

**Preliminary Report on the Second Research Cruise
by Kaiyo maru for fiscal 1989**

**Research on Pollock Stock in the International Waters
of the Bering Sea**

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Introduction

This is a preliminary report on research on pollock stock in the international waters of the Bering Sea conducted as the Second Research Cruise by Kaiyo maru for fiscal 1989. Additions and modifications were made to the prompt report compiled on board Kaiyo maru on its return cruise. Therefore, the contents reported here represent only a part of the data obtained from the research and its results are preliminary. Despite such limitations, this report may provide an overall picture of the research.

Like the previous research on pollock by Kaiyo maru in the Aleutian Basin, the present research was conducted with the participation of scientists of various countries concerned. These foreign researchers cooperated among themselves in such activities as dealing with catches, biological measurement and collection of various samples. They also collaborated with Japanese researchers in the implementation of the research. Highly efficient research was made possible, helped by favorable weather conditions and flexible application of research procedure to changing situation in the research area. We are convinced that ample results were obtained in terms of international cooperation and data collection, despite the short research period. I wish to express our sincere appreciation to Captain Teruo Morooka and all the crew of Kaiyo maru for their wholehearted cooperation.

Background and Objectives of the Research

Catches of pollock in the entire Bering Sea have increased rapidly over recent years, reaching 3,640,000 tons in 1987, because new fishery targeted at pelagic pollocks was developed in the international waters of the Bering Sea. Of the total catches, those from the international waters of the Bering Sea aggregated 1,280,000 tons, but harvesting targeted at pollock in the Aleutian Basin including the international waters, was conducted not only in the international waters but also off Bogoslof Island in the U.S. 200-mile zone, southeast of the Basin and the Kamchatka Basin in the U. S. S. R. 200-mile zone. Catches in the waters off Bogoslof Island in 1987 were 330,000 tons, and if those caught in the Kamchatka Basin are included, a total of about 2 million tons of pollock is estimated to have been taken from the Basin area.

To clarify whether these pollocks taken extensively in the Basin area belong to a single stock or what the relations are between the pollocks living in the Basin area and

those living on the continental shelf have become important and urgent international issues in order to establish a strategy for a rational utilization and management of pollock stock in the whole area of the Bering Sea. Accordingly, Japan has been positively promoting research targeted at pollock since 1988, and has been exerting efforts in conducting research under international cooperation to a maximum possible extent. As part of these research activities, the Fisheries Agency of Japan implemented the Second Research for fiscal 1989 by Kaiyo maru in January and February in 1990 in international waters of the Bering Sea with the aim to collect basic data concerning pollock stock in the said area.

Under the initial program, a joint research proposal was made to the U. S. S. R. Government in the hope to conduct the research in the Kamchatka Basin area in the U. S. S. R. waters where it was disclosed that high-density distribution of pollock was observed. But, as this proposal was not accepted by the U.S.S.R., the research was conducted only in a part of international waters of the Bering Sea in consideration of the limited length of the research period. From the information obtained in recent years, it was assumed that there is little possibility for high density distribution of pollock stock in international waters of the Bering Sea in the period of the present research. However, the attempt to conduct such a research, taking every possible opportunity, was deemed very significant in that it improves our knowledge on pollock stocks and further promote international joint research and studies.

This research was first proposed by Japan at the "International Conference on Cooperation in the Bering Sea Pollock Stock" held at the National Research Institute of Far Seas Fisheries in August 1989. Not only nations participating in the conference (the Republic of Korea and Poland) but also all the nations concerned were called upon for taking part in the research. As a result, one scientist each from the Republic of Korea, Poland, the United States and the U. S. S. R. participated in the research.

Research Vessel and Research Equipment

Kaiyo maru, a stern trawl-type research vessel owned by the Fisheries Agency, was 2,644 tons, with the total length of 91.87 m, width of 15 m and depth of 9.20 m. The vessel was equipped with various equipment for research of fishery resource and marine environment. In the present research, quantitative echo sounder system, midwater trawl net, CTD, and NORPAC net were mainly used. A quantitative echo sound-

er system (FQ-50) manufactured by Furuno Electric Co. was equipped with a recorder to record echogram data and a printer to print integral calculus results. A transducer, using a frequency of 50kHz, was installed in the ship's bottom at about 9-10 m from the sea surface.

The Kaiyo maru midwater trawl (KMT) net, used in the present research, was the same type as the one used in the two past Bering Sea pollock stock researches. Mesh size was within the range of 600 mm at the opening of the trawl net and 75 mm at the cod end, and the length from the middle part of head rope to cod end was 78.55 m. The otter board was about 6.0 m², and aerial weight was about 1.8 tons (one side), with the length of hand rope was 150 m. In the middle of the head rope was installed a transducer to monitor the water depth and the height of opening of the trawl net. The average height of opening of the trawl net, when towed at an average speed of 3.6 knots, was 17 m. According to the results of the previous research, the distance between wing tips of net in case towed at a speed of 3 knots, was about 25 m, although this measurement was not made in the present research.

The vertical distribution of the water temperature and conductivity (salinity) was measured by the CTD system manufactured by Neal Brown, and the temperature of surface water was measured with a bucket thermometer. Zooplanktons were collected using the NORPAC net with an aperture of 45 cm.

Cruise Itinerary, Research Areas and Research Procedure

Kaiyo maru left the Tokyo Port for the Bering Sea on January 20, 1990, after making calibration of the quantitative echo sounder system on the previous day. The ship steamed alongside the Kuril Islands and arrived in the Bering Sea off Attu Island on January 27. The vessel hour was set at the world time + 12 hours, by making 30-minute advancement of the clock each day between January 20 and 26. In the present research, the maximum possible sojourn in the research area were estimated at 10 days, therefore it was not possible to survey the entire international waters. It was decided from the outset that research was to be conducted in a part of the international waters. The criterion to select research area was the distribution of fish schools. For this purpose, information concerning the operation of Japanese fishing boats was collected from time to time during the cruise. As the operation of Japanese fishing boats concentrated in the southeastern area of the international waters in late January, that area was decided as the research area on January 27. At 05:00 on January 29, Kaiyo

maru arrived at a point of 50° 30' N and 176° 30' W, and started fish school searching survey by means of the quantitative echo sounder system. At 08:00 on the same day, the first CTD and NORPAC net observation was made at a point of 55° 56' N and 176° 30' W. The survey was followed by midwater trawling activities. In the research area, many fishing boats including those from Japan, the Republic of Korea, Poland and the U. S. S. R. were operating. As it was necessary to take heed not to hamper these operations, it was not possible to establish the fixed transect lines and survey stations for the research in advance. Fish school search survey was conducted mainly at night, using the quantitative echo sounder system, and oceanographic observation and midwater trawling were conducted during daytime.

Until February 3, in the area between 56° 00' N and 56° 30' N and 176° 30' W and 178° 00' W, oceanographic observation and midwater trawling were conducted during daytime, and fish school searching surveys were made in the areas between 55° 30' N and 56° 40' N latitudinally and 177° 00' W and 178° 30' W longitudinally. As virtually no echograms were observed in the area south of 56° 00' N and west of 177° 00' W, searching was conducted in the area east of 177° 00' W at nighttime on February 3. As a result, relatively clear echograms were observed around the area of 55° 40' N and 176° 30' W. Therefore, research was conducted near this point from February 4 to 6. No fishing boats operated in this area.

At 17:30 on February 6, the last midwater trawling was completed at the point of 55° 39' N and 176° 26' W, and the ship started the return cruise to Tokyo. Kaiyo maru proceeded southward taking mostly the same course as in the coming cruise and safely arrived and anchored off Haneda in the morning of February 15 as it made a smooth cruising not encountering stormy weather it had predicted. In the afternoon of the same day, the U. S. S. R. scientist who was pressed in the schedule for return trip to his home country disembarked using Kaiyo maru's craft. At 09:30 on February 16, the vessel came alongside the Harumi Pier of the Tokyo Port, marking the end of the research cruise.

Table 1 shows the results of the noon observation during the cruise, and Fig. 1 shows the track line on the basis of the noon position.

Research Items and Methods

Research items are largely divided into fish school search survey, midwater trawling research, biological measurement research and marine environment research. The fish

school search survey was conducted using the quantitative echo sounder system mainly at night with the cruising speed set at 8 knots per hour. The track line is shown in Fig. 2. When clear echogram was observed, a more detailed research followed in the surrounding area and preparations were made for the midwater trawling research on the next morning.

In midwater trawling research, towing was conducted mainly during daytime, and step-by-step towing and fixed horizontal towing were conducted within the depth range of 145-500 m according to echogram. In the beginning, three one-hour tows were conducted in a day but as it was inefficient in that few fish were caught. Therefore, from the third day, two tows were made a day with towing hours set at 2-3 hours at one time. Towing speed was within the range of 3.3-4.2 knots, with the average speed standing at 3.6 knots. Operation records are shown in Table 2 and the tow positions in Fig. 3. Number and weight of catches were recorded by species or species groups to clarify catch composition. But jellyfish was not counted as individuals.

Biological measurement was conducted for 40 each of male and female pollocks for each towing. All the individuals were measured when the number of the catch was less than 40, and, when it exceeded 40, the size of the surplus catch was measured for all the individuals by sex. However, as the number of catch in the last towing (ST-21) was large, not all the individuals were measured. The items of biological measurement consisted of fork length, weight, sex, weight of gonad and maturity of gonad. Besides these items, Japan collected gonad and stomach as specimens in formalin and also collected frozen pollock specimens for biochemical analysis. As age specific data, the Republic of Korea, Poland and the United States collected otoliths and the U. S. S. R. collected scales. The Republic of Korea conducted measurement of morphometrics and collected specimens for biochemical analysis, and Poland conducted measurement of morphometrics and meristics. Observation of stomach contents were conducted by the U. S. S. R.

Although CTD observation and collection of zooplanktons had been initially scheduled to be conducted at each tow point of midwater trawling, it was considered unnecessary to do so because of the limited extension of the research area and the limited duration of the research period. Further, one observation was made per day from the second day onward. Fig. 3 shows the observation points and Table 3 shows record items at each observation point. In CTD observation, the wire length was set at 1,00 m and data to the depth of 1,000 m were collected. In collection using NORPAC net, the length of wire was set at 330 m and vertical towing was made

at a speed of 1 m per second from the depth of 300 m. A water filtration device was attached to the net to measure the amount of filtrated water. The average amount of filtrated water per one towing was 56.7 m³ (Table 3)

Scientific Personnel

Japan: Takashi Sasaki, National Research Institute of Far Seas Fisheries

Republic of Korea: Won Sook H. Yang, Resources Division, National Fisheries Research & Development Agency

Poland: Andrzej Paciorkowski, National Sea Fisheries Institute

United States: Dennis Benjamin, Alaska Fisheries Science Center, National Oceanic and Atmospheric Administration

Soviet Union: Nicolay S. Fadeev, Pacific Research Institute of Fisheries and Oceanography (TINRO)

Kaiyo maru: All the crew assisted in the research activities, but the following officials in the ship's Research Section collaborated with the scientists specially in the conduct of the research and compilation of data.

Minekiyo Hasegawa
Toshimasa Yanagisawa
Yoshizo Suzuki
Seiji Toishi
Kei Miyamoto

Summary of Research Results

The research results compiled on board the ship during the cruise are summarized as follows:

1. The density of pollock in the research area was considered fairly low, judging from the records of echogram and SV values (mean volume back scattering strength) as observed on the record sheets of the quantitative echo sounder system.
2. Dot or mist like echogram was observed on the record sheet of the quantitative echo sounder system (Fig. 4). Dot like echogram appeared mainly in the depth of 150-250 m both during day and night time. Mist like echogram was seen in the depth of 400-500 m during daytime but in the depth of 150-300 m at night, thus indicating a clear difference in

depth between day and night. At night, both dot- and mist like echogram was simultaneously observed in the 150-300 m.

3. A total of 21 midwater trawlings were conducted in the depth of 145-500 m on the basis of echogram, and 2,320 pollocks (total weight of 1,855.7 kg) were caught (Table 4). Besides pollocks, smooth lumpsucker (320 fish total weight of 384.4 kg), squid (144 fish total weight of 19.7 kg), and jellyfish (total weight of 81.3 kg) were among the main catches.

4. In the towing operation at the depth of 400-500 m, lanternfishes, Pacific viperfish, northern smoothtongue, deepsea smelts, longfin dragonfish, northern pearleye, and various species of squid were caught incidentally (Table 4), suggesting that mist like echogram was the DSL by the middle and deep layer biotic community.'

. According to the results of the 14 midwater trawling irected at dot like echogram at the depth of 150-250 m (ST-2, 5, 17, 18, 19, 20, 21) and mist like echogram at the depth of 400-500 m (ST-7, 8, 9, 11, 14, 15, 16), pollocks were caught at both depth layers. The average CPUE (number of fish/hour) was 83 fish at the depth of 150-250 m and 42 fish at the depth of 400-500 m. The maximum CPUE was 162 fish at the depth of 150-250 m (ST-21), 90 fish at the depth of 400-500 m (ST-7) (Table 2). It is conjectured from these results that the 150-250 m depth layer represented a higher distribution of pollock than 400-500 m depth layer.

6. According to the information from Japanese fishing vessels operating in the research area, the average daily catch per vessel between January 22 to February 6 was in the range of 17.2 tons to 53.4 tons for large vessels and 9.0 tons to 31.9 tons for small vessels (Fig. 5). With the midwater trawling of Kaiyo maru, maximum catch per hour was 131.6 kg in ST-21 (Fig. 2). This means that only 3.2 tons can be caught even if the trawling net is operated for the whole day. The difference in catch volume from fishing vessels was due to the substantial gap in the fishing technology and the difference in the fishing gear. The midwater trawl net (KMT net) Kaiyo maru used in the present research is an old-fashioned one. It was not a modernistic midwater trawl net, commonly called rope net, which has been used by Japanese fishing boats in recent years. As the resistance of KMT net was great. it was towed at the speed of only 3.6 knot on the average. The net was small and the opening of the trawl net space at the time of towing was considered to be about one fifth of the net used by fishing boats.

7. The length composition of pollock was within the range

of 39 cm to 60 cm in terms of fork length, with the mode standing at 49-50 cm and the average length at 49.1 cm (Fig. 6). The mode of male was 48-49 cm, with the average length at 48.2 cm, and the mode of female was 49-50 cm, with the average length of 49.9 cm, indicating that the length of female was larger than that of male (Fig. 7).

8. Comparing the length of pollock caught in the 150-250 m depth layer and those caught in the 400-500 m depth layer, the mode of the two was within the range of 49-50 cm, and the average length from the 150-250 m depth layer was 49.3 m and the that from the 400-500 m depth layer was 49.0, thus indicating little or no difference (Fig.8). However, the percentage of large fish of 50 cm or more was 38% for the fish from the 150-250 m depth layer and 28% from the 400-500 m depth layer.

9. The average weight of pollock on the basis of precision measurement data was 810.6 g. The average weight of female was 876.3 g, as compared with 740.1 g for male. The average weights of pollock caught in the 150-250 m and 400-500 m depth layers were 800.7 g and 815.9 g, respectively, indicating a negligible difference.

10. The relation between length and weight of pollock was shown in Fig. 9, and the following formula was assumed to express it:

$$BW = 7.7618 \times 10^{-6} FL^{2.9783}$$

Here BW means weight (g) and FL means fork length (mm)

11. The average weight of ovary and spermary of pollock was 85.2 g and 58.5 g, respectively, occupying 9.7% and 7.9% of the body, respectively. Most of gonads of both male and female were mature. While part of the male were in the stage of spermatozoa discharge, female individuals having hydrated oocyte indicating the stage of spawning was only 0.7% out of 874 individuals for which maturity gonad was checked (Fig. 10). 93.7% of female pollock had fully mature ovary, with the immature ovary standing only at 5.3%.

12. No difference in catch by depth layer was observed by human eyes in the process of development of female gonad. However, distribution of indexes obtained through dividing the weight of gonad by body weight showed that gonad of the individuals caught in the 400-500 m depth layer showed more advanced development stage of gonad than those caught in the 150-250 m depth layer (Fig. 11)

13. The sex ratio of pollock was 45% male and 55% female, indicating that there were more females than males. No

difference in sex ratio due to the catch depth was observed.

14. According to the results of CTD observation, both water temperature and salinity showed a similar vertical distribution, and conspicuous thermocline were observed in the 120-200 m depth layer (Fig. 12). Pollock was distributed mainly in waters deeper than thermocline, but some were deemed to exist in the thermocline. In areas above thermocline, the water temperature was within the range of 2.3-2.9 degrees centigrade and there was no vertical changes. But the water temperature sharply rose in the thermocline, peaking out at 3.4-3.7 degrees centigrade in the 250-300 m depth layer, and subsequently gradually declining according to depth, reaching 2.7 degrees centigrade at the depth of 1,000 m. The vertical distribution of water temperature and salinity at the last observation point (ST-20) showed unclear thermocline, unlike those observed previously (Fig. 12). In other words, both water temperature and salinity gradually increased from surface layer to 200 m depth layer, suggesting that there was either mixture of sea water because of vertical mixing of water thermocline above and below or partial flow different water mass into the area of sea depth above thermocline.

15. In areas above thermocline, salinity stayed within the range of 33.04-33.11 0/00, then suddenly rose to 33.50 0/00 or higher, and later rose in pace with the water depth, reaching 34.32- 34.35 0/00 at the depth of 1,000 m (Fig. 12).

16. In addition to what was reported in the foregoing, research institutions of various countries participating in the present research are expected to conduct research on age composition, feeding habit, studies on histology of gonad and morphometrics and meristics as well as biochemical studies concerning pollock on the basis of specimens collected in the present research.

Table 1. Noon positions and observations during the research cruise by Kaiyo maru for pelagic pollock survey in the international waters of the Bering Sea in January and February of 1990.

Date	Position		Time difference from GMT	Survey stations	Weather	Wind		Air press. (mb)	Air temp. (° C)	Sea surf. temp. (° C)	Wave
	Latitude	Longitude				Dirac.	Force				
20 Jan.	35° -19.4' N	139° -19.4' E	+ 9:00		o	N	6	1019.5	6.1	10.8	4
z1	36° -27.2' N	142° -18.5' E	+ 9:30		bc	NE	1	1026.3	1.2	9.1	Cal m
z2	42° -41.8' N	145° -31.7' E	+ 9:30		b	ESE	3	1019.8	-1.6	1.7	3
z3	45° -42.2' N	150° -25.6' E	+10:00		o	WSW	6	997.2	1.0	1.5	5
z4	49° -30.0' N	155° -31.0' E	+10:30		c	SW	7	994.0	-0.6	1.3	7
z5	51° -29.9' N	162° -15.9' E	+11:00		o	SSE	5	999.5	-0.6	2.1	4
z6	52° -40.3' N	167° -25.9' E	+11:30		s	NE	7	992.5	0.4	2.8	7
z7	53° -43.3' N	172° -10.2' E	+12:00		o	WNW	2	998.0	-0.4	3.7	3
z8	54° -43.8' N	178° -22.3' E	+12:00		bc	SW	4	994.3	0.3	3.0	4
z9	56° -05.4' N	176° -41.7' W	+12:00	1~3	s	SW	4	974.5	2.0	3.0	4
≥0	56° -14.4' N	176° -58.8' W	+12:00	4~6	o	SW	7	997.2	0.5	2.8	6
≥1	56° -05.1' N	177° -25.1' W	+12:00	7~8	bc	WNW	3	995.0	0.4	2.8	3
1 Feb.	56° -06.8' N	177° -41.6' W	+12:00	9~10	o	N	5	991.5	-0.9	2.7	4
2	56° -14.1' N	177° -32.8' W	+12:00	11~13	oc	W	6	1000.9	-1.3	2.9	5
3	56° -15.9' N	177° -43.0' W	+12:00	14~15	s	NW	5	1006.5	-2.6	2.8	4
4	55° -38.2' N	176° -29.3' W	+12:00	16~17	bc	WNW	6	1012.0	-2.0	2.7	6
5	55° -42.6' N	176° -36.6' W	+12:00	18~19	o	WSW	4	1012.7	1.8	2.7	4
6	55° -38.6' N	176° -25.2' W	+12:00	20~21	s	WNW	3	1010.5	-1.0	2.7	3
7	54° -57.7' N	178° -04.2' E	+12:00		o	WNW	7	1012.6	-5.2	2.9	6
8	53° -44.1' N	170° -01.4' E	+11:30		oc	NW	5	1019.0	-6.0	3.0	5
9	51° -31.9' N	161° -28.3' E	+11:00		s	E	8	1007.5	-0.4	1.5	7
10	48° -16.1' N	155° -54.2' E	+10:30		s	WNW	7	1020.5	-3.8	1.0	6
11	45° -05.4' N	149° -20.4' E	+10:00		o	SE	5	1024.3	2.1	1.2	4
12	42° -04.6' N	145° -08.4' E	+10:00		b	WSW	6	1005.5	3.4	3.1	5
13	38° -46.7' N	141° -53.8' E	+ 9:30		c	WSW	5	1020.0	3.6	8.6	3
14	37° -21.6' N	141° -19.4' E	+ 9:00		o	N	3	1029.5	5.4	10.9	2
15	35° -34.6' N	139° -49.2' E	+ 9:00		d	NNW	5	1022.5	4.6	9.1	3
16	Came alongside the Harumi Pier of Port of Tokyo at 9:30 AM										

Table 2. Operation records of midwater trawl for pelagic pollock by Kaiyo maru in the international waters of the Bering Sea from January 29 to February 6 of 1990.

Station No.	ST-01	ST-02	ST-03	ST-04	ST-05	ST-06	ST-07	ST-08
Date	Jan. 28	Jan. 29	Jan. 29	Jan. 30	Jan. 30	Jan. 30	Jan. 31	Jan. 31
Start time of tow	0:40 0	14:25	18:40	08:30	13:35	17:25	08:30	13:45
End time of tow	0:40 0	15:25	19:35	09:30	14:35	18:25	09:30	16:45
Start position	55° 57.3' N	56° -14.7' N	56° -25.7' N	56° -22.8' N	56° -16.0' N	56° -08.5' N	56° -07.8' N	56° -05.4' N
of tow	178° 34.2' W	176° -39.7' W	176° -41.1' W	176° -57.8' W	176° -56.6' W	177° -00.0' W	177° -16.1' W	177° -28.3' W
End position	55° 58.7' N	56° -17.8' N	56° -26.1' N	56° -25.0' N	56° -18.6' N	56° -09.9' N	56° -09.4' N	56° -04.6' N
of tow	176° 40.0' W	176° -35.5' W	176° -34.6' W	176° -53.3' W	176° -51.0' W	176° -53.8' W	177° -10.5' W	177° -50.1' W
Towing hours (h-m)	0-00 0	01-00	00-55	01-00	01-00	01-00	01-00	03-00
Towing speed (kn)	.5	3.9	3.9	3.3	4.1	3.7	3.5	4.1
Towing distance (nm)	.5	3.9	3.6	3.3	4.1	3.7	3.5	12.3
Towing depth range (m)	Z1-3185	170-220	160-270	170-400	170-220	160-295	420-445	400-440
Height of net opening (m)	1-119	16-20	17-19	16-19	15-18	16-17	17-18	16-17
Type of echogram ¹	A	A	A	D	A	A	C	C
Range of echogram (m)	150-250	170-190	150-280	-	150-220	150-300	420-460	350-480
Pollock catch (number)	47	61	7	11	54	14	90	193
Pollock catch (kg)	41.8	51.2	5.9	7.9	45.7	12.5	75.6	158.7
Pollock CPUE (Number/hour)	47	61	8	11	54	14	90	64
Pollock CPUE (kg/hour)	41.8	51.2.	6.4	7.9	45.7	12.5	75.6	52.9

Table 2. Continued.

Station No.	ST-09	3-10	ST-11	ST-12 ²	ST-13	ST-14	ST-15	ST-16
Date	Feb. 01	Feb. 01	Feb. 02	Feb. 02	Feb. 02	Feb. 03	Feb. 03	Feb. 04
Start time of tow	08:35	14:50	09:35	13:06	16:35	09:40	13:15	09:40
End time of tow	10:35	17:50	12:00	-	17:35	12:00	17:00	12:00
Start position Lat.	56' -12.4 'N	56' -08.0 'N	56' -11.1 'N	56' -14.0 'N	56' -14.2 'N	56° -17.8 'N	56° -15.0 'N	55" -44.7 'N
of tow Long.	177' -38.1 'W	177' -34.9 'W	177' -47.1 'W	177° -26.1 'W	177' -18.1 'W	177' -28.6-W	177° -40.7 'W	176° -41.5 'W
End position Lat.	56° -08.4 'N	56° -03.7 'N	56° -14.1-N	-	56' -15.1 'N	56' -16.0 'N	56° -18.0 'N	55' -38.2 'N
of tow Long.	177' -50.7 'W	177' -55.7 'W	177' -32.7 'W	-	177' -11.8 'W	177' -42.9 'W	177° -16.9-W	176" -29.3 'W
Towing hours (h-m)	02-00	03-00	02-25	-	01-00	02-20	03-45	02-20
Towing speed (kn)	4.1	4.1	3.6	-	3.6	3.5	3.6	4.1
Towing distance (nm)	8.2	12.3	8.7	-	3.6	8.2	13.5	9. ti
Towing depth range (m)	360-460	210-470	400-450	-	250-400	445-500	400-460	410-440
Height of net opening (m)	16-18	15-18	17-10	-	15-18	17-19	16-17	17
Type of echogram ¹	A	A+C	C	C	A	C	C	C
Range of echogram (m)	350-450	300-450	450	420-460	200-300	400-500	400-480	420
Pollock catch (number)	85	116	56	4	5	72	66	60
Pollock catch (kg)	72.9	85.5	43.3	3.2	4.3	58.9	52.3	48.8
Pollock CPUE (Number/hour)	43	39	23	-	5	31	10	28
Pollock CPUE (kg/hour)	36.5	28.5	17.9	-	4.3	25.2	13.9	20.9

Table 2. Continued.

Station No.	ST-17	ST-18	ST-19	ST-20	ST-21
Date	Feb. 04	Feb. 05	Feb. 05	Feb. 06	Feb. 06
Start time of tow	14:50	09:30	12:55	09:25	12:55
End time of tow	17:00	12:00	15:02	12:00	17:00
Start position Lat.	55° -44.6 'N	55° -38.9 'N	55° -44.2 'N	55° -43.3 'N	55° -39.0 'N
of tow Long.	176° -41.4 'W	176° -53.2 'W	176° -32.1 'W	176° -42.2 'W	176° -25.6 'W
Endposition Lat.	55° -38.2 'N	55° -42.6 'N	55° -43.1 'N	55° -38.6 'N	55° -38.9 'N
of tow Long.	176° -30.0 'W	176° -36.6 'W	176° -36.6 'W	176° -25.2 'W	176° -52.1 'W
Towing hours (h-m)	02-10	02-30	02-07	02-35	04-05
Towing speed (kn)	4.2	3.8	3.6	4.1	3.7
Towing distance (nm)	9.1	9.5	7.6	10.6	15.1
Towing depth range (m)	145-220	180-225	200-250	165-215	190-270
Height of net opening (m)	15-16	17-18	16-18	16-18	15-18
Type of echogram ¹	B	B	D	B	B
Range of echogram (m)	120-250	200	-	100-250	150-220
Pollock catch (number)	254	204	98	160	663
Pollock catch (kg)	180.2	161.2	79.7	120.7	537.4
Pollock CPUE (Number/hour)	117	82	46	62	162
Pollock CPUE (kg/hour)	83.2	64.5	37.7	49.8	131.6

¹ Abbreviation of echogram:

A : Scattered dot like echogram

B : Dot like echogram

C : Weak mist like echogram

D : No echogram

² Unsuccessful tow because the tow was discontinued just after start of tow due to engine trouble.

Table 3. Records of oceanographic observations by Kaiyo maru in the international waters of the Bering Sea from January 29 to February 6 of 1990.

Station Number	ST-01	ST-02	ST-03	ST-05	ST-08	ST-10	ST-11	ST-14
Date	Jan. 29	Jan. 29	Jan. 29	Jan. 30	Jan. 31	Feb. 1	Feb. 2	Feb. 3
Time	08:05-09:02	13:06-13:58	17:03-18:09	12:05-13:05	12:02-12:54	13:00-14:13	08:04-08:57	08:00-09:00
Position Lat.	55° -56.3 ' N	56° -13.7 ' N	56' -25.3 ' N	56° -14.6 ' N	56' -05.1 ' N	56° -09.2 ' N	56° -10.1 ' N	56° -17.8 ' N
Long.	176" -29.9 ' W	176' -41.3 ' W	176' -43.6 ' W	176' -58.8 ' W	177° -25.1 ' W	177° -30.9 ' W	177° -51.8 ' W	177° -22.5-W
Bottom depth (m)	-	3,710	3,728	3,730	3,680	3,773	3,778	3,762
Weather	c	c	c	o	bc	o	bc	b
Wind direction	ENE	SW	W	SW	WNW	N	W	E
Wind force	4	4	3	7	3	5	6	4
Air pressure (mb)	975.5	974.5	977.0	997.2	995.0	991.5	1,000.4	1,007.6
Sea condition	4	4	3	6	3	4	5	4
Air temperature (° C)	3.0	1.8	2.6	0.5	0.4	-1.0	-1.3	-1.4
Sea surface temp. (° C)	2.9	2.7	2.6	2.6	2.6	2.5	2.0	2.6
CTD (m)	0-1,090	0-1,090	0-1,091	0~1,090	0-1,092	0~1,091	0~1,091	0-1,091
NORPAC (filtered vol.:m ³)	50.64	52.82	Not recorded	63.25	51.44	63.28	54.27	59.64

Table 3. Continued.

Station Number	ST-16	ST-18	ST-20
Date	Feb. 4	Feb. 5	Feb. 6
Time	08:00-09:00	08:01-09:03	08:00-08:56
Position Lat.	55° -46.9' N	55° -38.2' N	55° -44.2' N
Long.	176° -44.7' W	176° -56.3' W	176° -46.3' W
Bottom depth (m)	3,765	3,778	3,767
Weather	0	0	0
Wind direction	NW	WNW	WNW
Wind force	7	5	4
Air pressure (mb)	1,008.0	1,012.6	1,010.3
Sea condition	6	5	4
Air temperature (° C)	-2.6	-1.0	-2.2
Sea surface temp. (° C)	2.4	3.1	2.6
CTD (m)	0~1,089	0~1,089	0~1,089
NORPAC (filtered vol.:m ³)	48.62	71.04	52.16

Table 4. Catch records of midwater trawl operations by Kaiyo maru in the international waters of the Bering Sea from January 29 to February 6 of 1990.

Species'or species group	ST-01		ST-02		ST-03		ST-04		ST-05		ST-06		ST-07		ST-08	
	N	W(kg)														
Walleye pollock	47	41.80	61	51.20	7	5.90	11	7.90	54	45.70	14	12.50	90	75.60	193	158.70
Pacific cod	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Smooth lump sucker	7	9.30	10	13.40	4	5.60	2	6.00	4	4.40	10	10.90	4	6.20	4	8.70
Rougheye rockfish	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pacific lamprey	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Snipe eels	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	0.02
Deepsea smelts	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	0.07
Northern smoothtongue	-	-	-	-	1	0.02	-	-	-	-	8	0.06	1	0.01	2	0.01
Winged spookfish	-	-	-	-	-	-	-	-	-	-	-	-	1	0.08	-	-
Longfin dragonfish	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pacific viperfish	-	-	-	-	-	-	-	-	-	-	-	-	5	0.03	4	0.03
Northern pearleye	-	-	-	-	-	-	-	-	-	-	-	-	1	0.04	-	-
Lanternfishes	-	-	-	-	-	-	-	-	-	-	-	-	5	0.03	7	0.02
Dreamers	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Manefish	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Squids	1	0.15	-	-	4	0.25	2	0.19	-	-	9	0.21	8	0.45	30	1.74
Jellyfishes	-	5.70	-	2.90	-	5.60	-	-	-	1.50	-	7.90	-	8.20	-	0.70
T o t a l	55	56.95	71	67.50	16	17.37	15	14.09	58	51.60	41	31.57	115	90.64	242	169.99

Table 4. Continued.

Species ¹ or species group	ST-09		ST-10		ST-11		ST-12		ST-13		ST-14		ST-15		ST-16	
	N	W(kg)	N	W(kg)	N	W(kg)	N	W(kg)	N	W(kg)	N	W(kg)	N	W(kg)	N	W(kg)
Walleye pollock	85	72.90	116	85.50	56	43.30	4	3.20	5	4.30	72	58.90	66	52.30	60	48.80
Pacific cod	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Smooth lump sucker	17	30.90	13	13.50	6	13.80	1	0.40	3	3.90	5	6.00	10	24.70	24	60.60
Rougheye rockfish	-	-	-	-	1	2.10	-	-	-	-	-	-	-	-	1	2.30
Pacific lamprey	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Snipe eels	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Deepsea smelts	-	-	-	-	-	-	-	-	-	-	-	-	1	0.02	-	-
Northern smoothtongue	-	-	2	0.01	-	-	-	-	-	-	2	0.01	2	0.02	-	-
Winged spookfish	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Longfin dragonfish	-	-	-	-	-	-	-	-	-	-	-	-	1	0.03	-	-
Pacific viperfish	1	0.01	-	-	-	-	-	-	-	-	7	0.06	7	0.12	-	-
Northern pearleye	-	-	-	-	-	-	-	-	-	-	-	-	2	0.12	-	-
Lanternfishes	2	0.02	2	0.01	-	-	-	-	-	-	3	0.01	4	0.02	-	-
Dreamers	-	-	-	-	-	-	1	0.39	-	-	-	-	-	-	-	-
Manefish	-	-	1	0.60	-	-	-	-	-	-	-	-	-	-	-	-
Squids	12	1.20	30	6.95	12	1.60	5	0.62	4	1.00	8	0.27	15	4.74	2	0.25
Jellyfishes	-	8.40	-	7.40	-	1.80	-	3.40	-	8.80	-	3.10	-	6.20	-	0.90
T o t a l	117	113.43	164	113.97	75	62.60	11	8.01	12	18.00	97	68.35	108	88.27	87	112.85

Table 4. Continued.

Species'or species group	ST-17		ST-18		ST-19		ST-20		ST-21		Total	
	N	W(kg)	N	W (kg)								
Walleye pollock	254	180.20	204	161.20	98	79.70	160	128.70	663	537.40	2,320	1,855.70
Pacific ccd	-	-	1	1.05	-	-	-	-	-	-	1	1.05
Smooth lumpsucker	51	41.70	26	17.00	40	40.80	22	26.00	57	40.60	320	384.40
Rougheye rockfish	-	-	-	-	-	-	-	-	-	-	2	4.40
Pacific lamprey	1	0.90	-	-	-	-	-	-	-	-	1	0.90
Snipe eels	-	-	-	-	-	-	-	-	-	-	1	0.02
Deepsea smelts	-	-	-	-	-	-	-	-	-	-	2	0.09
Northern smoothtongue	-	-	-	-	-	-	-	-	-	-	18	0.14
Winged spookfish	-	-	-	-	-	-	-	-	-	-	1	0.08
Longfin dragonfish	-	-	-	-	-	-	-	-	-	-	1	0.03
Pacific viperfish	-	-	-	-	-	-	-	-	-	-	24	0.25
Northern pearleye	-	-	-	-	-	-	-	-	-	-	3	0.16
Lanternfishes	-	-	-	-	-	-	-	-	-	-	23	0.11
Dreamers	-	-	-	-	-	-	-	-	-	-	1	0.39
Manefish	-	-	-	-	-	-	-	-	-	-	1	0.60
Squids	2	0.10	-	-	-	-	-	-	-	-	144	19.72
Jellyfishes	-	3.60	-	0.50	-	1.70	-	1.20	-	1.83		81.33
T o t a l	308	226.50	231	179.75	138	122.20	182	155.90	720	579.83	2,863	2,349.37

1 English common name referred to Hart (1973): Pacific fishes of Canada.

Table 5. Size (fork length) composition of pelagic pollock caught in midwater trawl operations by Kaiyo maru in the international waters of the Bering Sea from January 29 to February 6 of 1990

Size class (cm)	ST-01		ST-02		ST-03		ST-04		ST-05		ST-06		ST-07		ST-08									
	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀								
35-36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-								
36-37	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-								
37-38	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-								
38-39	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-								
39-40	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-								
40-41	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-								
41-42	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-								
42-43	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-								
43-44	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-								
44-45	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-								
45-46	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2								
46-47	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-								
47-48	3	2	5	7	3	10	1	1	1	1	1	1	1	1	1	1								
48-49	4	1	5	4	2	6	1	1	2	1	1	1	1	1	1	1								
49-50	2	8	10	2	6	8	1	2	3	3	1	4	1	1	2	5								
50-51	3	6	9	-	6	6	-	1	1	6	2	8	-	3	3	7								
51-52	-	4	4	3	5	8	1	1	1	2	7	9	1	1	1	4								
52-53	-	2	2	-	5	5	-	1	1	9	9	1	2	3	1	2								
53-54	-	2	2	-	1	1	-	-	-	1	1	1	2	2	2	2								
54-55	-	4	4	-	-	-	-	-	-	-	-	-	-	-	-	-								
55-56	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-								
56-57	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-								
57-58	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-								
58-59	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-								
59-60	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-								
60-61	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-								
61-62	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-								
62-63	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-								
63-64	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-								
64-65	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-								
Total	13	34	47	27	33	60	3	4	7	4	7	11	28	26	54	5	9	14	35	55	90	76	117	193

Table 5. Continued.

Size class (cm)	ST-09		ST-10		ST-11		ST-12		ST-13		ST-14		ST-15		ST-16									
	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀								
35-36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-								
36-37	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-								
37-38	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-								
38-39	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-								
39-40	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-								
40-41	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-								
41-42	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-								
42-43	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-								
43-44	-	-	3	1	4	-	-	-	-	-	1	1	1	-	-	-								
44-45	1	-	3	1	4	-	-	1	-	-	-	1	1	2	-	-								
45-46	3	2	10	1	11	4	-	-	-	-	-	1	1	1	-	1								
46-47	8	1	9	-	9	7	-	-	-	-	5	-	4	1	5	2								
47-48	5	1	18	5	23	6	5	11	-	-	4	2	3	-	3	2								
48-49	2	9	11	10	5	15	9	5	14	-	15	2	2	1	3	5								
49-50	11	11	22	8	11	19	1	4	5	1	7	5	12	8	20	14								
50-51	5	9	14	4	7	11	2	4	6	-	4	7	11	5	7	15								
51-52	3	1	4	3	7	10	-	5	5	-	-	5	5	1	6	5								
52-53	2	4	6	1	5	6	-	2	2	-	1	5	6	4	8	3								
53-54	-	4	4	1	1	1	-	-	-	-	1	2	3	-	2	2								
54-55	-	2	2	-	-	-	-	-	-	-	1	1	1	2	3	1								
55-56	-	1	1	-	-	-	-	-	-	-	-	2	2	-	-	1								
56-57	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-								
57-58	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-								
58-59	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-								
59-60	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-								
60-61	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-								
61-62	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-								
62-63	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-								
63-64	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-								
64-65	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-								
Total	40	45	85	69	45	114	30	26	56	1	3	4	1	4	5	39	33	72	35	31	66	32	28	60

Table 5. Continued.

Size class (cm)	ST-17			ST-18			ST-19			ST-20			ST-21			Total		
	♂	♀	T	♂	♀	T	♂	♀	T	♂	♀	T	♂	♀	T	♂	♀	Total
35-36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
36-37	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
37-38	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
38-39	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
39-40	-	-	-	-	-	-	-	-	-	1	-	1	-	-	-	1	-	1
40-41	1	1	2	-	-	-	-	-	-	-	-	-	-	-	-	1	2	3
41-42	1	-	1	-	1	1	-	1	1	-	1	1	-	1	1	3	4	7
42-43	3	1	4	-	1	1	-	-	-	1	-	1	2	1	3	8	6	14
43-44	2	1	3	3	3	6	1	-	1	1	-	1	-	3	3	15	17	32
44-45	4	1	5	1	-	1	5	1	6	1	-	1	3	4	7	30	13	43
45-46	8	5	13	12	2	14	2	1	3	3	5	8	11	5	16	84	28	112
46-47	10	3	13	10	5	15	3	1	4	7	3	10	23	9	32	107	34	141
47-48	15	11	26	16	6	22	5	5	10	5	10	15	38	18	56	170	90	260
48-49	27	22	49	17	17	34	6	9	15	15	12	27	45	23	68	195	150	345
49-50	17	28	45	15	13	28	6	8	14	12	17	29	30	46	76	146	228	374
50-51	11	18	29	12	22	34	5	13	18	6	18	24	23	45	68	87	189	276
51-52	4	22	26	4	21	25	3	6	9	4	16	20	16	21	37	56	158	214
52-53	2	12	14	2	13	15	-	7	7	2	9	11	2	18	20	17	107	124
53-54	2	7	9	1	2	3	-	5	5	-	4	4	1	13	14	5	49	54
54-55	-	2	2	-	3	3	-	2	2	-	2	2	-	2	2	-	23	23
55-56	1	1	2	-	-	-	-	3	3	-	1	1	-	3	3	2	13	15
56-57	-	-	-	-	-	-	-	-	-	-	1	1	1	-	1	1	5	6
57-58	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	1	1	2
58-59	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
59-60	-	-	-	-	-	-	-	-	-	1	-	1	-	-	-	1	-	1
60-61	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
61-62	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
62-63	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
63-64	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
64-65	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	108	135	243	93	109	202	36	62	98	59	99	158	196	212	408	930	1,117	2,047

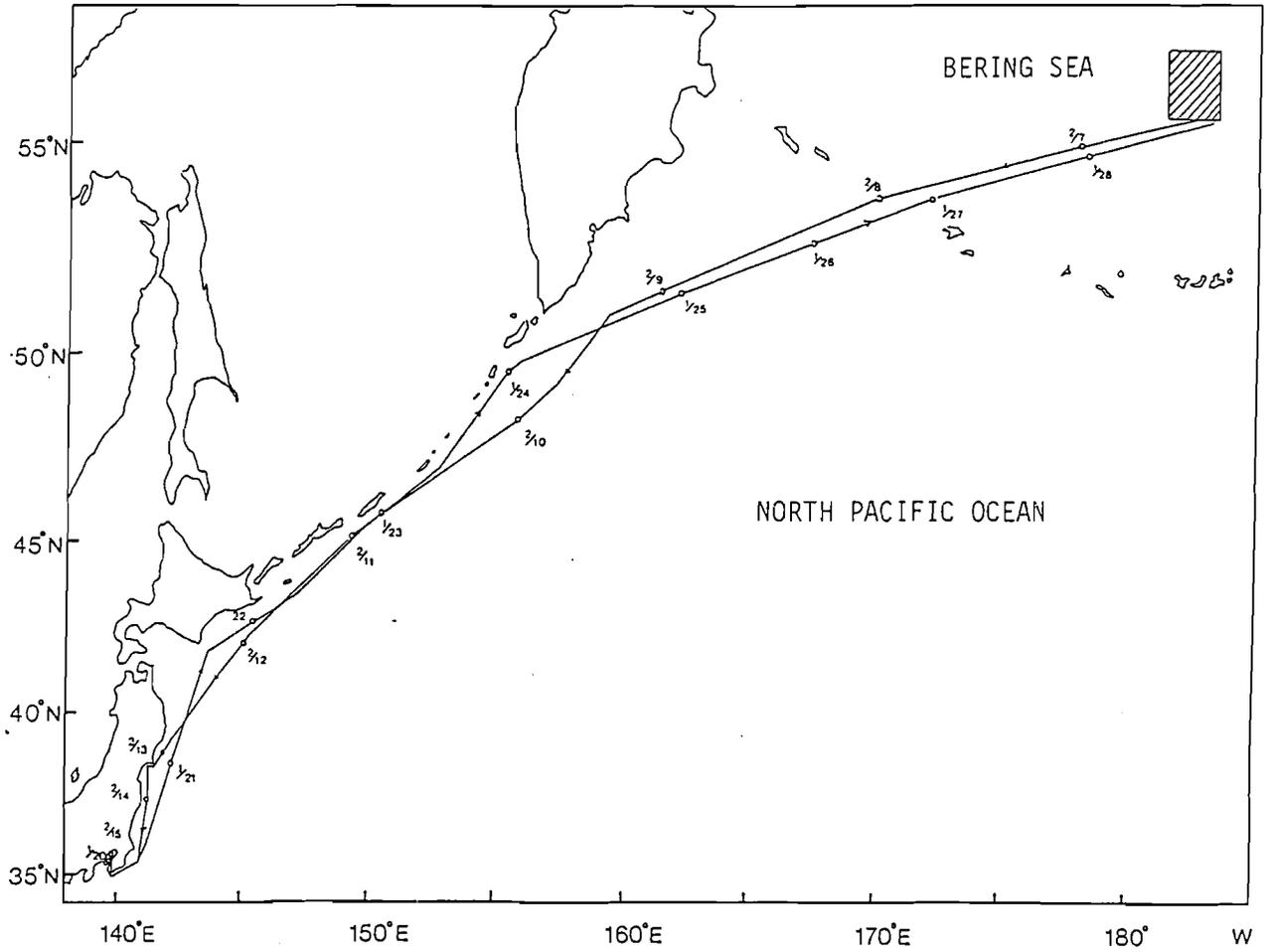


Figure 1. Track and noon positions of a cruise by Kaiyo maru for the pelagic pollock survey in the international waters of the Bering Sea from January 20 to February 16 of 1990.

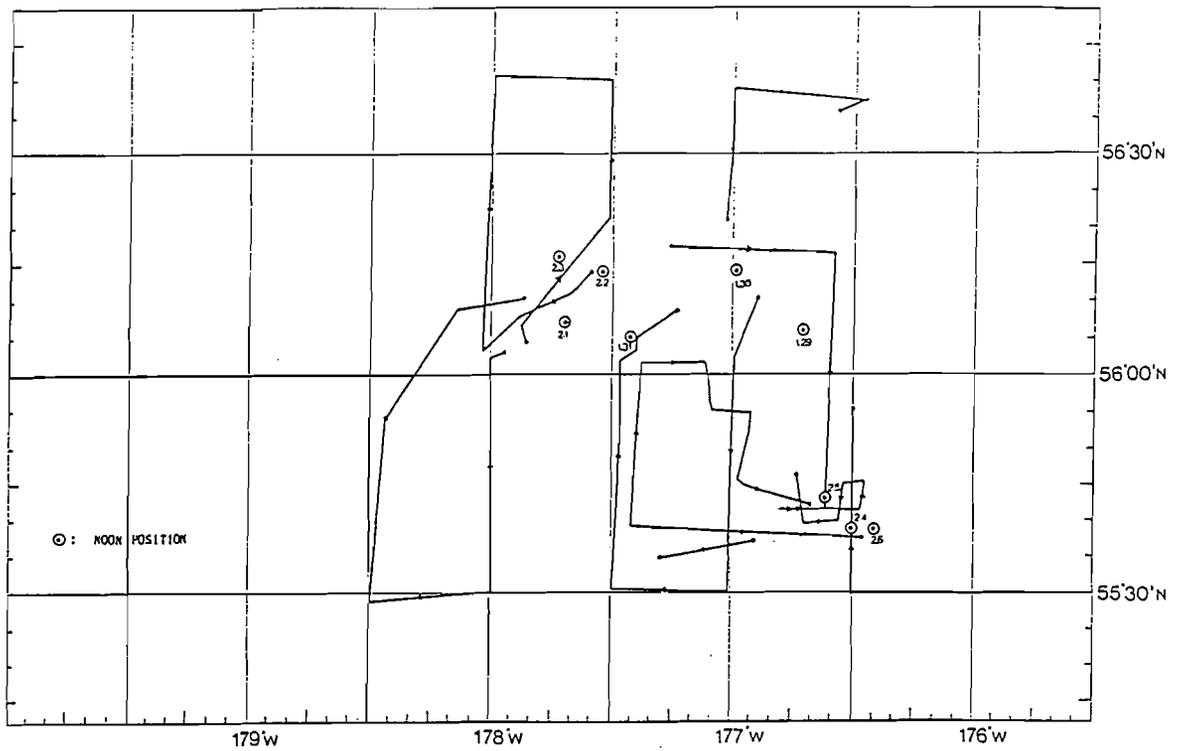


Figure 2. Track line for searching pelagic pollock school by Kaiyo maru using quantitative echo sounder system in the international waters of the Bering Sea from January 29 to February 6 of 1990.

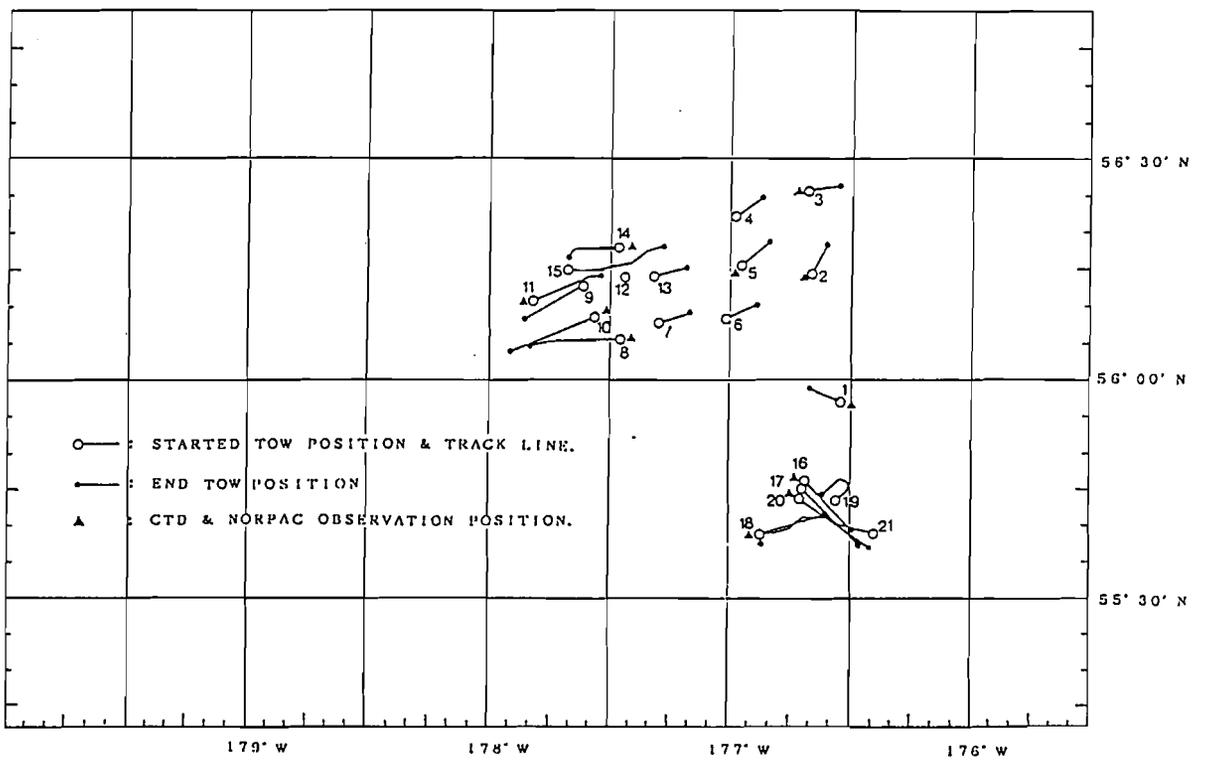
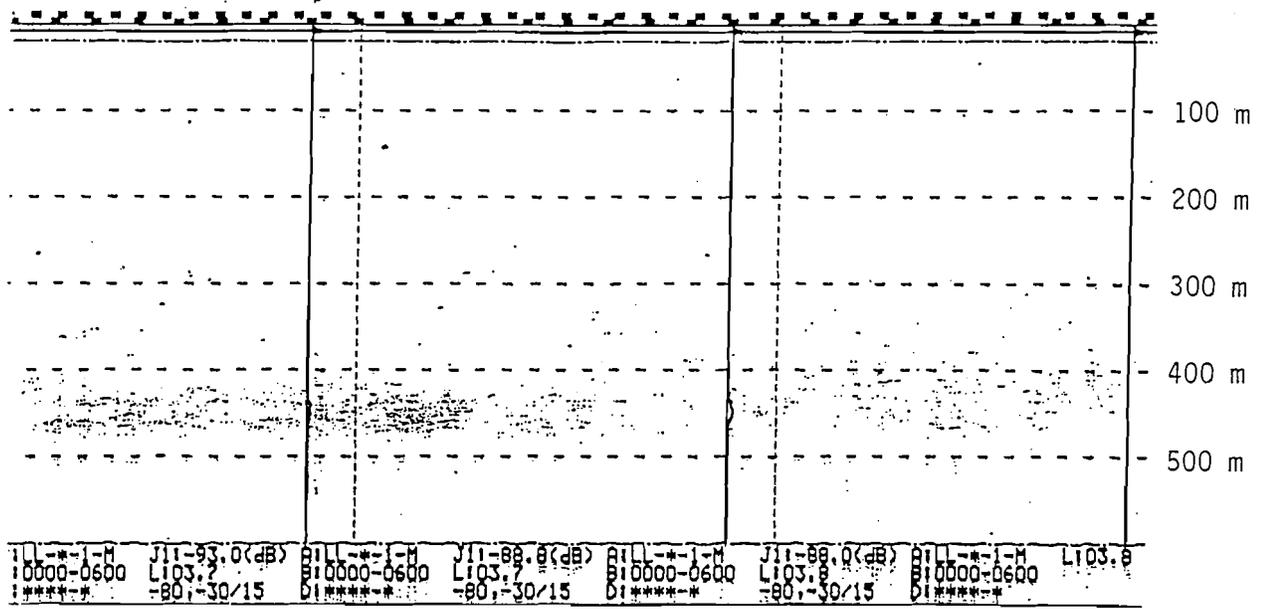


Figure 3. Track line of midwater trawl operations for pelagic pollock and oceanographic stations conducted by Kaiyo maru in the international waters of the Bering Sea from January 29 to February 6 of 1990.

ST-8



ST-20

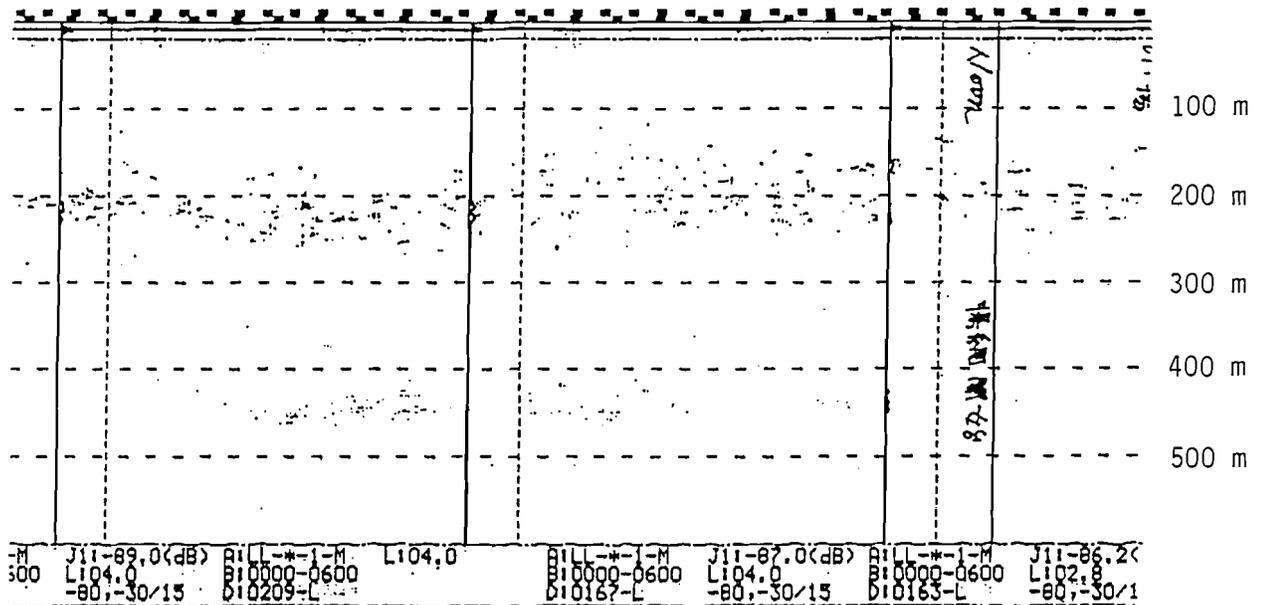


Figure 4. Echogram from quantitative echo sounder obtained in the pelagic pollock survey by Kaiyo maru in the international waters of the Bering Sea from January 29 to February 6 of 1990. The upper figure shows a weak mist like echogram observed in a 400-500 m depth layer at ST-8 and the lower figure shows a dot like echogram observed in a 150-250 m depth layer at at ST-20.

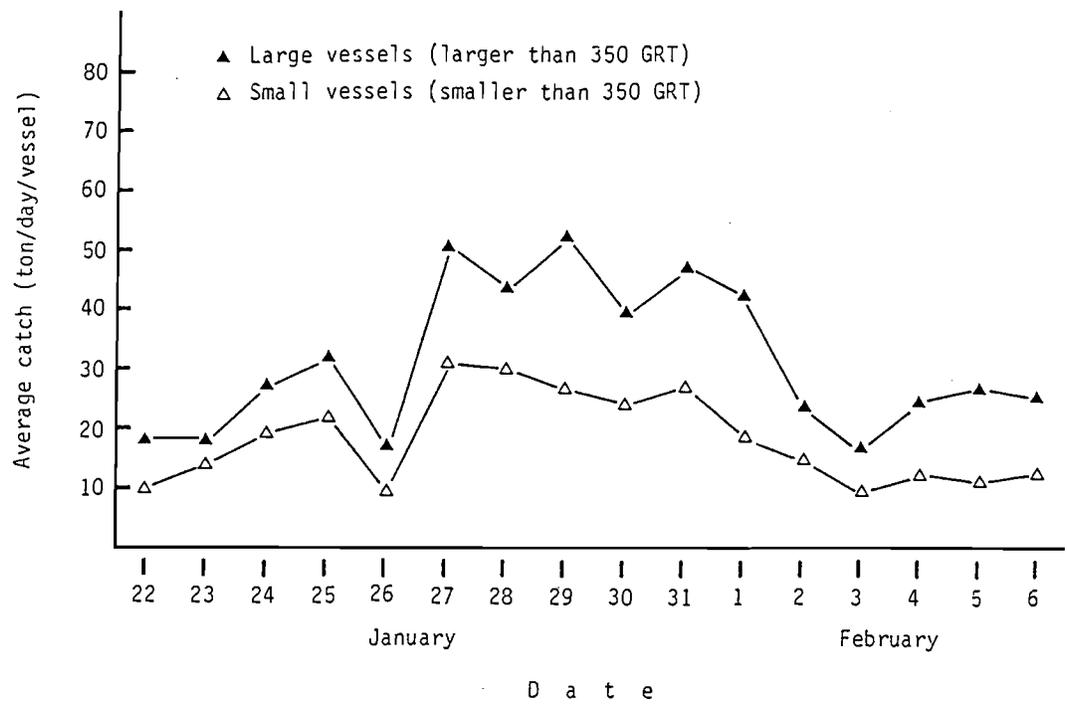


Figure 5. Average catch of pollock (ton/day/vessel) by Japanese trawl vessels operated in the international waters of the Bering Sea from January 22 to February 6 in 1990.

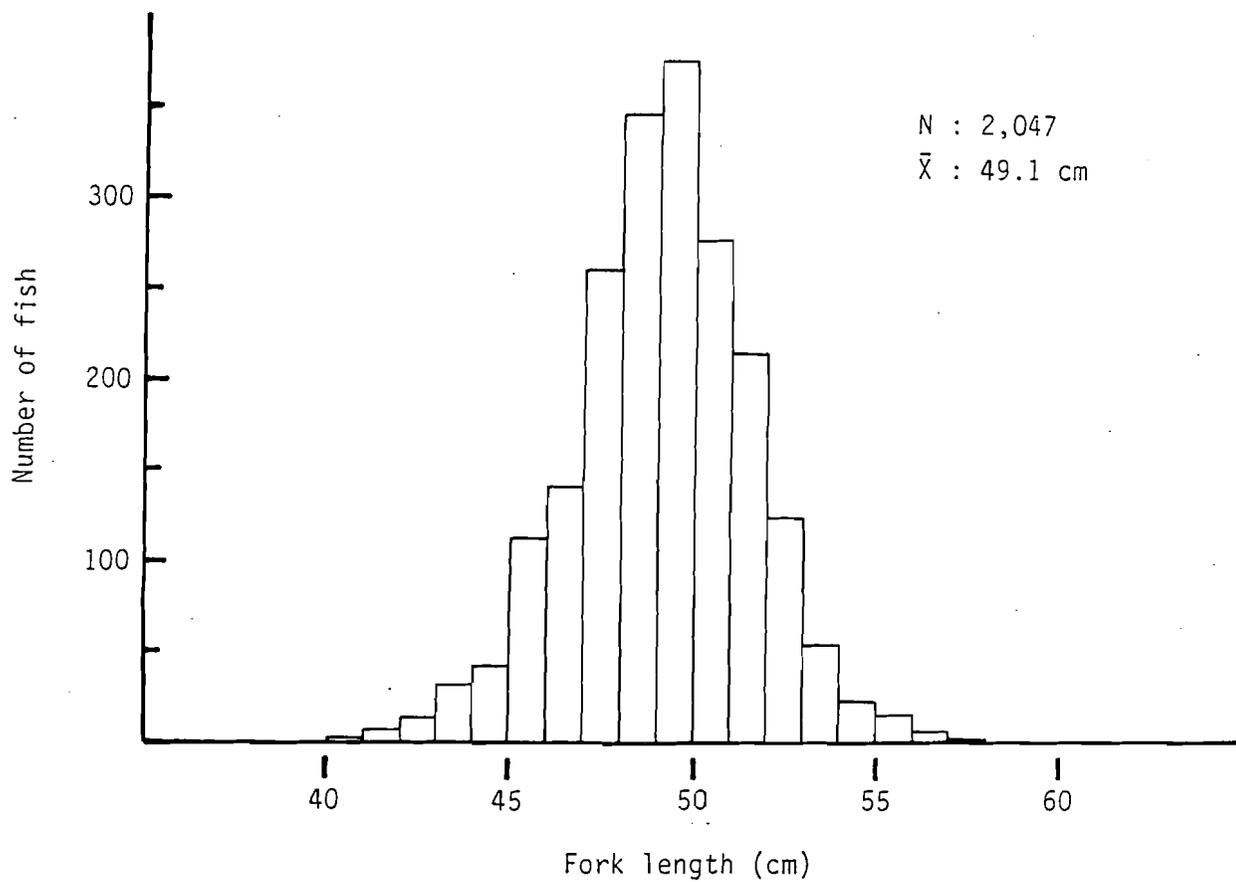


Figure 6. Size composition of pelagic pollock caught in midwater trawl survey by Kaiyo maru in the international waters of the Bering Sea from January 29 to February 6 in 1990.

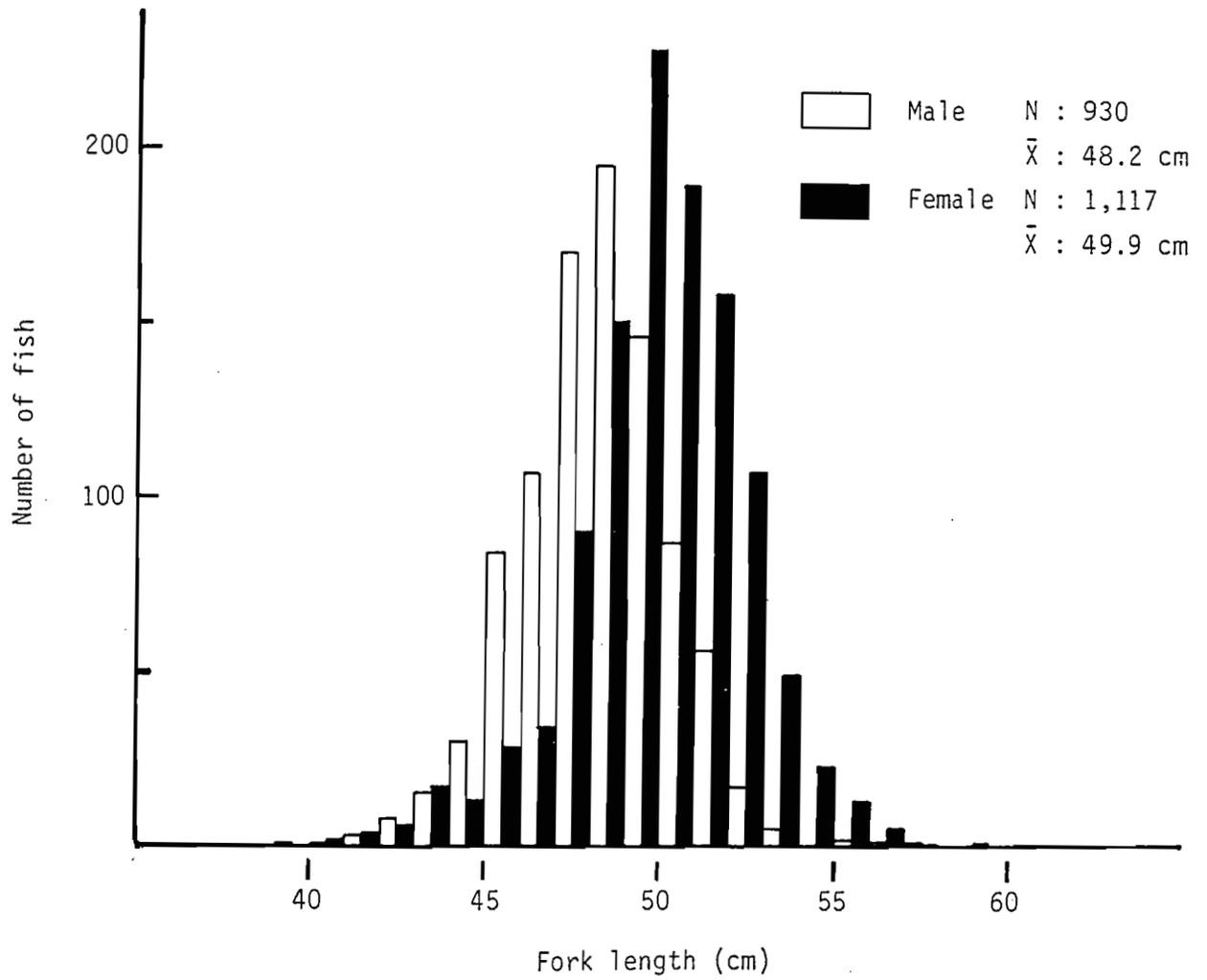


Figure 7. Size composition of pelagic pollock by sex caught in midwater trawl survey by Kaiyo maru in the international waters of the Bering Sea from January 29 to February 6 in 1990.

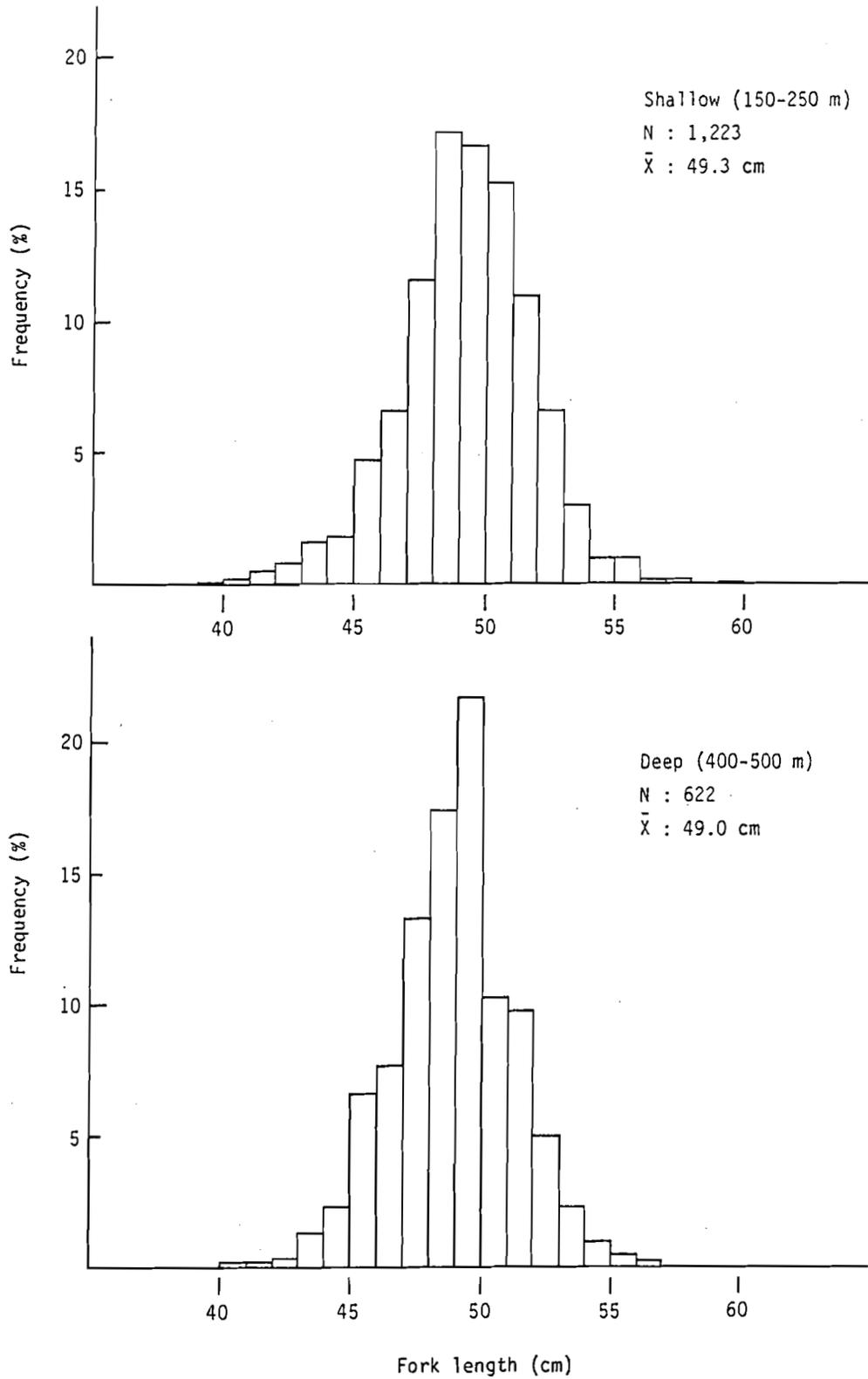


Figure 8. Size composition of pelagic pollock by depth layer caught in midwater trawl survey by Kaiyo maru in the international waters of the Bering Sea from January 29 to February 6 in 1990.

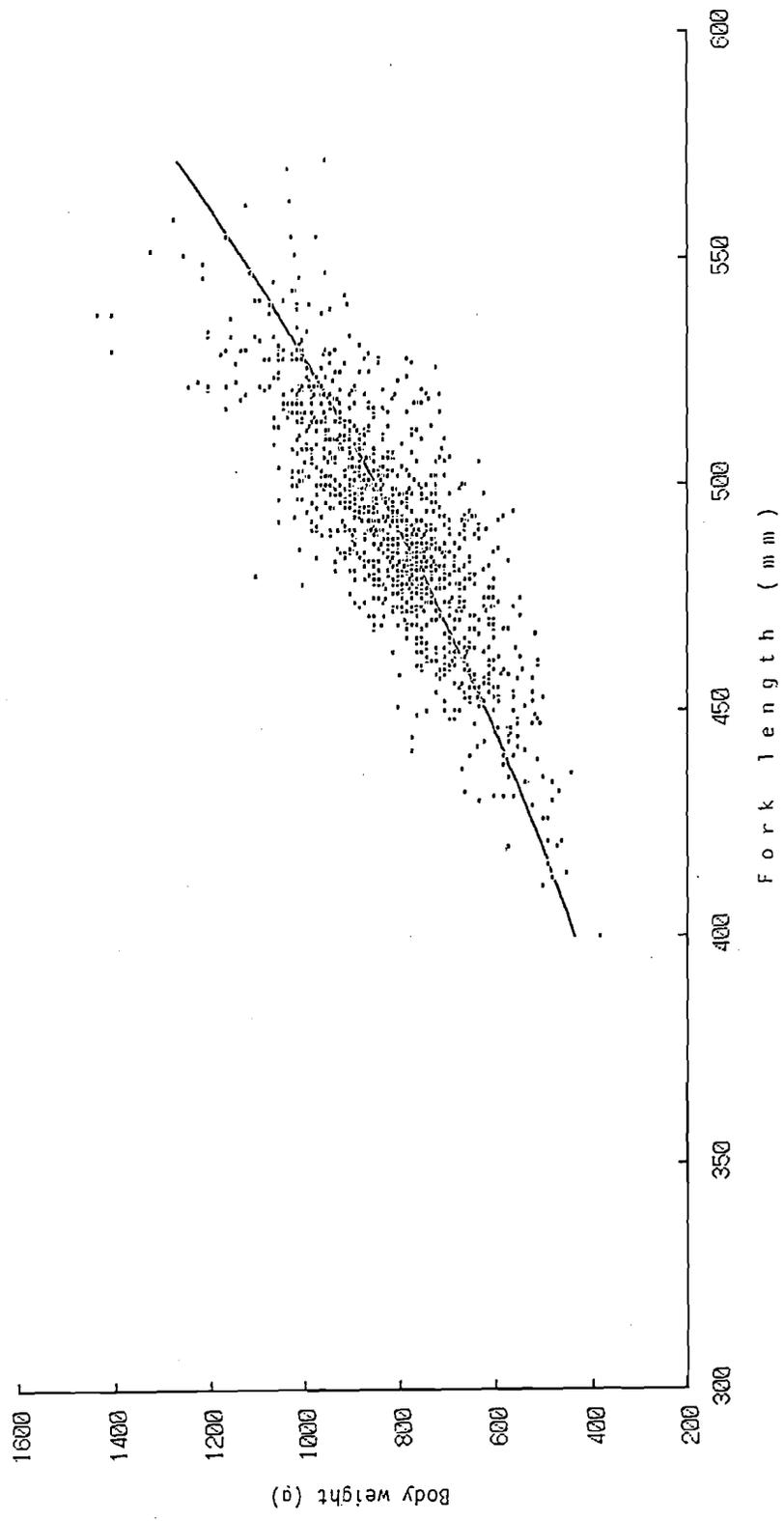


Figure 9. Length-weight relationship of pelagic pollock caught in midwater trawl survey by Kaiyo maru in the international waters of the Bering Sea from January 29 to February 6 of 1990.

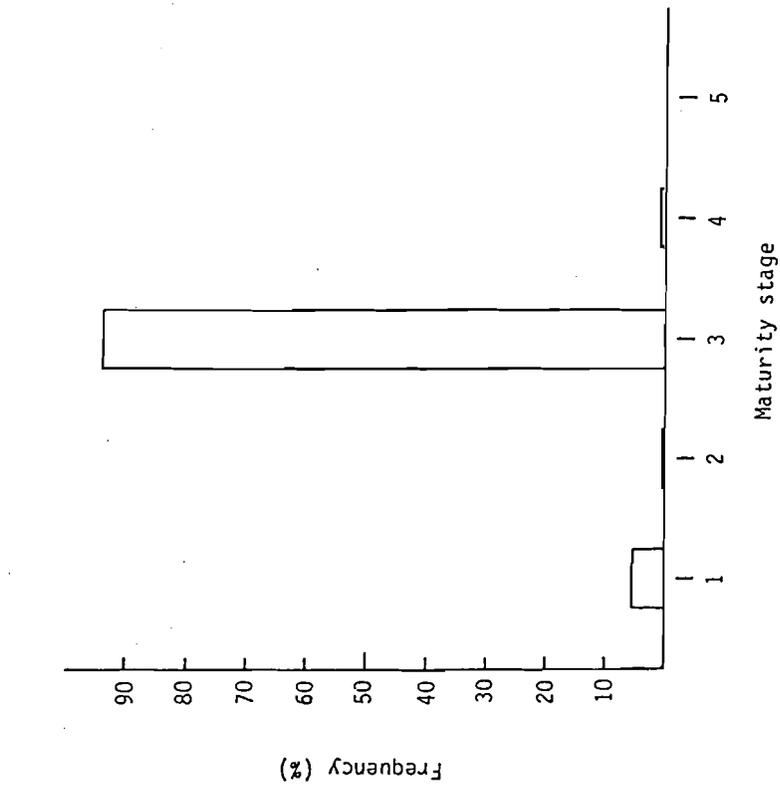


Figure 10. Frequency distribution of maturity stage of female pollock caught in midwater trawl survey by Kaiyo maru in the international waters of the Bering Sea from January 29 to February 6 of 1990.

Abbreviation : 1 = Immature
 2 = Maturing
 3 = Mature
 4 = Spawning
 5 = Spent

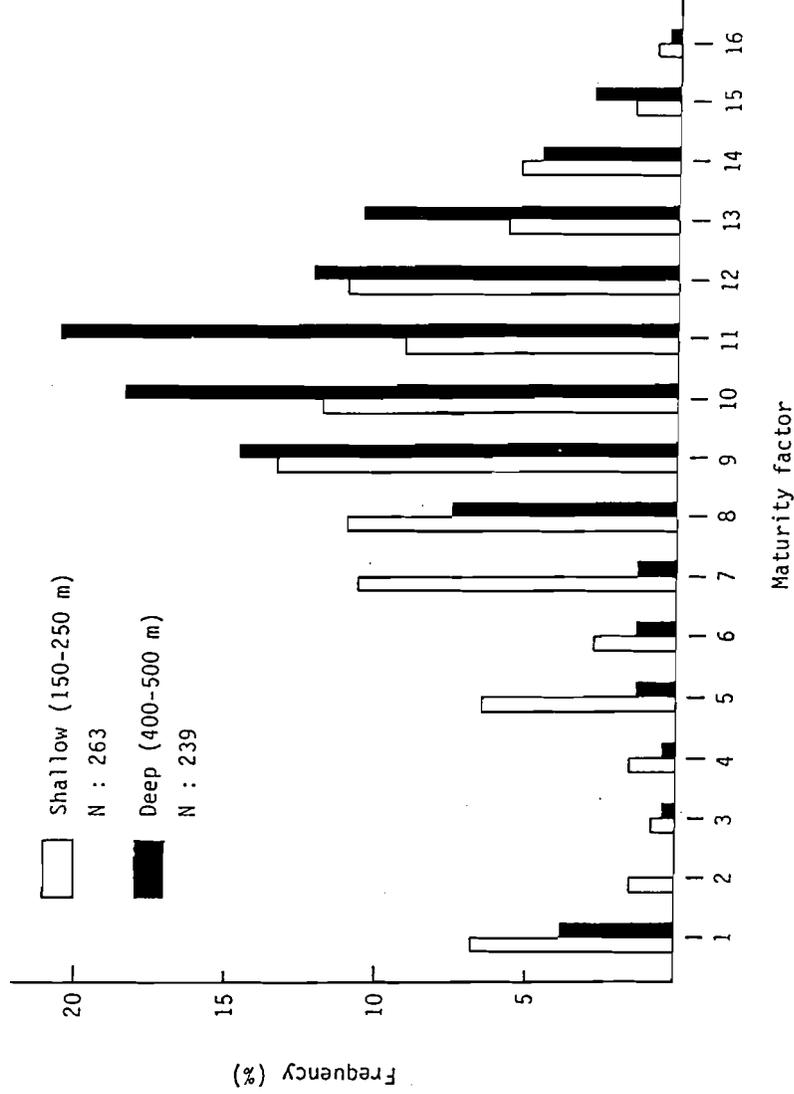


Figure 11. Frequency distribution of maturity factor of female pollock by depth layer caught in midwater trawl survey by Kaiyo maru in the international waters of the Bering Sea from January 29 to February 6 of 1990. Maturity factor was defined as $(GW/BW) \times 100$; GW is gonad weight in g and BW is body weight in g.

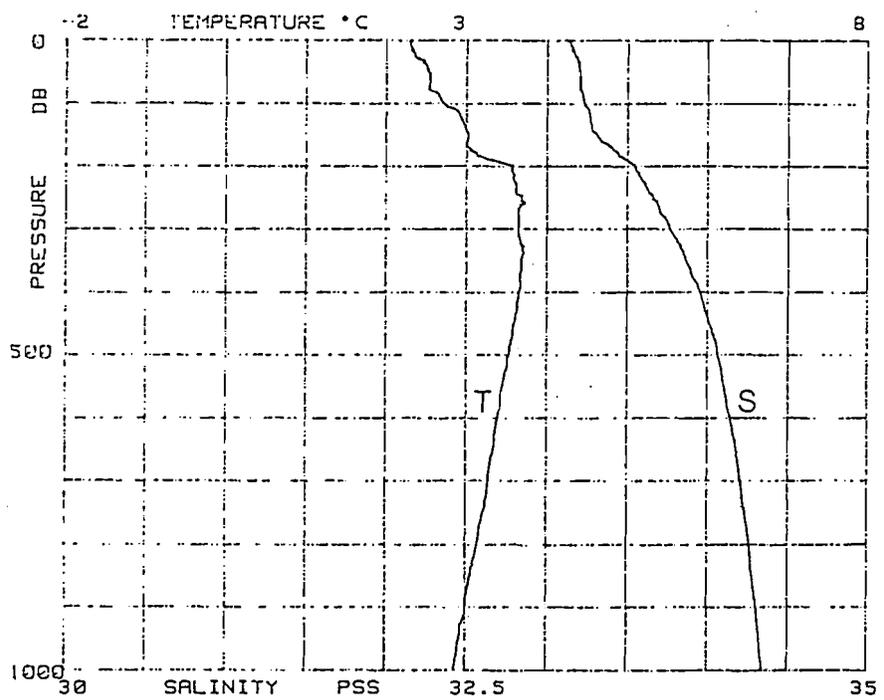
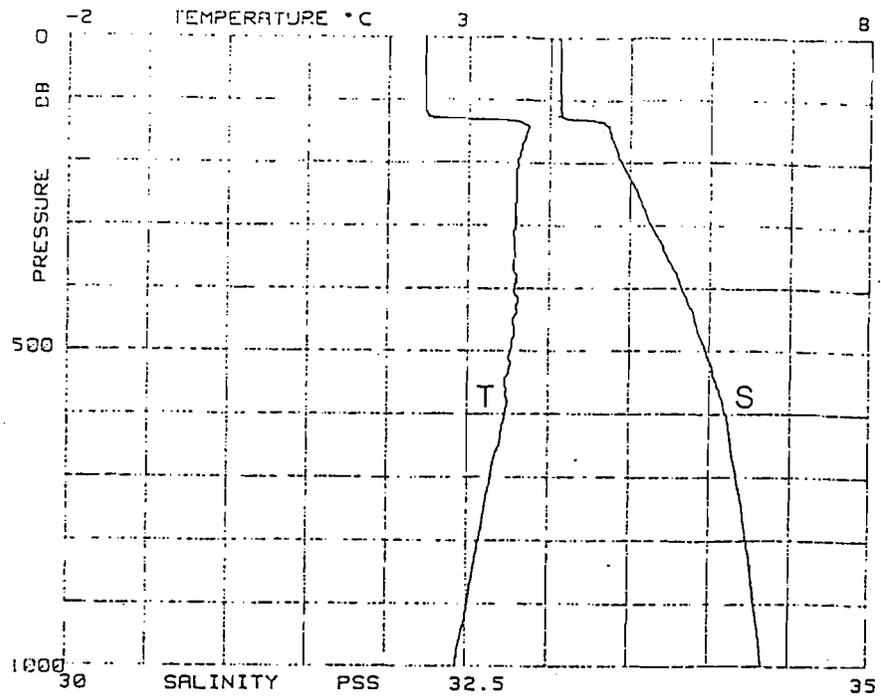


Figure 12. Vertical cross section of water temperature and salinity from CTD observations by Kaiyo maru at ST-5 and ST-20 in the international waters of the Bering Sea in January 30 and February 6 of 1990, respectively.