0.20, respectively. Comparable figures (i.e. for single rather than paired vessels) for the 1988/89 survey of Area V were 0.51 and 0.30 (Kato et al., 1990b).

Table 3 shows sampling efficiencies by school size. It can be seen that technical efficiency increased as the size of school increased, an observation also made on previous cruises (Kato et al, 1989 and 1990b; Fujise et al., 1990b). True sampling efficiency, however, decreased as the school size increased, as only two whales can be taken from schools of two or more animals.

Reasons for targeted whales not being sampled are summarized in Table 4. In the cases of both solitary animals and schools, the main reason for failure to take even one sample was losing sight of the targeted animal/school before chasing commenced. Failures after chasing had commenced were due to frequent swerving and/or high speed displayed by whales. In cases where one sample had already been taken from a school of two or more, the main reason for failing to take a second sample was losing sight of the whale. Researchers aboard the sighting/sampling vessels considered that there was a direct relationship between the frequency of lost sightings before chasing commenced, and sea and weather conditions.

Diminutive Form Minke Whales

Table 5 summarizes the samples of diminutive form minke whales taken during the cruise. The first sample, a female, was taken on Dec. 29 at 65°04S 178°12E, constituting the southernmost confirmation of this form (Kato et al., 1989,1990b; Fujise et al., 1990b). It was also remarkable for its size, measuring just 3.83 m in length. All other samples were taken in the northern part of the middle strata (between 60°34S and 61°09S). It is interesting to note that the stomach content of the southernmost sample was Euphausia while those of the other three animals were fish. Two solitary animals of this form were sighted on Jan. 22 at 60°44S 133°22E and on Feb. 21, at 60°41S 177°04E, but attempts to sample these failed. Estimated lengths were 6.0 and 4.5 m, respectively.

All diminutive form minke whales were subjected to comprehensive morphometrical and osteological examinations, and all biological samples of use in assessing reproductive status, age, growth rate, physiology, diet, parasites, environmental pollution, etc., were collected.

Biological Data, Sample Collections and Preliminary Analyses

Biological Data and Samples

Biological data and samples were collected aboard the NM3 from 327 whales (164 males, 163 females [incl. four diminutive forms]). Techniques and methods employed were the same as in 1989/90 (Fujise et al., 1990b). Biological data and samples are summarized in Table 6.

Preliminary Analyses of Samples

The following are preliminary analyses of minke whale samples (ordinal form only), made en route from the Antarctic to Japan. Detailed analyses and estimation of population will be presented in the future.

Biological Characteristics by Stratum and Period

Sex Ratio and Reproductive Status

Shown in Table 7 are the male sex ratio, and the reproductive status of all samples, by stratum and period. The reproductive status of females was determined by examining the ovaries, uterus and mammary glands. For males, reproductive status is best determined by histological examination of testis and epididymis tissue. However, as these samples have not yet been prepared, the following analysis uses the more

traditional means of determining sexual maturity, i.e. classifying a whale as sexually mature if its largest testis weighs 0.4 kg or more (Ohsumi, Masaki and Kawamura, 1970; Kato, 1986).

Of the 323 ordinal form minke whales sampled, 164 were male and 159 female, giving an overall ratio of males to females of 0.508:0.492. However, this varied by stratum. Excluding the southern stratum, Eastern Sector, in the first half (only four samples taken), the male sex ratio was higher in the middle strata (0.76-0.92) than in the southern strata (0.11-0.49). Imbalance of the sexes was particularly apparent in the second half when the lowest male sex ratio of all divisions (0.11) was found in the southern stratum, Eastern Sector, and the highest (0.92) was found in the middle stratum, Western Sector.

The proportions of mature whales by sex were 89.6% for males and 83.0% for females. Mature whales were particularly dominant in the southern strata (90.9-100% for males, 68.2-94.4% for females), but rather less so in the middle strata (82.1-92.3% and 50.0-83.3%, respectively).

Mature males were dominant among all samples combined (45.5%), followed by pregnant females (33.4%). However, there were variations in reproductive status by stratum and period. Mature males were dominant (65.9-79.2%) in both middle strata in both halves. In the southern stratum, Western Sector, in both halves, both mature males and pregnant females were strongly represented. In the southern stratum, Eastern Sector, in the second half (Ross Sea), pregnant females accounted for no less than 66.3% of the samples. Also notable in the latter stratum was the representation of resting females (13.8%) and the presence of ovulating females (3 samples; 3.8%). All the samples taken in this stratum in the first half (outside of the Ross Sea) had been mature males. Immature males were taken mainly in the southern strata. However, immature whales were not strongly represented in any stratum.

Body Length Composition

Body length compositions by sex, stratum and period are shown in Fig. 5. Mean body lengths (and standard deviations) by sex in each stratum and period are shown in Table 8.

Excluding the southern stratum, Eastern Sector, in the first half (just four samples were taken in this stratum; mean: 8.6 m; mode: 9.0 m), the means and modes of body lengths for males varied little from one stratum to the next, means ranging from 8.1-8.3 m and modes from 8.2-8.6 m.

Larger females were taken in the southern stratum, Western Sector, in the first half (mean: 8.6 m; mode: 9.0 m), and the southern stratum, Eastern Sector, in the second half (Ross Sea) (mean: 8.7 m; mode: 8.8 m). The proportion of large females was particularly high in the former stratum, 62.8% measuring 9.0 m or more.

It is noted that no animal less than 7.7 m in length was taken from the southern stratum, Eastern Sector, in the second half (Ross Sea).

Biological Characteristics by School Size

Reproductive Status

Table 9 shows compositions of reproductive status by school size in each stratum.

In the first half, almost all samples taken in the middle and southern strata, Eastern Sector, and in the middle strata, Western Sector, were from schools of 1-2 animals, and were overwhelmingly mature males. In the southern stratum, Western Sector, immature females (38.5%) and

mature males (30.8%) were well represented among solitary animals, followed by pregnant females (23.1%). Samples from schools of two animals or more, however, were mainly pregnant females and mature males.

In the second half, mature males dominated in the middle strata for all school sizes (57.1-100%), but immature males were also quite well represented in schools of 2-4 animals. In the southern stratum, Western Sector, most frequent were mature males, ranging from 25.0% for schools of two animals to 75.0% for solitary animals. In the case of schools of two animals, however, pregnant females predominated (50%). In the southern stratum, Eastern Sector, pregnant females were overwhelmingly predominant. Also noteworthy in this stratum was the frequency of resting females among solitary animals.

When samples from all strata are viewed as a whole, it is clear that mature males and pregnant females predominated regardless of school size. Other observations include: i) although immature animals were infrequent in schools of all sizes, no immature male was found in a school of five animals or more; ii) non-pregnant mature females were relatively more frequent among solitary animals and in schools of five animals or more; iii) all the non-pregnant mature females which were solitary were resting, while of the four taken from schools of five animals or more, two were resting and two were ovulating.

Body Length Composition

Fig. 6 shows body length composition and mean body length (and standard deviation) by sex and school size using data for all strata.

The length compositions for males show no apparent trend related to school size. Means of length are 8.1-8.4 m, and modes are 8.2-8.6 m.

As for females, lengths of less than 7.7 m were more frequent among solitary animals. Consequently the mean length for solitary animals was slightly shorter than for samples from schools of two or more, for which mean lengths covered a narrow range of 8.5-8.7 m. Modes of length for females ranged from 8.6-9.2 m.

EXPERIMENTS

Estimated Distance and Angle Experiment

Trials were conducted to evaluate the accuracy of estimates of distance and angle of sightings given by observers on the sighting/sampling vessels. Each vessel was required to assess eight sets of angles and distances from two platforms (barrel and upper bridge). All trials were conducted under good sighting conditions. Half of the trials were completed on the afternoon of Dec. 29, with all three vessels taking part. The KO1 conducted a few trials on the morning of Feb. 16, using available time just before the start of research in the middle stratum. The remaining trials were completed by all vessels on the afternoon of Mar. 4. The results of these experiments will be analysed and presented in the near future.

Monitoring Reaction Experiment

A series of experiments was conducted to observe the reactions of southern minke whales in the vicinity of a chasing vessel. The experiments were conducted on Dec. 24-25, at about 65°20S 172°40E, with the participation of all three sighting/sampling vessels. One vessel (chasing vessel) commenced navigation along a designated trackline, while the other two (monitoring vessels) drifted at a distance of 10

n.miles ahead of the first and 6 n.miles apart from each other (see Fig. 7). When the chasing vessel made a sighting, it closed with it at a speed of 15 knots. If the sighting proved to be a minke whale school, it commenced chasing in an identical manner to that which would normally be employed for sampling. The chase lasted for at least 30 minutes or until two good opportunities to fire a harpoon had been achieved. The chase was then terminated, and the vessel recommenced searching and returned to the trackline, as per normal procedure. During the chase, the monitoring vessels kept other minke whale schools in the vicinity under continuous observation either until the sighting was lost or until they were passed by the chasing vessel. A total of seven trials was conducted at different sites, with a combined duration of 10 hrs 11 minutes. In all, the behavior was observed of 11 schools, ranging in size from 1 to 10 animals. One of the trials, however, was seriously disrupted by a helicopter from the Greenpeace vessel Gondwana. The helicopter made low passes over a school of 7 minke whales, causing them to flee. Details of this experiment will be presented in the near future.

Biopsy Skin and Muscle Sampling Experiment

Tests were conducted of a newly developed air gun system (see Fig. 8) for collecting biopsy samples of both skin (blubber) and muscle tissue. The tests were conducted aboard the NM3 on the morning of Feb. 20, using the carcass of an 8.6 m minke whale. Two lengths of biopsy dart (10 and 15 cm) were used. Firing was conducted over two ranges (20 and 30 m) and at two angles of incidence (90° and 45°). A total of 10 trials was made, resulting in eight hits, one miss and one ricochet. Four of these trials were made at 90° incidence and over both firing ranges. Three were hits and yielded samples containing both blubber and muscle. The remaining six trials were made at 45° incidence. Of five hits, two provided samples containing both blubber and muscle. The weight of the blubber and muscle in samples containing both ranged from 2-4.5 gms for blubber and 0.8-2.5 gms for muscle.

Preliminary Feasibility Tests of Satellite Tagging System

Four different experiments were conducted with a satellite tagging system (see Fig. 9) to test: (1) the dart; (2) a delayed action separator; (3) firing performance; and (4) the linkage between the platform transmitter terminal (PTT) and a satellite.

Test (1) was designed to observe the penetration of the dart into the body of a whale, and was conducted in conjunction with the test of the biopsy sampling system.

Test (2) involved a newly developed technology designed to cut the wire between the dart and the PTT after the lapse of three months. Two "delayed action separators" were tested aboard the NM3 during the cruise. Both cut their wires on days exactly three months after the tests had been set up.

Test (3) was conducted to observe the performance of the total system (see Fig. 9) when fired from an air gun, including flight path and attachment to the body of a whale. For this test, shots were fired at a whale being delivered to the NM3 by a sighting/sampling vessel.

Test (4) was intended to confirm the linkage between the PTT and a satellite under conditions simulating the diving behavior of a minke whale. To achieve this, the PTT was attached to the end of a hydraulically operated arm and immersed in a tank of water. Every two

minutes, the PTT was lifted clear of the surface for a period of 2-3 seconds. The test commenced on Mar. 12, and was intended to run for two weeks. It was terminated prematurely, however, on Mar. 20, due to a clearly visible malfunction in the PTT.

Details of these tests will be presented in the near future.

OTHER SURVEYS

Mark Recovery (Discovery tag)

No marked whale was caught during the cruise.

Biopsy Skin Sampling

The sampling of skin from humpback whales had been considered for this cruise, but no humpback whales were encountered after the biopsy darts became available for the sighting/sampling vessels.

Natural Marking

Seven groups (10 animals) of blue whales, and 109 groups (169 animals) of humpback whales were seen. Attempts were made to photograph the natural markings of three blue whale groups and 16 humpback whale groups. A total of 116 pictures was taken. However, researchers responsible for taking the photographs felt that only a few would be useful for identifying individual whales due to the very few opportunities to photograph the underside of humpback flukes and the prolonged diving behavior of the blue whales observed.

Oceanographical Survey

Oceanographical research using an XBT was conducted by the T25 from Dec. 16 to Mar. 14. Weather permitting, data were collected daily, either at the end of the allotted research period or when research was suspended (e.g. topman-down steaming or drifting). A total of 81 observations was obtained during the survey. Details of the results will be presented elsewhere in the future.

Marine Debris

Observation of marine debris was conducted by the officer on watch of the NM3 from Nov. 25 to Dec. 23 and from Mar. 17 to Apr. 8.

DISCUSSIONS AND RECOMMENDATIONS

Research in the second year of this program was conducted in Area V, including a part of the Antarctic Ocean which can be considered extraordinary, the Ross Sea. Despite poor weather and sea conditions and a minor disruption caused by the Greenpeace vessel Gondwana, the cruise proceeded smoothly overall and succeeded in attaining its objectives. The impact of adverse weather and sea conditions on results cannot be discounted, however, over the entire period, unfavorable conditions were experienced during 51% of hours allocated for research. On occasion, therefore, research was conducted under less-than-ideal conditions, and this is considered to have had a substantial effect on sampling efficiency, in particular.

Technical sampling efficiency on this cruise was 0.52 which is lower than on preceding cruises in 1987/88 in Area IV (0.74; from Kato et al., 1989), '88/89 in Area V (0.51 for single vessel, 0.58 for paired vessels, and 0.55 for combined; from Kato et al., 1990b), and '89/90 in Area IV (0.69; from Fujise et al., 1990b). It is notable that sampling

efficiencies have been higher in Area IV (0.74 and 0.69) than in Area V (0.55 and 0.52). The low efficiency on the present cruise was mainly due to a low sampling rate for solitary animals and losing sight of secondary targeted whales in schools of two or more after the first sample had been taken. The number of animals targeted but lost was 296, or nearly twice that on the previous cruise (150). The principal reason for failing to take samples was losing sight of whales before chasing commenced. It was reported that in most of these cases, sight was lost under adverse conditions. It is clear that weather and sea conditions must be considered major factors when planning future cruises.

Table 10 shows the incidence of schools by size in each stratum. In the middle and southern strata, it can be seen that the incidence of solitary animals tended to decrease as time progressed while the incidence of schools of three or more animals increased and that of schools of two was stable. It is also noted that incidences of solitary animals in both strata in the Eastern Sector were higher than in the Western Sector, regardless of the period. This was probably due to the fact that the area away from the ice edge in the Eastern Sector is much greater than that in the Western Sector (see Figs 1 and 2), since solitary animals were frequently observed away from the ice edge. Further examination of these preliminary findings must be conducted in future.

As for spatial/temporal variations of reproductive status, the following stratification can be made: Sub-area 1 (middle strata, both halves and both sectors), in which mature males predominated; Sub-area 2, (southern strata, Western Sector, both halves), in which mature males and pregnant females predominated; Sub-area 3 (southern stratum, Eastern Sector, second half [Ross Sea]), in which pregnant females predominated.

The results of the second feasibility study in an area bounded by 53°S-77°30S and 168°E-180° revealed that mature males and immature individuals of both sexes predominated in the northern area, while pregnant females predominated in the southern area (Kato et al., 1990b). In the present survey, mature males predominated in the northern strata (Sub-area 1), and pregnant females in a southern stratum (Sub-area 3), while immature whales were poorly represented in all strata. It could be considered that reproductive structure in Sub-area 2 was intermediate between Sub-areas 1 and 3.

The second feasibility study also showed that mature males and immature animals tended to be solitary while pregnant females usually formed schools (Kato et al., 1990b), but this tendency was not apparent on the present cruise. However, the proportion of mature individuals of both sexes was slightly higher in schools of five or more. As for temporal changes of sex ratio, the percentage of males was higher in the second half of the present cruise than in the first half, a trend also observed in the aforementioned feasibility study.

In Sub-area 3 (Ross Sea), it is notable that the sampling of 11 resting females and three ovulating females meant that the proportion of non-pregnant mature females was relatively high. The ratio of pregnant females to resting females was just 3:1 among solitary animals taken there. This observation may prove of great interest when considering reproduction, segregation and/or migration of the southern minke whale.

Fig. 10 compares body length compositions by sex for the samples taken

by the present survey with those from the 1988/89 feasibility study and the 1986/87 commercial catch. Compared with the commercial catch, samples taken on this cruise cover a wider range of lengths for both sexes, and in particular show a higher proportion of small whales. While no males of 7.4 m of less in length or females of 7.2 m or less were taken commercially, in the present survey they accounted for 9.1% and 9.4%, respectively. Similar observations to these were made following the three previous cruises (Kato et al., 1989, 1990b; Fujise et al., 1990b). Significant differences (t-test, $p<0.001$) were found in mean body length in both sexes between the present survey (8.2 m for males, 8.5 m for females) and the last commercial catch (8.6 m and 9.0 m). The mode for males was smaller than in the commercial catch, whereas the mode for females was the same. Body length compositions in the present survey were similar to those in the feasibility study in Area V in 1988/89. The mean and mode of body length for males in the present survey were larger than those from the feasibility study. The mean length for males differed significantly (t-test, $P<0.01$) from those of the feasibility study, while the mean length for females was not significantly different and the mode for females was the same. It is noted that the proportion of small animals (7.0 m or less) was lower in the present survey (5.4% for males, 8.1% for females) than in the feasibility study in Area V in 1988/89 (10.8% and 10.0%), and the proportions of males of 9.0 m or more (10.9%) and females of 9.4 m or more (13.3%) were higher in the present survey than in the feasibility study (3.6% and 6.5%, respectively).

Among technical difficulties encountered in the construction of tracklines, particular consideration should be given to the distances between waypoints on the locus. In the southern strata these distances were extremely long (230-330 n.miles, compared with 80-100 n.miles in the IDCR cruises [Anon., 1984]) due to the limited number of research days (see above). When a north-south extension of the pack ice edge occurred between the waypoints, much of the trackline transected the pack ice resulting in a substantial part of the trackline being unsurveyed. It is therefore recommended that shorter distances between waypoints in southern strata be considered in future planning.

ACKNOWLEDGMENTS

Financial support for this cruise was provided by the Government of Japan. The project leader was Dr. Ikuo Ikeda, director-general of the Institute of Cetacean Research (ICR). Three sighting/sampling vessels and a mother ship were chartered by the ICR from Kyodo Senpaku Co. Ltd. Special thanks are due to Captains Kazunori Numano (NM3), Atsushi Ohwada (K01), Tokuya Sumihara (T25) and Shigeo Suzuki (T18), and their crews for their positive contribution in spirit and deed to the success of the cruise. Thanks are also due to Messrs. Shuuichi Kawashima and Katsuo Nemoto (supporting staff), and to Messrs. Shigeo Tabata and Yutaka Eguchi (biological research technicians). Chief engineer Seiichi Kawamuro of the NM3 and his staff assisted in the satellite tagging experiment.

REFERENCES

Anonymous. 1984. Report of the planning meeting for the IWC/IDCR Southern Hemisphere Minke Whale Assessment Cruise in 1984/85. Paper is available from the IWC secretariat.

Anonymous. 1986. Report of the 1985/86 IWC/IDCR Southern Hemisphere Minke Whale Assessment Cruise, Area V. Paper SC/38/Mi26 submitted to the Scientific Committee, May 1986.

Anonymous. 1990. Response to the resolution for reconsideration on the Japanese Research Program in the Antarctic for 1990/91, The Government of Japan, November, 1990. Paper submitted to the IWC, November, 1990.

Butterworth, D.S. and Best, P.B. 1982. Report of the Southern Hemisphere Minke Whale Assessment Cruise, 1980/81. Rep.int.Whal. Commn 32:835-881.

Fujise, Y., Kato, H. and Kishino, H. 1990a. Reproductive segregation of the minke whale population in high latitudinal waters with some estimations of pregnancy and sexual maturity rates, data from Japanese research takes in 1987/88 and 1988/89. Paper SC/42/SHMi10 submitted to the Scientific Committee, May 1990.

Fujise, Y., Yamamura, K., Zenitani, R., Ishikawa, H., Yamamoto, Y. Kimura, K. and Komaba, M. 1990b. Cruise report of the research on southern minke whales in 1989/90 under the Japanese proposal to the scientific permit. Paper SC/42/SHMi25 submitted to the Scientific Committee, May 1990.

Government of Japan. 1990. The 1990/91 research plan of whale resources in the Antarctic. Paper SC/42/SHMi9 submitted to the Scientific Committee, May 1990 (unpublished).

International Whaling Commission. 1983. Report of the Scientific Committee (ANNEX E, Appendix 5). Rep.int.Whal Commn 38:111-113.

Kasamatsu, F., Kishino, H. and Hiroyama, H. 1990. Estimations of the number of minke whale schools and individuals based on the 1987/88 Japanese feasibility study data. Rep. int. Whal. Commn 40:239-247.

Kasamatsu, F., Kishino, H. and Taga, H. 1990. Estimations of southern minke whale abundance and school size compositions based on the 1988/89 Japanese feasibility study data. Paper SC/42/SHMi2 submitted to the Scientific Committee, May 1990.

Kasamatsu, F. and Nishiwaki, S. 1990. Breeding grounds and southbound migration of southern minke whales with special reference to stock boundaries. Paper SC/42/SHMi20 submitted to the Scientific Committee, May 1990.

Kato, H. 1986. Study on changes in biological parameters and population dynamics of southern minke whales. Doctoral Thesis submitted to the Hokkaido University. 145pp. (In Japanese).

Kato, H., Hiroyama, H., Fujise, Y. and Ono, K. 1989. Preliminary report of 1987/88 Japanese feasibility study of the special permit proposal for southern hemisphere minke whales. Rep. int.Whal. Commn 39:235-248.

Kato, H., Kishino, H. and Fujise, Y. 1990a. Some analyses on age composition and segregation of southern minke whales using samples obtained from the Japanese feasibility study in 1987/88. Rep. int. Whal. Commn 40:249-256.

Kato, H., Fujise, Y., Yoshida, H., Nakagawa, S., Ishida, M. and Tanifuji, S. 1990b. Cruise report and preliminary analyses of the 1988/89 Japanese feasibility study of the special permit proposal for southern hemisphere minke whales. Rep. int. Whal.Commn 40:289-

300.
Kato, H., Fujise, Y. and Kishino, H. 1990c. Preliminary analyses on age and reproductive data of southern minke whales obtained from the Japanese research take in 1988/89. Paper SC/42/SHMi1 submitted to the Scientific Committee, May 1990.
Kishino, H., Kato, H., Kasamatsu, F. and Fujise, Y. 1988. Statistical method for the estimation of age composition and biological parameters of the population. Paper SC/41/SHMi3 submitted to the Scientific Committee, June 1988.
Ohsumi, S., Masaki, Y. and Kawamura, A. 1970. Stock of the Antarctic minke whale. Sci. Rep. Whales Res. Inst., Tokyo 22:75-125.
Ohsumi, S. 1979. Population assessment of the Antarctic minke whale. Rep. int. Whal. Commn 29:407-420.

Table 1a. Summary of sightings (no. of schools/no.of individuals) and searching distances in the first half. (P; Primary sightings, S; Secondary sightings.)

Species	Northern		Eastern				Western			
			South		Middle		South		Middle	
	P	S	P	S	P	S	P	S	P	S
Blue										
Fin			2/7				1/2		2/5	
Sei	1/1									
Minke (ordinal)	2/3	1/1	21/27	80/210	31/40	6/7	114/291	64/183	154/322	35/58
(diminutive)			1/1		2/2				2/2	
Sperm			83/91	62/70	7/8	1/1	35/37	20/22	5/5	1/1
Bryde's										
Humpback	1/2		26/41	35/56	6/8	1/2	23/34	12/17	1/2	
Killer			1/25	4/39	2/7	1/5	2/15		3/115	
Ziphiids	2/4		64/122	28/65	23/33	1/2	49/93	6/9	41/77	4/8
Pilot	7/78				1/1			1/10	2/66	1/2
Hourglass d.	1/5								5/31	3/15
Bottlenose w.			1/1		2/4		3/6		4/12	
Gray's beaked										1/1
Unidentified w.	5/5		20/21	17/21	21/21		41/43	4/6	27/35	1/1
Unidentified d.	1/20								5/25	
Searching dist. (n.miles)	205.1		1516.5		1868.6		1632.9		2720.7	

Table 1b. Summary of sightings (no. of schools/no.of individuals) and searching distances in the second half. (P; Primary sightings, S; Secondary sightings.)

Species	SECOND HALF									
	Northern		Eastern				Western			
			South		Middle		South		Middle	
	P	S	P	S	P	S	P	S	P	S
Blue			3/4	3/4					1/2	
Fin			1/1		7/8		4/9	6/23	16/35	1/1
Sei										
Minke (ordinal)		1/1	237/545	104/243	65/130	7/27	89/298	156/518	31/63	14/21
(diminutive)					1/1					
Sperm			35/37	4/5	6/6	1/1	5/5	3/3	1/1	
Bryde's										
Humpback			1/1		1/3			1/1	1/2	
Killer			13/532	4/73	9/144		2/32	3/30		
Ziphiids			1/1	1/3	42/59	1/1	2/5	1/2	19/31	
Pilot						1/25	8/49	5/133	2/230	1/10
Hourglass d.					7/32	2/8			7/90	1/4
Bottlenose w.					2/2	1/2				
Gray's beaked										
Unidentified w.			14/15		21/22		5/5		5/5	
Unidentified d.								1/10	1/25	
Searching dist. (n.miles)	7.0		1622.8		2469.4		1051.4		1665.5	

Table 1c. Total sightings (no. of schools/no.of individuals) and searching distances during the cruise.

Species	Total	
	Primary	Secondary
Blue	4/6	3/4
Fin	33/67	7/24
Sei	1/1	
Minke (ordinal)	744/1719	468/1269
(diminutive)	6/6	
Sperm	177/190	92/103
Humpback	60/93	49/76
Killer	32/870	12/147
Ziphiids	243/425	42/90
Pilot	12/375	4/47
Hourglass d.	28/207	13/167
Bottlenose w.	12/25	1/2
Gray's beaked		1/1
Unidentified w.	159/172	22/28
Unidentified d.	7/70	1/10
Searching dist. (n.miles)	14759.9	

Table 2. Sampling efficiencies by stratum and period.

	FIRST HALF Dec. 19, 1990 - Jan. 31, 1991					SECOND HALF Feb. 9, 1991 - Mar. 22, 1991					WHOLE PERIOD Dec. 19, 1990 - Mar. 22, 1991				
	No. of[1] whales seen (S)	No. of whales targeted (T)	No. of whales sampled (C)	Efficiency Tech. (C/T)	Efficiency True (C/S)	No. of whales seen (S)	No. of whales targeted (T)	No. of whales sampled (C)	Efficiency Tech. (C/T)	Efficiency True (C/S)	No. of whales seen (S)	No. of whales targeted (T)	No. of whales sampled (C)	Efficiency Tech. (C/T)	Efficiency True (C/S)
Northern Sector	3	3	1	0.33	0.33	-	-	-	-	-	3	3	1	0.33	0.33
Middle															
Western	324	96	45	0.47	0.14	63	40	24	0.60	0.38	387	136	69	0.51	0.18
Eastern	42	42	19	0.45	0.45	131	87	34	0.39	0.26	173	129	53	0.41	0.31
Total	366	138	64	0.46	0.17	194	127	58	0.46	0.30	560	265	122	0.46	0.22
Southern															
Western	288	154	76	0.49	0.26	302	72	43	0.60	0.14	590	226	119	0.53	0.20
Eastern	28	7	5	0.71	0.18	448	122	80	0.66	0.18	476	129	85	0.66	0.18
Total	316	161	81	0.50	0.26	750	194	123	0.63	0.16	1066	355	204	0.57	0.19
Total	685	302	146	0.48	0.21	944	321	181	0.56	0.19	1629	623	327	0.52	0.20

1) Number of whales of primay sightings except sightings during the transit.

Table 3. Sampling efficiencies by school size.

School size (I)	No. of schools seen (SS)	No. of schools targeted (TS)	No. of whales targeted (TW)	No. of whales sampled None	One	Two	To. (C)	Efficiency (C/TW)	(C/I*SS)
1	336	219	219	127	92	-	92	0.42	0.27
2	156	97	194	28	46	23	92	0.47	0.29
3	80	51	102	8	23	20	63	0.62	0.26
4	35	25	50	3	9	13	35	0.70	0.25
>=5	76	29	58	3	7	19	45	0.78	0.07
Total	683	421	623	169	177	75	327	0.52	0.20

1) No. of primary schools seen (SS) excludes sightings obtained during the transit.

Table 4. Causes of failure to collect samples by school size.

		Cause of failure										
	School size	Swer-ving	Prolonged diving	Speed	Sea condition	Time limit	Technical problem	Pack ice	Losing sight	Boundary	Logistic reason	Others
No whale sampled	1	21	8	13	5	1	2	2	74	-	-	1
	2	10	2	4	1	1	1	-	37	-	-	-
	3	3	1	2	-	-	1	-	9	-	-	-
	4	2	-	-	-	-	-	1	3	-	-	-
	>=5	2	-	-	-	2	-	-	2	-	-	-
	Total	38	11	19	6	4	4	3	125	-	-	1
One whale missed	2	2	-	3	2	1	-	1	34	-	3	-
	3	3	3	1	-	-	1	-	13	-	1	1
	4	-	-	1	-	-	-	-	8	-	-	-
	>=5	-	-	1	-	-	-	-	6	-	-	-
	Total	5	3	6	2	1	1	1	61	-	4	1

Table 5. Summary of diminutive form minke whales taken during cruise.

Sample no.	Date	Position sighted	School size	B.L. (m)	Sex	Food	Reproductive information
2	29.Dec.'90	65°04'S 178°12'E	1	3.83m	F	Euphausia	Immature
12	03.Jan.'91	61°09'S 175°21'W	1	7.47m	F	Fish	Pregnant, Fetus:103cm,Male
14	03.Jan.'91	60°40'S 176°34'W	1	6.61m	F	Fish	Pregnant, Fetus: 99cm,Female
118	26.Jan.'91	60°34'S 146°49'E	1	6.82m	F	Fish	Pregnant, Fetus:112cm,Female

Table 6. Summary of biological data and samples collected.

Samples and data	Number of whales		
	Male	Female	Total*)
Body length and sex	164	163	327
External body proportion	164	163	327
Photographic records of external character	164	163	327
Diatom film record and sampling	164	163	327
Standard measurements of blubber thickness (Three point on each whale)	164	163	327
Body weight	164	163	327
Body weight by parts and detailed measurements of blubber thickness	29	26	55
Earplug for age determination**)	164	163	327
Tympanic bulla for age determination	41	51	92
Largest baleen plate for age determination	41	43	84
Vertebral epiphyses sample	164	162	326
Skull measurement (length and breadth)	163	162	325
Mammary grand; lactation status, measurements and histology sample	—	163	163
Milk sample for chemical analysis	—	0	0
Ovary collection	—	163	163
Uterine horn; measurement and endometrium sample	—	162	162
Uterine fluid for sperm detection	—	163	163
Foetal number	—	112	112
(Foetal length	44	67	111)
(Foetal sex	44	67	111)
(Foetal weight	44	67	111)
(Foetus body proportion	44	66	110)
Collection of foetus	—	3	3
Testis and epididymis weight and tissue collection	164	—	164
Smear sample from testis and epididymis tissues	164	—	164
Blood sample for gonadal hormone assay	157	157	314
Tissue sample for hormone assay	—	71	71
Muscle, liver and heart samples for electrophoretic study	164	163	327
Foetus samples for electrophoretic study	—	106	106
Skin, muscle and kidney samples for DNA study	164	163	327
Foetus samples for DNA study	—	106	106
Tissue samples for heavy metal analyses	99	82	181
Tissue samples for organochlorine analyses	55	58	113
Stomach content, conventional record	164	163	327
Stomach content weight	163	163	326
Collection of stomach contents for the food and feeding study	14	23	37
Collection of intestine contents for the food and feeding study	0	4	4
Tissue samples of various parts the body for the lipid analyses	29	26	55
Stomach contents for the lipid analyses	5	7	12
Collection of whole skeleton	0	1	1
Checking external parasite including its sampling	40	38	78
Sampling of parasite in viscera	18	15	33

*) including four individuals of diminutive form.

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

Table 7. Male sex ratio and reproductive status of samples by stratum and period (excl. diminutive form).

Stratum and period	Male			Female							Male sex ratio
	Imm.	Mat.	Total	Imm.	Mat.					Total	
					Preg.	Ovu.	Rest.	Unk.	Total		
First half											
Eastern middle	1 (5.9)	12 (70.6)	13	2 (11.8)	1 (5.9)	-	1 (5.9)	-	2	4	0.76
Eastern south	-	4 (100)	4	-	-	-	-	-	-	-	1.00
Western middle	5 (11.4)	29 (65.9)	34	3 (6.8)	6 (13.6)	-	1 (2.3)	-	7	10	0.77
Western south	3 (3.9)	30 (39.5)	33	9 (11.8)	30 (39.5)	1 (1.3)	2 (2.6)	1** (1.3)	34	43	0.43
Second half											
Eastern middle	5 (14.7)	23 (67.6)	28	1 (2.9)	2 (5.9)	-	3 (8.8)	-	5	6	0.82
Eastern south	-	9 (11.3)	9	4 (5.0)	53 (66.3)	3 (3.8)	11 (13.8)	-	67	71	0.11
Western middle	3 (12.5)	19 (79.2)	22	1 (4.2)	1 (4.2)	-	-	-	1	2	0.92
Western south	- -	21 (48.8)	21	7 (16.3)	14 (32.6)	- -	1 (2.3)	- -	15	22	0.49
Combined*	17 (5.3)	147 (45.5)	164	27 (8.4)	108 (33.4)	4 (1.2)	19 (5.9)	1 (0.3)	132	159	0.51

*) Including a minke whale taken in the northern sector.

**) Uterus was damaged by the harpoon but both ovaries with corpus luteum and/or corpus albicans remained.

Table 8. Mean body length (and standard deviation) of samples in each stratum by sex (excl. diminutive form).

Stratum and period	Male			Female		
	Mean (S.D.)	Range	n	Mean (S.D.)	Range	n
First half						
Northern sector	- (-)	-	-	8.4 (0.00)	8.4-8.4	1
Eastern middle	8.1 (0.47)	7.0-9.0	13	7.1 (1.47)	4.9-8.6	4
Eastern south	8.6 (0.38)	8.1-9.0	4	- (-)	-	-
Western middle	8.2 (0.79)	5.3-9.0	34	8.5 (0.86)	6.8-9.4	10
Western south	8.2 (0.58)	6.4-8.9	33	8.6 (0.96)	5.7-9.8	43
Second half						
Eastern middle	8.2 (0.59)	6.9-9.1	28	8.3 (0.54)	7.3-9.0	6
Eastern south	8.3 (0.25)	7.8-8.5	9	8.7 (0.36)	7.7-9.4	71
Western middle	8.2 (0.63)	6.5-9.2	22	7.9 (1.40)	6.5-9.3	2
Western south	8.2 (0.44)	7.1-9.1	21	8.3 (0.92)	6.8-9.6	22
Combined	8.2 (0.60)	5.3-9.2	164	8.5 (0.80)	4.9-9.8	159

Table 9. Reproductive status and male sex ratio of samples by school size (excl. diminutive forms).

Stratum and period	School size	Male				Female						Total	Male sex ratio
		Imm.		Mat.		Imm.		Mat. Preg.		Mat. Other Mat.			
First half													
Eastern middle	1	-		7	(70.0)	2	(20.0)	1	(10.0)	-		10	0.70
	2	1	(14.3)	5	(71.4)	-		-		1	(14.3)	7	0.86
Eastern south	1	-		2	(100)	-		-		-		2	1.00
	2	-		2	(100)	-		-		-		2	1.00
Western middle	1	3	(11.5)	18	(69.2)	2	(7.7)	2	(7.7)	1	(3.8)	26	0.81
	2	2	(15.4)	9	(69.2)	0	0.0	2	(15.4)	-		13	0.85
	3	-		1	(50.0)	1	(50.0)	-		-		2	0.50
	4	-		-		-		2	(100)	-		2	0.00
	>=5	-		1	(100)	-		-		-		1	1.00
Western south	1	1	(7.7)	4	(30.8)	5	(38.5)	3	(23.1)	-		13	0.38
	2	-		8	(34.8)	-		13	(56.5)	2	(8.7)	23	0.35
	3	1	(7.7)	8	(61.5)	-		4	(30.8)	-		13	0.69
	4	1	(7.7)	5	(38.5)	2	(15.4)	4	(30.8)	1	(7.7)	13	0.46
	>=5	-		5	(35.7)	2	(14.3)	6	(42.9)	1	(7.1)	14	0.36
Second half													
Eastern middle	1	-		3	(75.0)	-		-		1	(25.0)	4	0.75
	2	2	(28.6)	4	(57.1)	1	(14.3)	-		-		7	0.86
	3	1	(9.1)	8	(72.7)	-		1	(9.1)	1	(9.1)	11	0.82
	4	2	(25.0)	5	(62.5)	-		1	(12.5)	-		8	0.88
	>=5	-		3	(75.0)	-		-		1	(25.0)	4	0.75
Eastern south	1	-		2	(7.7)	-		18	(69.2)	6	(23.1)	26	0.08
	2	-		2	(9.5)	2	(9.5)	14	(66.7)	3	(14.3)	21	0.10
	3	-		4	(23.5)	1	(5.9)	9	(52.9)	3	(17.6)	17	0.24
	4	-		-		1	(16.7)	4	(66.7)	1	(16.7)	6	0.00
	>=5	-		1	(10.0)	-		8	(80.0)	1	(10.0)	10	0.10
Western middle	1	-		2	(66.7)	-		1	(33.3)	-		3	0.67
	2	2	(20.0)	7	(70.0)	1	(10.0)	-		-		10	0.90
	3	1	(14.3)	6	(85.7)	-		-		-		7	1.00
	4	-		2	(100)	-		-		-		2	1.00
	>=5	-		2	(100)	-		-		-		2	1.00
Western south	1	-		3	(75.0)	-		1	(25.0)	-		4	0.75
	2	-		2	(25.0)	2	(25.0)	4	(50.0)	-		8	0.25
	3	-		5	(38.5)	3	(23.1)	5	(38.5)	-		13	0.38
	4	-		2	(50.0)	1	(25.0)	1	(25.0)	-		4	0.50
	>=5	-		9	(64.3)	1	(7.1)	3	(21.4)	1	(7.1)	14	0.64
Combined*)	1	4	(4.5)	41	(46.6)	9	(10.2)	26	(29.5)	8	(9.1)	88	0.51
	2	7	(7.6)	39	(42.4)	6	(6.5)	34	(37.0)	6	(6.5)	92	0.51
	3	3	(4.8)	32	(50.8)	5	(7.9)	19	(30.2)	4	(6.3)	63	0.56
	4	3	(8.6)	14	(40.0)	4	(11.4)	12	(34.3)	2	(5.7)	35	0.49
	>=5	-		21	(46.7)	3	(6.7)	17	(37.8)	4	(8.9)	45	0.47
	Total	17	(5.3)	147	(45.5)	27	(8.4)	108	(33.4)	24	(7.4)	323	0.51

*) including a minke whale taken in the northern sector.

Table 10. Incidence of schools by size in each stratum.

Area/School(%)	1	2	3	4	5=<	Total number of schools
First half						
North	50	50	0	0	0	2
Eastern south	71	29	0	0	0	21
Eastern middle	71	29	0	0	0	31
Western south	38	25	13	10	14	112
Western middle	62	20	6	3	8	154
Second half						
Eastern south	53	20	13	3	11	238
Eastern middle	51	20	15	9	5	65
Western south	34	23	16	7	20	90
Western middle	35	39	19	3	3	31
North	0	0	0	0	0	0

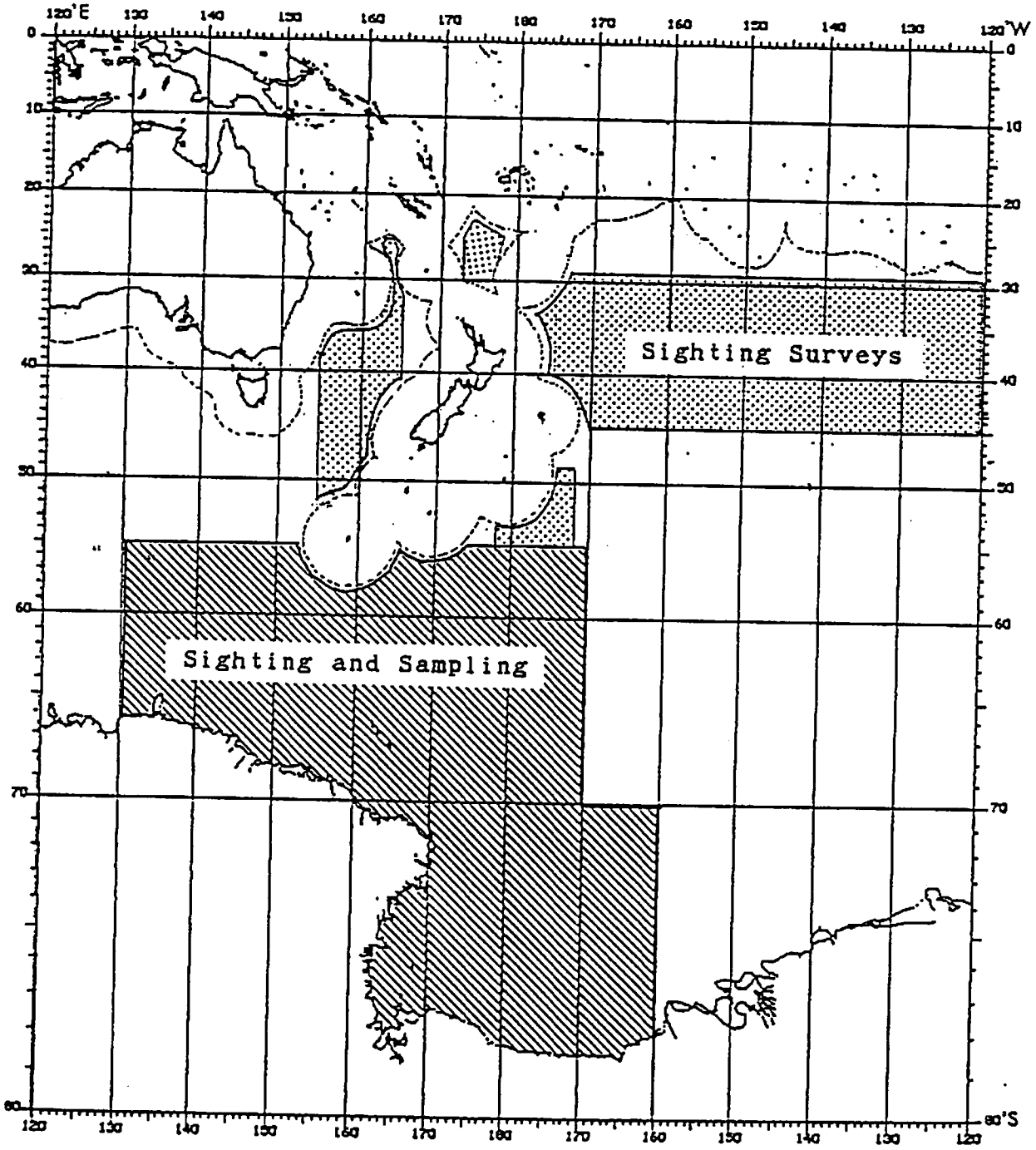


Fig. 1 Research areas covered in 1990/91.

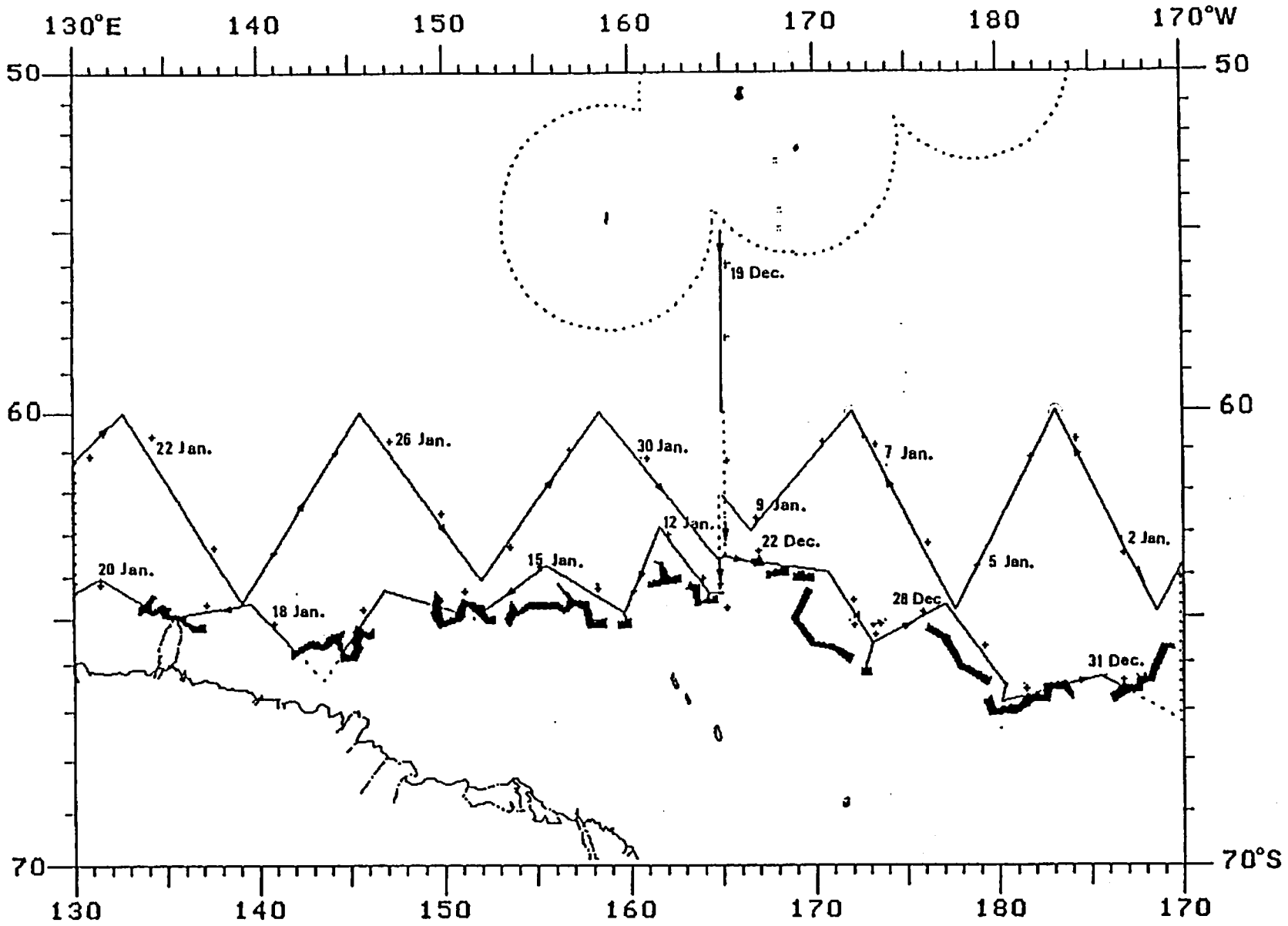


Fig. 2a. Cruise tracks in the first half in 1990/91. (Solid line: main trackline; broken line: transit between research areas; crosses: noon positions of NM3.)

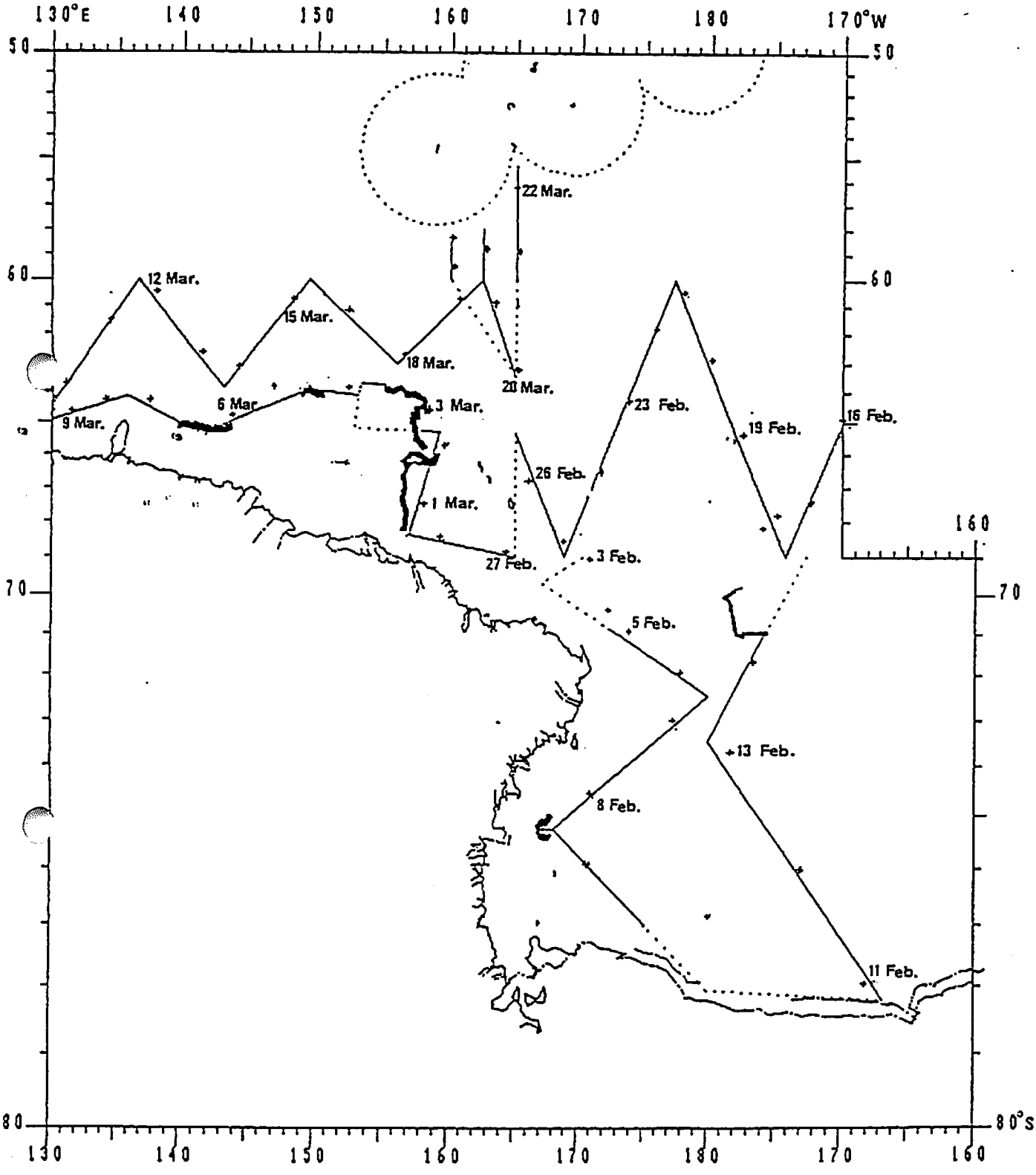


Fig. 2b. Cruise tracks in the second half in 1990/91. (Solid line: main trackline; broken line:transit between research area; crosses:noon position of NM3 until Mar. 15, that of sighting/sampling vessel after Mar. 16.)

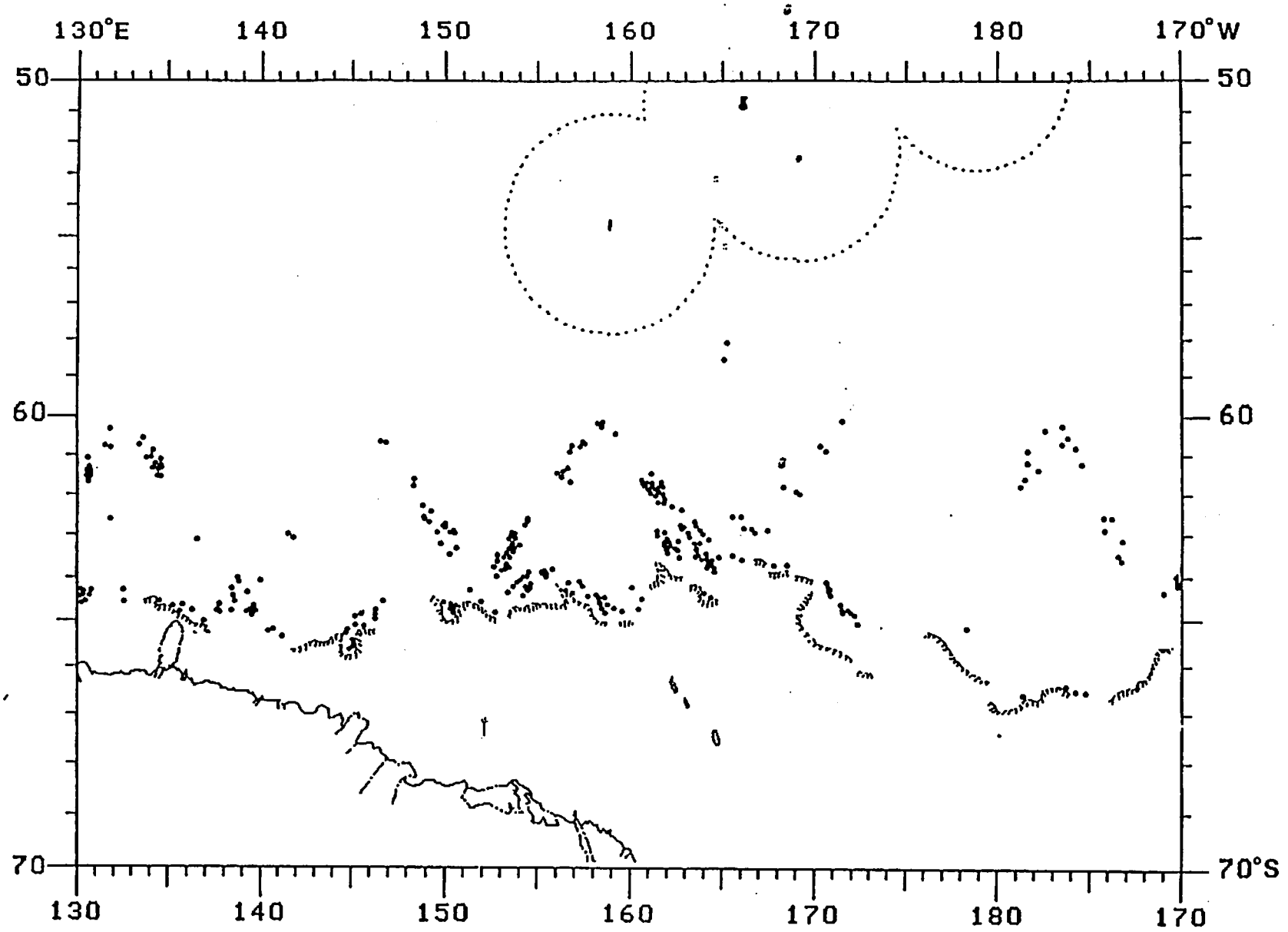


Fig. 3a. Distribution of primary minke whale sightings in the first half.

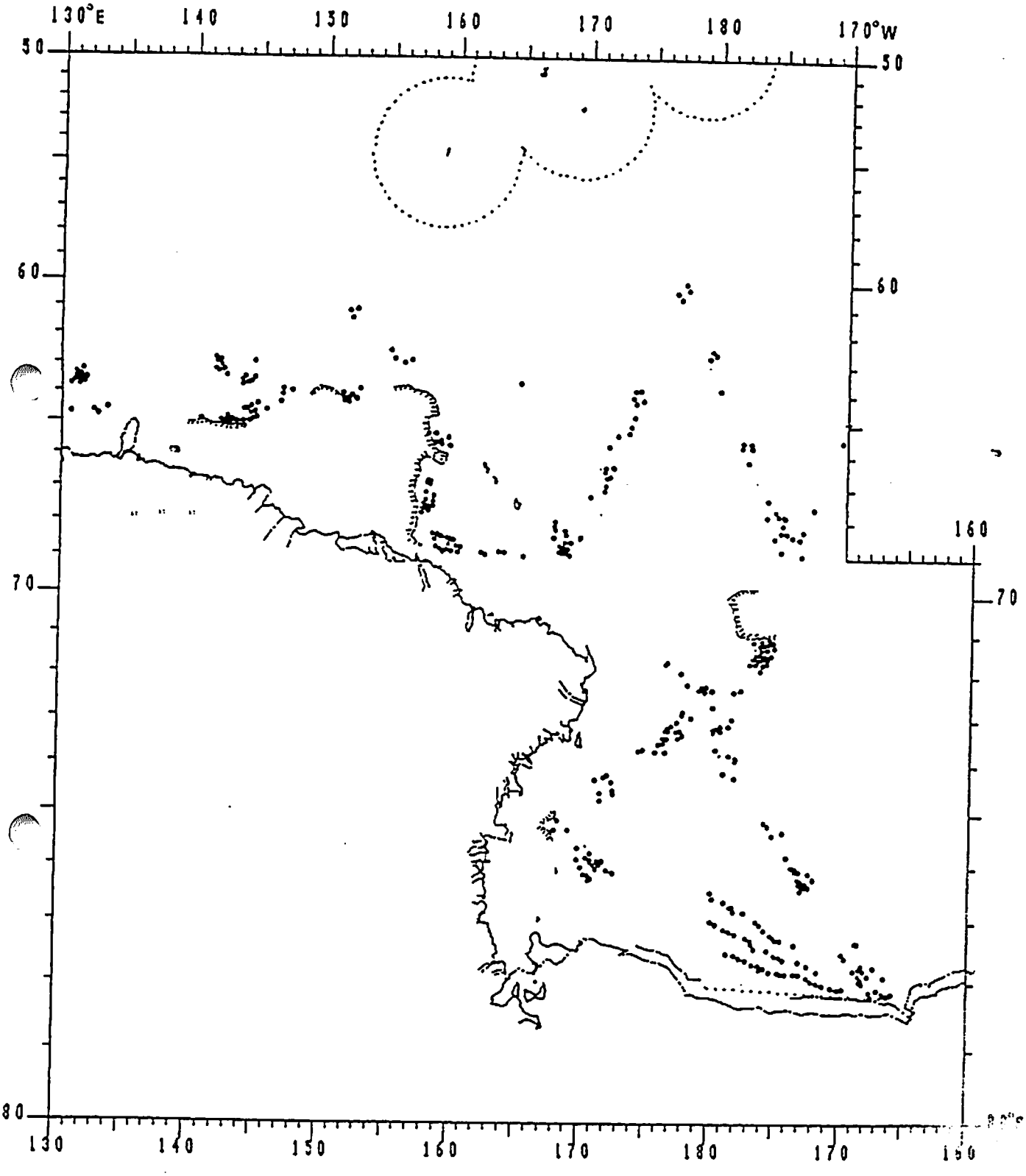


Fig. 3b. Distribution of primary minke whale sightings in the second half.

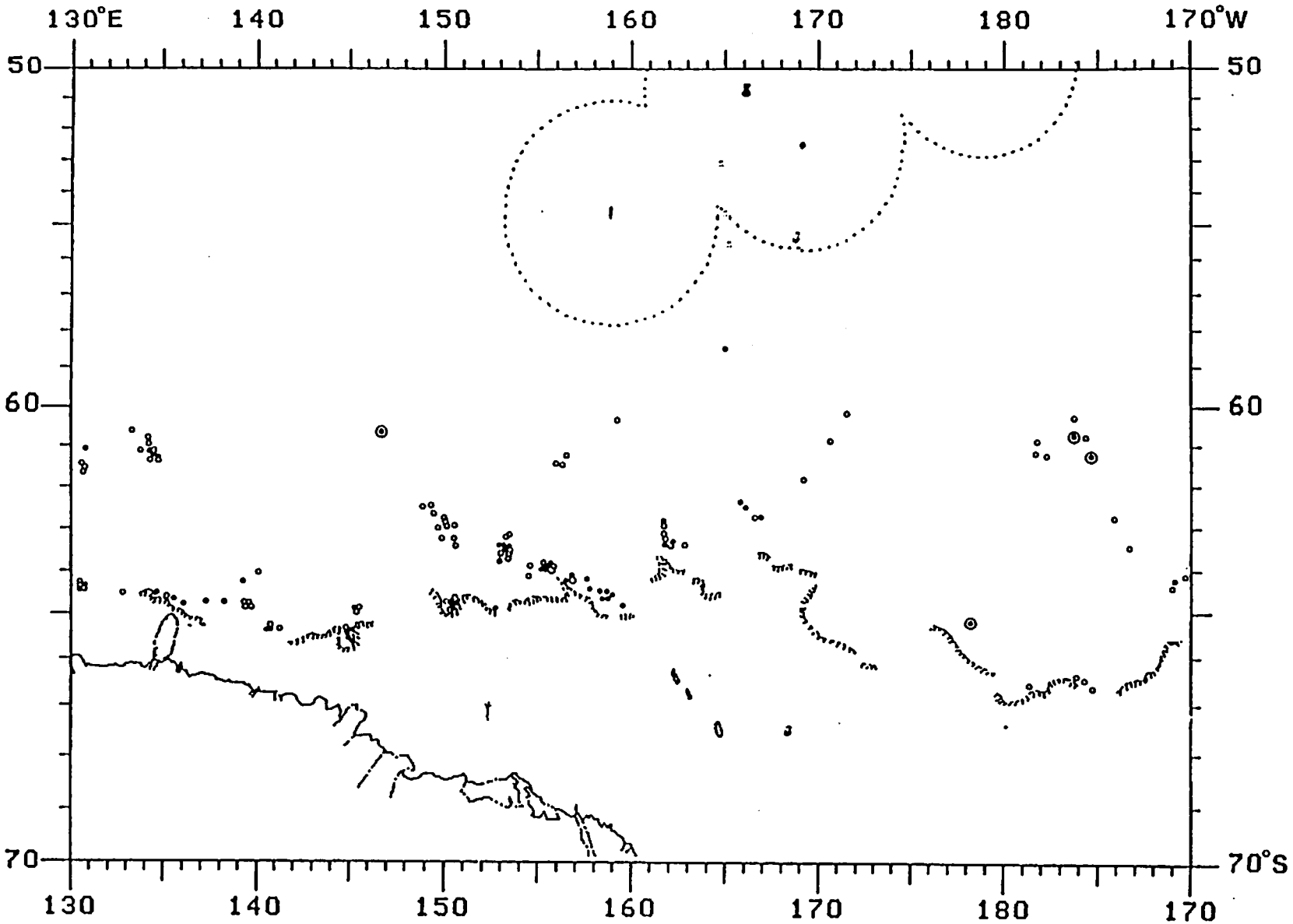


Fig. 4a. Distribution of samples in the first half based on original sighting positions. (Closed circle: female; open circle: male; open circle and closed circle: diminutive form.)

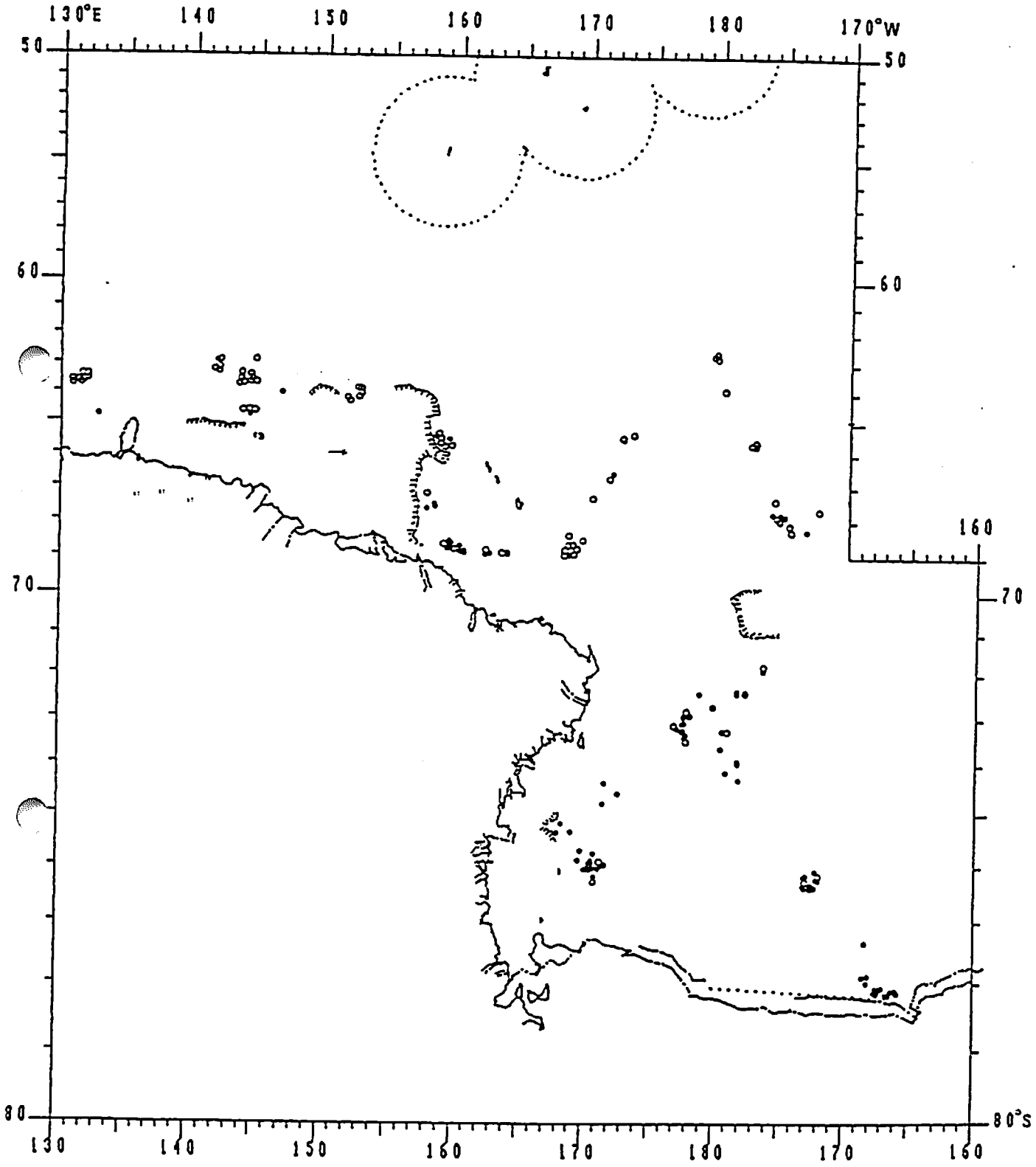


Fig. 4b. Distribution of samples in the second half based on original sighting positions. (Closed circle: female; open circle: male.)

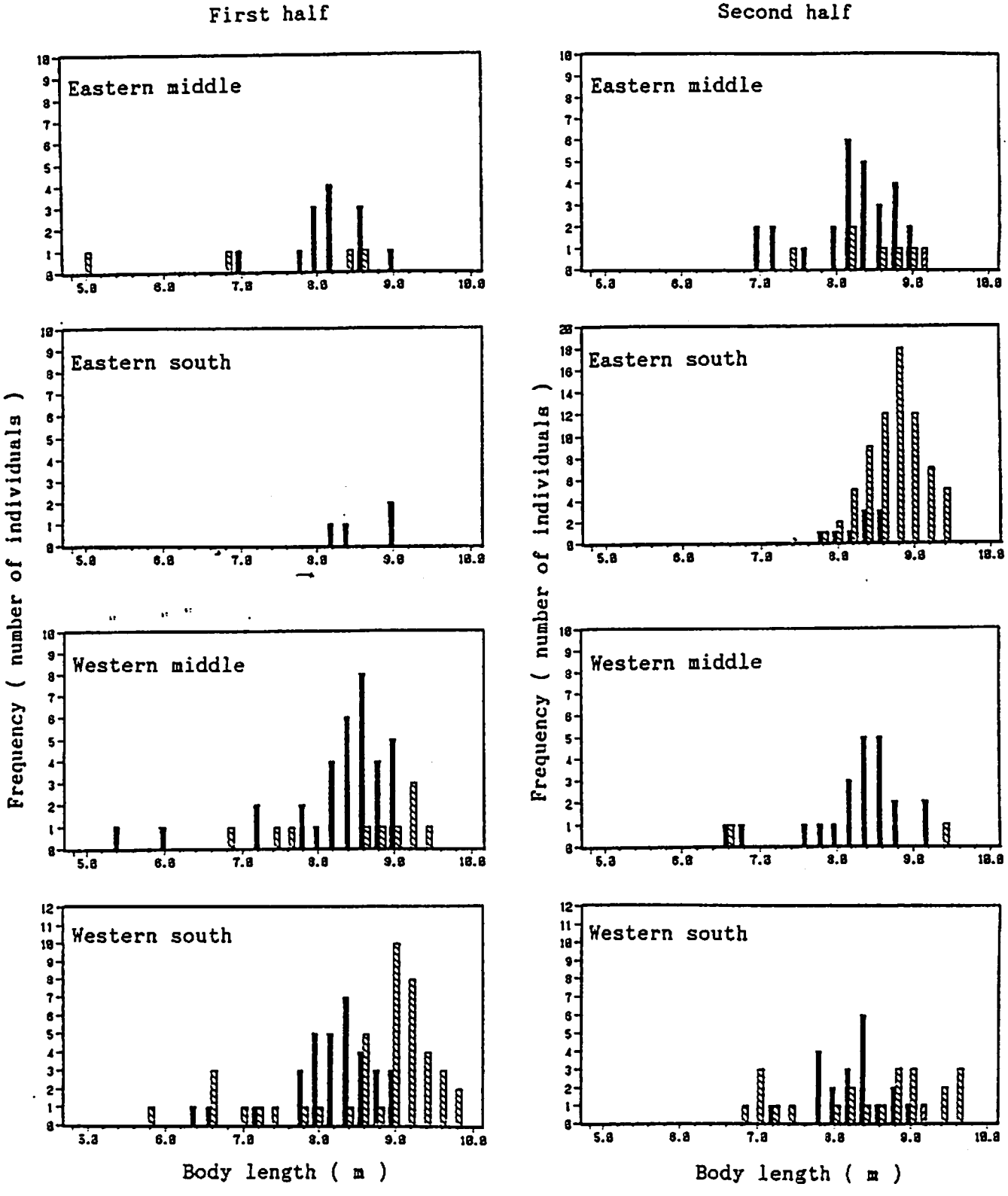
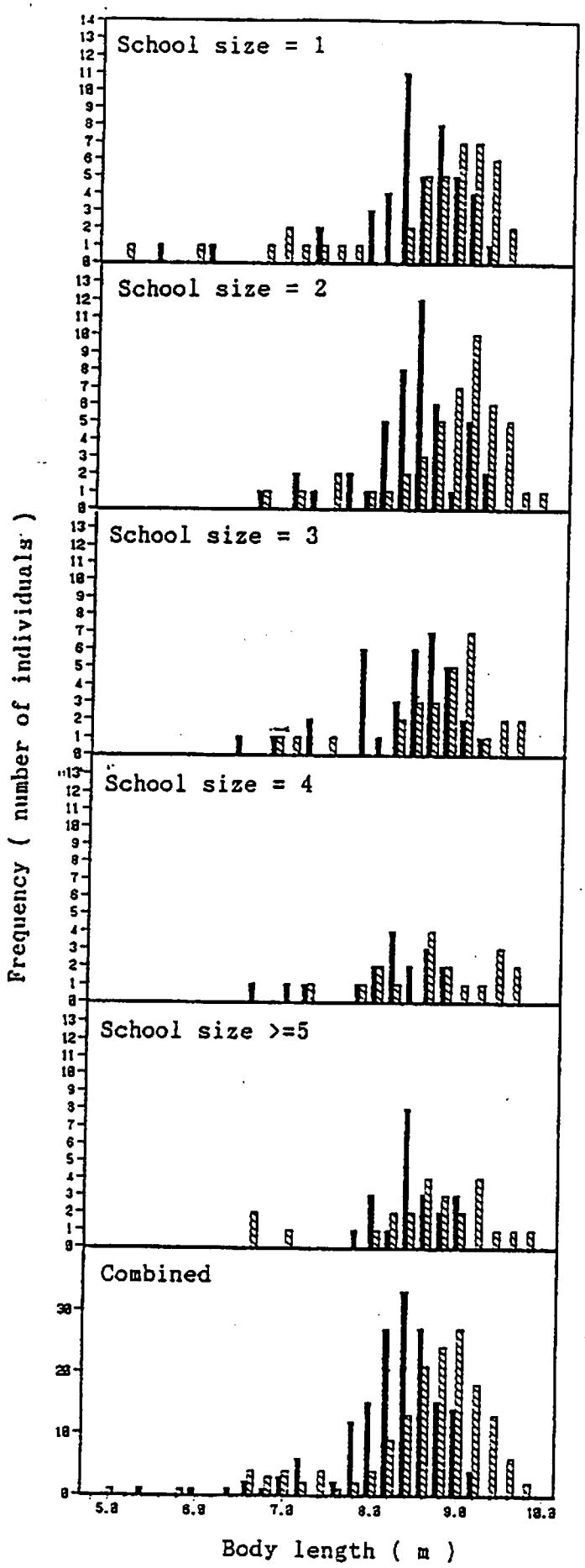


Fig. 5. Body length compositions (20cm intervals) by sex, stratum and period. Solid and hatched lines represent male and female, respectively.



Male: 8.2m (0.71)
5.3m-9.1m, n=45
Female: 8.3m (0.99)
4.9m-9.4m, n=43

Male: 8.2m (0.56)
6.5m-9.2m, n=46
Female: 8.7m (0.66)
6.5m-9.8m, n=46

Male: 8.2m (0.61)
6.4m-9.1m, n=35
Female: 8.6m (0.67)
6.8m-9.6m, n=28

Male: 8.1m (0.61)
6.6m-8.8m, n=17
Female: 8.6m (0.64)
7.2m-9.5m, n=18

Male: 8.4m (0.33)
7.7m-9.0m, n=21
Female: 8.5m (0.83)
6.5m-9.8m, n=24

Male: 8.2m (0.60)
5.3m-9.2m, n=164
Female: 8.5m (0.80)
4.9m-9.8m, n=159

Fig. 6. Body length compositions (20cm intervals), and mean body lengths with standard deviations, by sex and school size.

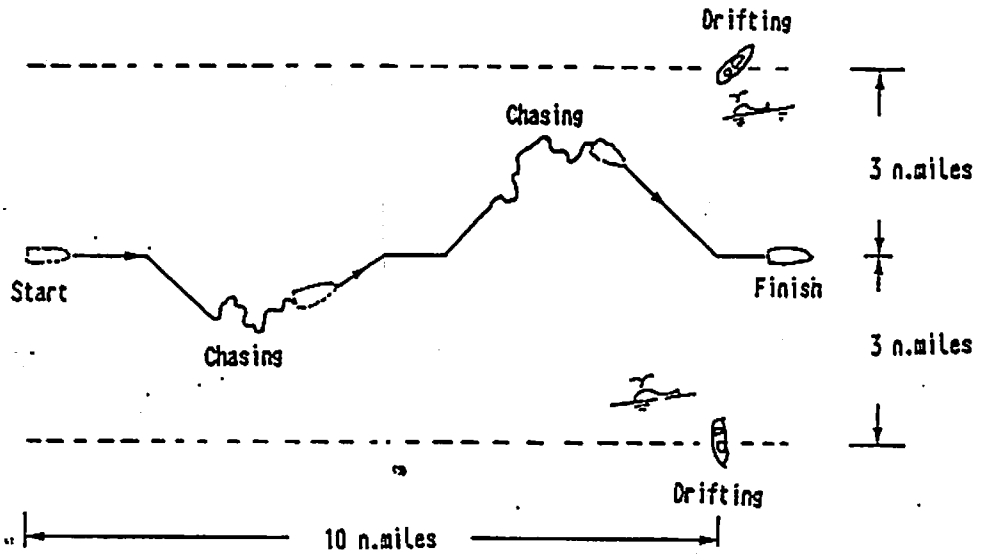


Fig. 7. Experiment to monitor reaction of minke whales in vicinity of chasing vessel.

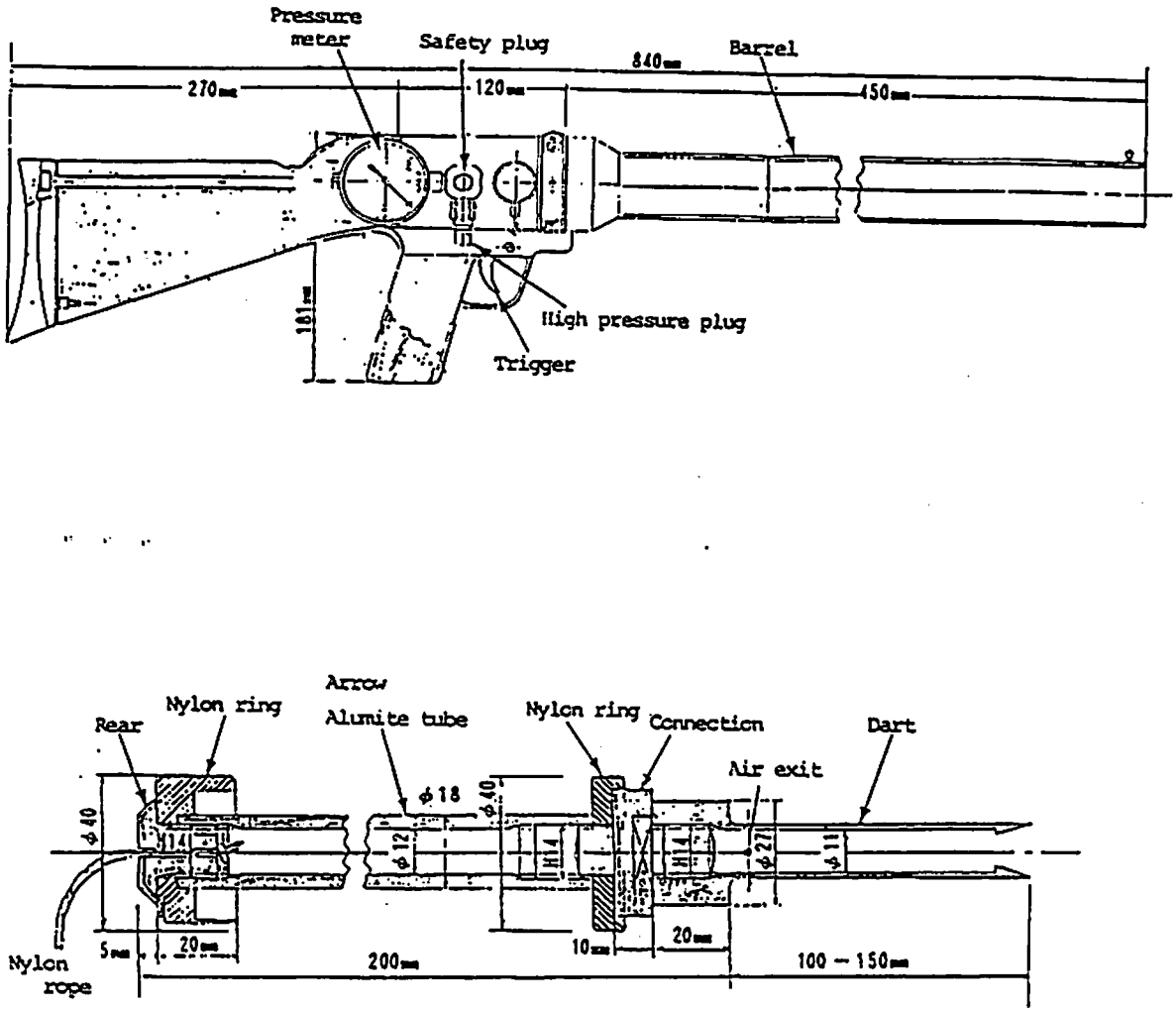


Fig. 8. Components and dimensions of biopsy sampling gun (top) and arrow.

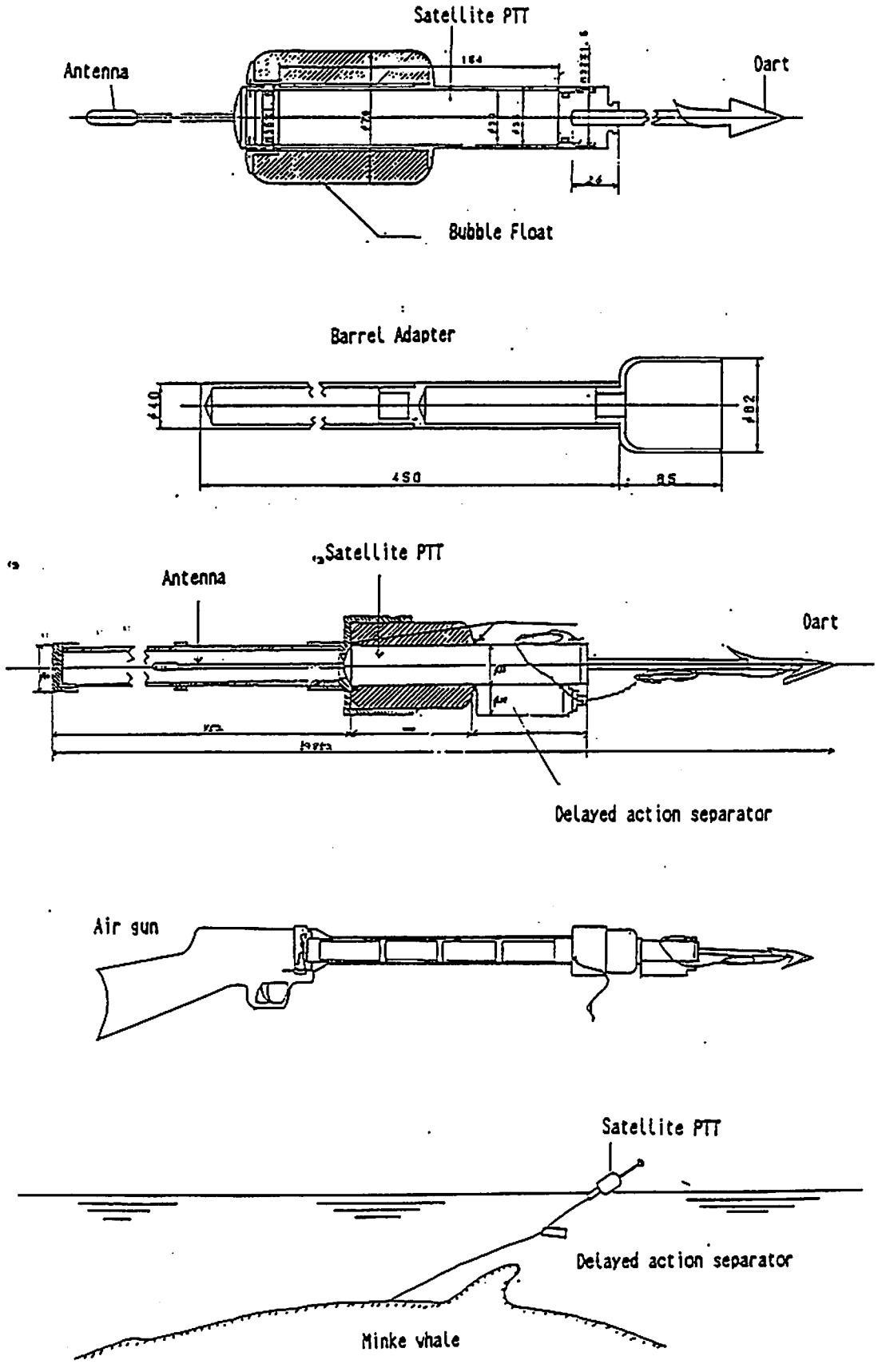


Fig. 9. Newly developed satellite tagging system. PTT and bubble float; Barrel adapter; Loading; total system; After attachment.

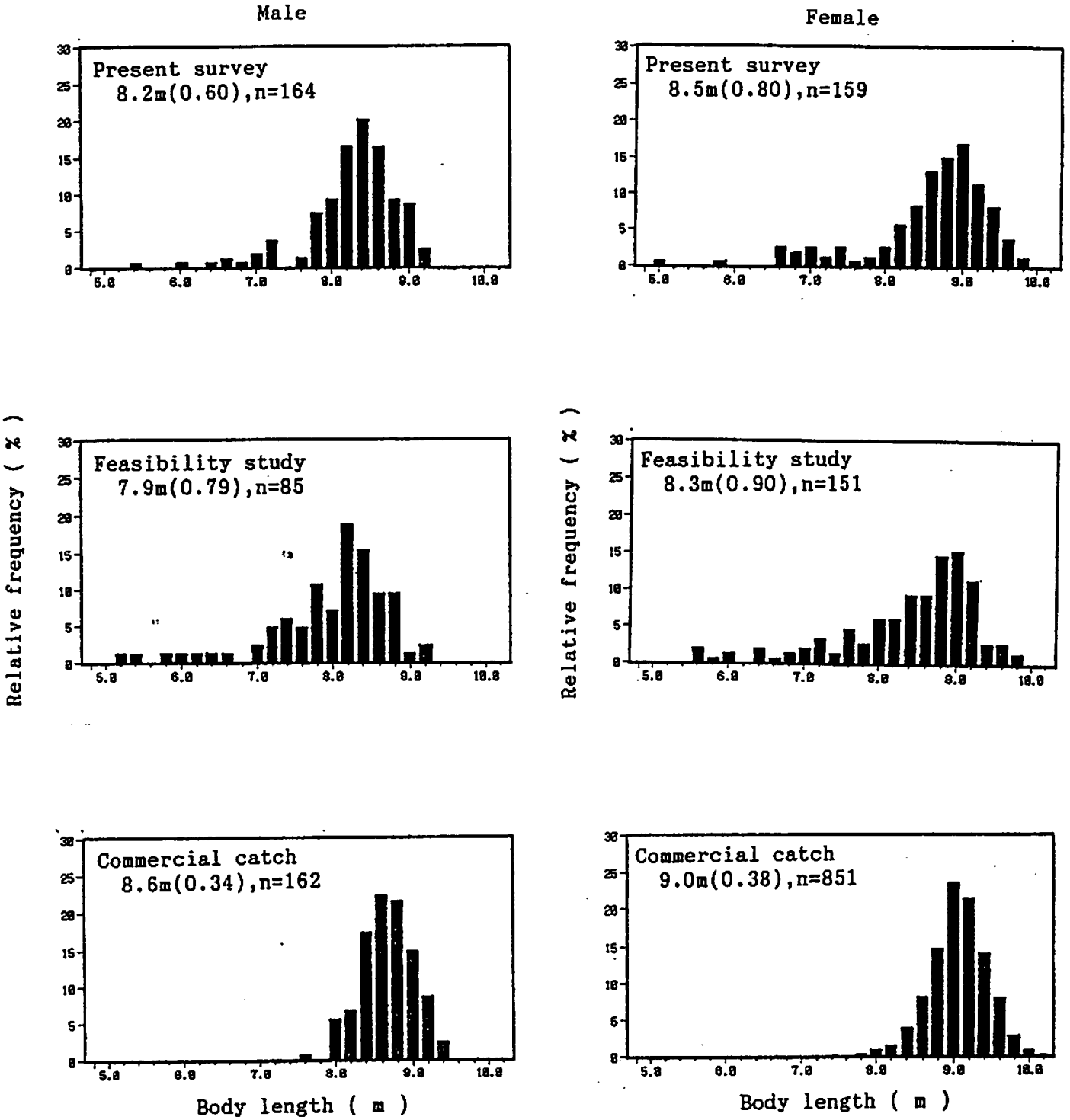


Fig.10. Comparison of body length compositions for 1990/91 survey with those for 1988/89 feasibility study in Area V (cited from Kato *et al.*, 1990), and for Japanese commercial catch in Area V in 1986/87.