Review of general methodology and survey procedure under the JARPA

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Abstract

The Japanese Whale Research Program under Special Permit in the Antarctic (JARPA) has been conducted every year since 1987/88 season. After two seasons of feasibility research, the full-scale research started in 1989/90 season. The program is designed to repeat surveys in the Antarctic Areas IV and V alternatively in each of the sixteen years of the research period. Area IV was divided into five strata and Area V was divided into four strata to investigate different density of distribution and segregation by sex and maturity of Antarctic minke whales *Balaenoptera bonaerensis* by regions. Although the whole research period ranged from the end of November to March, the regular research in the Areas IV and V was concentrated on January and February. From the 1995/96 season, the survey area expanded into a part of Areas III and VI to improve the stock structure study. In order to achieve four objectives of JARPA, it was characterized by combination of sighting and sampling survey. Track lines in the Areas IV and V were designed to cover the whole research area in the same manner. In principal, a saw tooth (right triangles) shape track line at intervals of 4 degrees longitude was settled in south strata and a zigzag track line at intervals of 15 degrees longitude or IDCR/SOWER style was settled in north strata. In order to obtain biological samples representing whole population in the research area, random sampling method under the line transect sighting survey was adopted. Two or three sighting/sampling vessels (SSVs) conducted sighting and sampling survey on the predetermined track-line with parallel sub-track lines. A dedicated sighting vessel (SV) was introduced from 1991/92 season and the SSVs followed the SV with distance over 12n.miles to avoid influence of sampling activity on sighting survey. One or two Antarctic minke whale(s) was sampled randomly from each primary sighted school within 3n.miles of the track line of each SSV. Individuals to be sampled in a school was chosen by a researcher on board using a series of tables of random sampling numbers (TRS), which were prepared in accordance with the size of the schools. A maximum of 330 Antarctic minke whales (300 with 10% allowance) was taken from the Area IV or V in every other season respectively. A maximum of 110 samples (100 with 10% allowance) were added for Areas IIIE or VIW since the 1995/96 season. Detailed biological survey was conducted to all the whales sampled on the research base ship. Some experiments in regard to sampling method were conducted to improve methodology of sighting /sampling survey. In parallel with lethal sampling survey, a variety of non-lethal surveys, e.g. oceanographic survey, photo identification and biopsy sampling for large baleen whales and prey survey, were conducted. Summary of research procedure and results in each cruise was also described.

1. Background

The Japanese Whale Research Program under Special Permit in the Antarctic (JARPA) has been conducted every year since 1987/88 season. In compliance with Article VIII of the International Convention for the Regulation of Whaling, JARPA was authorized by the Government of Japan and planned and conducted by the Institute of Cetacean Research (ICR). After two seasons of feasibility research in 1987/88 and 1988/89, the full-scale research started in 1989/90 season. The program was designed to repeat surveys in the Antarctic Areas IV and V alternatively in each of sixteen years of the research period. From the 1995/96 season, the survey area expanded into a part of Areas III and VI to improve the stock structure study (Government of Japan, 1989, 1995). The objectives of the research were as follows; 1) estimation of biological parameters of Antarctic minke whale *Balaenoptera*

bonaerensis stock, 2) elucidation of the role of whales in the Antarctic ecosystem, 3) elucidation of the effect of environmental changes on cetaceans, and 4) elucidation of the stock structure of the Antarctic minke whales to improve the stock management (Government of Japan, 1987ab, 1996).

In order to achieve these objectives, it was necessary to obtain unbiased biological samples representing whole population in the research area. Therefore, JARPA was characterized by combination of sighting and sampling survey. This paper reviews the survey procedure of JARPA with special reference to methodology of sighting and sampling.

2. General methodology

JARPA has been conducted under the consistent research methods during survey period. Table 1 shows an outline of all JARPA cruises from 1987/88 to 2003/04 season.

2.1. Research area and season

Main research area of JARPA was the Antarctic Area IV (70E - 130E) and Area V (130E - 170W) south of 60S. Except for the feasibility researches, the entire area of the each Area has been surveyed every other year. The research season was focused on the Antarctic summer season. Although the whole research period ranged from the end of November to the middle of March, the regular research in the Areas IV and V was concentrated on January and February, i.e. peak migration season of Antarctic minke whales in the Antarctic Ocean (see Appendix 1).

2.2 Stratification of the area

According to results of the two feasibility researches, which suggested different density of distribution and segregation by sex and maturity of Antarctic minke whales by regions, main research area in the full scale research was divided into small strata (Fig 1). Area IV was divided into two sectors, east and west, by 100E. They were further divided into two strata, a south stratum extending from the ice edge to a locus 45n.miles north, and a north stratum extending from the northern boundary of the south stratum to the northern boundary of the Area IV. The southern boundary of the West-south stratum between 70E and 80E was fixed at 66S and Prydz Bay stratum was defined as the southern area of this boundary. Area V was divided into the east and west sectors by 165E. The west sector was further divided into north and south strata in the same manner of the Area IV. The southern boundary of the East-north stratum was fixed at 69S and the East-south stratum (Ross Sea) was defined as southern area of this boundary. In some research seasons, northern boundary of the research area was expanded to the latitudinal line between 55S and 58S based on ice condition or research strategy (see section 4). A Special Monitoring Zone (SMZ) was established from 1992/93 to 1994/95 season to investigate seasonal variation of whale density (see section 2.3, 3.2 and 4). Except for such additional modifications, principal stratification manner in the Areas IV and V has been kept during all JARPA surveys.

2.3 Design of track lines

JARPA kept the design of research track line in each stratum of the Areas IV and V with a little modification. Fig. 2 shows the typical track line in each stratum of the Areas IV and V. It was designed to cover the whole research area in the same manner during all JARPA surveys. Followings are concepts of the track line design. Track lines of the feasibility researches are described in section 3.1.

1) South strata in the Area IV and the South-west stratum in the Area V

A saw tooth (right triangles) shape track line was settled at intervals of four degrees longitude. Southern waypoints (turning points) were set on the ice-edge and northern waypoints (northern boundary) were set on 45n.miles north of them. The latitude of starting point was randomly set at the starting longitudinal line of each south stratum.

2) North strata in the Areas IV and V

A zigzag track line was settled at intervals of 15 degrees longitude or IDCR/SOWER style (length of track line was determined by allocated days and expected searching distance per day).

Southern waypoints were set on the locus from the 45n.miles from ice-edge or northern boundary of the South strata. The latitude of starting point was randomly set at the starting longitudinal line of each north stratum.

3) Prydz Bay in the Area IV

The Prydz Bay was divided into the north and south zones, in which a latitudinal track-line was set respectively. These two track lines were diagonally connected and formed a z-shaped or an hourglass-shaped line.

4) South-east stratum in the Area V (Ross Sea)

Two longitudinal zigzag track lines adopted for the IDCR/SOWER were established. Length of the line was determined based on allocated research days and expected searching distance per day.

5) SMZ (see sections 3.2 and 4)

The track lines in the SMZ in the first two seasons were established in the same manner in the Areas IV and V. A zigzag track line of the IDCR/SOWER style was set without stratification in the third season.

6) Areas IIIE and VIW

In principle, a lap of eastward and westward zigzag track lines was set in the research area. However, the design of the track line was modified in some research seasons because of a research strategy (see section 4 and figs. 12 - 20).

2.4 Sighting survey

JARPA also kept its unique sighting and sampling method during all surveys. In order to obtain biological samples representing whole population in the research area, random sampling method under the line transect sighting survey was adopted.

Two or three sighting/sampling vessels (SSVs) conducted sighting and sampling survey on the predetermined parallel track lines 7n.miles apart (distance between parallel lines was changed by seasons, see section 4) at a standard speed of 11.5 knots.

The survey was operated under optimal research conditions (when the wind speed was below 25 knot in the south strata or 20 knot in the north strata and visibility was over 2n.miles), which ensured accuracy of sighting survey.

Sightings of whales were classified into primary and secondary sightings. The primary sightings were those seen in normal searching mode (three observers searched from the top barrel of the vessel on the predetermined track-line). The secondary sightings were those seen in out of normal searching mode (e.g. during confirming or chasing whales, no observer in the top barrel or the vessel engages in other work) or off the research time. In principle, the sighting survey by SSVs was conducted under the limited closing mode (NSC mode: when a sighting of suspected Antarctic minke whale was made on the predetermined track line, the vessel approached it and species and school size were confirmed).

A dedicated sighting vessel (SV) was introduced from 1991/92 season (see section 4). One of the three SSVs was allocated as the SV from 1991/92 to 1994/95 season. An additional SV was introduced from 1995/96 season. The sighting survey by the SV was conducted under the limited closing mode (ASP mode; same manner as NSC without sampling of whales) and the passing mode (NSP mode; even if sighting was made on the predetermined track line, the vessel did not approach the whale directly and searching from the top barrel was uninterrupted). The SSVs followed the SV with distance over 12n.miles to avoid influence of sampling activity on sighting survey (fig.3).

In addition to the sightings of Antarctic minke whales or whales suspected to be Antarctic minke whales, the SV approached large baleen whales such as blue whale *Balaenoptera musculus*, right whale *Eubalaena glacialis* and humpback whale *Megaptera novaeangliae* for conducting some experiments (see section 2.7). The SSVs also occasionally approached these whales for conducting some experiments.

A researcher on board recorded all the sightings of whales. The sighting record includes date and time of the sighting, position of the vessel, classification of the survey mode and the sightings

(primary or secondary), angle and distance from the vessel, species and school size, estimated body length, and etc.

2.5 Sampling method

Sampling scheme was described by Kato *et al*. (1989) in detail. One or two Antarctic minke whale(s) was sampled randomly from each primary sighted school within 3n.miles of the track line by the SSV. Individuals to be sampled in a school was chosen by the researcher on board using a series of tables of random sampling numbers (TRS), which were prepared in accordance with the size of the schools.

When the primary sighting of the Antarctic minke whales was occurred, the SSV approached to the school of whales within 0.2n.miles. Observers on the top barrel counted a number of whales and estimated body length of each animal. If a sighting was solitary whale, it was sampled immediately after the body length estimation. If a school was consisted of two or more animals, the researcher assigned a serial number to each individual, ranging from left to right. The first target whale was chosen using the TRS specific to the school size. When two whales should be sampled from a school, the second target was selected by the same manner after the first animal was sampled. In this case, the remaining individuals were renumbered according to the latest position in the school and TRS was used for the original school size minus 1. Although JARPA was originally planed to take samples from all primary sighted minke whales with a maximum of two whales from each school, it was reduced two to one since 1992/93 season in order to attach greater importance to the representative of the samples (Fujise *et al*., 1993b).

A maximum of 330 Antarctic minke whales (300 with 10% allowance) was taken from the Area IV or V in every other season respectively. A maximum of 110 samples (100 with 10% allowance) were added for Areas IIIE and VIW since the 1995/96 season. Sampling of dwarf form minke whales was ceased from 1993/94 season because the result of genetic study revealed that two types of southern hemisphere minke whales were different each other (Government of Japan, 1993).

2.6 Biological survey

Detailed biological survey was conducted to all the whales sampled on the research base ship. Table 2 summarizes data and samples collected. These data and samples were analyzed for the objectives of JARPA and some were used for collaborative studies in various fields such as histology, physiology, embryology, pharmacology, pathology and reproductive physiology.

2.7 Non-lethal survey

Besides the biological survey, JARPA conducted a variety of non-lethal survey. These surveys especially contributed to study on large baleen whales, prey species and oceanography.

2.7.1 Photo-identification and biopsy sampling

The following species were targeted for photographic record of natural markings by SV, blue, humpback and right whales. In addition to the species targeted for photo-identification, Fin whales *Balaenoptera physalus* were also targeted for biopsy sampling. Cross bows and air guns developed by ICR (Kasamatsu *et al*, 1991) were used for it. These surveys were also conducted by the SSVs occasionally.

2.7.2 Prey species and oceanographic survey

SV conducted the following surveys; 1) hydro-acoustic survey using a passive acoustic system (EK500 38kHz, 120kHz, 200kHz, SIMRAD, Norway) to elucidate distribution and abundance of prey species of Antarctic whales (since 1998/99 season), 2) consecutive measuring of surface water temperature, conductivity, surface chlorophyll, dissolved oxygen and surface particle by Electric Particle Counting and Sizing System (EPCS, since 1999/2000 season), 3) XBT, XCTD and CTD survey and 4) marine debris recording in the research area. All marine debris found in the stomach of Antarctic minke whales was recorded and collected on the research base ship.

2.7.3 Others

Following experiments were conducted in several seasons; observation of behavior of blue, fin and beaked whales, air and sea water sampling for environmental monitoring, satellite tagging for baleen whales, acoustic monitoring for large baleen whales, and etc. Some of these were conducted under test stage.

2.8 Pre-determined distance a day.

The pre-determined distance per day is a task on daily movement on the research track line. It was applied to JARPA from 1989/90 season in order to make the survey smooth. The SSVs had to make night steaming to the start point of next day, when they did not achieved pre-determined distance during the daytime (so-called "skip"). The "skip" was caused by shortage of searching distance in a day due to bad weather condition and/or sampling activity in the high-density area of whales. It was concerned that the "skip" might cause biased population estimate because SSV tended to skip over high-density area of whales after sampling activity of a day (IWC, 1998). However, this "skip" decreased because the survey in the Areas IV and V was conducted once in the peak migration season of Antarctic minke whales from 1992/93 season (see section 3.2). Since the SSVs were able to allocate longer days in the regular research area than before, the distance of night steaming was determined in each occasion considering the length of un-researched track line and research schedule. Therefore the "skip" in recent seasons occur mainly by shortage of research days allocated to a certain area due to prolonged bad weather condition rather than sampling activity in a day. An effect of the "skip" and adjustment on the population estimate is considered in a separated paper (Hakamada *et al*., 2005).

3. Experiments to improve methodology of the survey

In the JARPA cruises, some experiments were conducted to improve methodology of sighting /sampling survey. These experiments were in regard to (1) construction of track lines, (2) seasonal and spatial coverage, (3) research on neighboring area, and (4) sampling method.

3.1 Construction of track lines (feasibility researches; 1987/88 – 88/89 season)

In the two feasibility researches, the cruise track line was drawn as longitudinal line in the northern part of research area and drawn like a trace of a billiard ball reflection in the southern part (Figs. 4 and 5). However, in the following full-scale surveys, this 'reflection' method (Kato *et al*. 1989) was changed to zigzag line in a stratified stratum (see sections 2.2 and 2.3) to elucidate the segregation of Antarctic minke whales in relation to their migration pattern and biological parameters (Government of Japan, 1989).

3.2 Seasonal and spatial coverage

Some experimental research areas were set in the Areas IV and V during the JARPA cruises. These additional areas were principally surveyed before and /or after the regular survey of the Areas IV and V so that the regular survey in the Antarctic summer season (the peak migration period of Antarctic minke whales) was not disturbed. Appendix 1 shows research period in each stratum by the season.

3.2.1. Twice cover of the entire Area (1989/90 – 1991/92)

From 1989/90 to 1991/92, the Areas IV and V were covered twice at different times to analyze the changes of population density of whales by season and area (Government of Japan, 1989, 1990a, 1990b and 1991). Thus, it was found that the peak migration season of Antarctic minke whales corresponded to the later half of the first period and the first half of the second period of the survey covered (see Appendix 1).

3.2.2. Special monitoring zone (SMZ; 1992/93 - 1994/95)

The SMZ was established to investigate seasonal change of distribution of Antarctic minke whales. It was set in a part of the Areas IV and V and surveyed in each before and after the regular survey. Therefore, the SMZ was surveyed three times practically (Fujise *et al*. 1993b, Government of Japan, 1993). The regular surveys in the entire Area s IV and V were conducted in the peak migration season of Antarctic minke whales.

3.3 Feasibility research on neighboring area (Areas IIIE and VIW; 1995/96 - 2004/05)

Since 1995/96 season, the survey area was expanded into eastern part of Area III (Area IIIE; 35E - 70E) and western part of the Area VI (Area VIE; 170W - 145W) to improve the stock structure study. The original objective of the expansion to the Areas IIIE and VIW was a feasibility research on stock identification to examine the hypothesis of the occurrence of more than one stock in the Areas IV and V (Government of Japan, 1995, 1996).

3.4 Sampling method

3.4.1 Experiment to monitor whale reaction to the vessel

This experiment was conducted in order to assess the effects on sighting survey by chasing activity of the SSV (did the sampling activity disturb other whales ahead?). One SSV surveyed in usual manner while the other two vessels (observer vessels) drifted at a distance of 10n.miles ahead of the SSV and 6n.miles apart from each other. The observer vessels observed reaction of schools of Antarctic minke whales around them while the SSV conducted normal sighting survey, chasing and harpooning (simulated harpooning was done in several experiments). The experiment was conducted from 1990/91 to 1992/93 and 1995/96 seasons. A total of 16 sets of trial was conducted and 69 schools of Antarctic minke whales were observed. In summary, no obvious whale reaction to sampling activity was observed except for one case that a school showed negative movement when the SSV approached 1.5n.miles from them (Government of Japan, 1990b, Kasamatsu *et al*, 1993., Fujise *et al*., 1993a, 1993b, Nishiwaki *et al*., 1996).

3.4.2 Feasibility research of modification of sampling method (S-experiment)

During the 49th IWC Scientific Committee meeting, modification of the sighting and sampling method of JARPA was proposed (Schweder, 1998). Japan decided to conduct a limited scale feasibility research on whether the modified method was workable or not (Government of Japan, 1999). The feasibility research (S-experiment) was conducted in the East-south stratum in the Area IV (1999/2000 season) and the West-south stratum in the Area V (2000/01 season). During the S-experiment period, all SSVs stayed at the point where the survey of the day was finished until next day. Different from the ordinal research manner, they never moved forward without sampling survey even if it was bad weather condition. Target for sample was selected according to the predetermined interval for each school size. One or two individuals were collected from the targeted school (Ishikawa *et al.* 2000, Nishiwaki *et al*, 2001). The S-experiment was ceased in following seasons because there were several problems in practice.

4. Outline of the research cruises

Table 1 summarizes outline of JARPA. Followings are summary of research procedure and results in each season. Details are described in each cruise report of JARPA (see References).

4.1. 1987/88 season (Feasibility research in Area IV, fig. 4)

The first feasibility research was conducted between 105E and 115E in the Area IV. The research area was divided into two strata; a southern stratum (from the pack ice edge to 60S) and a northern stratum (from 55S to 60S). The distance between parallel track lines of two SSVs was 6n.miles. Research period was 70 days from 17 January to 26 March 1988. Total searching effort of two SSVs was 8,482n.miles and the primary sightings of Antarctic minke whale were 226 schools / 654 individuals. A total of 273 whales (including one dwarf minke whale) was sampled (Kato *et al.* 1989).

4.2. 1988/89 season (Feasibility study in Area V, fig. 5)

The second feasibility research was conducted between 168E and 180E south of 52S of the Area V. The research area was stratified to latitudinal three strata; north (52S - 60S), middle (60S - 69S) and south zone (69S - ice edge). As the sampling rate of the second targeted whale in a school of two or more was relatively low in the previous research, an additional SSV was introduced from this season. The three SSVs were grouped into two vessels (pair) and one vessel (single), which were allocated each of two parallel track lines. The research period was 79 days from 12 January to 31 March 1989.

Total searching effort of three SSVs was 9,614.2n.miles and the primary sightings of Antarctic minke whale were 340 schools / 743 individuals. A total of 241 whales (including five dwarf minke whales) was sampled (Kato *et al.* 1990).

4.3. 1989/90 season (Area IV, fig. 6)

After the two feasibility researches, the full-scale research started since 1989/90 season. The entire Area IV was divided into five strata (see section 2.2) and northern area between 55S and 60S was also surveyed twice using longitudinal track line on the way to and from the Area IV. Northern boundary of the West-north stratum in the first period was shifted from 60S to 58S because of extended ice edge. Each stratum was surveyed twice. The distance between parallel three track lines was 9 n. miles apart each other. The research period was 96 days from 6 December 1989 to 12 March 1990. Total searching effort of three SSVs was 17,094.4 n. miles and the primary sightings of Antarctic minke whale were 767 schools / 1,978 individuals. A total of 330 whales (including three dwarf minke whales) was sampled (Fujise *et al.*, 1990).

4.4. 1990/91 season (Area V, fig. 7)

The entire Area V was divided into four strata (see section 2.2) and northern area between 55S and 60S was also surveyed using longitudinal track line on the way to and from the Area V. Each stratum was surveyed twice. Track line design for IDCR/ SOWER was adapted in the South-west stratum. The research period was 94 days from 19 December 1990 to 22 March 1991. Total searching effort of three SSVs was 14,759.9n.miles and the primary sightings of Antarctic minke whale were 750 schools/ 1,725 individuals. A total of 327 whales (including four dwarf minke whales) was sampled (Kasamatsu *et al.*, 1993).

4.5. 1991/92 season (Area IV, fig. 8)

The northern area between 55S and 60S was surveyed using longitudinal track line on the way to and from the Area IV. Northern boundary of the West-north stratum in the first period was shifted from 60S to 58S because of extended ice edge. Each stratum was surveyed twice. One of the three SSVs (a SSV on the main course) was allocated as the SV in south strata and the Prydz Bay to improve the research effort. The research period was 112 days from 5 December 1991 to 25 March 1992. Total searching effort of SV and SSVs was 18,204.5n.miles and the primary sightings of Antarctic minke whale were 616 schools / 2,061 individuals. No Antarctic minke whale was sighted in the East-north stratum in the second period. A total of 288 whales was sampled (Fujise *et al.*, 1993a).

4.6. 1992/93 season (Area V, fig. 9)

The SMZ survey started. It was set in the Area V between 130E and 155E south of 60S and stratified to the north and south strata in the same way as the regular research area. The research period was 112 days from 3 December 1992 to 23 March 1993. The first SMZ survey was conducted from 3 to 25 December 1992 and the second survey was conducted from 10 to 24 March 1993 after the regular research of the Area V (30 December 1992 -6 March 1993). Sampling method was changed to taking one whale from a school in order to achieve better representation of the whale population. One of the three SSVs (a SSV on the main course) was allocated as the SV in all the research areas to improve the research effort. Total searching effort of SV and SSVs was 13,492.3n.miles and the primary sightings of Antarctic minke whale were 933 schools / 3,049 individuals. A total of 330 whales (including three dwarf minke whales) was sampled (Fujise *et al.*, 1993b).

4.7. 1993/94 season (Area IV, fig. 10)

The SMZ in this season was set in the Area IV between 110E and 130E south of 60S and stratified to north and south strata in the same way as the regular research area. The research period was 107 days from 3 December 1993 to 19 March 1994. The first SMZ survey was conducted from 3 to 19 December 1993 and the second survey was conducted from 5 to 19 March 1994 after the regular research of the Area IV (21 December 1993 -3 March 1994). One of the three SSVs was allocated as the SV in all the research area. The SV surveyed main course and followed by two SSVs on the main course and a parallel sub-course 12n.miles south. Total searching effort of SV and SSVs was 17,930n.miles and the primary sightings of Antarctic minke whale were 688 schools / 1,619

individuals. A total of 330 whales was sampled. Dwarf minke whales were not targeted for sample from this season (Nishiwaki *et al.* 1994).

4.8. 1994/95 season (Area V, fig. 11)

The SMZ was set in the Area V between 165E and 170W south of 60S and it was not stratified. The research period was 109 days from 3 December 1994 to 21 March 1995. The first SMZ survey was conducted from 3 to 17 December 1994 and the second survey was conducted from 13 to 18 February and from 15 to 21 March 1995. The regular research of the Area V was conducted from 18 December 1994 to 14 March 1995. One of the three SSVs was allocated as the SV in all the research area. Total searching effort of SV and SSVs was 14,038.6n.miles and the primary sightings of Antarctic minke whale were 823 schools / 2,453 individuals. A total of 330 whales was sampled (Nishiwaki *et al.* 1995).

4.9. 1995/96 season (Area IV and eastern part of the Area III, fig. 12)

The first feasibility research in the Area IIIE (35E–70E, south of 60S) was conducted. A maximum of 110 samples (100 with 10% allowance) was allocated for the Area IIIE. The research period was 118 days from 26 November 1995 to 22 March 1996. Area IIIE was surveyed twice before (26 November - 22 December 1995) and after (5 - 22 March 1996) the regular survey of the Area IV (22 December 1995 - 1 March 1996). A new dedicated SV was introduced. The SV surveyed main course and the three SSVs followed on the parallel three research track lines each other (fig. 3). The distance between parallel track lines was changed to 7n.miles. Total searching effort of the SV and three SSVs was 21,455.5n.miles and the primary sightings of Antarctic minke whale were 893 schools / 2,021 individuals. A total of 440 whales was sampled (Nishiwaki *et al.* 1996).

4.10. 1996/97 season (Area V and western part of the Area VI, fig. 13)

The first feasibility research in the Area VIW (170W–145W) was conducted. A maximum of 110 samples (100 with 10% allowance) was allocated for the Area VIW. The research period was 103 days from 30 November 1996 to 13 March 1997. Area VIW was surveyed twice before (30 November 1996 - 4 January 1997) and after (12 - 13 March 1997) the regular survey of the Area V (4 January- 12 March 1997). Total searching effort of the SV and three SSVs was 17,755.6n.miles and the primary sightings of Antarctic minke whale were 852 schools / 2,608 individuals. A total of 440 whales was sampled (Nishiwaki *et al.* 1997).

4.11. 1997/98 season (Area IV and Area IIIE, fig.14)

The research period was 99 days from 7 December 1997 to 14 March 1998. Area IIIE was surveyed twice before (7 - 31 December 1997) and after (5 - 14 March 1998) the regular survey of the Area IV (31 December 1997 - 9 March 1998). Total searching effort of the SV and three SSVs was 21,598.4n.miles and the primary sightings of Antarctic minke whale were 672 schools / 1,373 individuals. A total of 438 whales was sampled. The results of this season were characterized by low density of Antarctic minke whales in the south strata and low proportion of pregnant females among whales collected in the south strata and the Prydz Bay in the Area IV (Ishikawa *et al.* 1998, Ishikawa, 2003).

4.12. 1998/99 season (Area V and Area VIW, fig. 15)

The SV equipped scientific echo sounder for a hydro acoustic prey survey. The research procedure in this season had to be changed because a fire broke out in the research base ship (NM) on the way to the Antarctic. The NM should be repaired and the research fleet started the survey nearly two months later than usual. The sighting survey started from 13 January 1999 and sighting/sampling survey started from 24 January 1999 in the East-north stratum in the Area V. The research period was 103 days and the area VIW was surveyed from 17 to 31 March 1999 after the survey of the Area V (13 January- 16 March 1999). Total searching effort of the SV and three SSVs was 5193.6n.miles and the primary sightings of Antarctic minke whale were 826 schools / 2,665 individuals. A total of 389 whales was sampled (Nishiwaki *et al.*, 1999).

4.13. 1999/2000 season (Area IV and Area IIIE, fig. 16)

Northern boundary of the Area IIIE was expanded to 58S to increase the number of samples apart from the ice edge in the early period of feeding season of Antarctic minke whales. The research period was 96 days from 5 December 1999 to 10 March 2000. The Area IIIE was surveyed from 5 to 26 December 1999 before the regular survey of the Area IV (27 December 1999 - 10 March 2000). Total searching effort of the SV and three SSVs was 16,341.5n.miles and the primary sightings of Antarctic minke whale were 1,507 schools / 6,581 individuals. A total of 439 whales was sampled (Ishikawa *et al.*, 2000).

4.14. 2000/01 season (Area V and Area VIW, fig. 17)

The research period was 100 days from 11 December 2000 to 20 March 2001. The Area VIW was surveyed from 11 December 2000 to 1 January 2001 before the regular survey of the Area V (1 January- 20 March 2001). Total searching effort of the SV and three SSVs was 26,425.7n.miles and the primary sightings of Antarctic minke whale were 1,881 schools / 4,903 individuals. A total of 440 whales was sampled (Nishiwaki *et al.*, 2001).

4.15. 2001/02 season (Area IV and Area IIIE, fig. 18)

Northern boundary of the Area IIIE was expanded to 58S to increase the number of samples apart from the ice edge in the early period of feeding season of Antarctic minke whales. In order to improve sighting survey and hydro acoustic survey, the SV allocated 4 hours for the closing mode (ASP) and 8 hours for the passing mode (NSP) a day from this season. Area IIIE was surveyed twice before (29 November - 25 December 2001) and after (28 February – 8 March 2002) the regular survey of the Area IV (25 December 2001 – 27 February 2002). The research period was 101 days from 29 November 2001 to 8 March 2002). Total searching effort of the SV and the three SSVs was 14,394.4n.miles and the primary sightings of Antarctic minke whale were 1,867 schools / 4,374 individuals. A total of 440 whales was sampled (Ishikawa *et al.*, 2002).

4.16. 2002/03 season (Area V and Area VIW, fig. 19)

Track line design for IDCR/ SOWER was adapted in the South-west stratum in the Area V. The research period was 95 days from 2 December 2002 to 8 March 2003. The Area VIW was surveyed from 3 December 2002 to 1 January 2003 before the regular survey of the Area V (5 January - 8 March 2003). Total searching effort of the SV and three SSVs was 18,126.2n.miles and the primary sightings of Antarctic minke whale were 2,461 schools / 6,583 individuals. A total of 440 whales was sampled (Nishiwaki *et al.*, 2003).

4.17. 2003/04 season (Area IV and Area IIIE, fig. 20)

Area IIIE was surveyed from 30 November to 23 December 2003 before the survey of the Area IV (26 December 2003 – 3 March 2004). The research period was 95 days from 30 November 2003 to 3 March 2004). Total searching effort of the SV and the three SSVs was 19,287.4n.miles and the primary sightings of Antarctic minke whale were 1,092 schools / 3,256 individuals. Meanwhile a total sighting number of humpback whales was 1,690 schools / 3,134 individuals and was overwhelmed those of Antarctic minke whales in the Area IV. A total of 440 whales was sampled (Ishikawa *et al.*, 2004).

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Table 1. Outline of the JARPA. △: a part of the Area IV or V was surveyed. Entire Area x2: the Area IV or V was surveyed twice. SMZ: special monitoring zone was surveyed before and after the entire area survey. Expanded area: the Area IIIE or VIW survey was added to the regular survey. NM: research base ship, SSV: sighting and sampling vessel, SV: sighting vessel.

No	Season	Experiment	RESEARCH AREA				Research period (days)	Research vessel			Sample number (dwarf minke whale)				
			IIIE	IV	V	VIW		NM	SSV	SV	IIIE	IV	V	VIW	Total
1	1987/88	Feasibility		△			1988.1.17 – 1988.3.26 (70)	1	2			273			273 (1)
2	1988/89	Feasibility			△		1989.1.12 – 1989.3.31 (79)	1	3				241		241 (5)
3	1989/90	Entire Area x2		○			1989.12.6 – 1990.3.12 (97)	1	3			330			330 (3)
4	1990/91	Entire Area x2			○		1990.12.19 – 1991.3.22 (94)	1	3				327		327 (4)
5	1991/92	Entire Area x2		○			1991.12.5 – 1992.3.25 (112)	1	2	1		288			288
6	1992/93	SMZ			○		1992.12.3 – 1993.3.25 (113)	1	2	1			330		330 (3)
7	1993/94	SMZ		○			1993.12.3 – 1994.3.19 (107)	1	2	1		330			330
8	1994/95	SMZ			○		1994.12.3 – 1995.3.22 (110)	1	2	1			330		330
9	1995/96	Expanded area	○	○			1995.11.26 – 1996.3.22 (118)	1	3	1	110	330			440
10	1996/97	Expanded area			○	○	1996.11.30 – 1997.3.13 (103)	1	3	1			330	110	440
11	1997/98	Expanded area	○	○			1997.12.7 – 1998.3.14 (98)	1	3	1	110	328			438
12	1998/99	Expanded area			○	○	1999.1.13 – 1999.3.31 (78)	1	3	1			329	60	389
13	1999/2000	Expanded area	○	○			1999.12.5 – 2000.3.10 (97)	1	3	1	109	330			439
14	2000/01	Expanded area			○	○	2000.12.11 – 2001.3.20 (100)	1	3	1			330	110	440
15	2001/02	Expanded area	○	○			2001.11.29 – 2002.3.9 (101)	1	3	1	110	330			440
16	2002/03	Expanded area			○	○	2002.12.2 – 2003.3.8 (96)	1	3	1			330	110	440
17	2003/04	Expanded area	○	○			2003.11.30 – 2004.3.3 (94)	1	3	1	110	330			440

Table 2. Example of data and samples collected by biological survey on the research base ship in JARPA.

DATA	Subject	SAMPLES	Subject
Photographic record of external character	All	Diatom film record and sampling	All
Body length and sex identification	All	Serum sample for physiological study	All
Measurement of external body proportion	All	Earplug and tympanic bone for age determination	All
Body weight	All	Baleen plates for age determination and morphological study	All
Body weight by total weight of parts	1 per day	Vertebral epiphyses sample for physiological study	All
Skull measurement (length and breadth)	All	Ovary	All females
Standard measurement of blubber thickness (five points)	All	Histological sample of endometrium and mammary gland	All females
Detailed measurement of blubber thickness (14 points)	1 per day	Milk sample for chemical analysis	Lactating females
Mammary gland; lactation status and measurement	All females	Histological sample of testis and epididymis	All males
Breadth measurement of uterine horn	All females	Testis and epididymis stamp smear for sperm detection	All males
Testis and epididymis weight	All males	Tissue samples for genetic study	All including fetuses
Weight of stomach content in each compartment	All	Tissues and stomach contents for heavy metal analysis	All
Photographic record of fetus	All fetuses	Tissues and stomach contents for organochlorine analysis	All
Fetal length and weight	All fetuses	Tissues and stomach contents for lipid analysis	1 per day
External measurements of fetus	All fetuses	Stomach contents for food and feeding study	All
Number of ribs	All	External and internal parasites	All
Craniometric study	2 per season	Fetus in early stage	All
Gross pathological observation	All	Sk]eleton for educational exhibition	Occationally

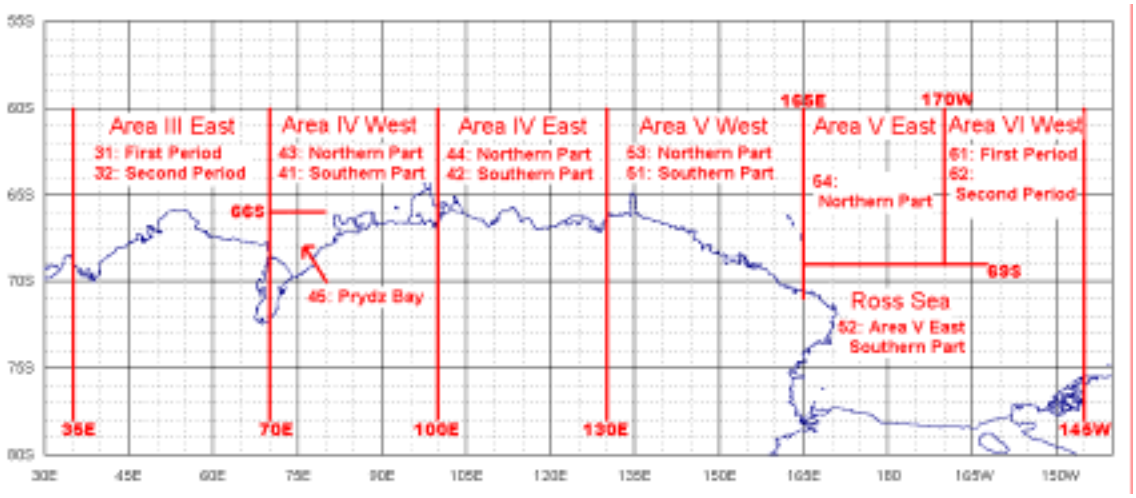


Fig.1. Research area of JARPA (Area IIIE, Area IV, Area V and Area VIW) showing small strata.

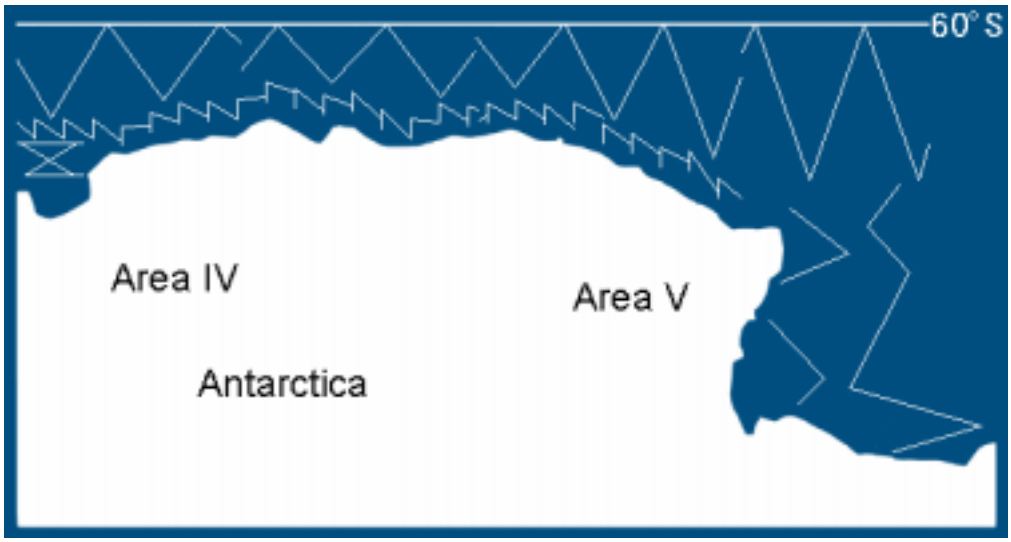


Fig.2. Concept of the design of research track lines in JARPA.

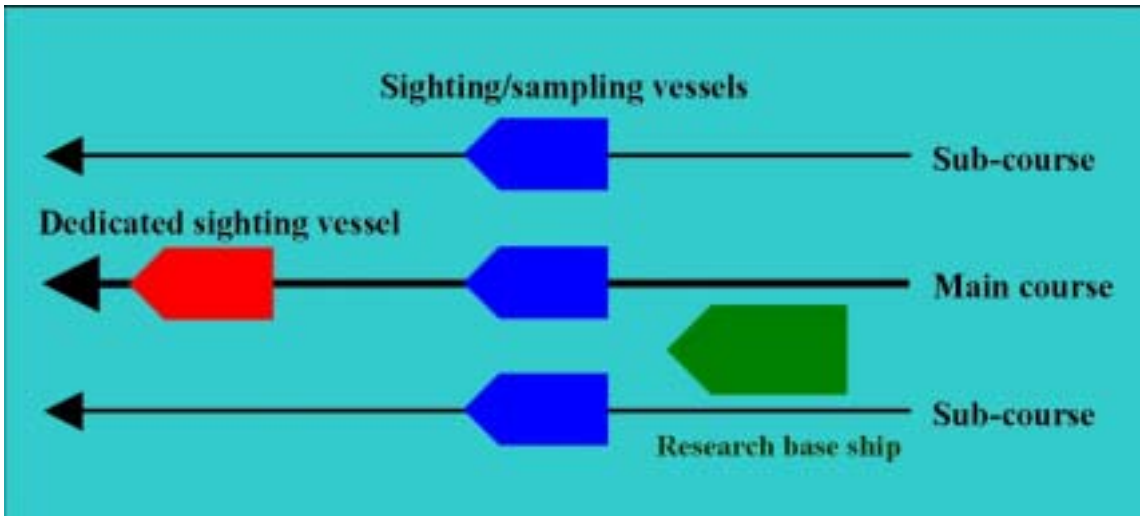


Fig3. Allocation of the SV and the three SSVs. The research base ship follows SV and SSVs not to affect sighting and sampling survey.

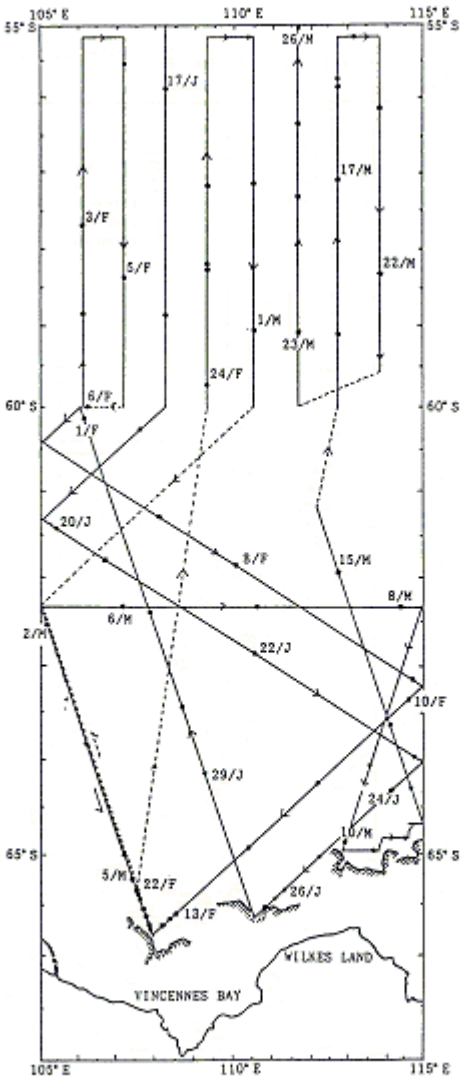


Fig.4. Research track line in the 1987/88 feasibility research in the part of Area IV (Kato *et al.* 1989).

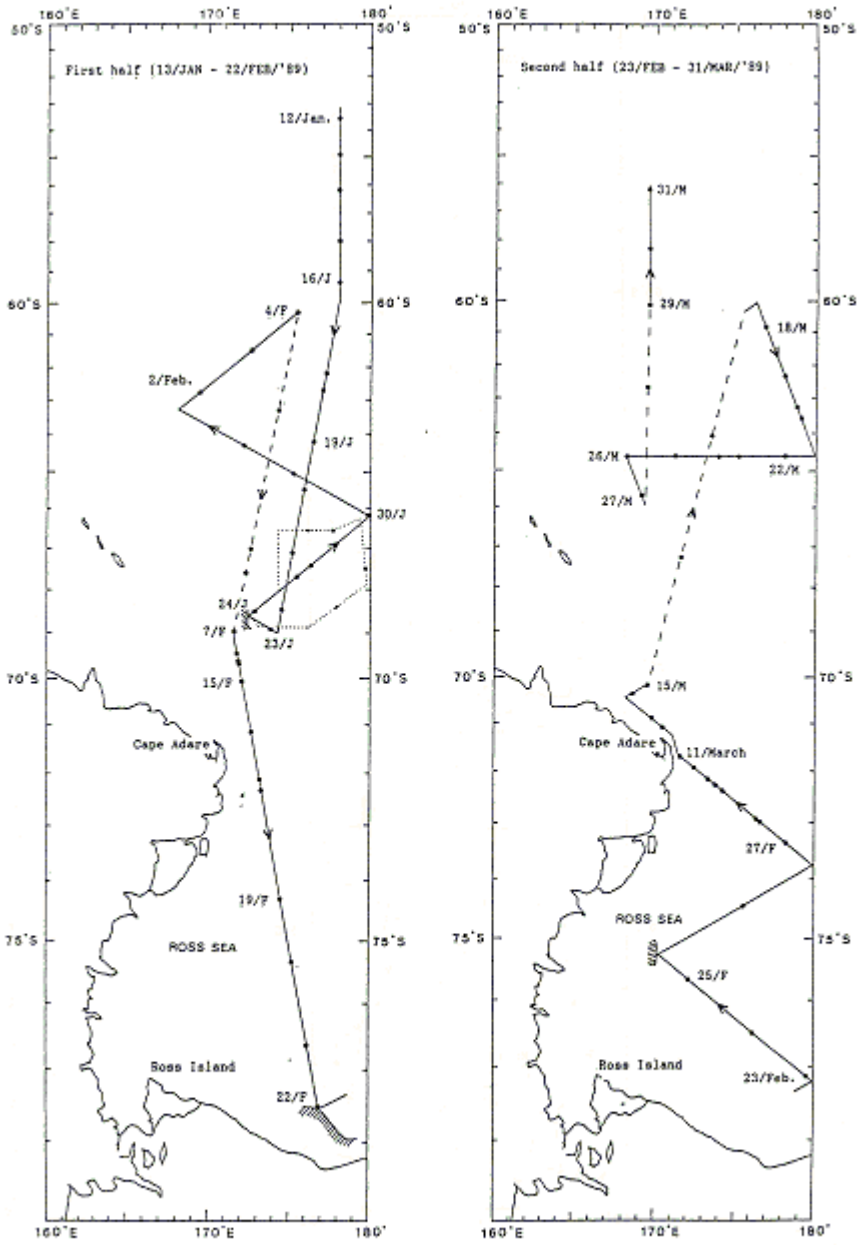


Fig.5. Research track line in the 1988/89 feasibility research in the part of Area V (Kato *et al.* 1990).

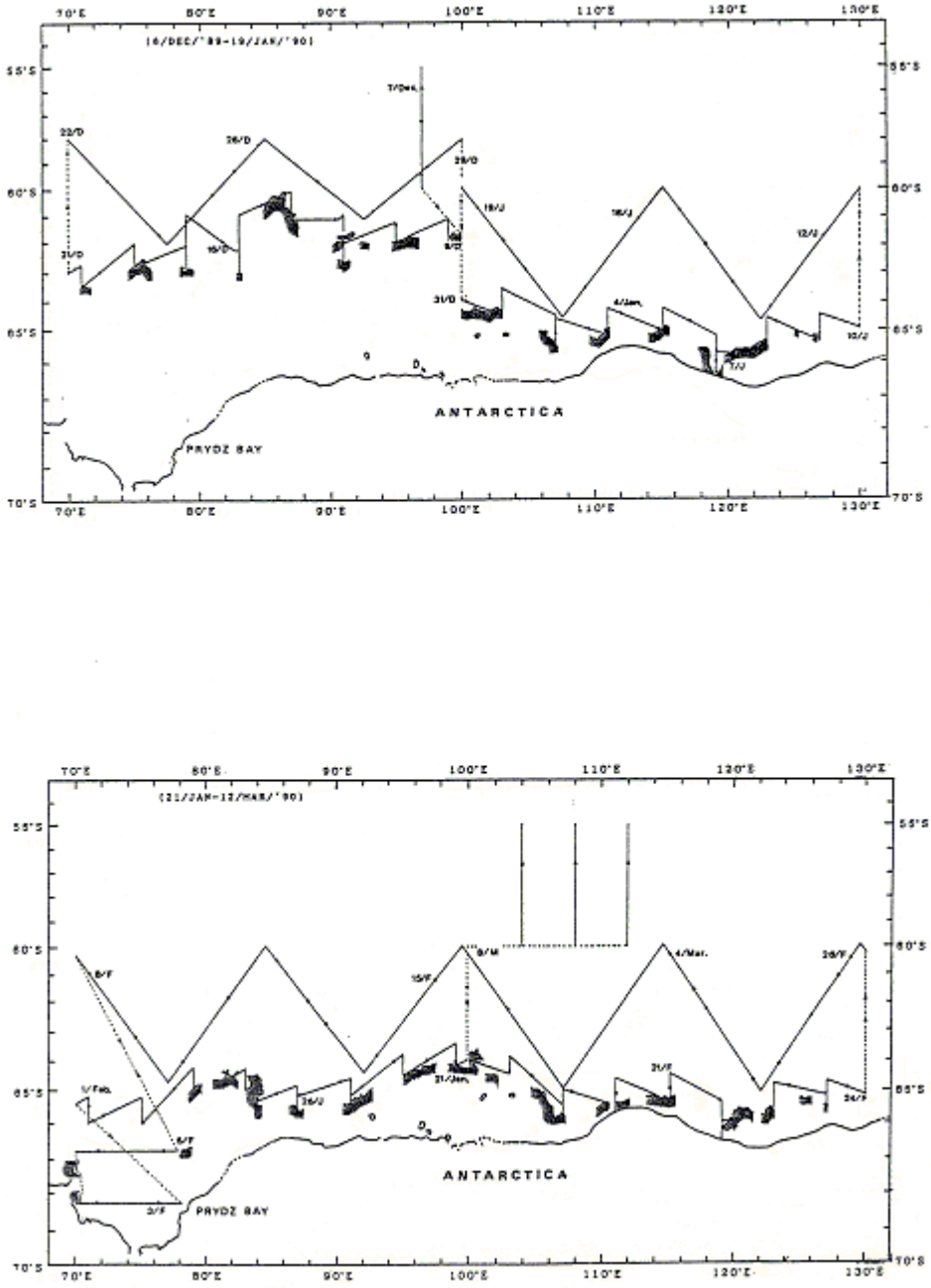


Fig.6. Research track line in the 1989/90 season in the Area IV. Upper represents the first period and lower represents the second period (Fujise *et al.* 1990).

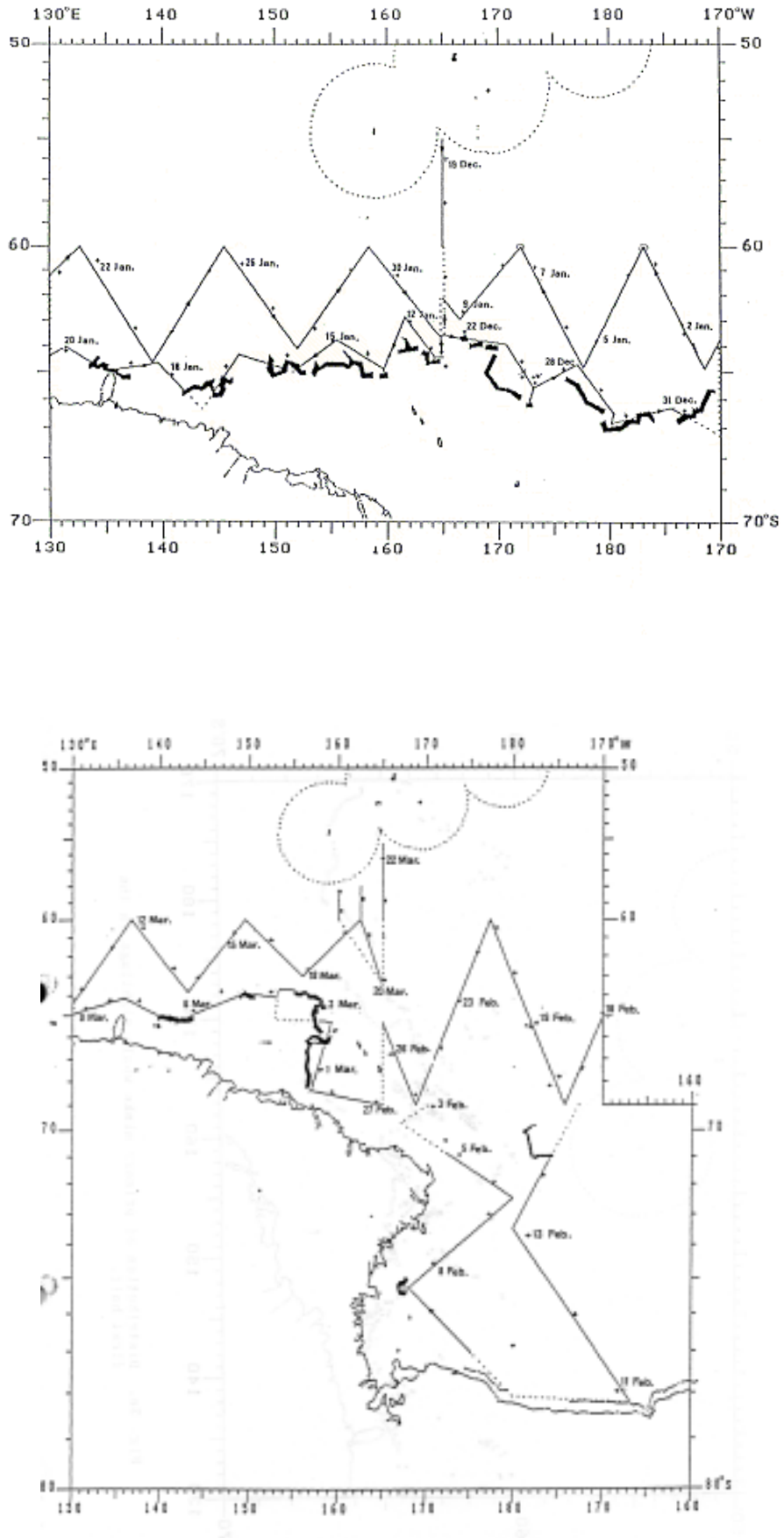


Fig.7. Research track line in the 1990/91 season in the entire Area V. Upper represents the first period and lower represents the second period (Kasamatsu *et al.* 1993)

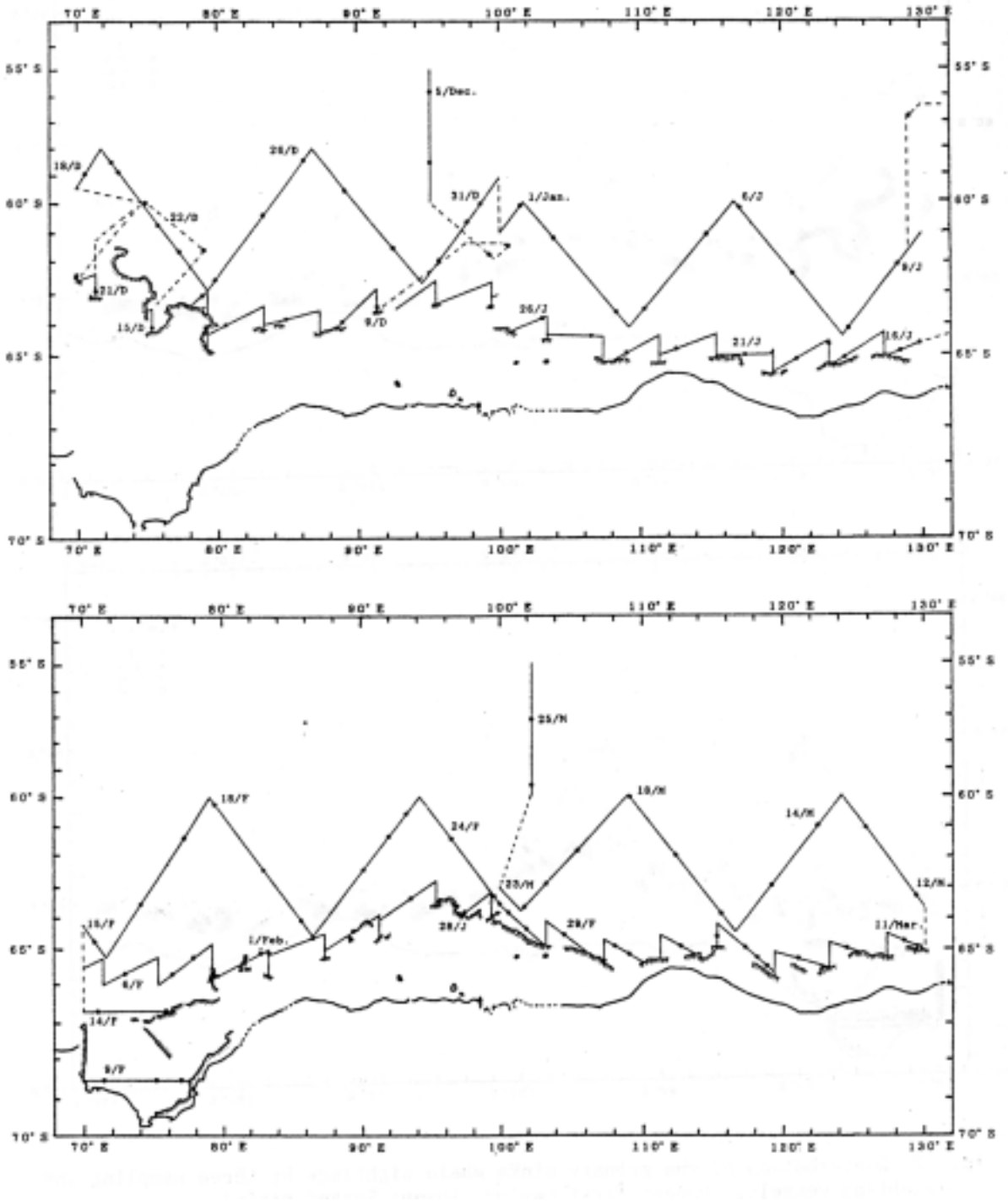


Fig.8. Research track line in the 1991/92 season in the entire Area IV. Upper represents the first period and lower represents the second period (Fujise *et al.* 1993a)

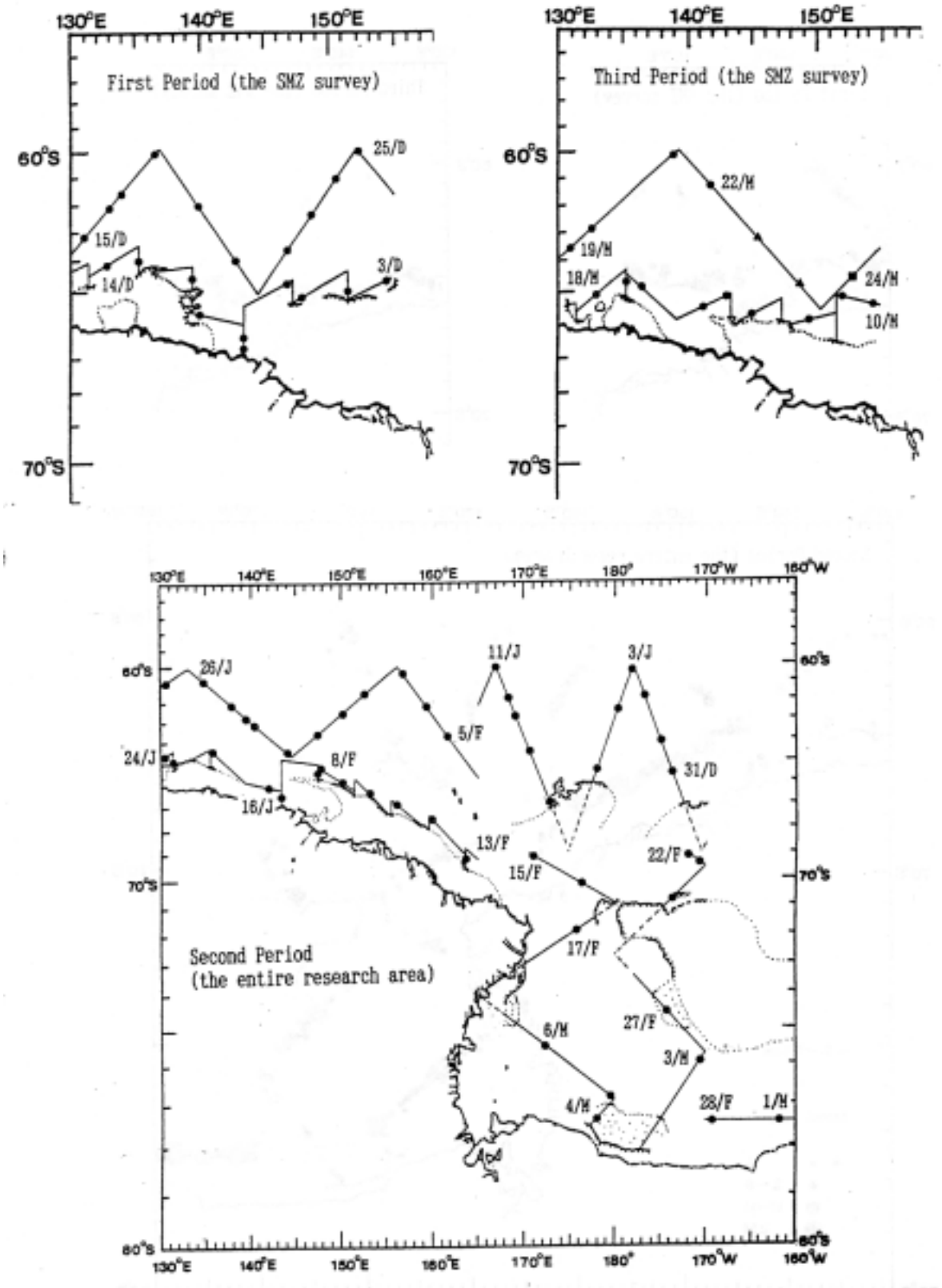


Fig.9. Research track line in the 1992/93 season in the entire Area V with SMZ. Upper figures represent the SMZ survey conducted before (left) and after (right) the regular survey of the entire research area (Fujise *et al.* 1993b).

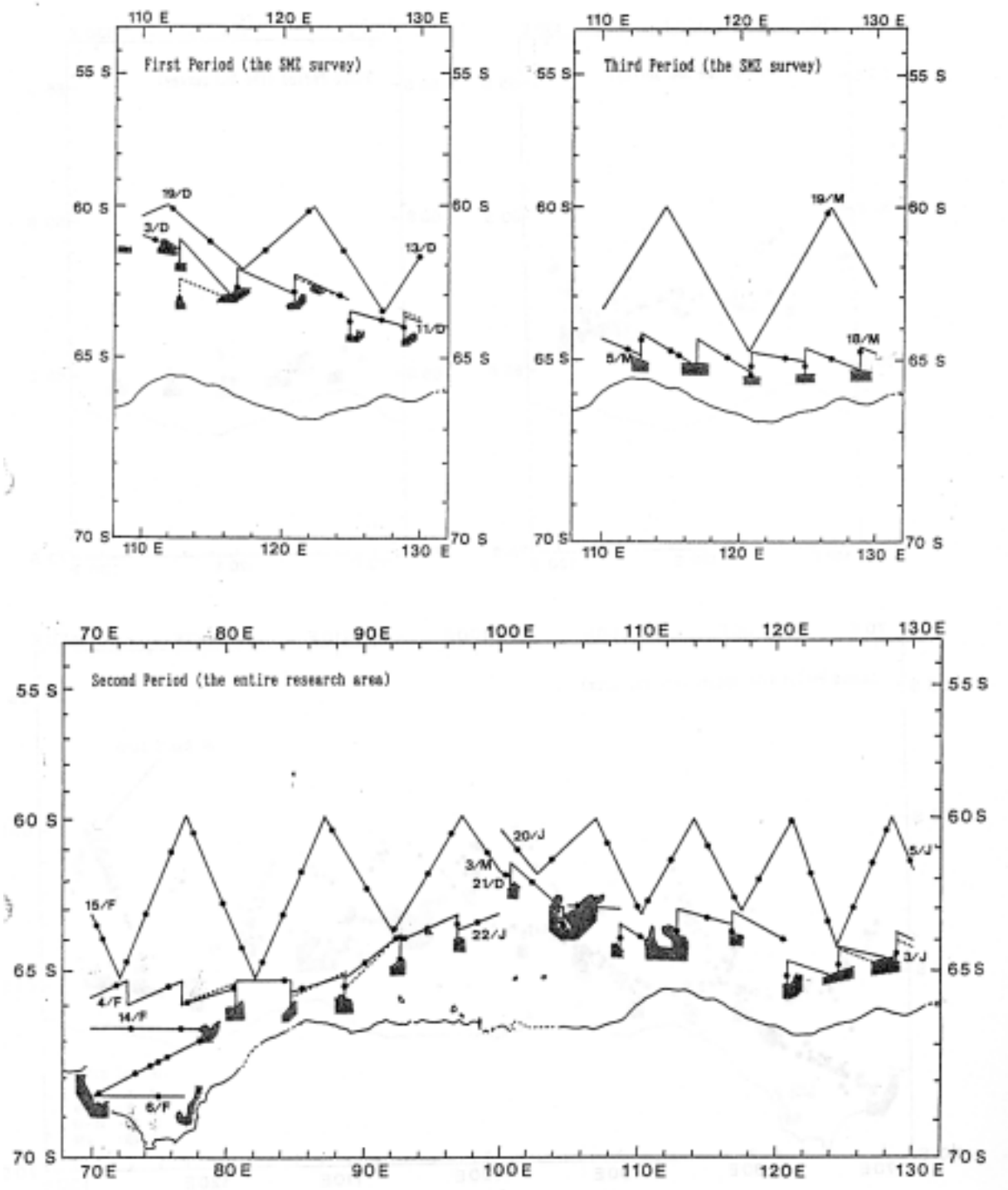


Fig.10. Research track line in the 1993/94 season in the entire Area IV with SMZ. Upper figures represent the SMZ survey conducted before (left) and after (right) the regular survey of the entire research area (Nishiwaki *et al.* 1994).

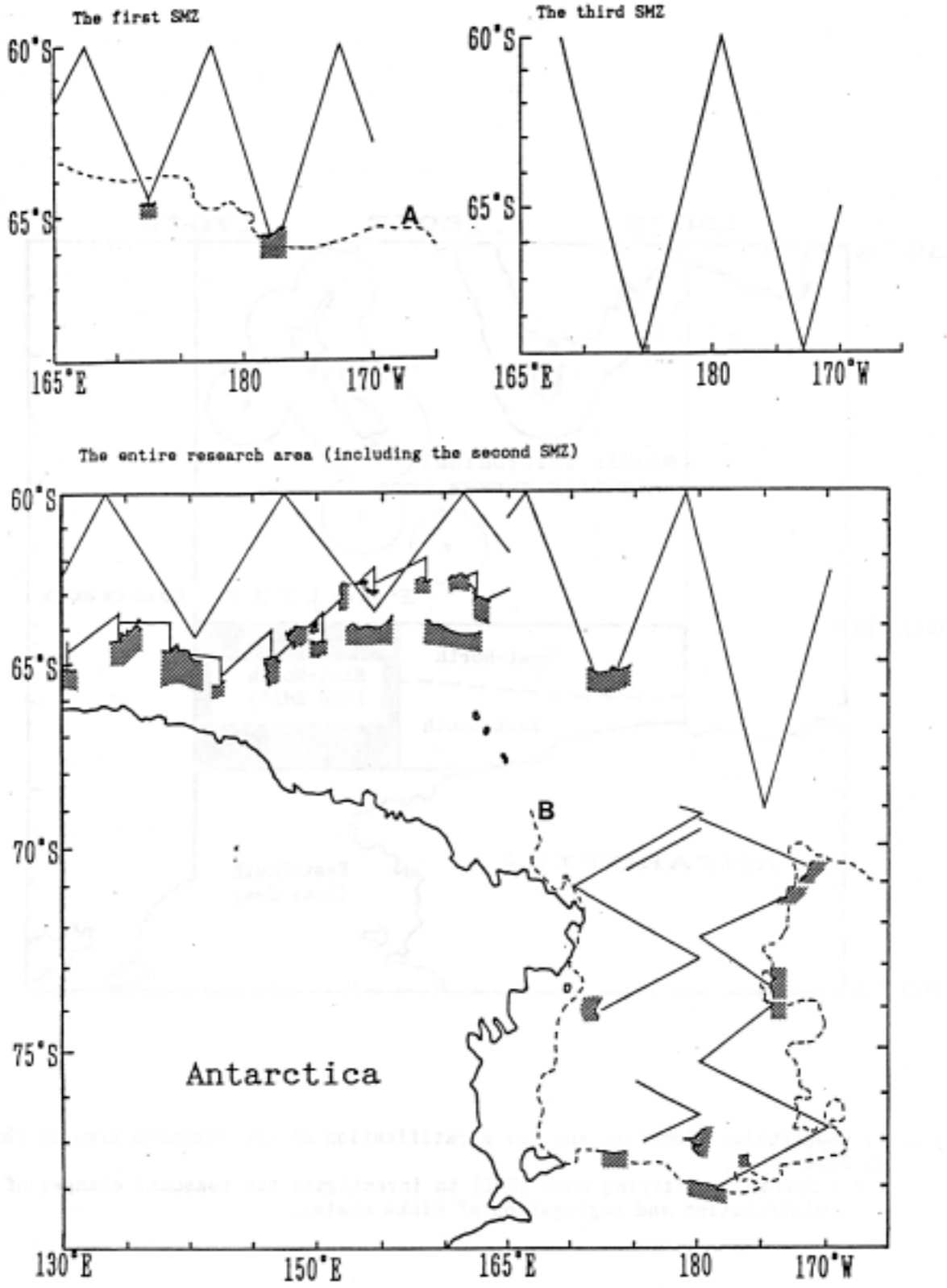


Fig.11. Research track line in the 1994/95 season in the entire Area V with SMZ. Upper figures represent the SMZ survey conducted before (left) and after (right) the regular survey of the entire research area (Nishiwaki *et al.* 1995).

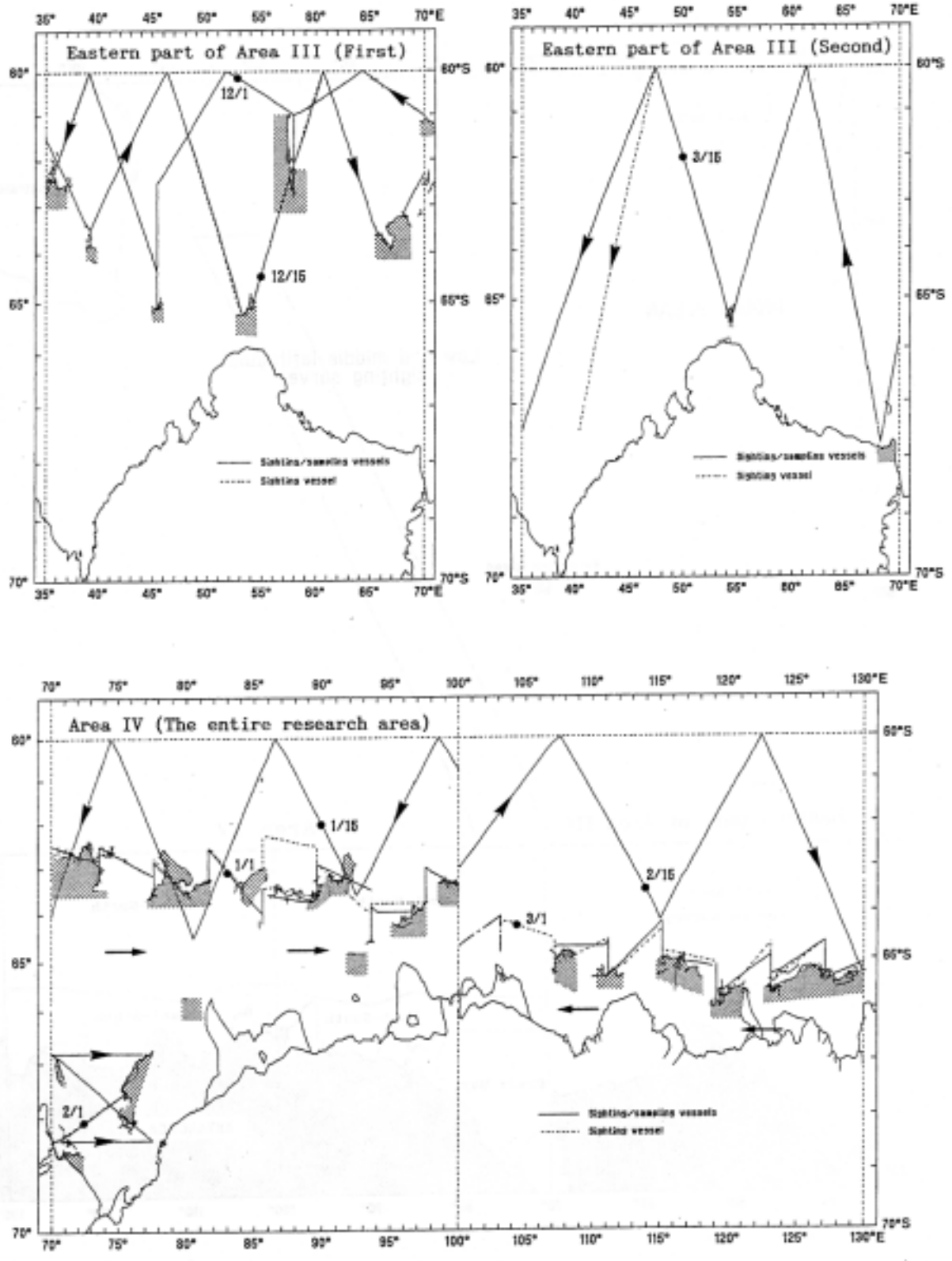


Fig.12. Research track line in the 1995/96 season in the Area IIIE and Area IV. Upper figures represent the Area IIIE survey conducted before (left) and after (right) the Area IV survey (Nishiwaki *et al.* 1996).

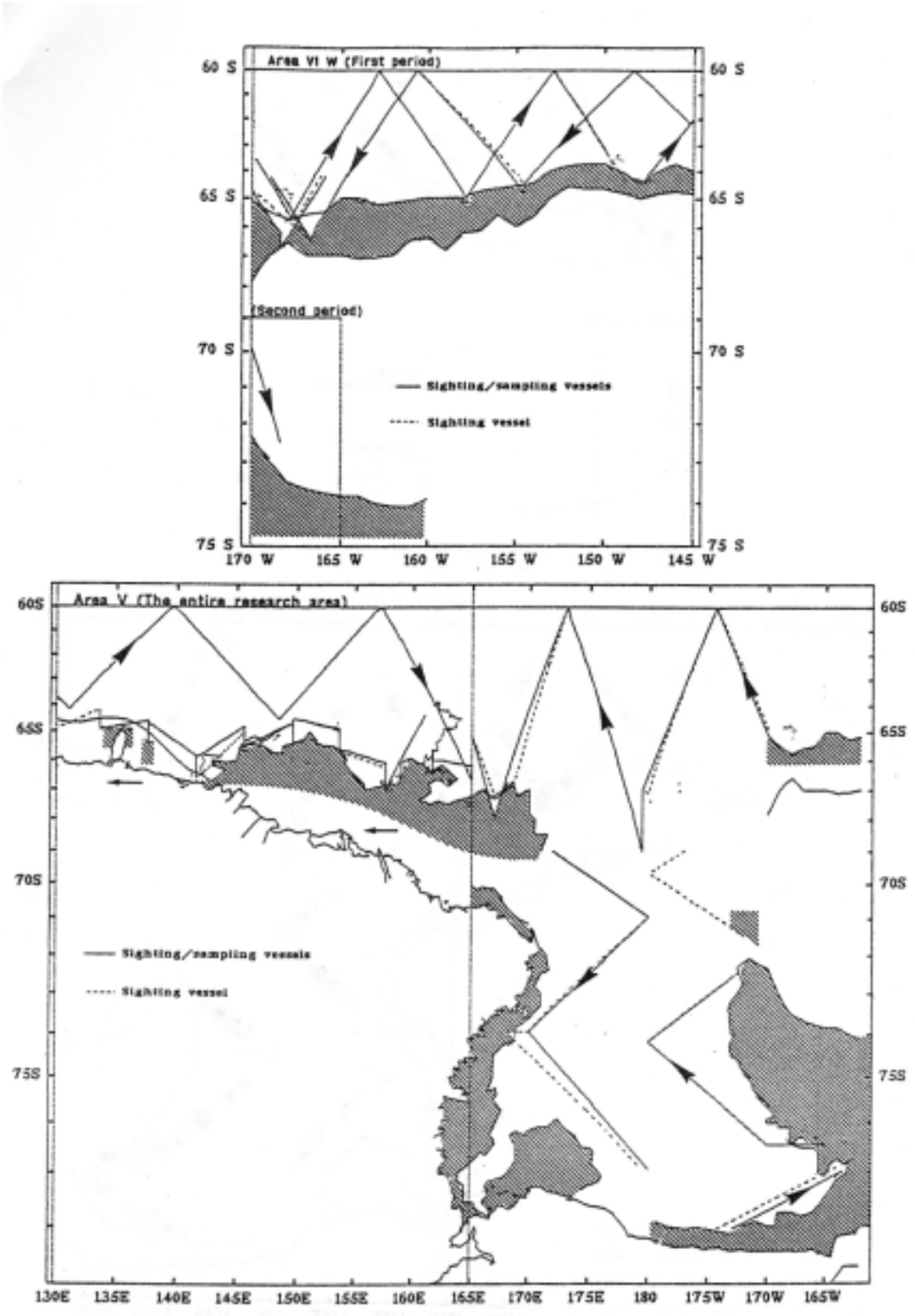


Fig.13. Research track line in the 1996/97 season in the Area VIW and Area V. Upper figure represents the Area VIW survey conducted before and after the Area V survey (Nishiwaki *et al.* 1997).

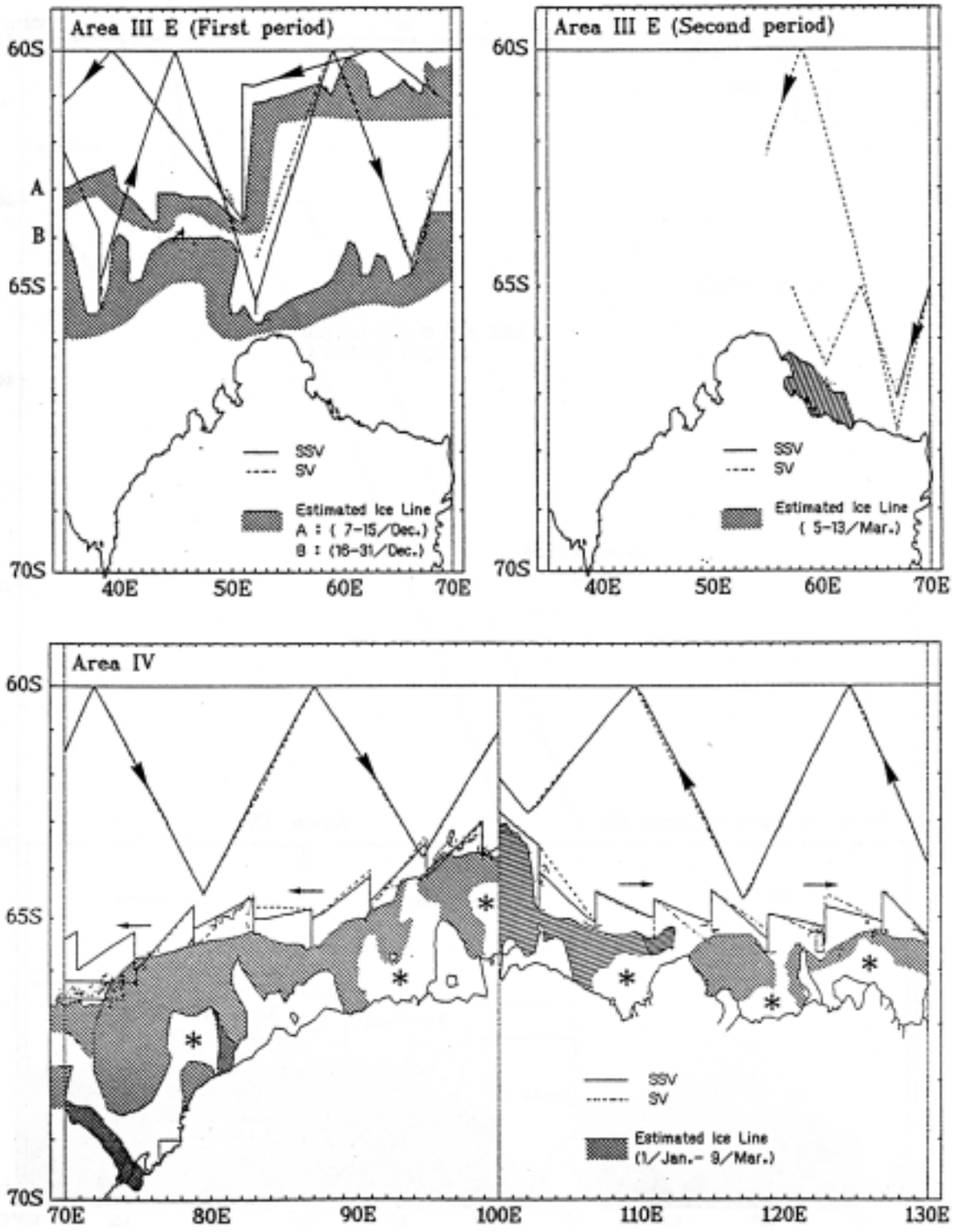


Fig.14. Research track line in the 1997/98 season in the Area IIIE and Area IV. Upper figures represent the Area IIIE survey conducted before (left) and after (right) the Area IV survey (Ishikawa *et al.* 1998)

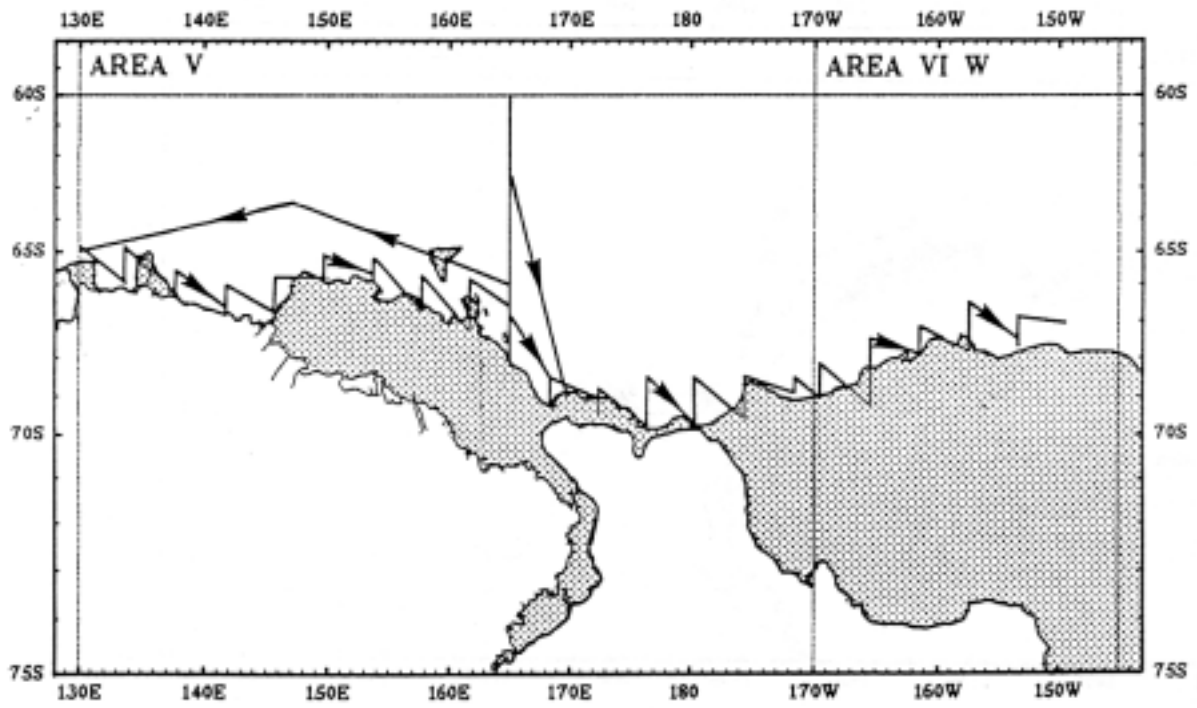


Fig.15. Research track line (SSVs) in the 1998/99 season in the Area VIW and Area V (Nishiwaki *et al.* 1999)

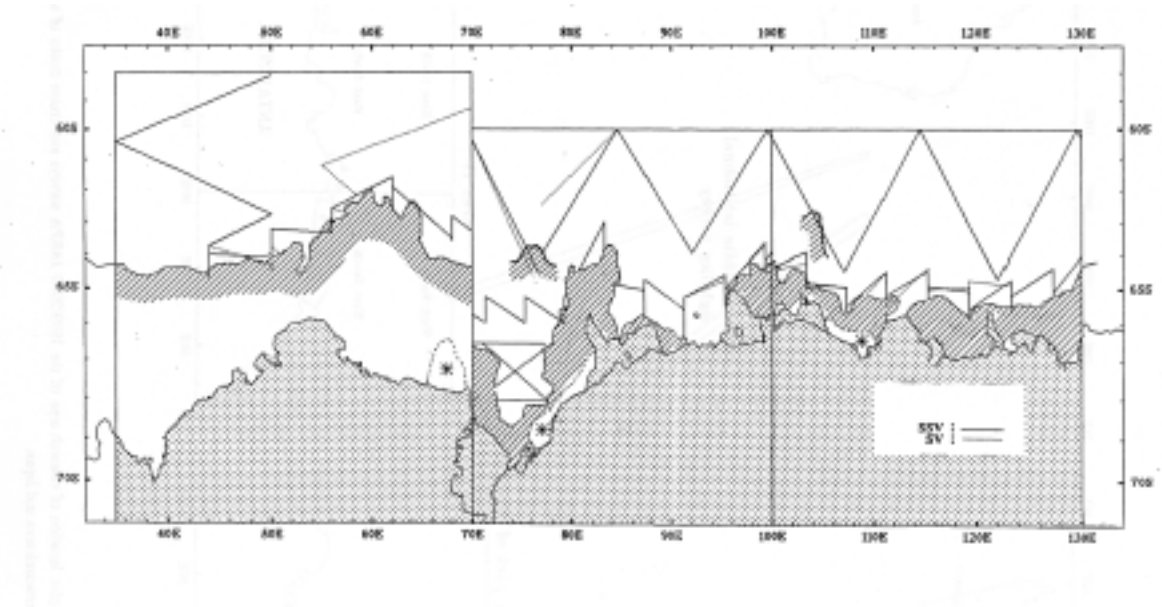


Fig.16. Research track line in the 1999/2000 season in the Area IIIE and Area IV (Ishikwa *et al.* 2000)

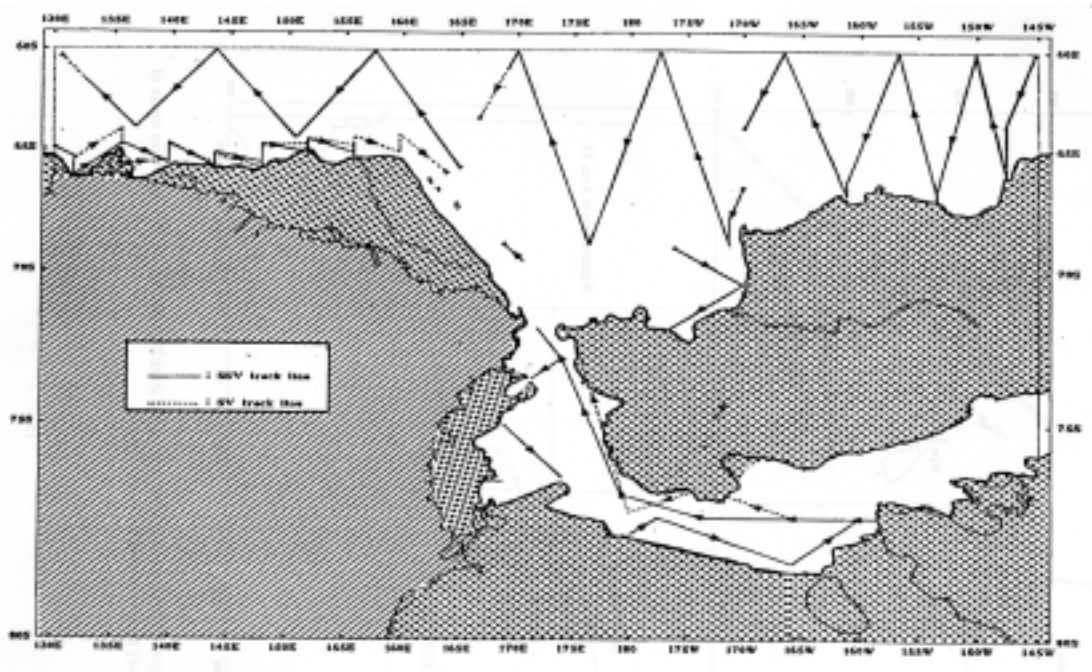


Fig.17. Research track line in the 2000/01 season in the Area VIW and Area V (Nishiwaki *et al.* 2001)

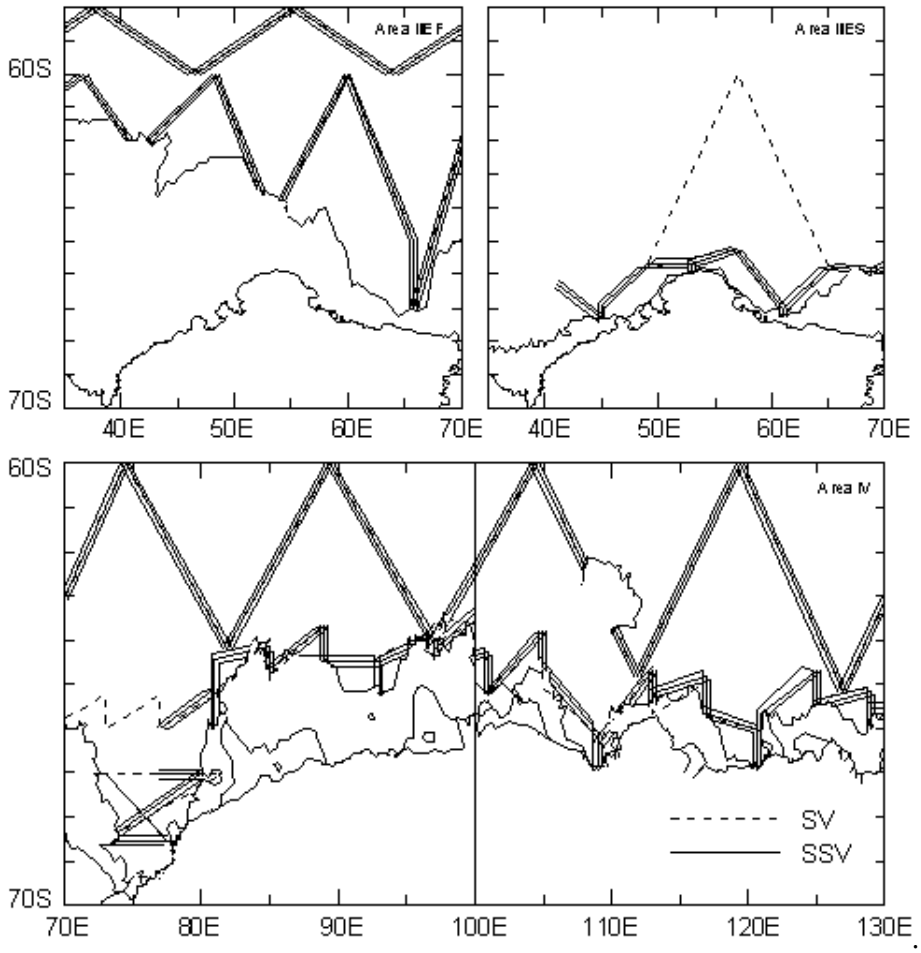


Fig.18. Research track line in the 2001/02 season in the Area IIIE and Area IV. Upper figures represent the Area IIIE survey conducted before (left) and after (right) the Area IV survey (Ishikawa *et al.* 2002).

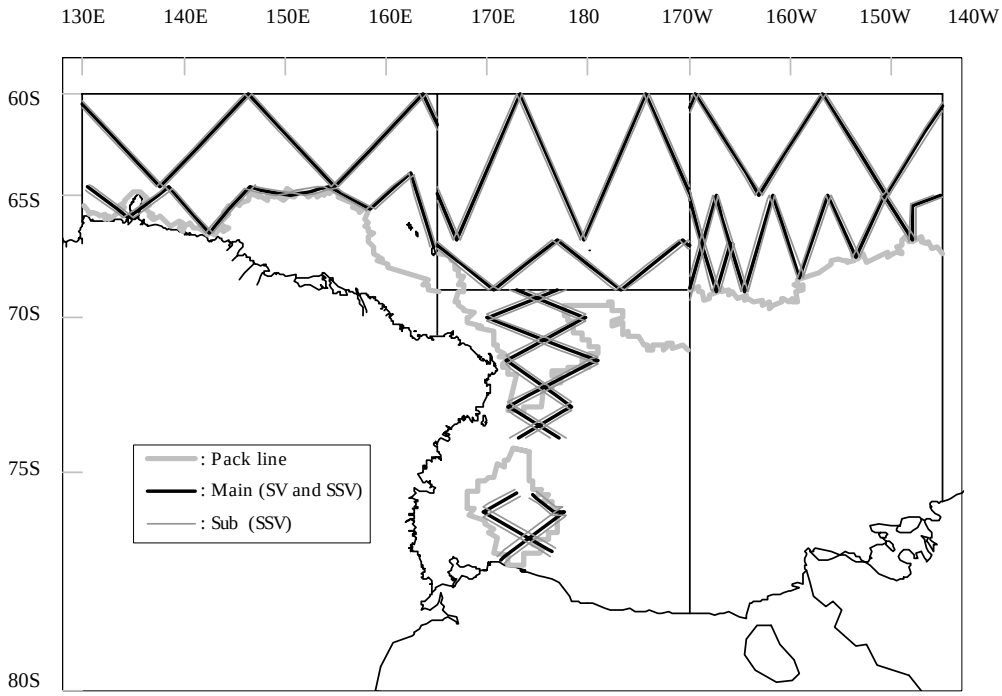


Fig.19. Research track line in the 2002/03 season in the Area VIW and Area V (Nishiwaki *et al.* 2003).

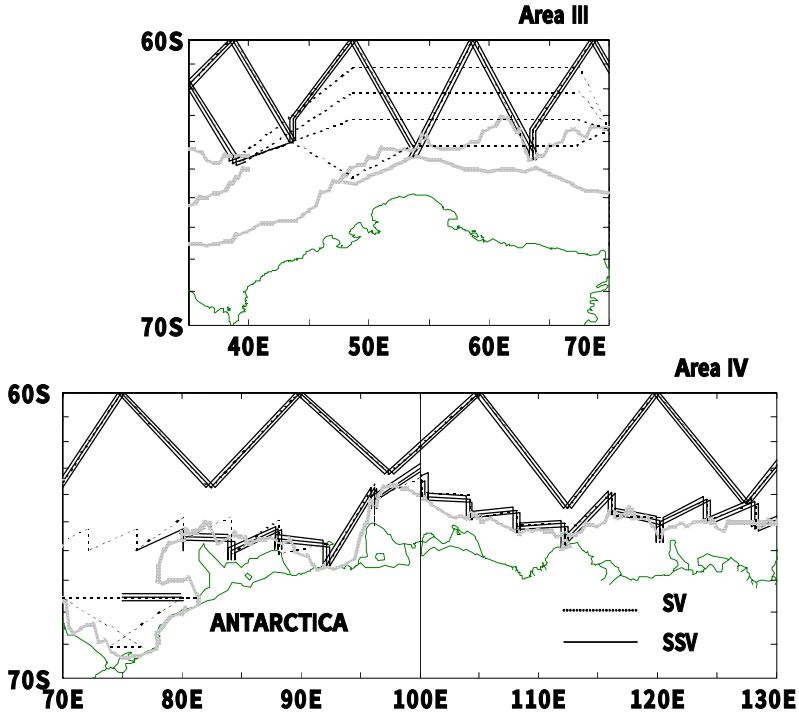
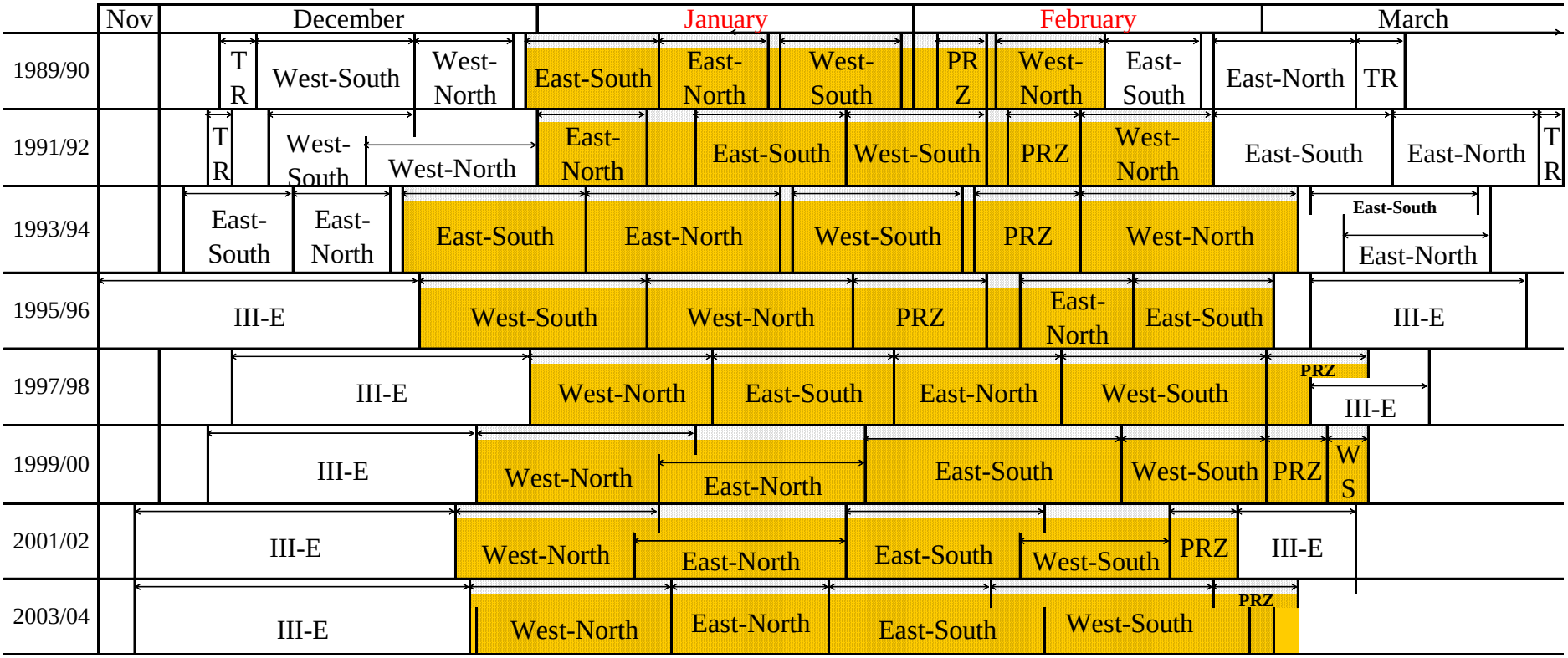


Fig.20. Research track line in the 2003/04 season in the Area IIIE and Area IV (Ishikawa *et al.* 2004).

Appendix 1a. Research period of each stratum by the research season in the Area IV and the Area IIIE. Shaded area represents research in the entire Area IV in the peak migration period of Antarctic minke whales. TR; research on transit line, PRZ; Prydz Bay.



Appendix 1b. Research period of each stratum by the research season in the Area V and the Area VIE. Shaded area represents research in the entire Area V in the peak migration period of Antarctic minke whales. WN; West-North stratum, WS; West-South stratum.