

Cruise Report of the Japanese Whale Research Program under
a Special Permit for North Pacific Minke Whales in 1994

Yoshihiro Fujise*, Toshiya Kishiro**, Ryoko Zenitani*,
Koji Matsuoka, Masahiro Kawasaki* and Kunikazu Shimamoto*

*: The Institute of Cetacean Research, 4-18, Toyomi-cho, Chuo-ku, Tokyo 104, Japan,

** : National Research Institute of Far Seas Fisheries, 5-7-1, Orido, Shimizu, Shizuoka 424, Japan.

ABSTRACT

A feasibility study of the Japanese whale research program under special permit in North Pacific (JARPN) was conducted for 65 days from 5 July to 7 September, 1994, in a part of sub-area 9 using one research base and two sighting/sampling vessels.

Twenty one minke whales were sampled from 42 schools (43 animals) sighted. Tissue samples related to genetics, morphology, biology, pollutant and parasite studies, and data were collected to determine the stock structure of the western North Pacific minke whale. The fleet surveyed a total of 6,980.1 n.miles and made 29 primary (30 animals) and 16 secondary (16 animals) sightings of minke whales. Minke whales were distributed widely in the research area, and high-density area was not observed. A number of schools of larger baleen whales, especially, blue whales were sighted in the cruise (blue :19 animals, fin: 33, sei: 20, hump-back: 20). Biological survey indicates the minke whale consumes various types of pelagic zooplankton and fishes from area to area, such as krill in the northern part of the research area, Pacific saury in the middle latitudinal zone and Japanese anchovy and/or sardine in the southern part.

INTRODUCTION

Comprehensive assessment of North Pacific minke whale stock was made at the 43rd Annual Meeting of the Scientific Committee of the International Whaling Commission (IWC/SC) in 1991, which suggested a current stock estimate of 25,049 animals on the Okhotsk Sea - West Pacific stock (IWC, 1992). Later the Simulation Trial Working Group was established to discuss conditions in trials and other matters (IWC, 1993). However, a hypothesis which assumes presence of more than one stock or sub-stock was proposed in the Working Group on the ground that there are some uncertain elements in the past research results on stock structure. At the 46th IWC/SC, the Government of Japan submitted a "Research Program for Clarification of Minke Whale Stock Struc-

ture in the Northwestern Part of the North Pacific" (SC/46/NP1) (Government of Japan, 1994). The objective of the present research was to verify whether the hypothesis for the presence of stocks or sub-stock under the above-mentioned conditions are valid.

The first Japanese whale research program under special permit in North Pacific (JARPN) was implemented as a feasibility studies for 65 days from 5 July to 7 September, 1994, in a part of sub-area 9 (north of 35°N, 158-170°E) -- an area designated by the IWC -- to take 100 samples of minke whales. The objective of this research was to collect information on minke whale distribution and research environment, such as ocean climate, in order to examine the plausibility of the presence of the West Pacific stock (W-Stock).

This cruise report outlines the contents of research activities.

RESEARCH METHOD

Research fleet

Two sampling vessels, *Toshimaru No.25* (739.92GT) and *Toshimaru No.18* (758.33GT) engaged in sighting survey and collection of whale samples. Further, *Toshimaru No.25* conducted ocean observation by means of XBT. *Nisshinmaru* (7,440GT), the research mothership, took command of the fleet and conducted biological research of whales, manufacturing of by-products and engaged in surveys on marine debris.

Research area

The research area, designated by IWC/SC, was sub-area 9 (See Fig. 1). The southern boundary of the research area was set at 42°N because, according to sighting information obtained by whale search boats and research vessels in the past, most of minke whales in this area were sighted in the area north of 42°N (Kasamatsu and Hata, 1985). Foreign 200-mile zones -- Russia and the US -- were excluded from research area. Further, from 22 August, the southern boundary of the research area was moved to 45°N where isothermal line of water temperature of 15 degrees was located because sighting of whales was confined to the area of water temperature of 15 degrees or lower because of the relations between minke whales and water temperature.

Cruise trackline

Fig. 2 shows the research cruise track. The black dots in the figure represent the noon positions of the mothership. The research course was established as in the following pursuant to the billiard method by means of fixed angle of reflection, adopted in the feasibility research on minke whales in the Antarctic (1987/88 and 1988/89). The starting point of the research was selected randomly from between 157°E and 170°E at 42°N.

The direction at the start of the research was selected randomly from 180° between 270°W and 90°E. The angle of reflection at the boundary was selected randomly between 10 degrees and 90 degrees. As a result, the starting point was set at 42°N and 161°34'E, with the compass direction at the time of start set at

75 degrees and the angle of reflection at 50 degrees. In case two directions (right and left) could be selected at the turning of vessels around the boundary, the compass direction at the turning was decided randomly at each point. On 10-11 August and 6-7 September (i.e. four days), special research was conducted by establishing a separate research track different from normal cruise track in order to secure the number of samples (Fig. 2). As the southern boundary of the research area was moved to 45°N from 22 August, the compass direction was changed to 75 degrees on 28 August when the boundary was reached. Sub-tracks were established at a distance of 6 n.miles on both sides in parallel to the main track established (as stated earlier). Sampling vessels were allocated on the two sub-tracks, and rotated for each research day. However, to engage in joint sampling activities by the two sighting and sampling vessels, the distance between the sub-tracks was changed from 12 n.miles to 6 n.miles on 26 July.

WHALE SIGHTINGS

Sighting method

The whale sighting method similar to that used in the present IWC/IDCR cruise was employed. In principle, sighting was conducted at a speed of 11.5 knots from 30 minutes after sunrise to 30 minutes before sunset (or from 06:00 to 19:00), with two topmen assigned at the barrel. As for searching method, sighting data were collected under the similar sea conditions as in the IWC/IDCR cruise (research code: BC).

Even in case research conditions did not meet, similar searching activities were conducted under the sea condition where sampling was possible. In this case, records were made using an independent research mode (research code: BS) so that it could be distinguished from normal sighting surveys. The starting point of research for the next day was set at a point ahead of the research terminal points on each subtrack. Limited-scale closing method was employed, which targeted at whale schools which could be minke whales or the same species out of the whale schools which were identified as primary sighting. As regards sighted schools of blue, humpback and right whales, closing was made to photograph whales for natural marking.

Cetacean species sighted

Table 1 shows the whale species sighted during the research catch. During 65 days, a total of 46 animals from 45 schools (30 animals from 29 schools in the primary sighting, and 16 animals from 16 schools in the secondary sighting). Although species identification was not made, six schools appeared to be those of minke whales. All the minke whales sighted in this area were all single-animal schools except one. As for other large baleen whales, fin whales (33 animals from 21 schools), sei whales (20 animals from 13 schools), humpback whales (20 animals from 12 schools) and a school of a right whale accompanied by calf. What should be noted in the research this time is the sighting of blue whales. During the 65-day period, 19 animals from 13 schools (10 animals from 6 schools in the primary sighting and 9 animals from 7 schools in the secondary sighting). As for toothed whales, 169

sperm whales were sighted from 151 schools, 151 killer whales from 25 schools, and 84 Ziphiidae from 35 schools. Among dolphins and porpoises, Dall's porpoises were found in the largest number (2,296 animals from 420 schools), followed by Pacific white-sided dolphins and common dolphins.

Searching distance

The distribution of sighting effort under BC and BS modes is shown in Table 2 and Table 3, respectively. The searching distance under BC mode -- which is normal sighting survey -- was 3,981.7 n.miles (1,586.8 n.miles in the first half and 2,394.9 n.miles in the second). The searching distance under BS mode was 2,998.4 n.miles, more or less the same as that under BC mode. In the first half, the effort under BC mode concentrated on the south side, especially southwest side, of the area. In the north side, little or no surveys were made under BC mode because of thick fog. The survey under BS mode was conducted on the north side of the area where BC-mode survey was made, showing that visibility and sea conditions was adverse (e.g. fog) in the north side of the research area. In the second half, searching under BC mode concentrated on the central part of area where special research was conducted. On the other hand, searching effort was given to the surrounding area, especially the north side, for survey under BS mode.

Distribution of minke whales sighted

Fig. 3 shows sighting distribution of whale schools of minke whales or "what appeared like minke whales." Between 5 July to 7 September, a total of 46 animals from 45 schools were sighted, including primary and secondary sightings. Of them, 6 schools were not identified as minke whales. They were classified as "what appeared like minke whales." As shown in the past sighting research results, these sightings showed dispersion throughout the research area, and there was no high-density area as in the Antarctic. Predominant part of sightings was made with body, with few cases made with blows and jumps. Distance from the vessel and whale at the time of sighting were all within the range of one mile except for one case in which the whale was sighted with jumps. The perpendicular distance was within the range of 0.6 n.mile.

Tables 4 and 5 show the density indexes (the number of primary sightings per 100 n.miles of searching) of minke whales by one square degree under BC and BS modes, respectively. The density of minke whales was 0.82 under BC mode in the first half but declined to 0.29 in the second. A tendency of visible decline in the number of sightings was observed from July to August, as shown in the sighting information by whale search boats and sighting survey vessels. On the other hand, under BS mode, the density was approximately 0.3 both for first and second half, and there seemed to have been no difference in sighting of minke whales under the adverse sea conditions. The area showing relatively high density index was found in the zone of 44°N in the first half. In the second half, areas showing relatively high index was found in the zone of 46°N to 48°N.

Distribution of large whales sighted

Fig. 4 shows sighting distribution of five large baleen whale species (blue, fin, sei, right and humpback whales). In the first half, numbers of sightings occurred mainly in the north side of the research area north of 46°N. A total of 18 humpback whales from 11 schools were sighted, and on the south side, 4 fin whales from 4 schools, together with blue whales and sei whales. In the second half, there were many sightings in the area south of 48°N. Only one school of humpback whales was sighted, while there were many sightings of fin, blue and sei whales. Blue whales and fin whales were sighted almost in the same areas: the east side (46-49°N, 166-170°E) and the west side (44-47°N, 157-161°E) of the research area. Particularly, in the eastern area, 17 blue whales from 11 schools and 28 fin whales from 17 schools were sighted. Sei whales tended to be sighted on the south side from the area where blue and fin whales were sighted. A school of a right whale accompanied by a calf was sighted near 42°N -- the southern boundary of the research area.

SAMPLING OF MINKE WHALES

Sampling method

Sampling activities were conducted in principle only on minke whales sighted in the primary sighting with a target of obtaining 100 samples. However, most of minke whales in the area (44 out of 45 schools) were spread extensively as single-animal schools. Further, there was no area where the schools of minke whales were concentrated, and sighting per research day was 1-2 schools. Therefore, from 22 July, 1994, minke whales of secondary sighting were also made target of sampling. It was decided that two sampling vessels would cooperate in the sampling of sighted schools.

Using this method, sampling was made on 43 animals from 42 schools out of the 45 schools of minke whales sighted during 65 days. As a result, 21 minke whales were sampled.

Sampling efficiencies

Table 6 shows the number of sighting, sampling and sampling efficiency of minke whales. Sampling was attempted on 43 minke whales from 42 schools sighted during the period from 5 July to 7 September. As a result, 22 animals (15 animals in the first half and 7 in the second) remained not-sampled. Technical sampling efficiency (the ratio of the sampled animals to all targeted animals) was 0.34 for the first half and 0.65 for the second. This difference was considered due to the fact that two vessels cooperated in sampling activities to the sighted minke whales schools in the second half. The real sampling efficiency (the percentage of sampled animals vis-a-vis sighted animals) also showed similar results (0.33 and 0.59).

The cause of the failure to sample 22 animals is shown in Table 7. In the first half, 7 out of 15 animals (or 47% of the total) were lost before being confirmed, and 4 animals were lost due to prolonged diving. In the second half, all whales of the schools sighted under BC and BS modes, except one (which dived for a long interval), were sampled. As regards sighting under conditions other than above, it was due to loss of targeted

whales before confirmation when whales were sighted under poor visibility or adverse weather. Another cause was the difficulty in grasping the swimming direction of whales in the water by on-the-sea sighting because of poor water color in the research area.

Distribution of whales sampled

The positions of 21 minke whales sampled during the research period are plotted in Fig. 5. Although the sighting positions of sampled minke whales are distributed virtually throughout the area, they were shown to be leaning toward the center of the research area between 160°E and 165°E in the first half as compared with the sighting distribution of minke whales (Fig. 3), and therefore, minke whales sighted near the east-west boundary of the research area could not be sampled. In the second half, on the other hand, distribution similar to that in the sighting distribution was observed.

Biological research

All of the 21 minke whales samples were retrieved onboard the mothership for biological research. Table 8 shows the research items and the number of animals surveyed. There were 47 items of research, including ecological, morphological, osteological research, in addition to collection of samples for genetic analysis and analysis of polluting substances. Upon returning home, these materials and samples were distributed to researchers in charge of analysis. And upon completion of biological research, by-products were manufactured pursuant to Article VIII of the International Convention for the Regulation of Whaling.

EXPERIMENT AND OCEANOGRAPHICAL SURVEY

Experiment to estimate distance angle

Experiment to estimate distance angle was conducted onboard two sampling vessels in the afternoon of 7 September. *Toshimaru No.25* conducted six experiments and *Toshimaru No.18* seven experiments, with six topmen, captain and gunners taking part. Onboard each vessel, eight experiments each were conducted by six observers at the barrel and seven at the upper bridge. Total number of experiments was 104 for each vessel.

Sampling experiment of biopsy samples

No biopsy sampling experiment was conducted in the research area due to the non-ideal sampling condition. It was conducted during sighting surveys on the return cruise. *Toshimaru No.25* attempted collection of biopsy samples on one minke whale from one school sighted on 12 September. Two dart shootings were attempted to this individual using a biopsy gun, but no samples were collected as the darts failed to hit the whale body.

Natural marking

Closing were used for the natural marking, and the following whales sighted were photographed onboard the two sampling vessels: 5 blue whales from 3 schools, 2 humpback whales from one school and 2 right whales from one school (female accompanied by

a calf). The total whales sighted were: 19 blue whales from 13 schools (primary sighting: 10 animals from 6 schools; secondary sighting: 9 animals from 7 schools), 20 humpback whales from 12 schools (primary sighting: 14 animals from 9 schools; secondary sighting: 6 animals from 3 schools); 2 right whales from one school (primary sighting). Of them, 3 blue whales, one humpback whale and two right whales were photographed.

XBT survey

XBT survey was conducted on board *Toshimaru No.25* from 5 July to 7 September. One observation was made per day in the research area, but no observation could be made because of adverse weather on 13 July, 6 August and 6 September. Along with XBT water temperature measurement, weather, wind direction, wind intensity, atmospheric pressures, temperature, water color and surface water temperature were recorded. Fig. 6 shows XBT observation points. XBT observation was conducted at a total of 62 points: 31 points each in the first half and second half.

Marine debris survey

Stomach contents

Man-made objects were found in the stomach contents of five of 21 animals collected. The artificial objects included cap of polyethylene bottle, vinyl bags, plastic and wooden fragments. These objects were photographed and collected.

Marine debris

The observation of marine debris was conducted onboard *Nisshinmaru* for eight days from 1-4 July and from 8-11 September. Observation totaled 96 hours and 45 minutes (51 hours and 45 minutes in the first half, and 45 hours in the second). A total of 53 cases of debris were observed during this time. By type, styrofoam (19 cases) and buoy (19 cases) constituted the largest portion, followed by petrochemical products such as plastic vinyl, wooden chips, metal cans, cloth, electric bulbs, bamboo pieces, and drift wood.

PRELIMINARY ANALYSIS

Sex ratio and size composition of caught

Eighteen of the 21 animals caught were male and 3 were female. Table 9 shows the average size by sex for collected animals during the research period. The average length of male both for the first and second half was 7.4m, with most males being animals of 7m, except one animal of 6.12m caught in the central area in the second half. On the other hand, there were 3 females, with the body length of 4.79, 7.07 and 7.55m. The two females caught in the first half were immature animals, and the other caught in the second half was a mature animal pregnant with a female embryo.

Fig. 7 compares body length distribution of minke whales taken during past operations of Japanese small-type whaling (Kato, 1992), and that of whales sampled under special permit in sub-area 9. It seems that the peak of the length distribution of male minke whales from sub-area 9 match with one of the two peaks

observed in Eastern Hokkaido and Sanriku. A lack of small individuals is observed in sub-area 9.

Conception date

The length of a fetus found in a mature female sampled on 19 August in sub-area 9 during the JARPN, was 94.2 cm. Fig. 8 shows the relationship of fetal length and month in different areas around Japan (Best and Kato, 1992). From this figure, it can be extrapolated that the fetus sampled in sub-area 9 was conceived on March/April, and the mother seems to have a similar reproductive cycle of whales of 'Okhotsk Sea - West Pacific' stock (areas V and VI).

Feeding habit

Feed organisms were detected from the stomach of 20 sampled animals. A detailed examination of the stomach content of the whales sampled will be completed in the near future. A preliminary observation of the stomach content conducted at the time of the biological survey, revealed that the main prey species of the minke whale in the research area are pelagic fishes such as Pacific saury (*Cololabis saira*), Japanese anchovy (*Engraulis japonicus*) and sardine (*Sardinops melanostictus*) and euphausiids (*Thysanoessa longipes*, *T. inspinata*, *T. inermis*, T. Tamura, pers. comm.). As an exceptional case, a stomach of minke whale was filled with Pacific pomfret (*Brama japonica*) with 40cm of body length. As regards of distribution of prey species, it was made clear that the minke whale consumes various types of pelagic fishes from area to area, such as krill in the northern part of the research area, saury in the middle latitudinal zone and anchovy and/or sardine in the southern part (Fig. 9).

DISCUSSION

The present research was conducted in sub-area 9 for 65 days from 5 July to 7 September, 1994, collecting 21 samples of minke whales. However, the initial aim of collecting 100 samples was not achieved. The reason was ascribed first to abnormal weather in summer of 1994. It was an exceptionally hot summer, causing serious water shortage throughout Japan. The rise of water temperature was observed in the seas surrounding Japan as the high atmospheric pressures in the Pacific developed larger than in ordinary years. The research area in the North Pacific was also affected by this anomalous climate.

Fig. 10 shows the time proportion for each research mode in the daily research hours. The daily research length was 720-780 minutes although there was some fluctuations due to the time of sunrise and sunset. In July, the number of days in which research under ordinary mode (BC mode) could be conducted throughout the day was only 2 days (7.4%) because of adverse sea conditions. The number of days in which 50% or more could be covered was only 4 days (14.8%). For the entire month of July, research under BC mode was conducted only for 9,372 hours, which was 23% of the total hours allotted for research. Research under BS mode was 8,402 hours (20%), while research was not possible for 23,622 hours, or 57%, because of adverse sea conditions due to foggy

weather. In August, there were 10 days (32.3%) in which 50% or more could be researched under BC mode. For the entire month of August, research under BC mode and BS mode was 34% and 21%, respectively, while research was not conducted for the 45% of the research hours because of foggy weather. Out of 7 days of research conducted in September, that under BC mode was 18.1% (1,737 hours), with 50% (4,824 hours) being in the sea condition not conducive to research because of foggy or stormy weather. According to the results of sighting survey of *Toshimaru No.25* which researched almost the same area from 3-27 August, 1990, a total of 2,607.1 n.miles were searched in 25 days, with the average daily searching distance standing at 104.2 n.miles (Buckland et al., 1992). The distance covered under BC mode per day during the present research was 61.3 n.miles (48.0 n.miles in the first half and 74.8 n.miles). This means that the sea conditions suited for sighting was only about 60% of the 1990 research.

On the other hand, the Japan Meteorological Agency (JMA) has recorded several kinds of marine climatological data in the North Pacific for a period of 30 years, from 1961 to 1990 (JMA, 1993). We have examined the data on visibility during that period, for an area comprised between 40°N and 50°N and 160°E and 180°. According to this source, visibility of 4km or more for the months of July was 52.0% in average and August was 64.6%. Visibility of 2 n.miles (about 4km) or more was considerably lower in this season than the average of 30 years (e.g. July: 23%, August: 34%).

Secondly, it should be pointed out that the research area was not main feeding ground for the minke whale but the area of passage for north-south migration. For this reason, there was no area of concentration of minke whales as in the Antarctic, and the sightings of the animals were scattered. In the research, taking the comments of IWC/SC members into consideration, it was decided to increase sighting effort and to conduct sighting surveys in parallel with the sampling research, as in the case of research in the Antarctic. However, as the distribution of minke whales differ from the Antarctic, it was difficult to collect samples from minke whales distributed widely with the research method in which sighting and sampling were combined. Therefore, it will be necessary to reconsider the proportion of sampling activities and sighting surveys in the future.

ACKNOWLEDGEMENTS

We owe greatly to the advice and guidance of Dr. Hiroshi Hatana-ka, chairman of the Council on the North Pacific Minke Whale Research (also Director of the National Research Institute of Far Seas Fisheries, IFS), who was responsible for formulation of the research program as well as planning in implementation, as well as Dr. Fukuzo Nagasaki and Dr. Seiji Ohsumi, the Institute of Cetacean Research (ICR), the organization implementing the research. We thanks to Mr. Masayuki Komatsu and his staff, Fisheries Agency of the Ministry of Agriculture, Forestry and Fisheries for their support. Also our thanks are due to our colleague of

the IFS and ICR who extended guidance through participation in the formulation of implementation programs, including theoretical discussion on the research.

In actual implementation, we are indebted to the cooperation from Messrs. Shigeru Tanifuji and Shuji Kawashima of Kyodo Senpa-ku Co. Ltd., Mr. Daisuke Tohyama, captain of *Nisshinmaru*, Mr. Atsuhi Ohwada, captain of *Toshimaru No.25*, Mr. Toshiaki Tsurii, captain of *Toshimaru No.18*, and all the crew of the research fleet. Finally, I thank my colleagues at the Research Department of the ICR who helped us greatly in preparing for the research and continued assistance from land during the research.

The present research project was implemented under the assistance from the Ministry of Agriculture, Forestry and Fisheries.

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Table 1. Summary of sightings (no. schools/no. individuals) conducted by the two sighting and sampling vessels and research base.

Species	Searching mode [*]								
	BC		BS		BO		OE ^{**}	Combined	
	Prim.	Second.	Prim.	Second.	Prim.	Second.	Second.	Prim.	Second.
First period (July 5 - August 6, 1994)									
Minko whale	13/14	1/1	5/5				4/4	18/19	5/5
Like minko whale	2/2		1/1				2/2	3/3	2/2
Blue whale	1/1						1/1	1/1	1/1
Fin whale	2/2		2/2					4/4	
Sei whale		1/1							1/1
Humpback whale	1/3		8/11				2/4	9/14	2/4
Sperm whale	25/32	1/1	6/7		1/1		1/1	32/40	2/2
Killer whale	4/23	1/5	1/6				2/6	5/29	3/11
Unidentified Mesoplodon	1/3		1/3				1/3	2/6	1/3
Unidentified Ziphiidae	7/14		5/15				3/4	12/29	3/4
Dall's type Dall's porpoise	76/345	1/10	76/271				45/206	152/616	46/216
Unidentified type Dall's porpoise	25/88		23/69				4/14	48/157	4/14
Unidentified large cetacean		1/1	2/2					2/2	1/1
Unidentified small cetacean	1/3							1/3	
Unidentified dolphin	50/178		33/77	1/2	1/1		10/17	84/256	11/19
Unidentified cetacean	13/13		11/12					24/25	
Second period (August 7 - September 7, 1994)									
Minko whale	7/7		4/4				11/11	11/11	11/11
Like minko whale	1/1							1/1	
Blue whale	2/3		3/6				6/8	5/9	6/8
Fin whale	5/10		10/14				2/5	15/24	2/5
Sei whale	9/15		2/3				1/1	11/18	1/1
Humpback whale							1/2		1/2
Right whale	1/2							1/2	
Sperm whale	72/80	7/7	28/29	2/2			8/9	100/109	17/18
Killer whale	11/85		5/20				1/6	16/105	1/6
Cuvier's beaked whale	2/4							2/4	
Baird's beaked whale	1/7						1/4	1/7	1/4
Unidentified Ziphiidae	6/15		6/9				1/3	12/24	1/3
Dall's type Dall's porpoise	84/794	2/7	34/138	1/3			12/47	118/932	15/57
Unidentified type Dall's porpoise	22/92	1/100	12/86				2/26	34/178	3/126
Common dolphin							1/8		1/8
Pacific white-sided dolphin			5/1,208					5/1,208	
Unidentified large cetacean	5/6		2/3	1/2			1/1	7/9	2/3
Unidentified small cetacean	1/2							1/2	
Unidentified dolphin	28/484		7/44				3/7	35/528	3/7
Unidentified cetacean	14/17		7/8				2/2	21/25	2/2

* : See text

** : Including three secondary sightings (3/3 minko whales and 1/1 like minko whale) by the research base.

Table 2. Searching distances (n.miles) of BC mode searching by one degree and research period

First period (July 5 - August 6, 1994)

	Longitude (° E)													Total
	157	158	159	160	161	162	163	164	165	166	167	168	169	
51° N														0.0
50° N														0.0
49° N								3.1						3.1
48° N				19.0	4.5		3.3							26.8
47° N			71.0	63.4	4.3						4.1			142.8
46° N		13.4	17.3							18.8	6.6	58.6		114.7
45° N	1.7	103.3			1.5	9.6		44.9	4.3	90.1	79.5	68.8	8.7	412.4
44° N	36.2	21.1	16.2	59.0	58.9	91.6	75.5	70.7	68.9	9.9	3.7	16.8	16.7	545.2
43° N	26.9	57.6	63.6	28.6			17.7		5.7					200.1
42° N					4.6	1.6		79.0	41.2	15.3				141.7
Total	64.8	195.4	168.1	170.0	73.8	102.8	96.5	197.7	120.1	134.1	93.9	144.2	25.4	1,586.8

Second period (August 7 - September 7, 1994)

	Longitude (° E)													Total
	157	158	159	160	161	162	163	164	165	166	167	168	169	
51° N														0.0
50° N									6.1	10.4				16.5
49° N						7.3			72.8	58.8				138.9
48° N						4.1	40.0	14.7	121.1	9.4				189.3
47° N						27.0		88.5		29.7	29.7			174.9
46° N					42.3	134.7	168.0	118.8	81.9	67.7	7.1	7.6	14.1	642.2
45° N		5.1	86.2	82.8	31.7	2.0	135.6	140.5						483.9
44° N	11.7	29.4			104.0	228.0	20.5							393.6
43° N						45.5	63.1							108.6
42° N					10.6	71.3	165.1							247.0
Total	11.7	34.5	86.2	82.8	188.6	519.9	592.3	362.5	281.9	176.0	36.8	7.6	14.1	2,394.9

Table 3. Searching distances (n.miles) of BS mode searching by one degree and research period

First period (July 5 - August 6, 1994)

	Longitude (° E)													Total
	157	158	159	160	161	162	163	164	165	166	167	168	169	
51° N														0.0
50° N														0.0
49° N						12.2	15.5	37.0		23.9	5.0		44.9	139.5
48° N			1.4	32.5	2.3	7.8	48.0	72.5	14.5					179.0
47° N			33.8	54.9	9.6				10.8		56.6	3.8		169.5
46° N		16.6	15.8	9.7	37.2		2.7	3.7	10.1	13.2	66.4	30.4	17.8	223.6
45° N		5.8			10.2	23.5			23.9	100.1	7.9	4.1	53.9	229.4
44° N	33.4				2.7	76.4			57.1	23.0	12.8	2.1		207.5
43° N	53.9	26.3				6.3	50.0	28.5	64.0	41.2	10.3			280.5
42° N					1.7	4.0	22.5	118.9	35.5	28.7				211.3
Total	87.3	48.7	51.0	97.1	63.7	130.2	139.7	260.6	215.9	230.1	159.0	40.4	116.6	1,640.3

Second period (August 7 - September 7, 1994)

	Longitude (° E)													Total
	157	158	159	160	161	162	163	164	165	166	167	168	169	
51° N										19.9	8.7			28.6
50° N								2.7	56.8	138.8	12.2			210.5
49° N						13.1	44.4	13.8	42.0	16.9				130.2
48° N						3.8		20.1	22.0	13.4	31.8	26.5		117.6
47° N						27.8					52.6	66.2	26.0	172.6
46° N						55.5	31.6					27.1	13.4	127.6
45° N	21.0	46.8				111.2	70.4	85.6	1.7	7.2	7.1	0.5		351.5
44° N	32.8	39.2	1.8		25.1	1.8								100.7
43° N			18.7	15.9	23.4	2.0	1.3							61.3
42° N					57.5									57.5
Total	53.8	86.0	20.5	15.9	106.0	215.2	147.7	122.2	122.5	196.2	112.4	120.3	39.4	1,358.1

Table 4. Density indices (no. of schools/100 n.miles) of minke whales by BC mode searching by one degree

First period (July 5 - August 6, 1994)

	Longitude (°E)													Total
	157	158	159	160	161	162	163	164	165	166	167	168	169	
51°N														
50°N														
49°N								0.00						
48°N				0.00	0.00		0.00							0.00
47°N			0.00	1.58	0.00						0.00			0.00
46°N		0.00	0.00							0.00	0.00	0.00		0.00
45°N	0.00	0.97			0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.24
44°N	2.76	0.00	0.00	0.00	1.70	3.28	0.00	4.24	0.00	0.00	0.00	5.95	0.00	1.65
43°N	0.00	1.74	0.00	0.00			0.00		0.00					0.50
42°N					0.00	0.00		0.00	2.43	0.00				0.71
Total	1.54	1.02	0.00	0.59	1.36	2.92	0.00	1.52	0.83	0.00	0.00	0.69	0.00	0.82

Second period (August 7 - September 7, 1994)

	Longitude (°E)													Total
	157	158	159	160	161	162	163	164	165	166	167	168	169	
51°N														
50°N									0.00	0.00				0.00
49°N						0.00			0.00	0.00				0.00
48°N						0.00	0.00	6.80	0.83	0.00				1.06
47°N						0.00		0.00		0.00	0.00			0.00
46°N					0.00	0.74	0.00	0.00	1.22	0.00	0.00	0.00	7.09	0.47
45°N		0.00	1.16	0.00	0.00	0.00	0.00	0.00						0.21
44°N	0.00	3.40			0.00	0.00	0.00							0.25
43°N						0.00	0.00							0.00
42°N					0.00	0.00	0.00							0.00
Total	0.00	2.90	1.16	0.00	0.00	0.19	0.00	0.28	0.71	0.00	0.00	0.00	7.09	0.29

Table 5. Density indices (no. of schools/100 n.miles) of minke whales by BS mode searching by one degree

First period (July 5 - August 6, 1994)

	Longitude (°E)													Total
	157	158	159	160	161	162	163	164	165	166	167	168	169	
51°N														
50°N														
49°N						0.00	0.00	0.00		0.00	0.00		0.00	0.00
48°N			0.00	0.00	0.00	0.00	2.08	0.00	0.00					0.56
47°N			0.00	1.82	0.00				0.00		0.00	0.00		0.59
46°N		0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00	3.29	0.00	0.45
45°N		0.00			0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00
44°N	0.00				0.00	2.62			0.00	0.00	0.00	0.00		0.96
43°N	0.00	0.00				0.00	0.00	0.00	0.00	0.00	0.00			0.00
42°N					0.00	0.00	0.00	0.00	0.00	0.00				0.00
Total	0.00	0.00	0.00	1.03	0.00	1.54	0.72	0.00	0.00	0.00	0.00	2.48	0.00	0.30

Second period (August 7 - September 7, 1994)

	Longitude (°E)													Total
	157	158	159	160	161	162	163	164	165	166	167	168	169	
51°N										0.00	0.00			0.00
50°N								37.04	0.00	0.00	0.00			0.48
49°N						0.00	0.00	0.00	0.00	0.00				0.00
48°N						0.00		0.00	0.00	7.46	3.14	0.00		1.70
47°N						0.00					0.00	0.00	0.00	0.00
46°N						0.00	0.00					0.00	7.46	0.78
45°N	0.00	0.00				0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00
44°N	0.00	0.00	0.00		0.00	0.00								0.00
43°N			0.00	0.00	0.00	0.00	0.00							0.00
42°N					0.00									0.00
Total	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.82	0.00	0.51	0.89	0.00	2.54	0.29

Table 6. Numbers of minke whales sighted and sampled by sampling vessels and their sampling efficiencies.

Stratum	Sighted		Targeted		Sampled		Sampling efficiencies	
	Sch. (A)	Ind. (B)	Sch. (C)	Ind. (D)	Sch. (E)	Ind. (F)	Technical (F/D)	True (F/B)
First	23	24	22	23	7	8	0.34	0.33
Second	22	22	20	20	13	13	0.65	0.59
Total	45	46	42	43	20	21	0.49	0.46

Table 7. Causes of failure to collect samples targeted by searching mode and research period. A = long diving; B = quick/mobile behavior; C = rough sea condition; D = technical problems; E = missing of the targeted animal before chasing; F = other.

Mode	Period	Reasons why whales could not be sampled						Total
		A	B	C	D	E	F	
BC	First	3	0	0	2	6	1	12
	Second	0	0	0	0	0	0	0
BS	First	1	1	0	0	1	0	3
	Second	1	0	0	0	0	0	1
Other	First	0	0	0	0	0	0	0
	Second	0	1	1	1	3	0	6

Table 8. Summary of biological data and samples collected.

Samples and data	Number of whales		
	Male	Female	Total
Body length and sex	18	3	21
External body proportion	18	3	21
Photographic record of external character	18	3	21
Diatom film record and sampling	18	3	21
Standard measurements of blubber thickness (three points)	18	3	21
Detailed measurements of blubber thickness	12	3	15
Body weight	18	3	21
Body weight by parts	12	3	15
Blubber, muscle, liver and kidney tissues for DNA study	18	3	21
Muscle, liver and heart tissues for isozyme analysis	18	3	21
Muscle, liver and kidney tissues for heavy metal analysis	18	3	21
Blubber, liver, kidney, muscle, brain and bone tissues for organochlorine analysis	18	3	21
Tissues for lipid analysis	12	3	15
Mammary gland; lactation status, measurements and histological sample	-	3	3
Ovary collection	-	3	3
Uterine horn; measurement and endometrium sample	-	3	3
Uterine mucus for sperm detection	-	3	3
Collection of stomach contents for organo- chlorine study	9	1	10
Photographic record of fetus	-	1	1
Fetal sex (identified by visual observation)	(0)	(1)	(1)
Fetal length and weight	(0)	(1)	(1)
External measurement of fetus	(0)	(1)	(1)
Collection of fetus	(0)	(1)	(1)
Testis and epididymis; weight and histological sample	18	-	18
Smear samples from testis and epididymis tissues	18	-	18
Urine sample for sperm detection	12	-	12
Serum sample for gonadal hormone assay	18	3	21
Stomach content, conventional record	18	3	21
Weight of stomach content in each compartment	18	3	21
Collection of stomach contents for the food and feeding study	18	3	21
Collection of stomach contents for heavy metals study	9	1	10
Collection of stomach contents for organochlorine study	9	1	10
Collection of stomach contents for lipid analysis	6	1	7
Collection of external parasites	12	2	14
Collection of parasites from 1st stomach	13	2	15
Collection of parasites from 2nd stomach	18	3	21
Collection of parasites from 3rd stomach	15	1	16
Collection of parasites from 4th stomach	13	1	14
Collection of parasites from small intestine	18	2	20
Earplug for age determination	18	3	21
Tympanic bulla for age determination	12	1	13
Largest baleen plate for age determination	18	3	21
Vertebral epiphyses sample	18	3	21
Skull measurement (length and breadth)	18	3	21
Detailed measurements of skull	12	2	14
Collection of skull	2	0	2
Collection of whole skeleton	4	2	6

Table 9. Mean body length and standard deviation (S.D.) of samples by sex and research period.

Sex	Period	Mean	S.D.	Range	n
Male					
	First	7.42 ± 0.19		(7.21 - 7.70)	6
	Second	7.37 ± 0.50		(6.12 - 8.09)	12
	Combined	7.39 ± 0.42		(6.12 - 8.09)	18
Female					
	First	5.93 ± 1.14		(4.79 - 7.07)	2
	Second	7.55			1
	Combined	6.47 ± 1.20		(4.79 - 7.55)	3

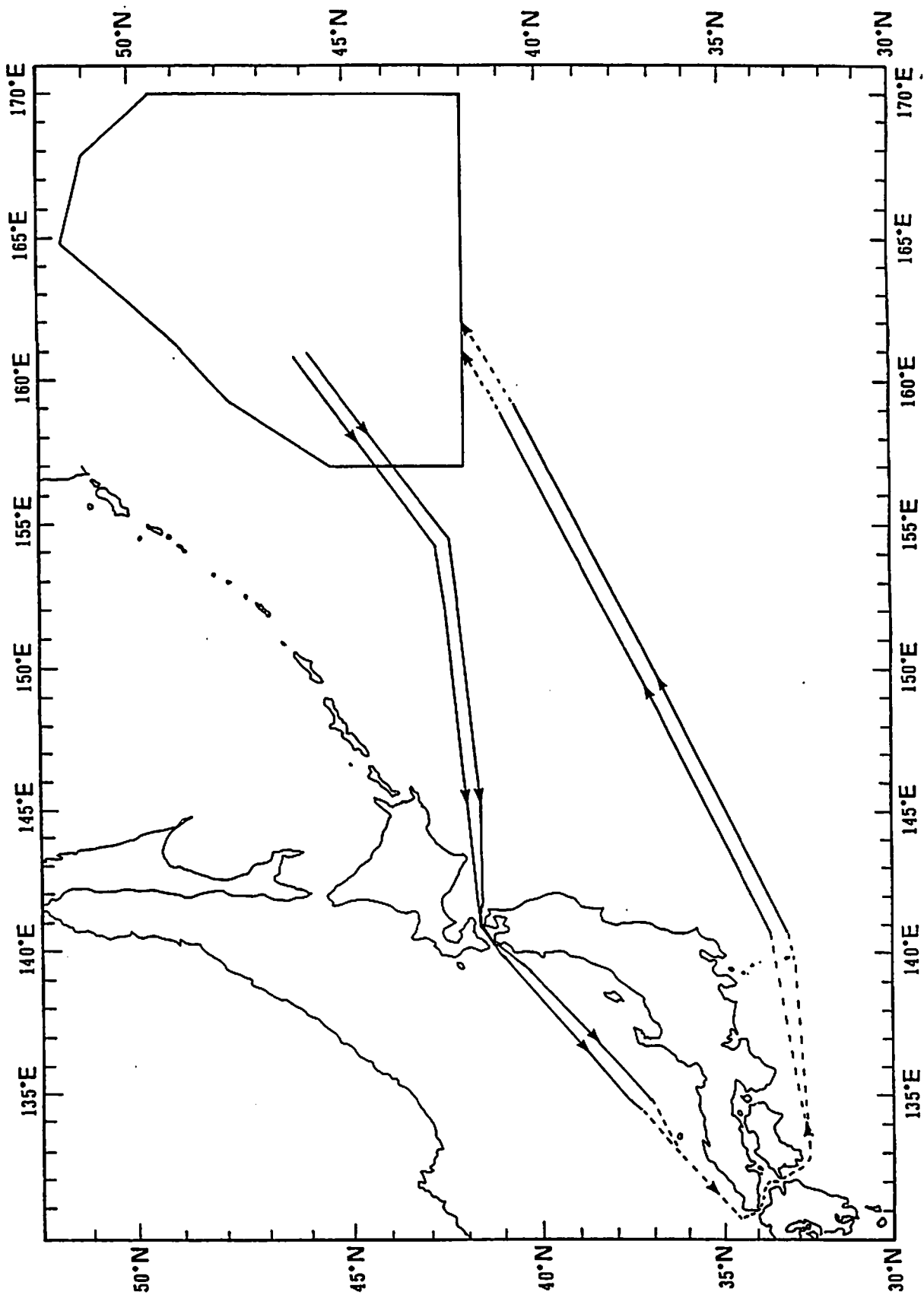


Fig.1. Geographic location of research area and cruise track of sighting survey for the JARPN in 1994.

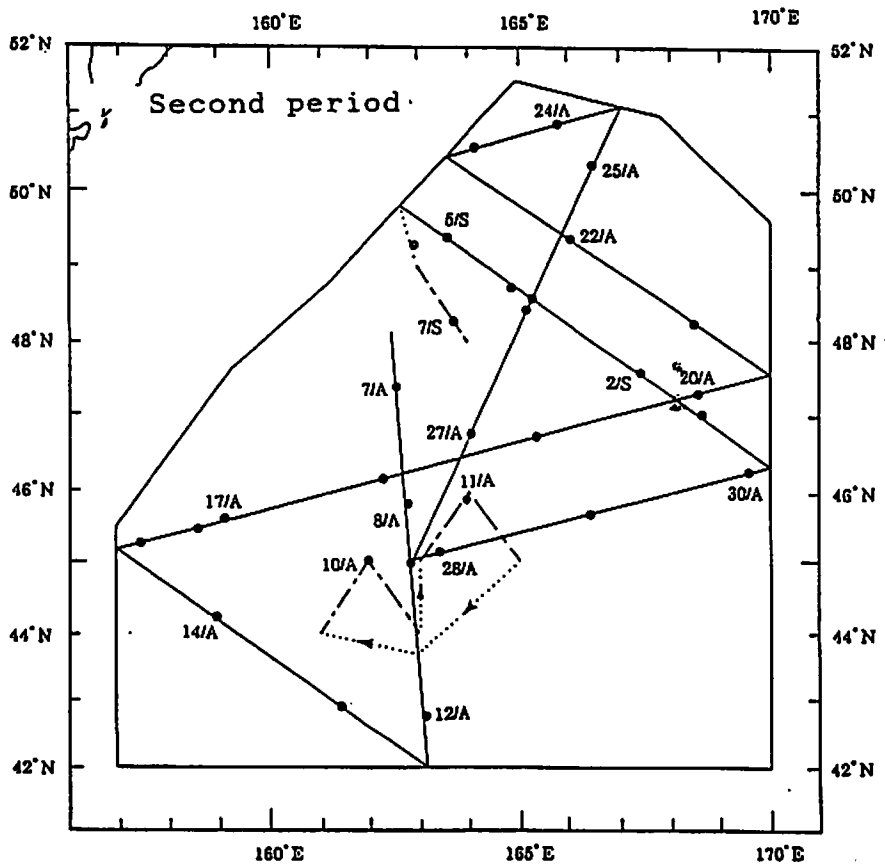
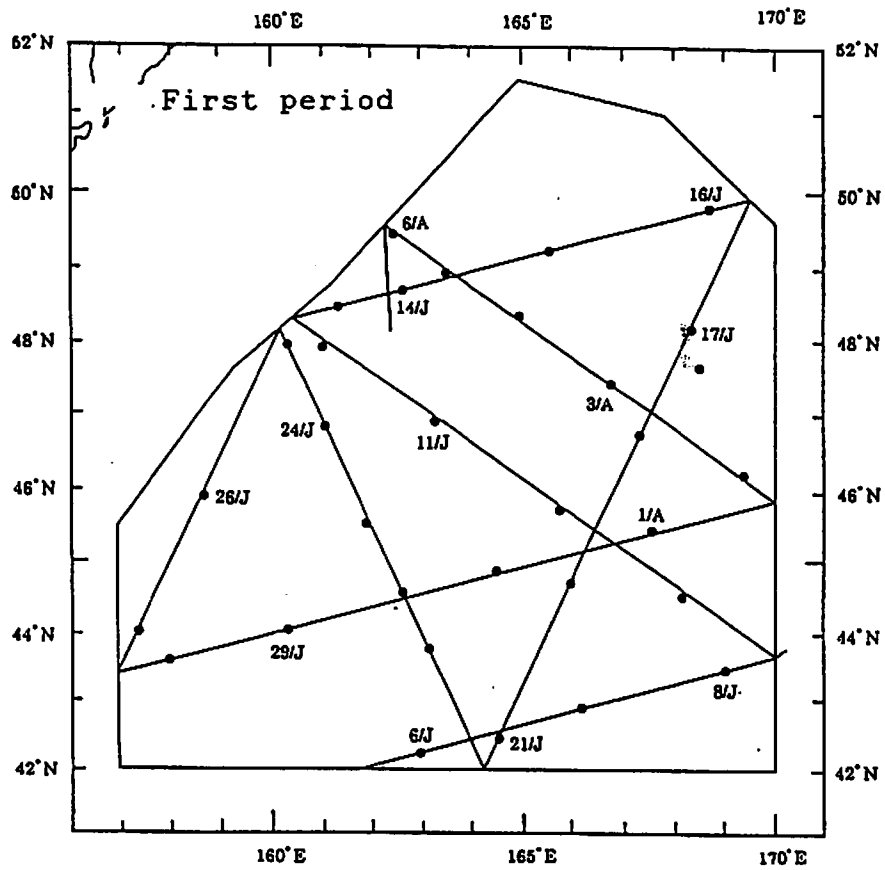


Fig.2. Cruise track and noon position of the research base (NM) for the JARPN in 1994.

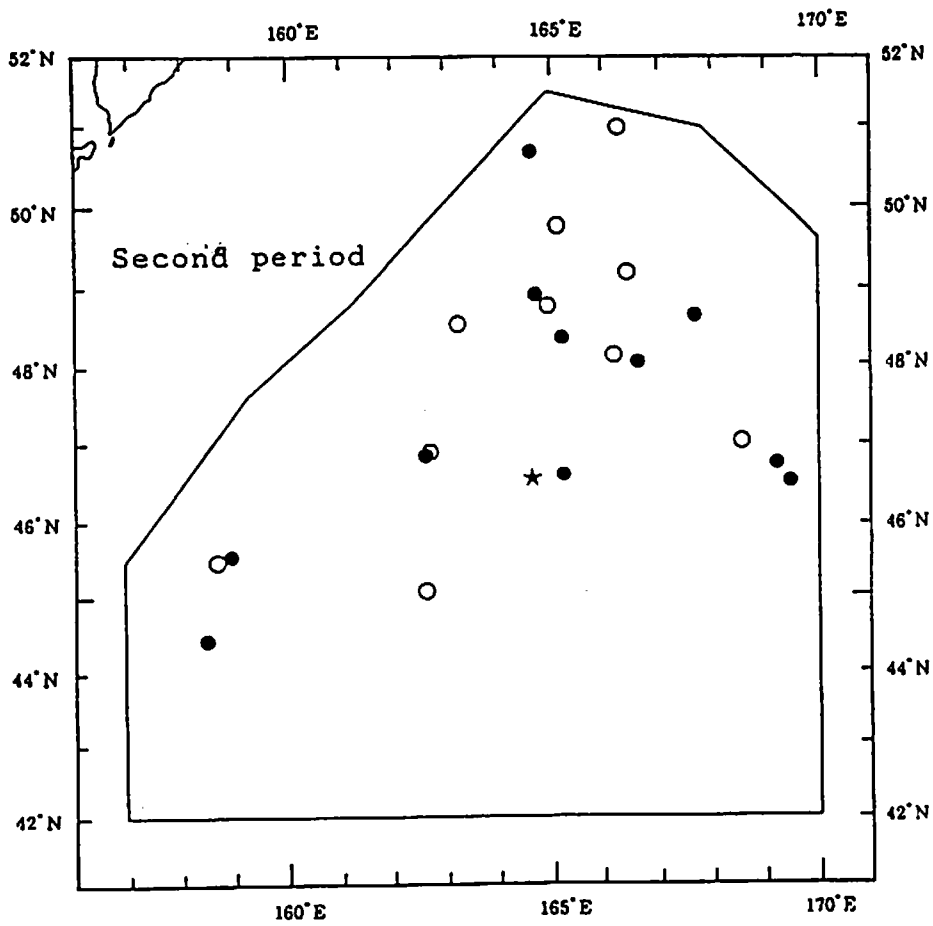
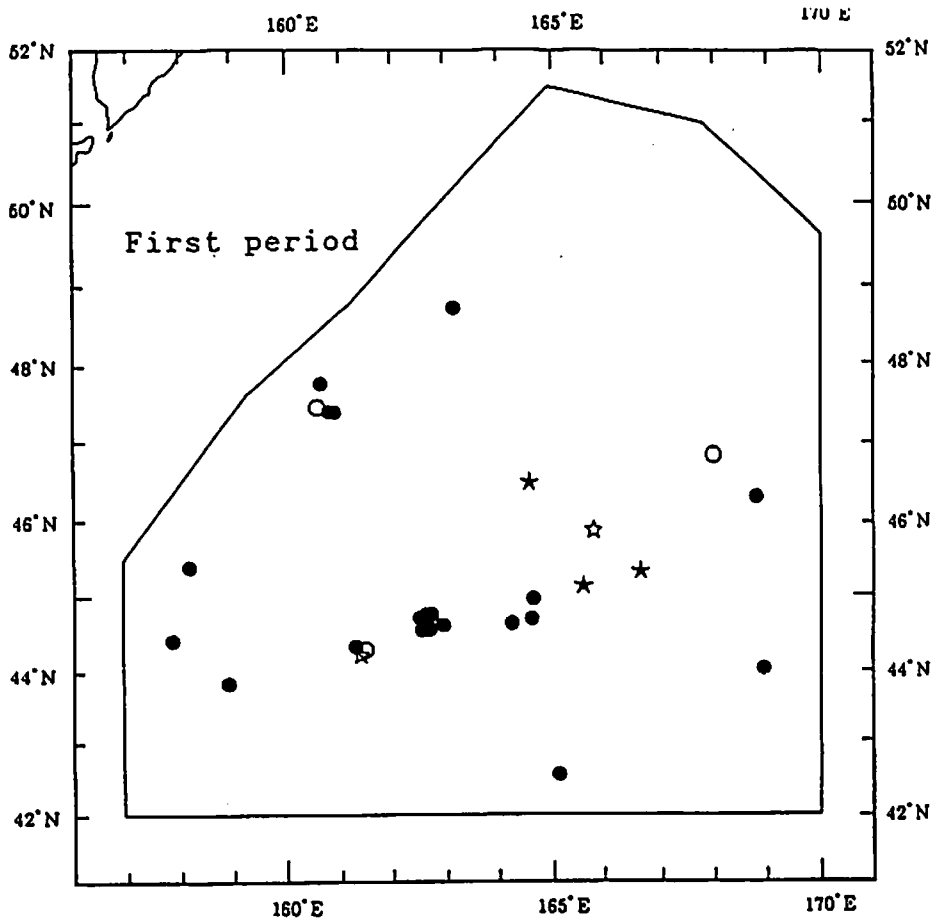


Fig. 3 . Distribution of minke whale by two sampling and sighting vessels.
 Minke whale: ●primary, ○secondary; Like minke whale: ★primary, ☆secondary.

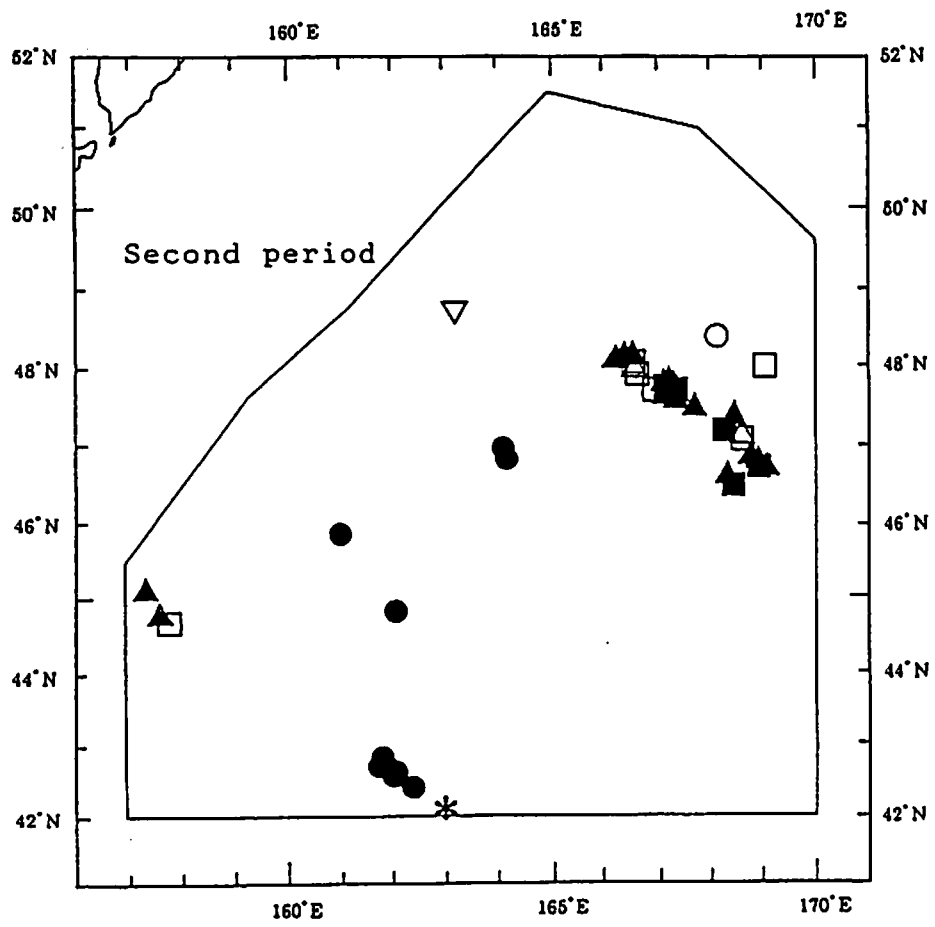
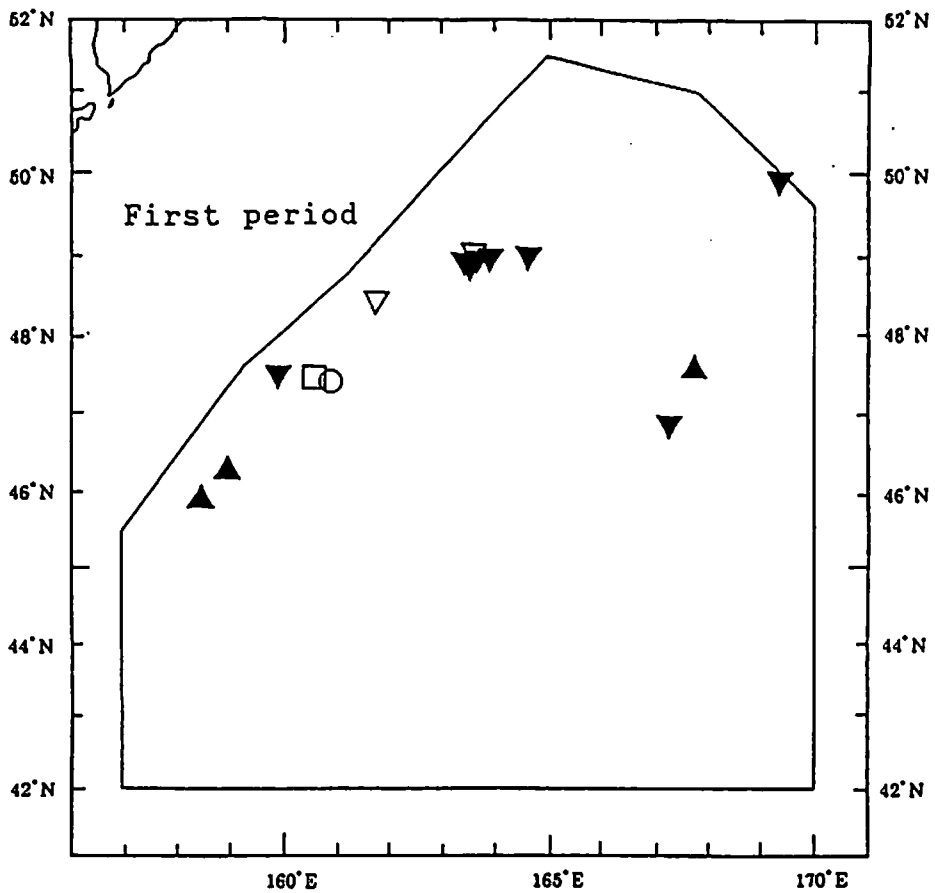


Fig. 4 . Distribution of blue, fin, sei, humpback and right whales sighted by two sampling and sighting vessels.
 Blue whale : ■ primary, □ secondary; Fin whale: ▲ primary, △ secondary;
 Humpback whale: ▼ primary, ▽ secondary; Sei whale: ● primary, ○ secondary;
 Right whale : * primary.

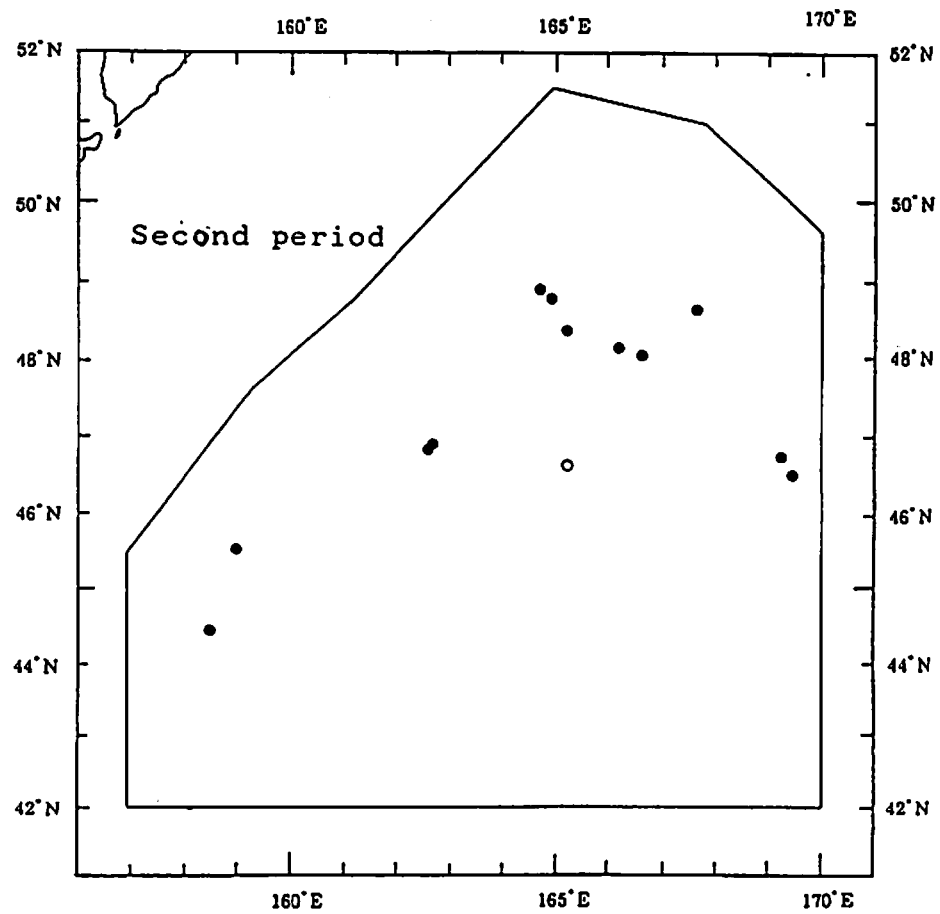
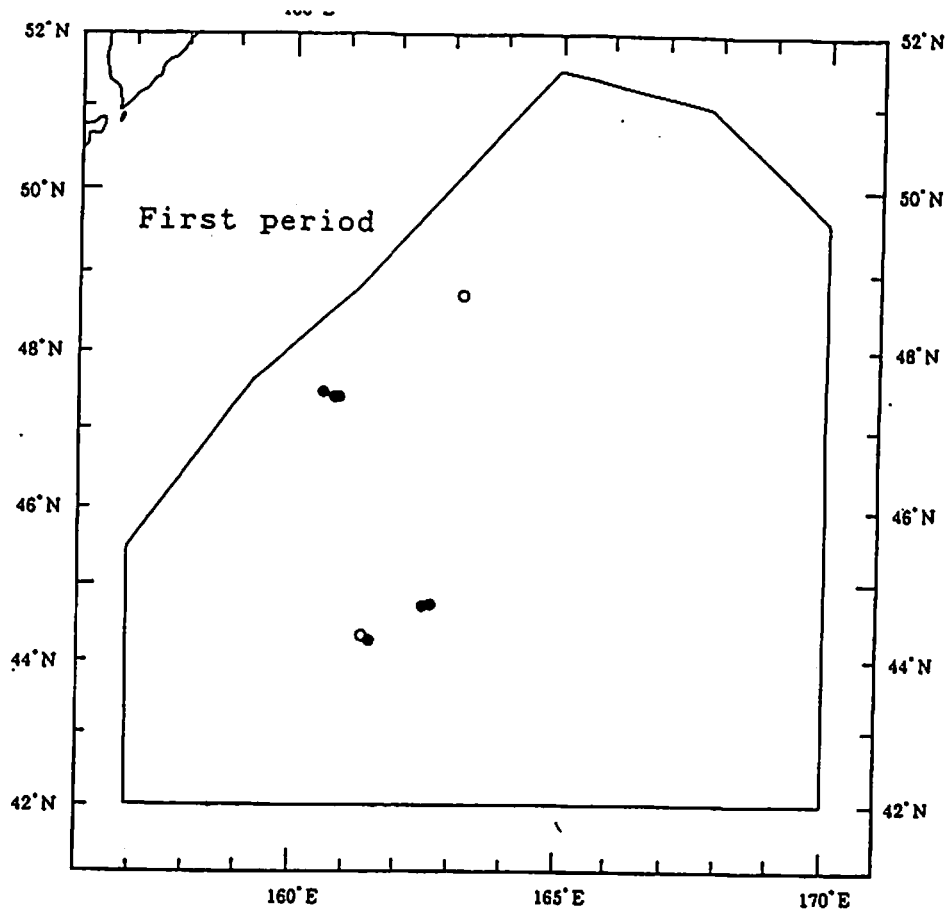


Fig. 5. Distribution of sampled minke whales based on their sighting position. ●: Male; ○: Female.

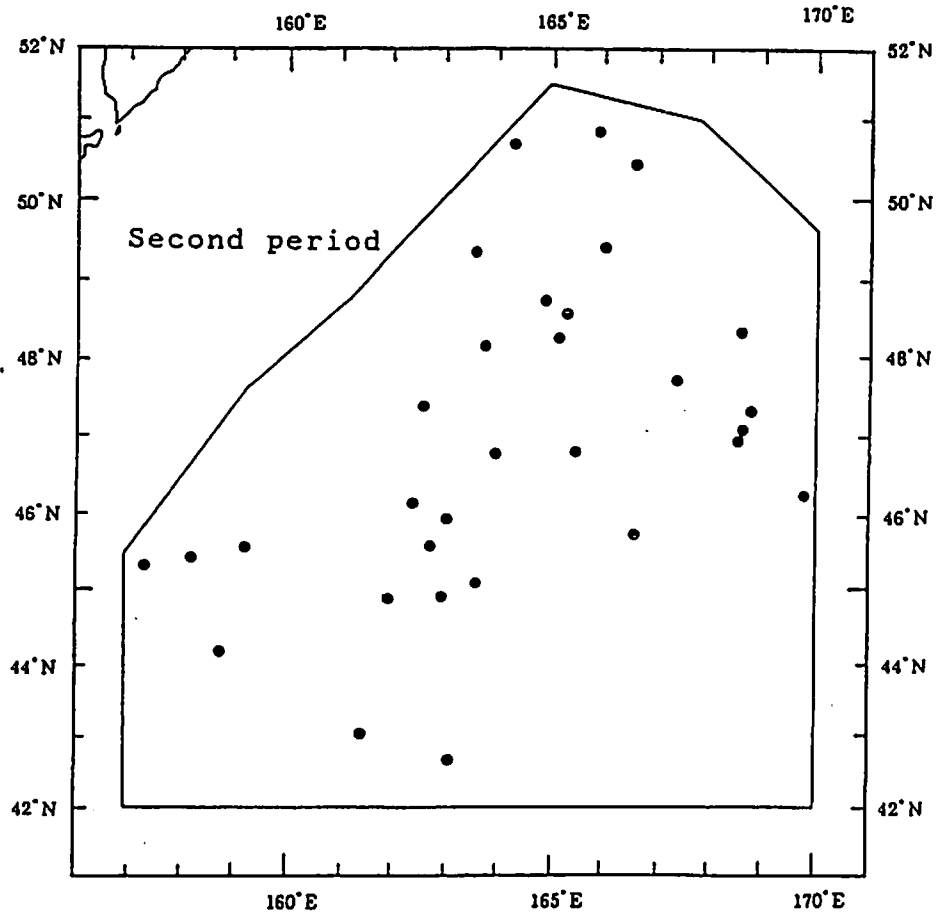
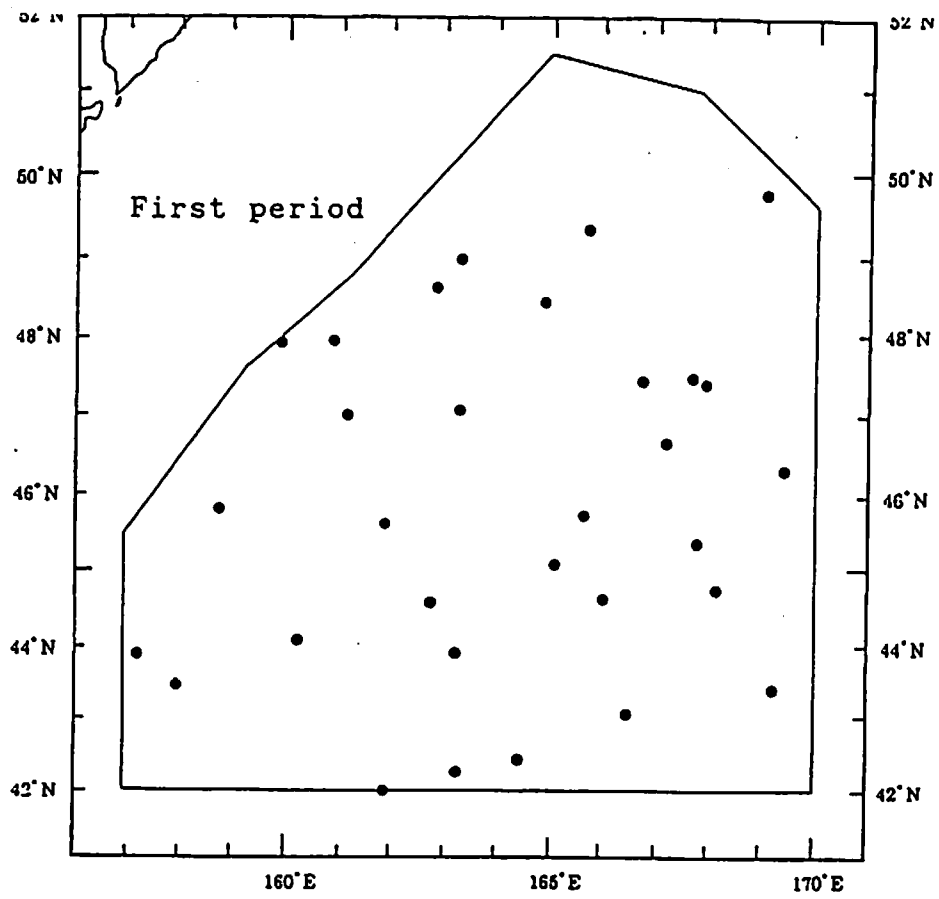


Fig. 6. Locations of the XBT survey conducted.

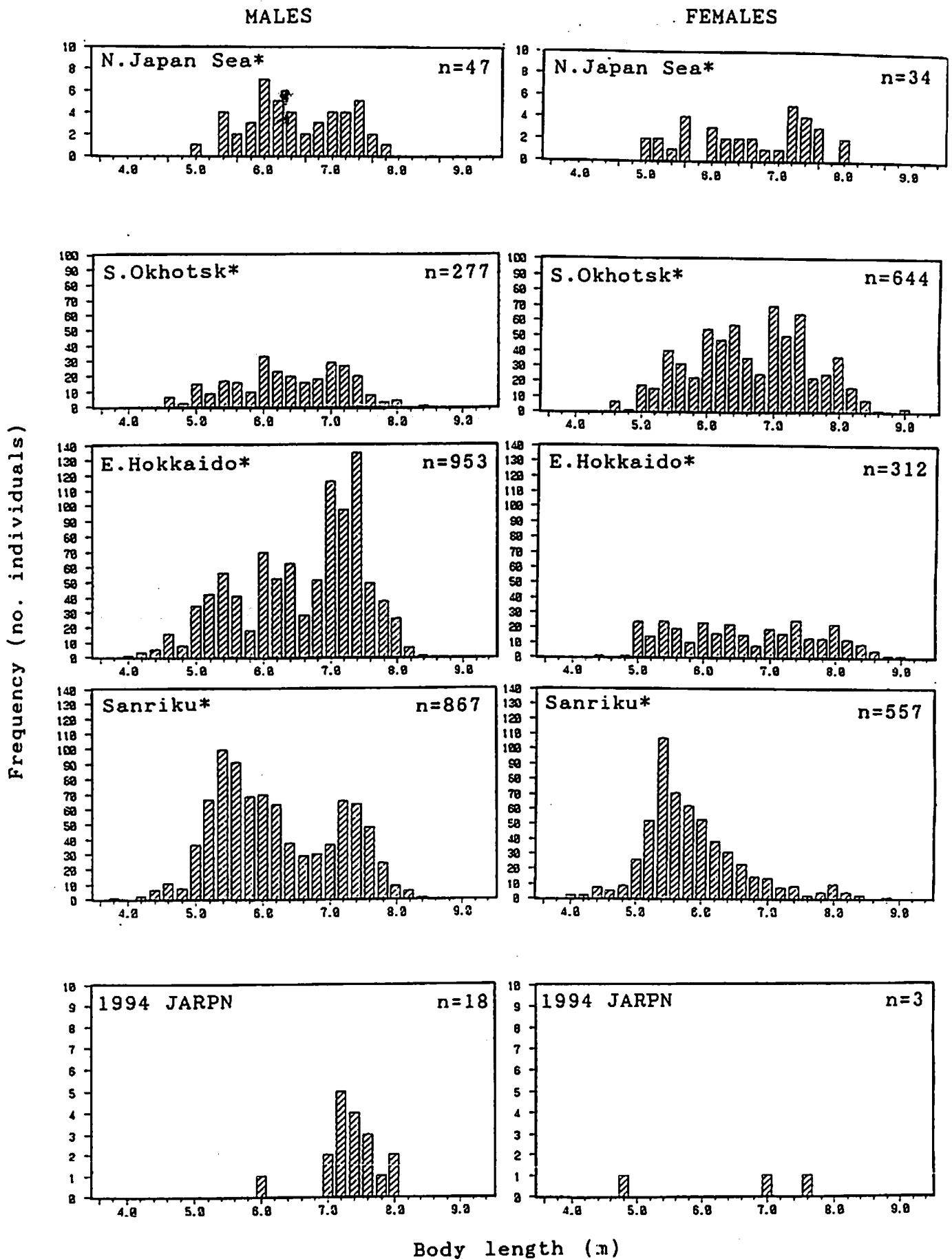


Fig. 7. Body length distribution of minke whales captured from 1977 to 1987, in four Japanese whaling ground. Figure also shows the length distribution of whales sampled in sub-area 9 by the JARPN in 1994. * After Kato(1992).

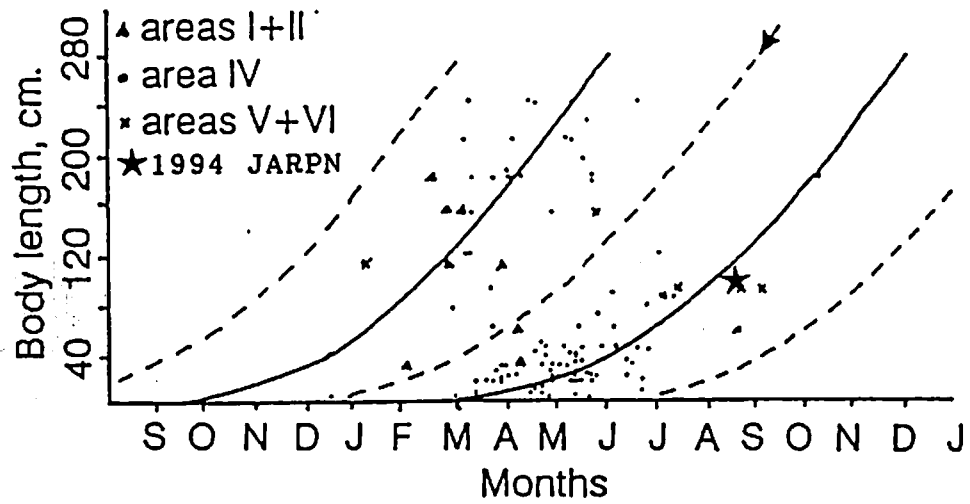


Fig. 8. Relationship between length of fetuses and months in waters around Japan (Best and Kato, 1992). A 94.2cm-fetus sampled in August 1994 in sub-area 9 is also plotted.

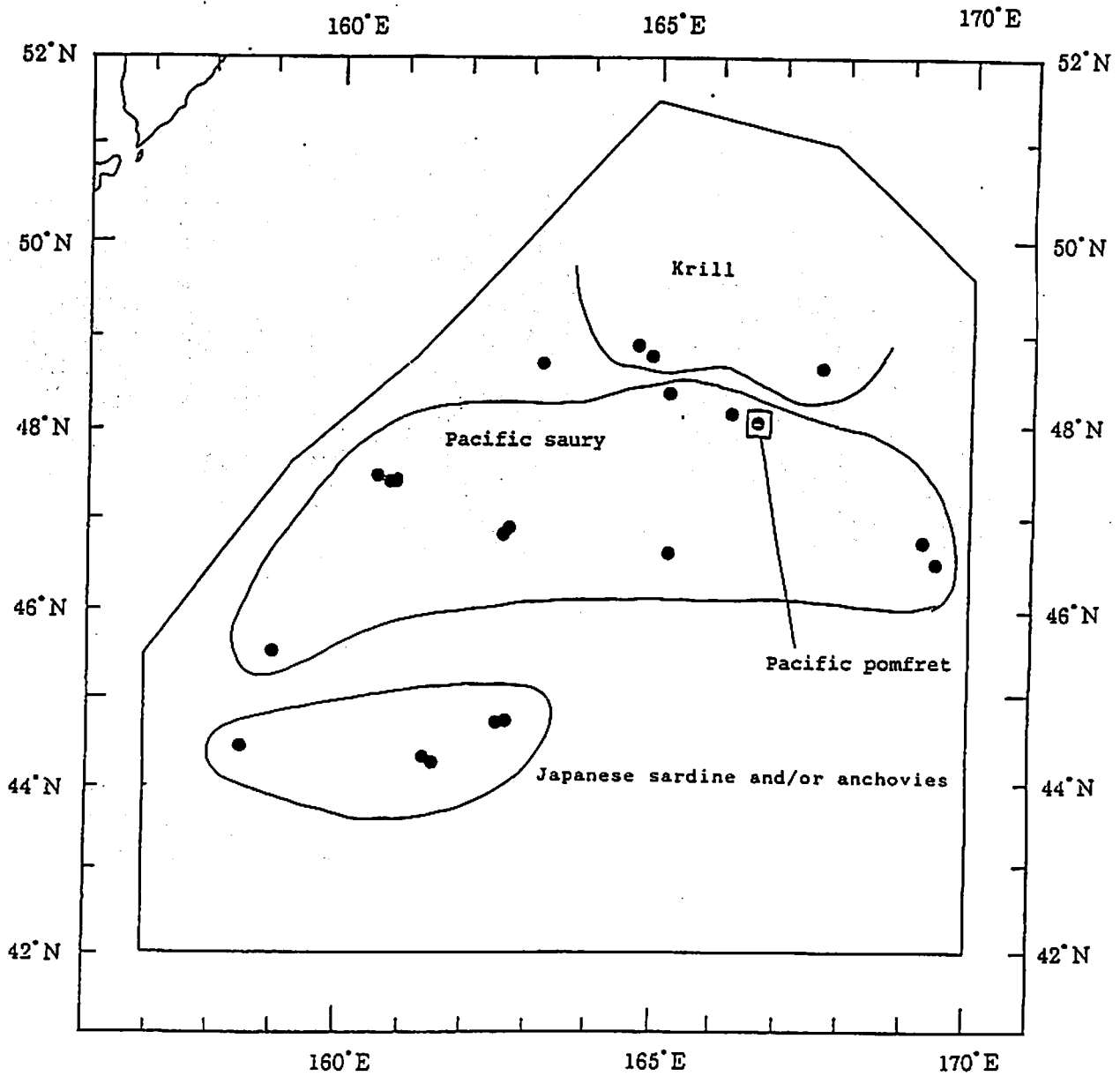


Fig. 9. Distribution of minke whales sampled and food species occurred from their stomach contents in the 1994 JARPN survey.

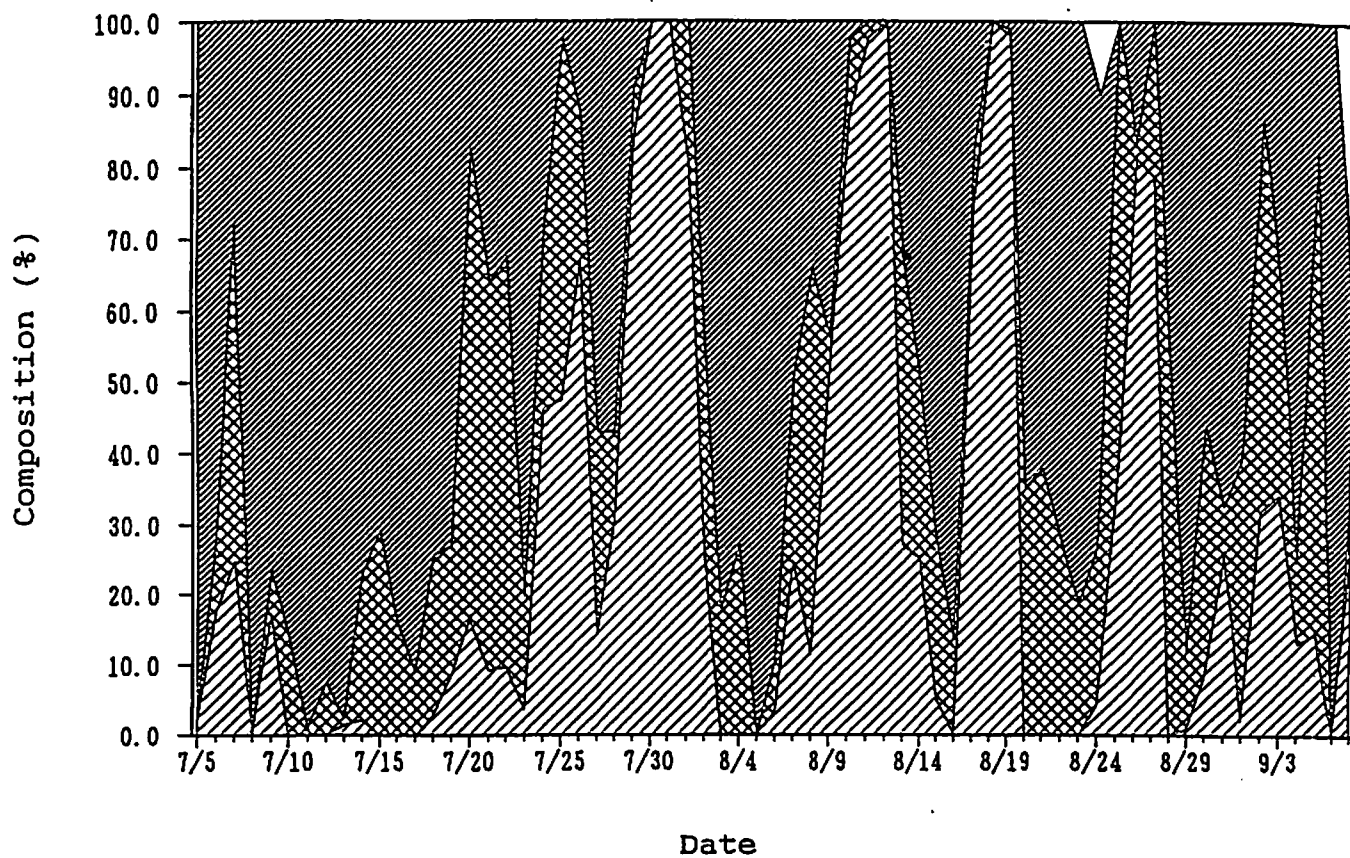


Fig.10. Changes of daily composition of research activities in the 1994 JARPN cruise. : BC mode survey, : BS mode survey, : No survey by rough sea condition or poor visibility.

APPENDIX

Sighting surveys conducted on the going cruise

Fig. 1 shows research track of the going cruise. The black dots in the figure shows the noon positions of the two sampling vessels. Sighting surveys on the going cruise were conducted for four days from 1 July (the day after the port departure on 30 June, 1994). Sighting surveys on the return cruise were conducted for five days (8-12 September).

A research track via the Sea of Japan to Shimonoseki was selected with a view to avoid typhoons. The searching distance in the going cruise (1-4 July) for the two vessels combined were 265.2 n.miles, and that in the return cruise (8-12 September) was 246.2 n.miles.

Table 1 shows all whale species sighted during the going and return cruise. The sighting position of minke whales, blue and Bryde's whales sighted during the sighting survey were plotted in Fig. 1. As regards large baleen whales, no minke whales were sighted in the going cruise, with only one Bryde's whale of one school. As for toothed whales, 7 sperm whales from 2 schools and 3 false killer whales from one school were sighted. Among dolphins and porpoises, common dolphins (426 animals from 15 schools) were found in the largest number, followed by striped dolphins (50 animals from 6 schools). Other dolphins sighted were Dall's porpoises, Pacific white-sided dolphins, northern right whale dolphins. During the return cruise, 2 minke whales from 2 schools were sighted primarily in the Sea of Japan side. Attempts were made to collect biopsy samples from one animal from one school. However, after chasing of 79 minutes, the whale did not come into shooting range, ending up in failure to collect samples. Further, 2 blue whales from one school were sighted in the research area on 8 September (the day after the completion of the research.) Other whales and dolphins sighted were sperm whales (4 animals from 3 schools), Dall's porpoises (2 animals from one school), and Stejneger's beaked whales (4 animals from 3 schools).

Table 1. Summary of sightings (no. individuals / no. schools) conducted by the two sighting and sampling vessels in sighting survey for the JARPN in 1994.

Transit to research area (July 1-4, 1994)

Species	Searching mode				
	BC		OE	Combined	
	Prim.	Second.	Second.	Prim.	Second.
Bryde's whale			1/1		1/1
Sperm whale			7/2		7/2
False killer whale	3/1			3/1	
Unidentified pilot whale	30/1			30/1	
Dalli type Dall's porpoise			5/1		5/1
Pacific white-sided dolphin			53/2		53/2
Striped dolphin			50/6		50/6
Northern right whale dolphin			5/1		5/1
Common dolphin	168/11		258/4	168/11	258/4
Unidentified dolphin	5/1			5/1	
Unidentified small cetacean	6/2			6/2	

Transit from research area (September 8-12, 1994)

Species	Searching mode				
	BC		OE	Combined	
	Prim.	Second.	Second.	Prim.	Second.
Minke whale	2/2			2/2	
Blue whale			2/1		2/1
Sperm whale		2/1	2/2		4/3
Unidentified Mesoplodon	4/1			4/1	
Dalli type Dall's porpoise	2/1			2/1	
Unidentified dolphin	2/1			2/1	
Unidentified cetacean	1/1			1/1	

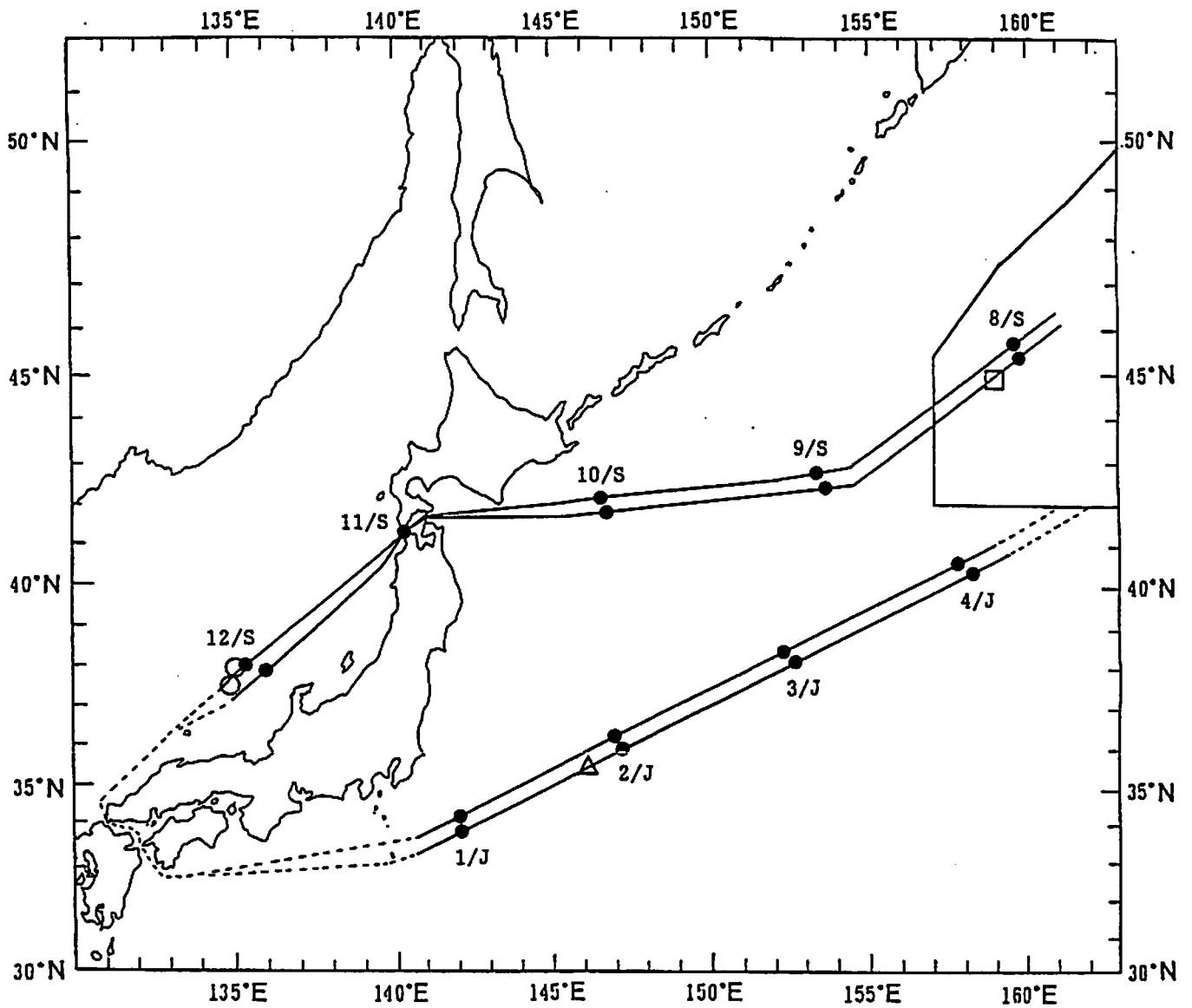


Fig. 1 . Cruise track and noon positions of two sampling and sighting vessels and distribution of minke: ○, blue: □ and Bryde's: △ whales sighted by two vessels in sighting survey for the JARPN in 1994. Solid and broken lines represent the course of the searching and moving respectively.