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OBSERVATIONS OF FISHING OPERATIONS ON A KRILL TRAWLER AND DISTRIBUTIONAL BEHAVIOUR OF KRILL OFF WILKES LAND DURING THE 1985/86 SEASON

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Abstract

Japanese krill fishing operations were observed on board a commercial vessel and the actual operation described in detail. "Fish-finder" was mose useful in detecting swarms, while sonar was used to judge the towing direction. The size of fished swarms ranged from 100 m to 10 km with different distributions occurring in different fishing areas. While catch per towing time reflects within-swarm density, catch per day was thought to be a good index to measure abundance of a concentration. Comparison of such an index across time and space may prove difficult due to problems of standardization when data from different vessels are to be used.

Résumé

Les opérations de pêche de krill japonaises ont été observées à bord d'un navire commercial et les opérations proprement dites ont été décrites dans le détail. Le "détecteur de poissons" a été très utile pour détecter les bancs, alors que le sonar a servi à estimer la direction de chalutage. La taille des bancs pêchés allait de 100 m à 10 km, la répartition variant selon le secteur de pêche. Alors que la prise par temps de chalutage reflète la densité au sein du banc, la prise par jour semblait un bon indice pour mesurer l'abondance d'une concentration. La comparaison de cet indice sur le plan temporel et spatial pourra s'avérer difficile étant donné les problèmes de standardisation lorsque doivent être utilisées les données provenant de différents navires.

Resumen

Se observaron operaciones pesqueras de krill japonesas a bordo de una nave comercial y se describió en detalle la operación en sí. El "Fish-finder" ("Localizador de peces") fue de gran utilidad en la detección de cardúmenes, mientras que el sonar fue usado para decidir la dirección de remolque. El tamaño de los cardúmenes pescados varió de 100 m a 10 km, observándose diferentes distribuciones en distintas áreas pesqueras. Mientras que la captura por tiempo de remolque refleja la densidad dentro del cardúmen, se pensó que la captura por día era un buen índice para medir la abundancia de una concentración. La comparación de tal índice a través del tiempo y el espacio puede resultar difícil debido a los problemas de estandarización cuando deban utilizarse datos de diferentes embarcaciones.

Резюме

С борта коммерческого судна велось наблюдение за японскими промысловыми операциями при промысле криля, и дается детальное описание этих операций. "Рыбоискатель" оказался наиболее полезным при обнаружении скоплений, в то время как гидролокатор использовался при определении направления траления. Размеры обловленных скоплений варьировались от 100 м до 10 км с различным распределением на разных промысловых участках. Величина "улов на время траления" отражает плотность внутри скопления; считалось, что величина "улов за день" является хорошим показателем для определения численности концентрации. Сравнение таких показателей по временной и пространственной шкале может оказаться нелегким делом, т.к. при использовании данных с различных судов возникают трудности с их стандартизацией.

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1. INTRODUCTION AND MATERIALS

It is now becoming a necessity to develop stock assessment of krill not only to manage the stock but also to monitor and manage the Antarctic ecosystem as a whole. The usefulness of CPUE (catch per unit effort) data as an index of krill abundance is now under investigation in the "Krill Simulation Studies of CPUE" by the Scientific Committee of CCAMLR. This study desperately needs information on fishing operational strategies and aggregation behaviour of krill.

This document summarizes information collected on board a commercial vessel, including information on the fishing strategies and actual operation and on the distributional behaviour of krill necessary for the interpretation of CPUEs.

Information utilized in this report was collected on board Zuiyo Maru No. 2 (3 023 tons, Hakodate Kokai Gyogyo Co.) throughout the 1985/86 season off Wilkes Land. The operational features may not necessarily be the most representative of the Japanese krill fishery in the past there, or at present in the Scotia Sea.

2. THE FISHING STRATEGIES

2.1 Favorite Krill Quality

Three types of products were produced by Zuiyo Maru No. 2 : fresh-frozen krill (for fishing bait and food in fish culture), boiled-and-frozen krill (for human consumption), and meal (for food in fish culture). In addition to these products, Japanese vessels produce peeled krill meat (for human consumption), and more than half the total Japanese catch is used for direct human consumption. Processing constraints differ according to the product. Fresh-frozen and boiled-and-frozen krill must be processed within 3 hours of capture, whereas meal can be processed much later.

The major products of Zuiyo Maru No. 2 were fresh-frozen and boiled-and-frozen krill. The determining factors were as follows :

1. "Greenness"
   "Green" krill were commonly found during January off Wilkes Land. They have a green hepatopancreas as a result of intensive feeding on phytoplankton and were avoided because of their dirty appearance, unfavorable smell and inferiority in taste. Processing options were affected by krill greenness (Table 1). Of the three types of above products, fresh-frozen krill is the most sensitive to greenness.

2. Size
   Although instructions for reporting size of krill in the logbook required categorization of the krill by body length, this vessel took body height as well into consideration in the categorization : LL (larger than 45 mm, and 7.3 mm in average height), L (between 35 and 45 mm in length, and 6.5 mm in average height), and M (below 35 mm in length, and 4.3 mm in average height). Generally the largest size category is the most preferable to the fishery. The smaller classes are less valuable due to marketing competition with the smaller euphausid species, *Euphausia pacifica*, fished off northern Japan.

   But the smaller sized krill, on the other hand, tend to be less green and they are caught preferentially if only green krill are available to the fishery.

3. Gravid females
   Gravid females were sought especially when green krill were unavoidable because egg diminishes the green appearance and adds tastiness.

4. Body color

   Transparent krill (called "white") are firm and look delicious, while brick red/pink krill (called "pink") are flaccid and easy to crush. This grading has come to be adapted following that used for shrimps. White are more valuable than pink.

2.2 Macroscale Ground Selection

The krill fishery has not been a self-sustaining operation economically and hence a combination with other bottom trawling operations was sought. Historical fishing grounds used by Japanese krill expeditions are divided geographically into three regions : off Enderby Land, off Wilkes Land (including George V Land), and the Scotia Sea.

In earlier years, the trawlers operated in the fishing grounds off Enderby and Wilkes Lands. This is partly due to the survey on the feasibility of a krill fishery started off Enderby Land by the Japan Marine Fishery Resources Research Center (JAMARC) and partly due to the least transit times to Japan and fishing grounds of demersal fish off Africa. In recent years, the through-year activity of the trawlers has come to be incorporated into the fish and squid-harvesting off South America and New Zealand and almost all the vessels operate in the Scotia Sea. Only one or two vessels operate off Wilkes Land and none operates off Enderby Land.

Besides this logistic/economic advantage, the Scotia Sea ground has other desirable factors, e.g. the better catch rates and the higher proportion of the LL sized krill, which are indispensable for the recently developed technology used in producing peeled krill meat. Another advantage is the geographical feature which diminishes worry about cargo work.

In contrast, the quality of krill of Wilkes Land is better than that in the Scotia Sea (Table 2). For example, catches may be kept for processing fresh-frozen products for about three hours, one hour longer than in the Scotia Sea. Flaccid krill have become a problem since the Scotia Sea became the main operating area.

Zuiyo Maru No. 2, in 1985/86, chose the ground off Wilkes Land, although she had to engage in squid fishing off the Falkland Islands afterwards. The reason was that the quality of krill off Wilkes Land had been extremely good (white krill, the largest size class and high percentage of gravid females) in the previous season and similar quality was expected based on information from vessels of another company that had already been operating there. Unfortunately there was no white krill by the time the vessel reached there, but it was decided to operate in this ground.

2.3 Searching for Krill Concentrations

Krill distribution is too patchy to be able to come across harvestable concentrations by a random "walk-search" method, so the vessel made use of various information. In Table 3 are shown frequencies of causes of major shifts of Zuiyo Maru No. 2 in search of a new fishing ground during the season.

The most important information was the historical distribution of good harvesting areas. Such areas tend to occur in rather limited areas, possibly linked to oceanographic features such as submarine rises, the eddying effect around the tips of glaciers or the Antarctic Divergence. These features may hold krill in that area for a prolonged period. The best fishing area operated by Zuiyo Maru No. 2 in 1985/86 season was within the area of good harvesting in the past.

During operations, the crew collected data along the expedition route on the quality and quantity of krill and water temperature. These data were utilized to forecast a change in biological and fishing conditions to determine whether to return to the areas previously found but abandoned successively.

Communication with other fishing vessels and sometimes with the cargo ship were made to enhance the ability to find high density areas.

Minke whales were not a useful cue, as usual. They were seen in low krill density areas as frequently as in high density areas. This was partly because fishing areas were far away from the pack ice edge where minke whales feed on krill. Icebergs were not useful to find krill concentrations. Within concentrations, however, they could sometimes be useful to detect swarms until they moved away with the current in a day or so.

The vessel was very experienced and eager to find high density areas. She increased frequency of directional changes immediately after detecting low density krill to find her way into density areas.

2.4 Detection of Swarms

Once the vessel succeeded in finding areas of high krill density (concentrations), detection of individual swarms was the basic activity of the operation. The fishing vessel tended to select the larger sized swarms to tow. The distribution of swarms thus selected and actually towed varied in size from 100 m to 10 km (Figure 1). Extremely large swarms extended over 5 km with very low density.

In Table 4 are shown the relative frequencies of cues used in detecting swarms on which tows were made. Fish-finder was the most important cue throughout the season. In high density areas, the number of swarms per unit area was so high that there was little need to rely on sonar which gave a wider horizontal effective search width. Also in areas where swarms exceeded more than 3-4 km length/diameter but their densities were too low for being detected by sonar, fish-finder was the only method on which to rely.

When swarms were small and scattered (generally in the beginning of the season), sonar was indispensable in detecting them. It could detect krill swarms at ranges of 300-400 meters when swarms were dense and well below the surface. (Krill swarms are generally denser in the Scotia Sea and the detectable range may extend up to 800 meters.) Although fish-finder can detect swarms at any depth just below the vessel, sonar could miss dense swarms because of its narrow vertical range of detection. The main usage of sonar in the high season was to detect the direction of extension in order to judge the direction of towing.

Surface swarms, which usually occurred only in the half-light period after sunset, were difficult to detect by sighting. Another vessel which had crews experienced in whale sightings seemed to use sighting to some extent.

3. FISHING AREAS

3.1 Fishing Areas in the 1985/86 Season Off Wilkes Land

As a result of operations by Zuiyo Maru No. 2, the characteristics of six fishing areas (Figure 2) are summarized in Table 5. In those areas, operations were continued more than three days. Among them, areas H2 and J met best with the requirement of production where a constant daily catch of over 50 tons was attained. In the best harvestable area H2, which had been a good fishing area in the past as well, the vessel's maximum capacity of daily catch of 100 tons was reached. Area H1 may correspond to the periphery of the concentration H2, judging from the similarity in length frequency histograms. Area J, which was found based on the information from the cargo ship, seemed to correspond to the Antarctic Divergence.

Other areas such as F, D and B were less dense, although area D and B provided a fairly good yield of white krill in the previous season. In those offshore areas, the concentrations may vary from year to year.

3.2 High Yielding Fishing Area for the Past Four Years

Around area H2, there have been good yielding areas for the past four seasons except in the 1984/85 season when vessels were concentrated on white krill found offshore (Figure 3). The spatial scale of this good concentration was 100-300 km from east to west and 30-50 km from north to south and corresponds to meso-scale aggregations according to the diagram of Haury et al. (1977). Submarine rises seemed to hold krill in this area. Krill abundance surveys by research vessels should be designed in such a way as not to miss this scale of concentrations.

4. CATCH RATES

4.1 The Utility of Catch Per Day and Catch Per Haul in Juding the Worth of Fishing Areas

When the vessel moved to a new area, catch per haul of the first few hauls gave a base to determine whether to stay or to leave. If krill quality was bad in the first haul, the vessel left irrespective of the catch per haul. A level of about three tons of catch per haul was used as the criterion.

The decision to leave areas where they had kept on operating was made on the basis of catch per day. If catch per day was less than 50 tons, the vessel left the area and moved to new areas.

4.2 Interpretation and Usefulness of CPUE

Data obtained from individual operations are catch and towing time. Accumulated catch and number of hauls by day can be calculated easily. Thus catch per day, catch per haul and catch per towing time are major CPUEs from the krill fishery.

Catch per towing time seems to be a good index of the within-swarm density when towing was made on a small number of swarms or on swarms in clumps. But when more than several swarms were fished in one towing, such density would obviously be underestimated due to inter-swarm paucity. When swarms were very dense and large, hauls were made on a single swarm alone and so catch per towing time indexed more accurately within-swarm density. Figure 4 shows the chart of the net recorder when the haul was made on the highest density swarm in the season. The absolute density of this swarm was estimated as 40 g/m^3 under the assumption of filtering rate equals 1.0.

Catch per haul may not be used as an index of within-swarm density or concentration density. During the operation of Zuiyo Maru No. 2, catch was kept to 7-10 tons per haul at the maximum in order to maintain freshness. The captain paid great attention to maintaining this level through making use of the net recorder chart and adjusting towing time (or number of swarms fished). As shown in Figure 5 this adjustment was made successfully up to a certain level of catch per towing time, but above this, there seems to be a tendency to increase catch per haul as a failure.

Catch per day, on the other hand, seems to be a good index of abundance in concentration. This is because of the strategy of the fishery to continue to take daily catches as close to its maximum processing capacity. Once a vessel finds a concentration of krill suitable for more than several days operation, it continues 24 hours operation in order to maximize the daily catch. The number of hauls and towing time are adjusted, under constratints of desired level of catch per haul, based on swarm density and within-swarm density. Such processes form a kind of Operations Research which is not explicitly stated by the captain but is practised in actual operation based on his experience.

There are, however, several problems associated in utilizing catch per day as an index of abundance. When catch per day reaches the maximum processing capacity, it may not be a sensitive index any further. Areas of green krill within a concentration may be avoided as well as small sized swarms, which obviously causes underestimation of abundance (although greenness or size composition seem to be properties of the concentration rather than swarms wihtin the concentration). The proportion of small sized swarms, in contrast to the fishable ones, within a concentration is closely connected with the swarming behaviour of krill and is not well known to date.

Catch per day, however, may be useful in detecting yearly changes in relative abundance of krill in a concentration. The area of such a concentration may be measured easily based on the extension of the operated position. Change in the formation of concentrations in geographical location, area and density (catch per day) as well as length composition seems to be a possible means of detecting yearly changes in krill biomass in that area. Comparison of such an index across time and space may prove difficult when data from different vessels are to be used because of problems in standardization.

4.3 Difficulty in Measuring Searching Time

Searching time may be useful for estimating the density of swarms within a concentration or measuring abundance in a much wider area. Searching time is almost equivalent to the duration between the completion of one haul and the start of the next in low density areas, and may be measurable. On the other hand, searching time is very short and difficult to define in high density areas, where constraints are imposed mainly by food processing capacity. For example, in high density area H2, the vessel did not have to be so serious about searching any longer. While newly caught krill were being processed, the vessel moved around to pass time and detected many swarms here and there. As the time for the next towing approached, the vessel shot at a swarm/swarms just encountered. When no swarm was found in the vicinity of the vessel at that time, the vessel returned to the swarms previously detected and marked on the chart. In such a situation, searching time may be recorded as almost nil and thus be of no use for any index. Sometimes the captain could not resist the temptation to haul high density swarms the vessel just encountered and so had to keep the net in the water until processing of the catch from the previous tow was completed.

Table 6 shows the time budget measured on board Zuiyo Maru No. 2. Searching time consists of primary searching effort and confirmation to keep in contact with previously found swarms; it was quite difficult to distinguish the two.

5. TEMPORAL CHANGES IN CATCH RATES

5.1 Diurnal Migration of Krill and Change in Catch Rates

Diurnal changes in the vertical distribution of krill and density were exhibited through the results of operation. In mid-summer (first half of January), under conditions of permanent daylight, krill maintained a fairly constant vertical distribution (Figure 6). When a period of darkness appeared (latter half of January), krill exhibited a diurnal vertical migration to surface at night. Catch per towing time tended to be a little higher during the half-light period after sunset. In late-summer (latter half of February), when the period of darkness became longer, krill went through a regular cycle of condensation - aggregating in dense swarms during the daytime and migrating to the surface after sunset then quickly dispersing in density and vertical distribution, which resulted in a big drop in catch rates by night. In March, when night time extended as long as seven hours, swarms dispersed so perfectly at night that the vessel had to spend many hours searching.

5.2 Longer Temporal Scale Change

Catch per towing time was not stable in each fishing area. In dense area H2, where operations took place for about a month, catch per towing time fluctuated greatly not only from day to night but also over longer temporal scales (Figure 7). The period of operation in area H2 is divided into three decades ; from mid-February to end-February (period I, 80 hauls in total), from end-February to early-March (period II, 90 hauls in total) and from early-March to mid-March (period III, 72 hauls in total). Catch per towing time in period II was twice as high as that in periods I and III although there was hardly any difference in catch per day and catch per haul between them. Since the operation in each period was done almost entirely on the same concentration, the change in catch per towing time may reflect temporal changes in within-swarm density in the concentration. Nothing is known about changes in krill abundance between these periods. Note that this concentration did not move although icebergs moved with the current, usually northwestward.

6. LENGTH FREQUENCY DISTRIBUTION OF KRILL

6.1 Congruence of Length Frequency Distribution Between Samples from Different Parts of the Net

Length measurements of samples from the catch were made in order to investigate whether the length frequency distribution of samples from one part of the catch can be regarded as representative. One set comprises two samples from the same haul each containing 150 individuals of krill, one sample taken from the mouth of the net and the other from the end of net. After the comparison of paired samples from 30 sets of measurements, it was concluded that krill were well mixed in the net and sampling from one part of the catch might be a good representative.

6.2 Variations in Size Compositions Between Sequential Hauls

In areas such as area O (Figure A-4) where the overall length frequency distribution was unimodal, the size composition of catch of sequential hauls was constant throughout the operations (Figure 8). Samples of over 40 mm in length were sexed by eye and are represented as the shadowed part in the figure.

In areas such as H2, where the overall length frequency distribution was bimodal, the proportion of large and small sizes often varied between sequential hauls with fairly stable modes (Figure 8). It may indicate, therefore, that the proportion differs swarm by swarm. Since swarms were many in number and their locations kept changing, the vessel could not select swarms which contained mainly large sizes.

6.3 Overall Size Composition in the 1985/86 Season

The size composition off Wilkes Land tends to differ year to year in contrast to the rather stable proportion of LL sizes in the Scotia Sea. This season was characterized by a bimodal length frequency distribution, lacking a mode at 40 mm (Figure 9). Whether this paucity of the 40 mm size class was due to changes in year class strength or due to water movement carrying these sizes away is unknown.

7. CONCLUSIONS

The fishing vessels search effectively for krill concentrations over a wide area where experience indicates several concentrations may be found. Since the vessels move to, and remain in, high density areas, CPUE seems to be less likley to reflect annual variation in large scale krill abundance. Detailed information on large spatial scale from research vessels is also required for estimating variability in krill abundance on such a large scale.

This distribution and distributional behaviour of krill shows significant spatial and temporal changes. High concentrations tend to occur in rather limited areas, based on the accumulated data of fishing expeditions. Thus by investigating the properties of these concentrations, such as spatial scales, within-swarm densities and size compositions, it may be possible to obtain useful information on what distributional parameters of krill accurately reflect the annual change in large scale krill abundance.

ACKNOWLEDGEMENTS

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Table 1. Utility of krill in different feeding condition

feeding condition	utility
non-feeding	for all processing options; especially fresh-frozen krill
moderately feeding	for all processing options; especially boiled-and-frozen krill
intensively feeding ("green")	for processing into peeled meat and fish meal

Table 2. Comparison of krill qualities off Wilkes Land and in the Scotia Sea

	off Wiles Land	in the Scotia Sea
feeding condition	less "green"	"green"
shell	strongly built	easy to crush
body color	white	pink
texture	firm	soft and flaccid
by-catch	negligible	salps may cause problem

Table 3. Causes of shift of vessel in search for a new fishing area

causes	frequency
Good area in past:	6
Return to areas previously used/found during season (in hope of quality improvement):	4
Communication with other vessels:	4
Ice condition:	2
Iceberg with sea birds on it:	2

Table 4. Relative frequencies of cues used in detecting swarms (%)

cue	month		
	January	February	March
fish finder	59	86	76
sonar	39	14	23
sighting	2	0	1

n = 641 in total

Table 5. Characteristics of each fishing area

Fishing area	Period	Catch/day (tons)	Catch/haul (tons)	Catch/time (tons/min.)	Main cue for locating area	Reason for leaving area	By-catch
F	1-4 Jan.	25	2.6	0.14	Communication with other vessels	Poor catch	None
D	6-9 Jan.	43	4.3	0.11	Return to area in hope of quality improvement	Poor catch	None
B	11-14 Jan.	33	3.9	0.05	Return to area in hope of quality improvement	Poor catch	None
J	15-31 Jan.	65	5.6	0.12	Communication with other vessels	Drop in ratio of gravid females	Fish (Paralepididae) by a negligible amount
H1	5-10 Feb.	67	5.4	0.14	Good harvesting area in past	Drop in catch	Fish (Channichthyidae) by a negligible amount
H2	11 Feb.- 14 Mar.	99	9.2	0.35	Good harvesting area in past	Finish of the operation	Fish (Channichthyidae) by a negligible amount

Table 6. Time budget of Zuiyo Maru No.2 in 1985/86 off Wilkes Land

Item	First Jan.	Latter Jan.	Month First Feb.	Latter Feb.	First Mar.
Searching	56 %	31	40	35	35
Towing	28	42	37	24	21
Net handling	13	20	16	14	15
Idling	0	0	0	15	4
Cargo work	3	7	7	12	22
Drifting	0	0	0	0	3

Searching; the time between finishing one haul and starting the next, i,e, primary searching effort + confirmation to keep in contact with the swarms

Net handling; entry to and withdrawal from water

Idling; due to bad weather, engine kept going

Drifting; engine stopped

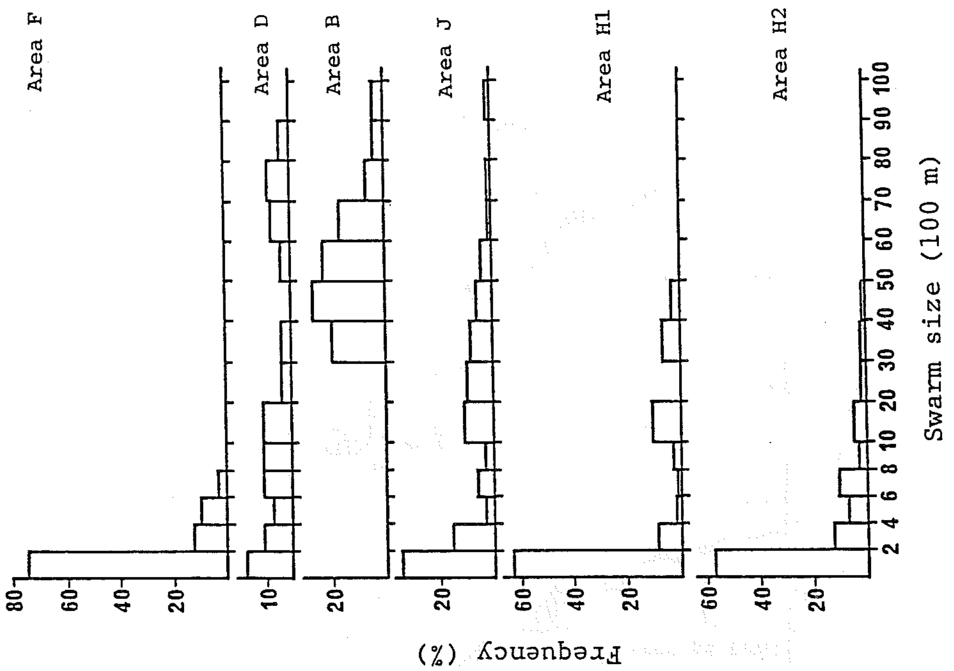

Fig. 1. Frequency distributions of swarm sizes towed in each fishing area

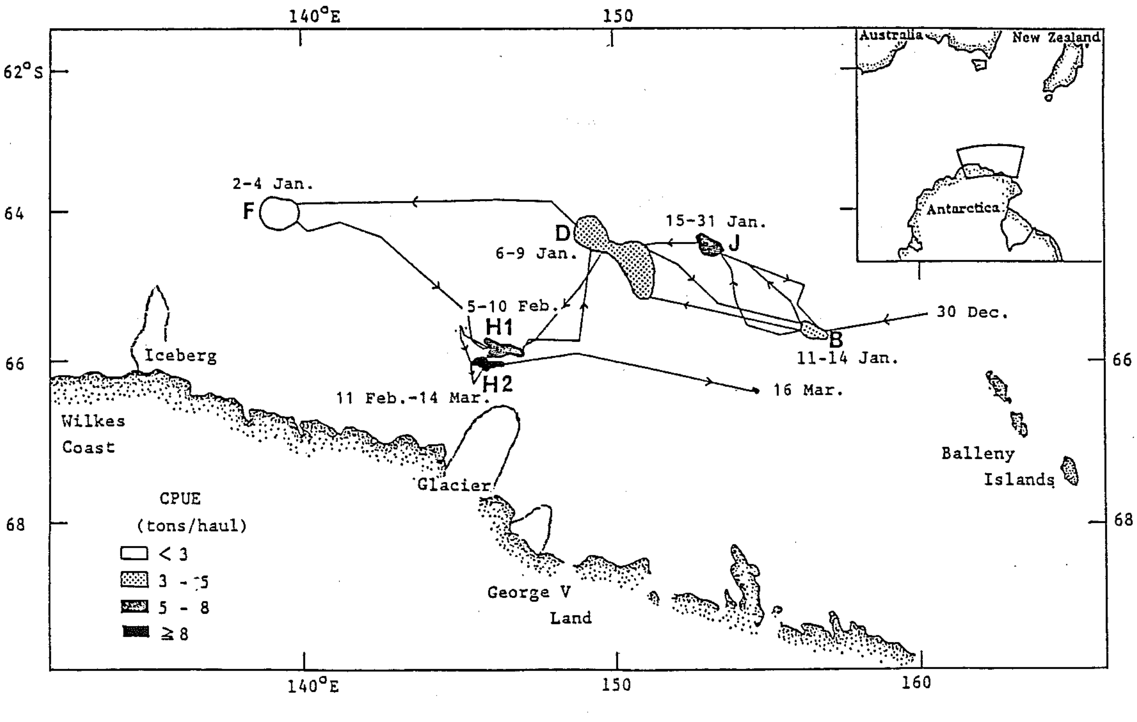

Fig. 2. The cruise track of Zuiyo Maru No.2 in the 1985/86 season.
Range of fishing grounds are encircled

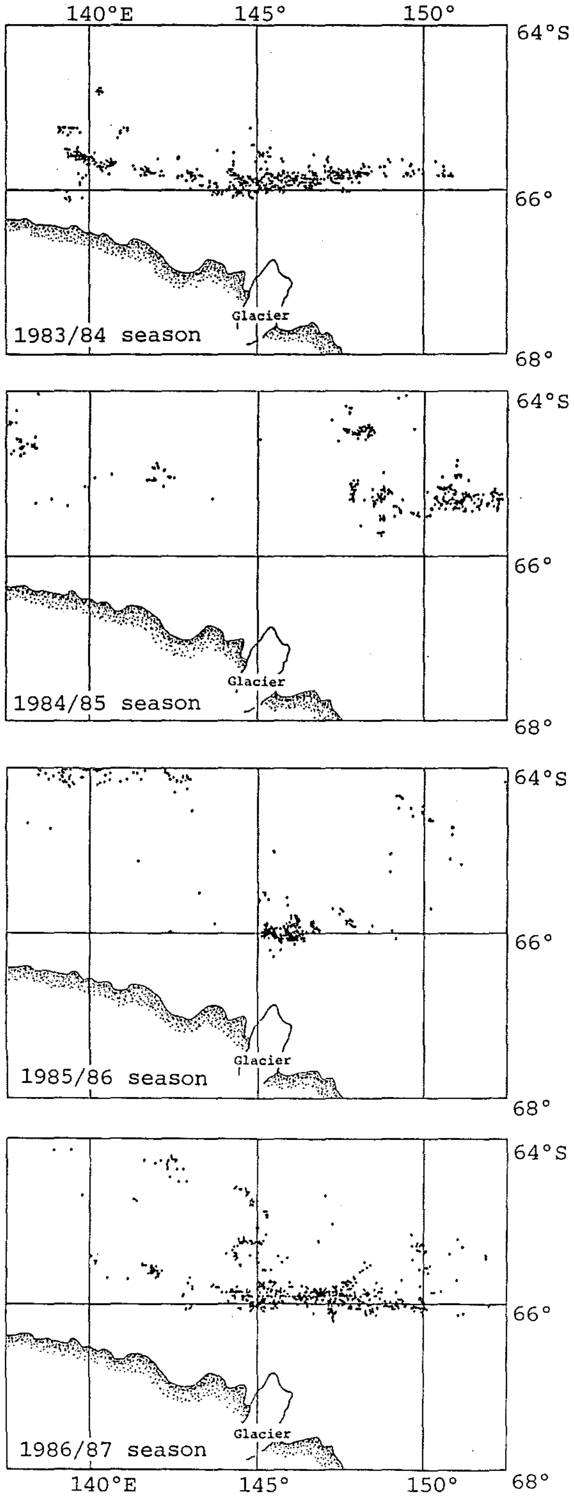

Fig. 3. Operated area around area H2 by Japanese krill fishery from 1983/84 to 1986/87 seasons.
• shows starting position of individual towing.

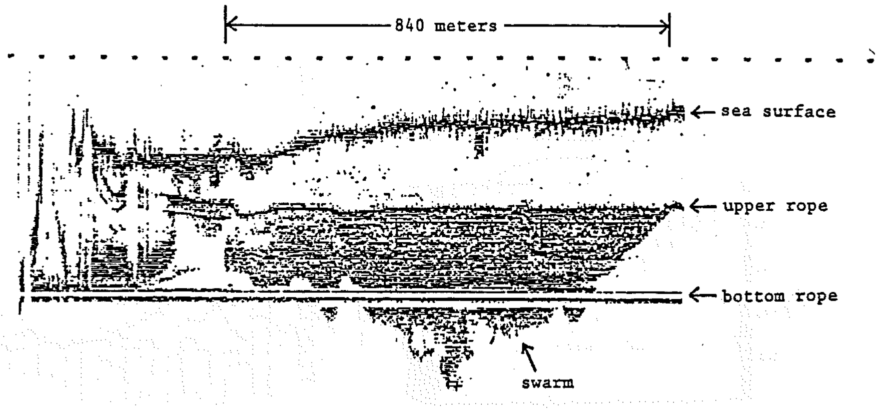

Fig. 4. Chart of net recorder when the densest swarm was fished . 20 tons of krill was caught in 14 min. of towing. Absolute density was estimated as 40 g/m^3

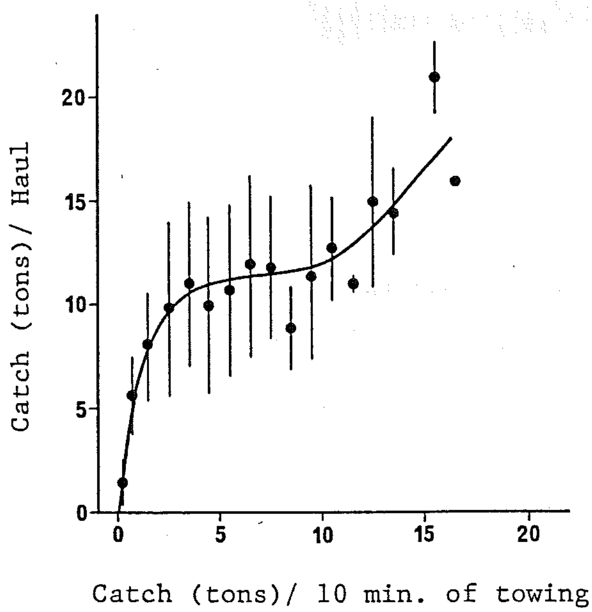

Fig. 5. Catch per haul against catch per towing time. Vertical bars show ± standard deviations

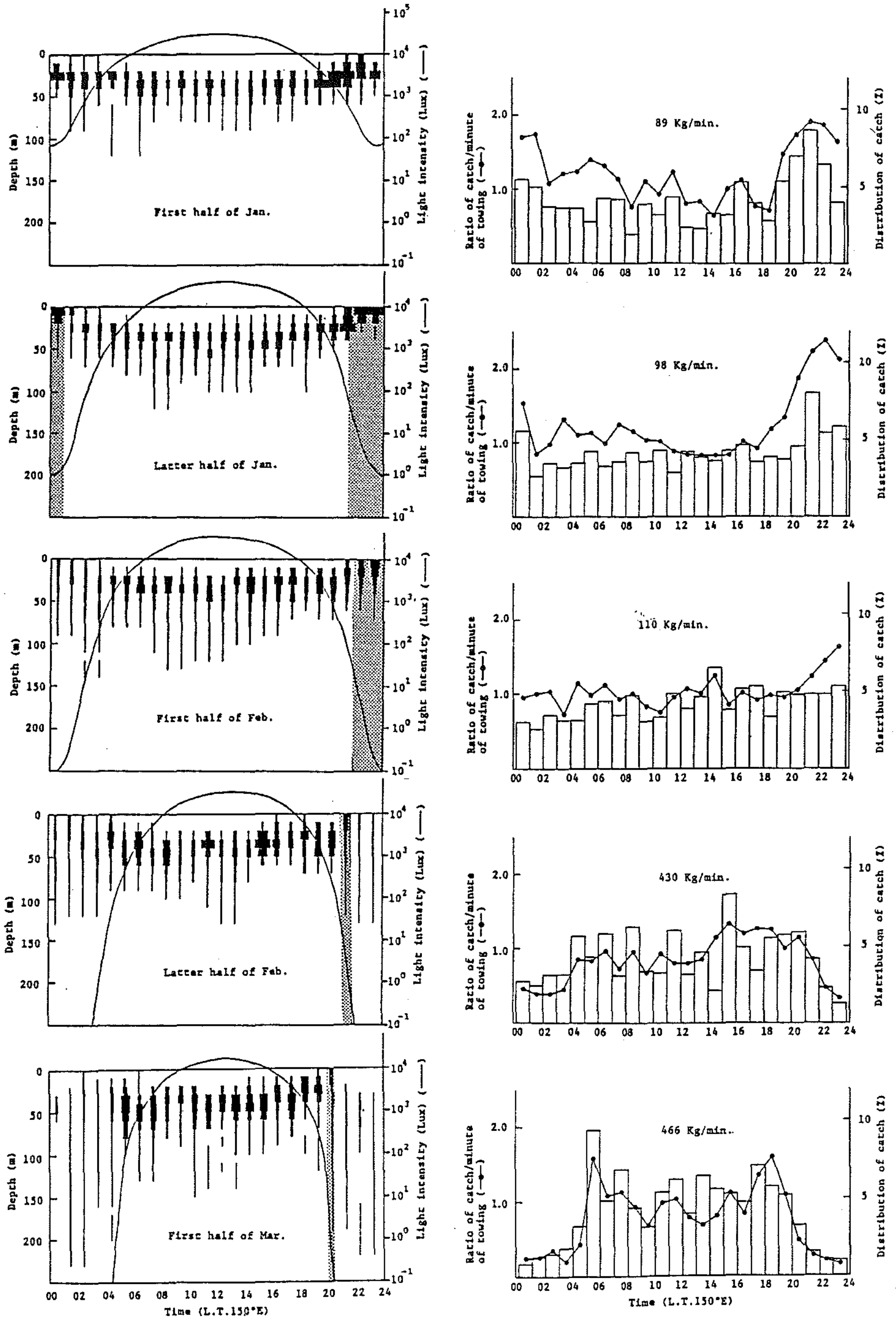

Fig. 6. Profiles of diurnal variations of mean light intensity, vertical distribution of krill, catch per haul and catch per towing time. Catch per towing time is standardized to mean catch per towing time during daytime (06:00-18:00) which is shown in right figure. Shading indicates the period of frequent occurrence of surface swarms.

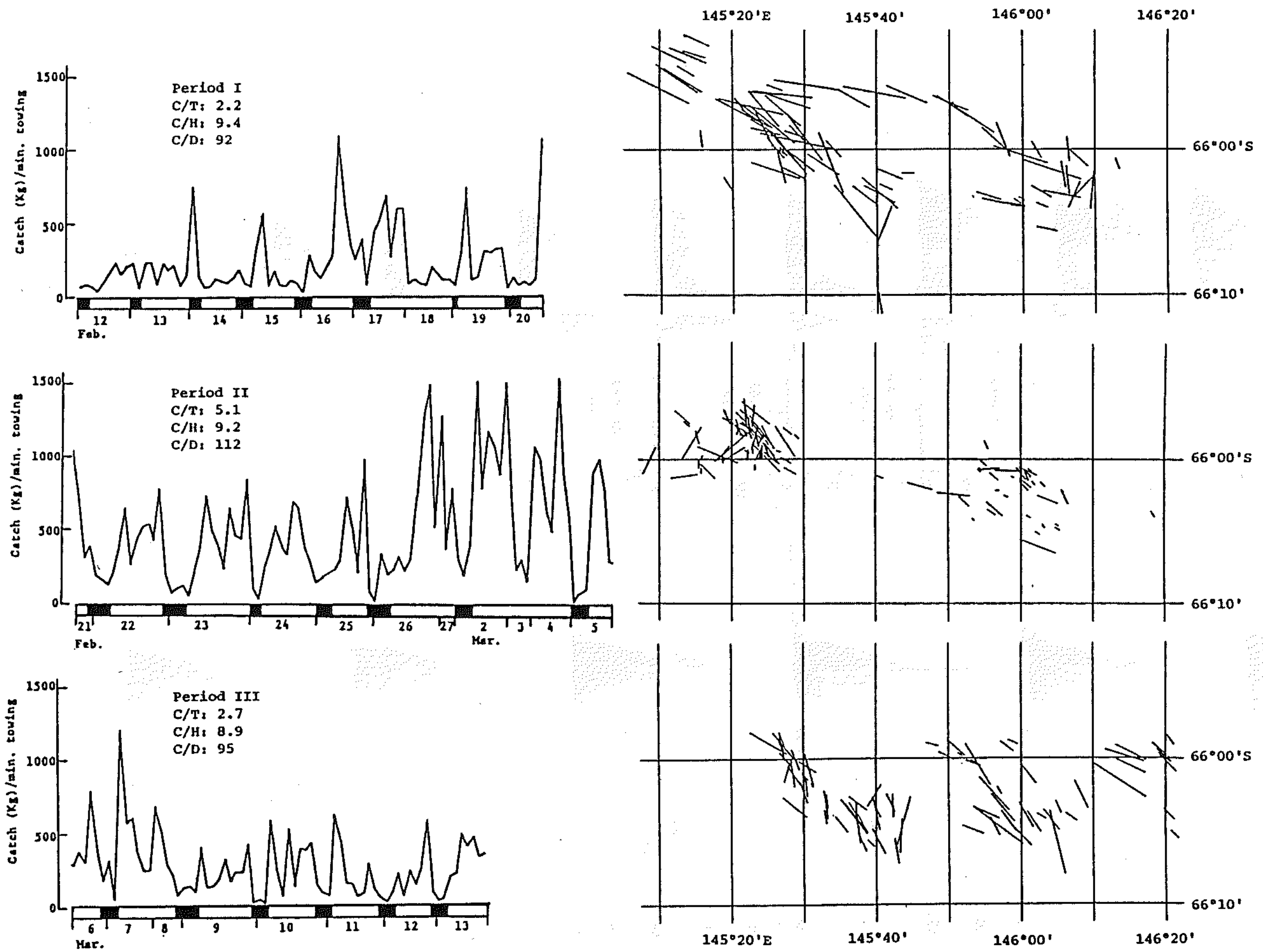

Fig. 7. Catch per towing time and towed tracks for three successive periods in area H2.

C/T: catch (tons) per 10 min. of towing
C/H: catch (tons) per haul
C/D: catch (tons) per day

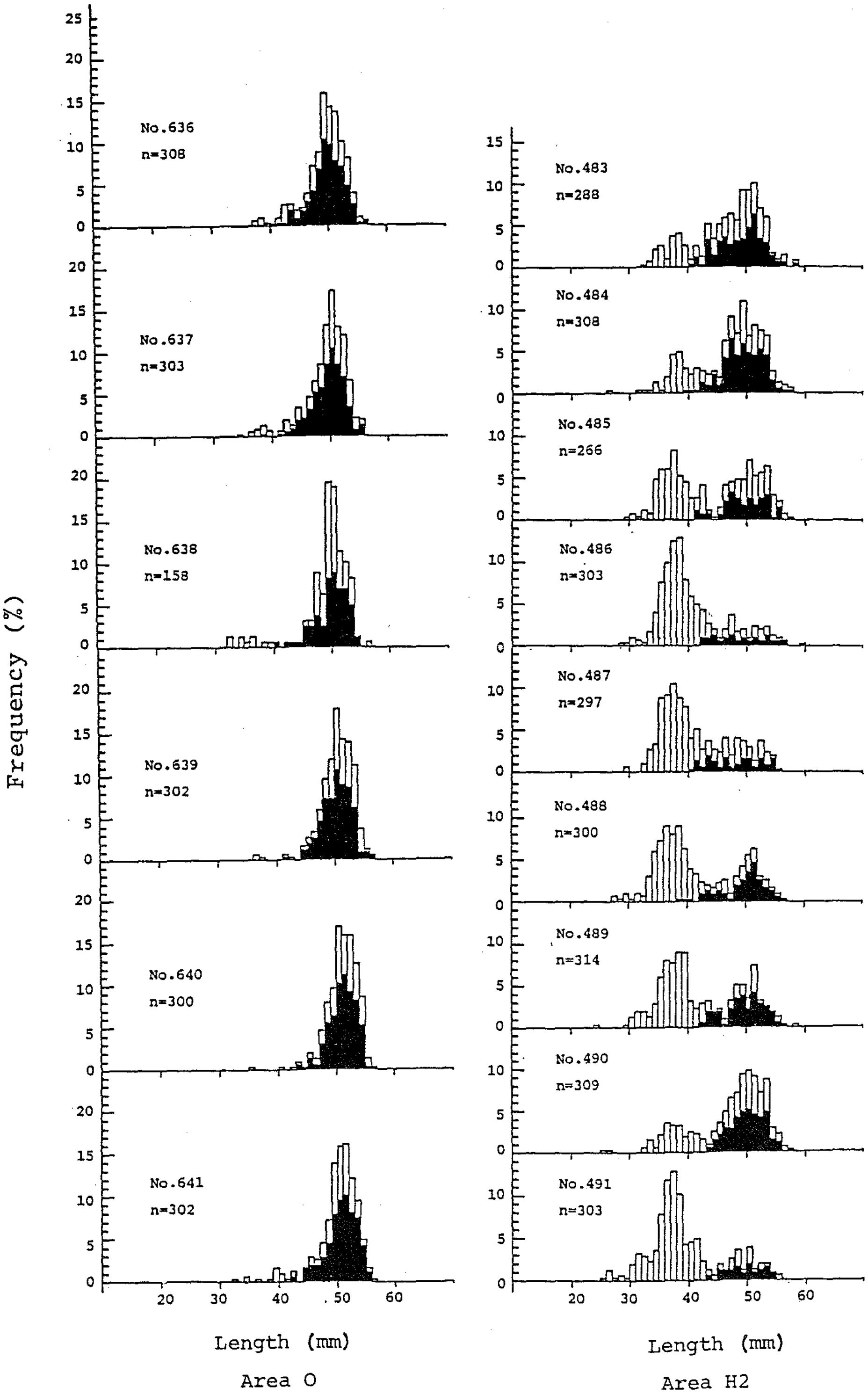

Fig. 8. Variations in size composition between sequential hauls.

Shadowed part of each histograms represents the proportion of females (see text). Area O is shown in Fig. A-4.

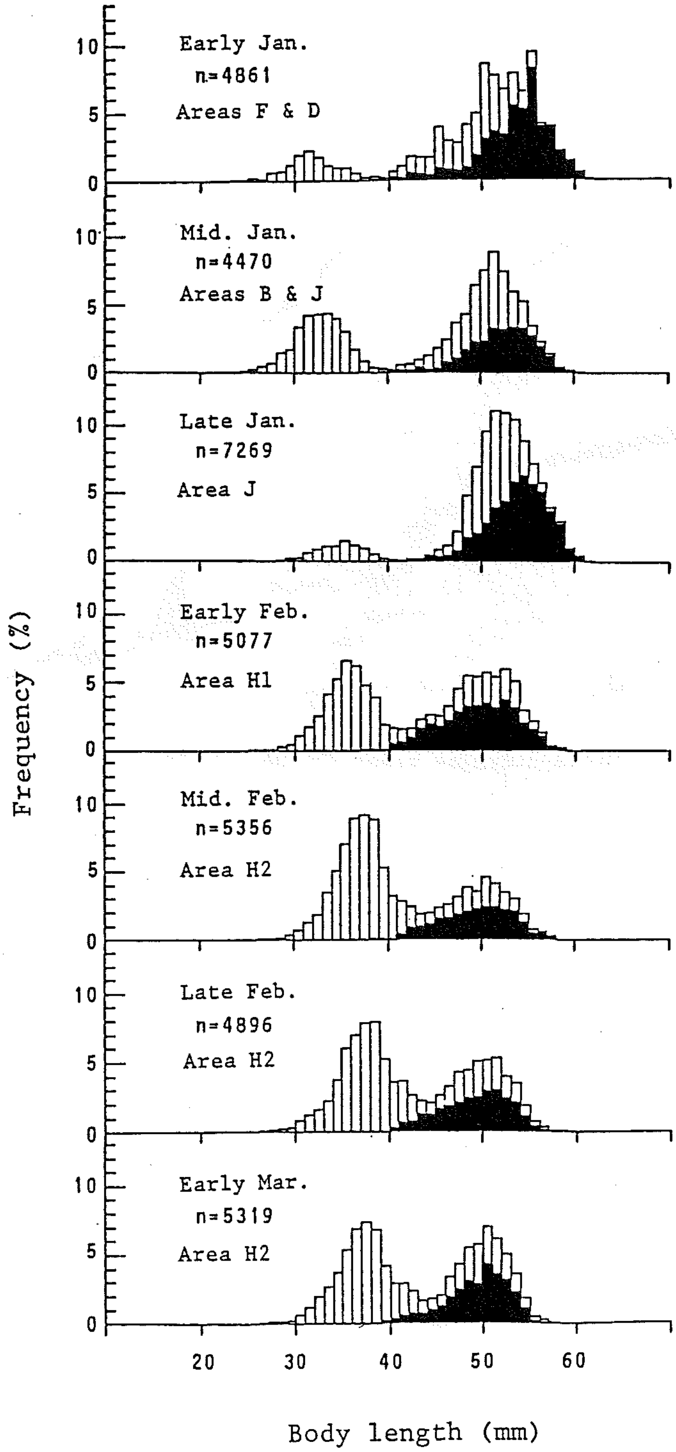

Fig. 9. Length frequency histograms during the season.
Shadowed part represents the proportion of females (see text).

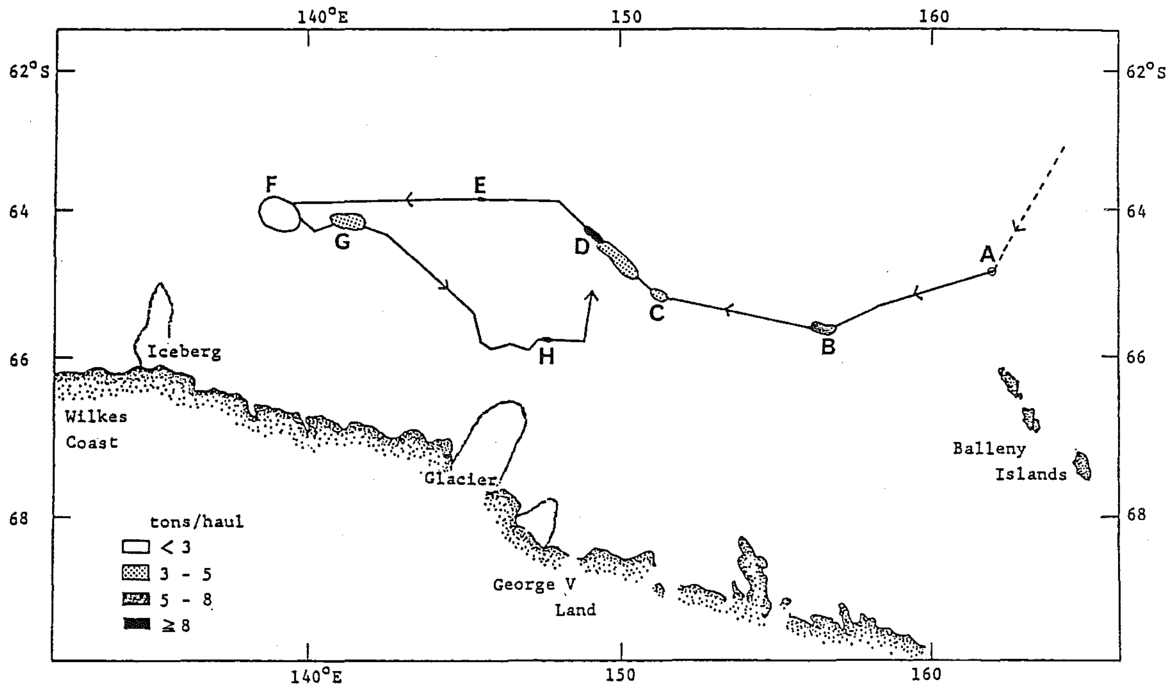

Fig.A-1.Cruise track [30 Dec.-6 Jan.]

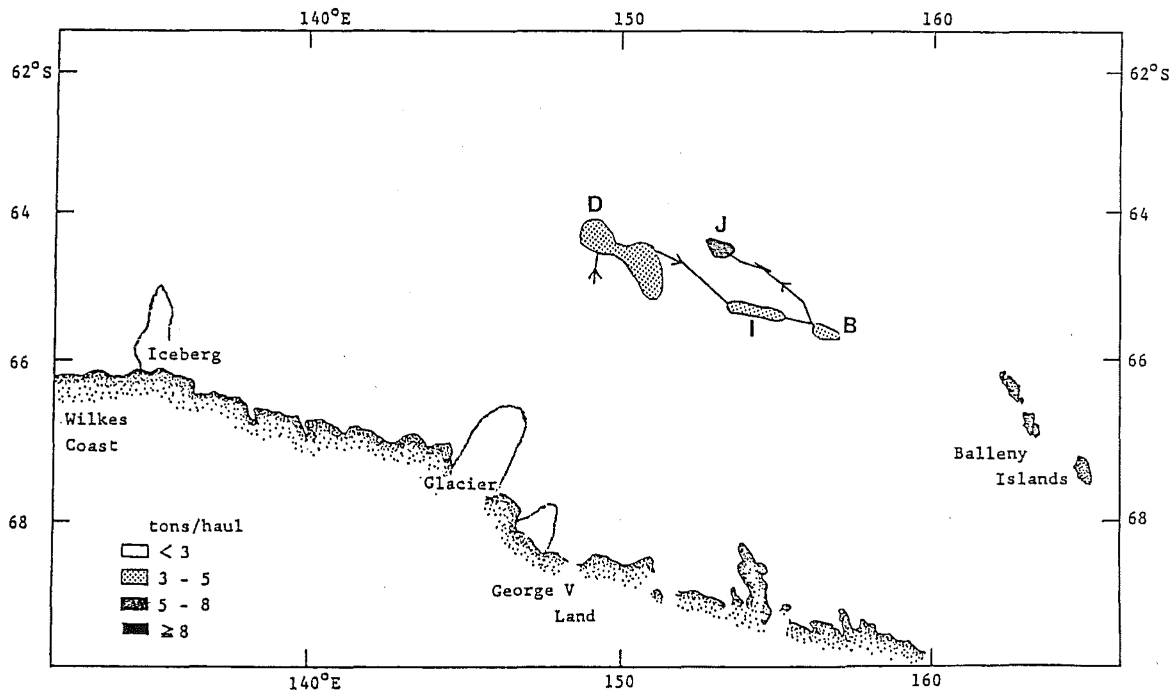

Fig. A-2. Cruise track [6-31 Jan.]

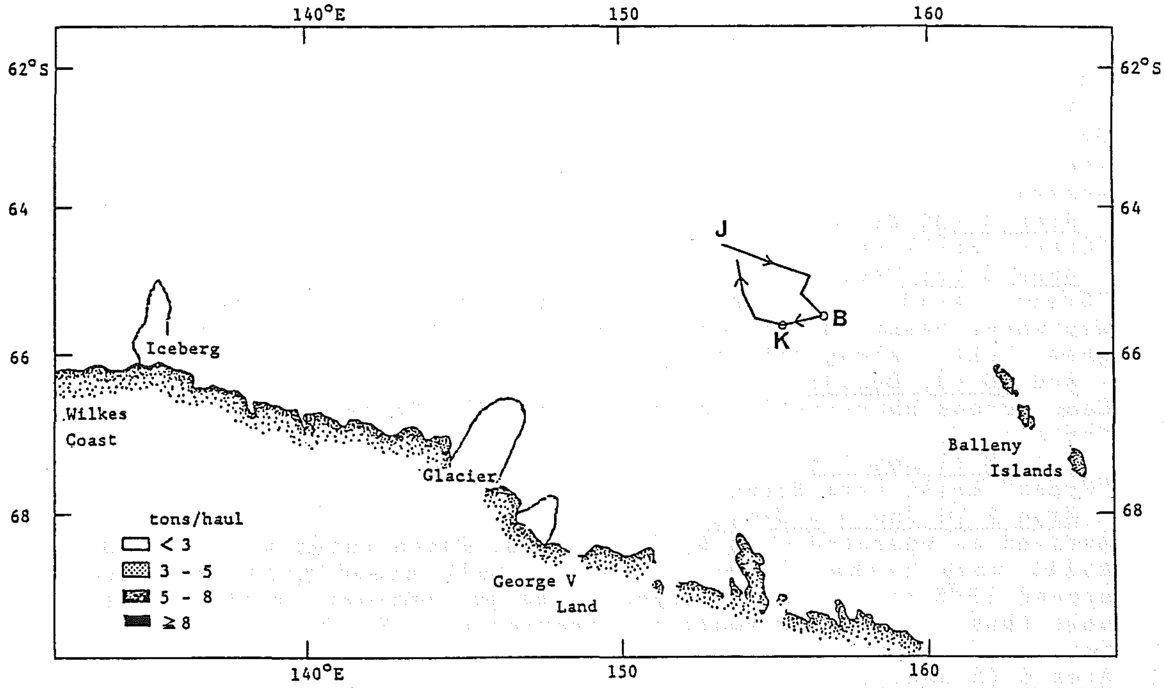

Fig. A-3. Cruise track [31 Jan.-1 Feb.]

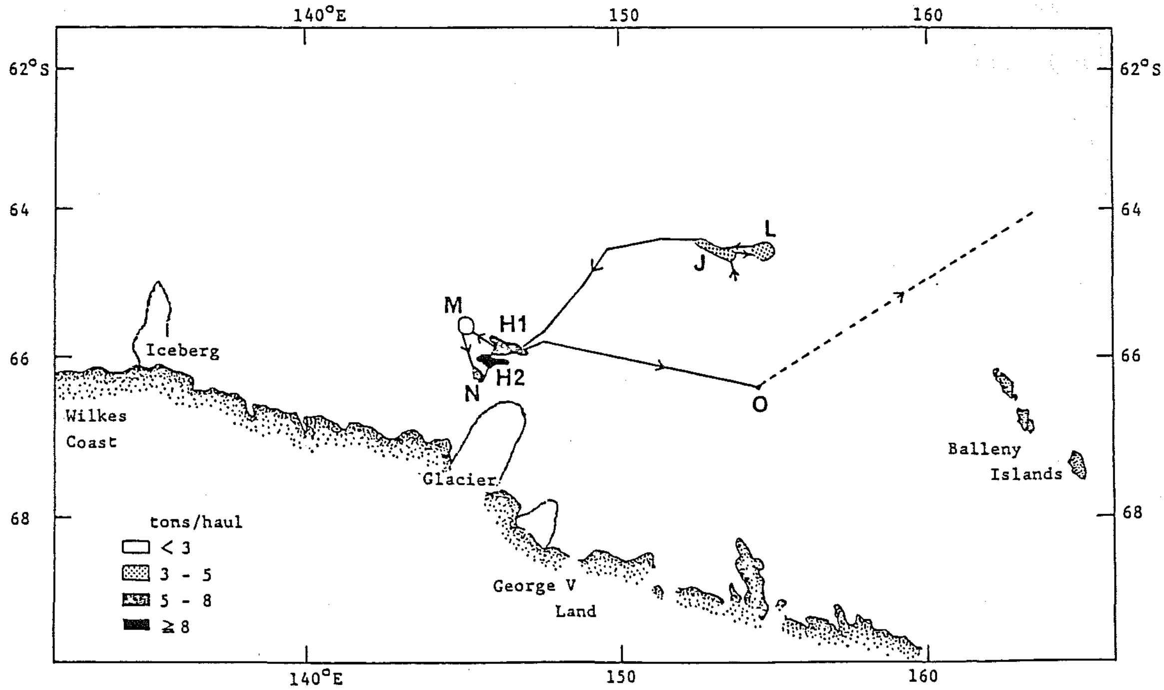

Fig. A-4. Cruise track [2 Feb.-16 Mar.]

APPENDIX

Cruise track and detail explanation of operation

30 Dec.- 6 Jan. (Fig.A-1)

Area A (30 Dec.):

Operation started. Headed to Ehiko Maru at area F, along 65°S, where a good catch of "white" krill was gained in the previous season.

Area B (30 Dec.):

"Green" krill were detected and moved west.

Area C (31 Dec.):

"Green" Krill were detected (not abundant). Turned north-westwards based on information that Ehiko Maru was fishing "less" green krill along 64°S.

Area D (31 Dec.):

Came across harvestable concentration, but "green" krill. So left for area F.

Area E (1 Jan.) :

"Green" krill were found (not abundant).

Area F (2 Jan.- 4 Jan.) :

Arrived in operated area by Ehiko Maru. Catch rates were poor and krill were rather "green". Also small sized krill appeared around 139°E and it was thought to be predominant further to the west (based on the accumulated experience). So turn east heading for area H where a good yield was obtained in past.

Area G (5 Jan.):

On the way to Area H, less abundant area was found.

Area H (6 Jan.):

"Green" krill were found, so left in a hurry. Decided to return to harvestable area D located previously on 31 Dec. in the hope of quality improvement by this time.

6-31 Jan. (Fig.A-2)

Area D (6 - 9 Jan.):

Dense swarms found on 31 Dec. were disappeared. "Greenness" was improved but catch rates were poor, so moved toward area B where "green" krill were detected on 30 Nov. in the hope of quality improvement.

Area I (10-11 Jan.):

On the way to area B, "green" and small krill were detected (not abundant).

Area B (11-14 Jan.):

Low catch rates and low percentage of gravid females with little improvement of "greenness". Moved to the mushroomed shaped swarms at 64°40'S and 154°40'E informed by the cargo ship on 12 Jan. Accumulated information said that krill were scare further to the east except in the vicinity of Balleny Islands where krill were dark "green".

Area J (15-31 Jan.):
A fairly good harvestable area was located to the north-west of the informed position of the mushroomed swarms. Ehiko Maru joined to Zuiyo Maru No.2 on 17 Jan. and operated together afterwards.

31 Jan. - 1 Feb. (Fig.A-3)
Area J (15-31 Jan.):
Catch per haul kept on going fairly good, but toward the end of January the percentage of gravid females decreased, that made krill look "green". So left for area B again in the hope of quality and quantity improvement.
Area B (31 Jan.):
No krill. So moved to area K(65°30'S,155°00'E) where "white" krill were fished in the previous season.
Area K (31 Jan.):
No krill. So returned to area J.
Area J (1 Feb.):
Not only the percentage of gravid females but also catch rates were low. On the other hand Ehiko Maru was fishing gravid females at area L, so moved to area L.

2 Feb. - 16 Mar. (Fig.A-4)
Area L (2 Feb.):
The percentage of gravid females was high, but catch rates were extremely poor. So returned to area J.
Area J (3 Feb.):
There seemed to be little hope in the quality and quantity improvement any more in this area. And the company requested to take 500 tons of M-sized krill. So gave up this area where LL-sized krill were dominant and headed for area H (near to pack ice edge) where L and M sized krill tend to be dominant according to the accumulated experience.
Area H1 (5-10 Feb.):
M-sized krill were dominant and catches were good at first. But it did not last, so Zuiyo Maru No.2 had to move.
Area M (11 Feb.):
Catch rates were very poor, so turned south to pack ice edge where krill tend to be abundant.
Area N (11 Feb.):
Krill were abundant but "green". Also scattered ices were seen and it was felt dangerous for operation. So turned to the north.
Area H2 (11 Feb.-14 Mar.):
At last found the way into the best fishing area in that season. Krill were less "green" or "white", and L or M in size. Catch rates were so good that the processing rate reached the saturation. In mid-March icing began and catch rates declined gradually. The production goal was almost accomplished on 14 Mar., a very stormy day, left for the port in Chile.
Area O (16 Mar.):

Came across dense swarms around good yielding area in past. Size was LL. Operations for the 1985/86 season was completed after 12 hours' fishing there.

Légendes des tableaux

Tableau 1	Utilité du krill dans différentes conditions alimentaires.
Tableau 2	Comparaison de la qualité du krill au large de la Terre de Wilkes et dans la Mer de Scotia.
Tableau 3	Causes du déplacement des navires à la recherche d'une nouvelle zone de pêche.
Tableau 4	Fréquences relatives des procédés utilisés pour détecter les bancs (%).
Tableau 5	Caractéristiques de chaque zone de pêche.
Tableau 6	Utilisation du temps du Zuiyo Maru N° 2 en 1985/86 au large de la Terre de Wilkes.

Légendes des figures

Figure 1	Répartitions des fréquences de tailles des bancs pêchés au trait dans chaque zone de pêche.
Figure 2	Trajet de l'expédition du Zuiyo Maru N° 2 pendant la saison 1985/86. Les différents secteurs de pêche sont entourés.
Figure 3	Zone couverte autour de H2 au cours des opérations de pêche au krill par le Japon des saisons 1983/84 à 1986/87. • indique la position de départ de chaque trait.
Figure 4	Graphique de l'enregistreur du chalut au moment où le banc le plus dense a été pêché. Vingt tonnes de krill ont été prises en 14 minutes de chalutage. La densité absolue a été estimée à 40 g/m^3.
Figure 5	Prise par trait par opposition à la prise par temps de chalutage. Les barres verticales indiquent les écarts types $\pm$.
Figure 6	Profils des variations diurnes de l'intensité moyenne de la lumière, de la répartition verticale du krill, de la prise par trait et de la prise par temps de chalutage. La prise par temps de chalutage est standardisée pour signifier la prise moyenne par temps de chalutage durant la journée (06.00-18.00 h) indiquée dans la figure de droite. Les hachures indiquent la période d'occurrence fréquente de bancs de surface.
Figure 7	Prise par temps de chalutage et trajets des traits au cours de trois périodes successives dans la zone H2. C/T = prise (tonnes) pour 10 minutes de chalutage; C/H = prise (tonnes) par trait; C/D = prise (tonnes) par jour.

Figure 8 Variations dans la composition en longueurs entre des traits séquentiels. La partie foncée de chaque histogramme représente la proportion de femelles (voir texte). La zone O est indiquée à la Figure A-4.

Figure 9 Histogrammes des fréquences de longueurs pendant la saison. La partie foncée représente la proportion de femelles (voir texte).

Figure A-1 Trajet de l'expédition (30 décembre - 6 janvier).

Figure A-2 Trajet de l'expédition (6 - 31 janvier).

Figure A-3 Trajet de l'expédition (31 janvier - 1 février).

Figure A-4 Trajet de l'expédition (2 février - 16 mars).

Encabezamientos de las Tablas

Tabla 1 Utilidad del krill en diferentes condiciones de alimentación.

Tabla 2 Comparación de la calidad del krill aguas afuera de la Tierra de Wilkes y en el Mar de Scotia.

Tabla 3 Causas del desplazamiento de los buques en busca de una nueva zona de pesca.

Tabla 4 Frecuencia relativa de los indicadores usados en la detección de cardúmenes (%).

Tabla 5 Características de cada zona de pesca.

Tabla 6 Distribución del tiempo del Zuiyo Maru N° 2 en 1985/86 aguas afuera de la Tierra de Wilkes.

Leyendas de las Figuras

Figura 1 Distribución de las frecuencias de los tamaños de los cardúmenes remolcados en cada zona de pesca.

Figura 2 Trayectoria de la expedición del Zuiyo Maru N° 2 en la temporada de 1985/86. Las extensiones de las zonas de pesca se indican con círculos.

Figura 3 Area alrededor de H2 explotada por la pesquería de krill japonesa desde la temporada de 1983/84 hasta la de 1986/87. • indica la posición de partida de cada remolque.

Figura 4 Carta del registrador de red cuando se pescó el cardumen más denso. Se capturaron veinte toneladas de krill en 14 minutos de remolque. La densidad absoluta fue estimada en 40 g/m^3.

Figura 5 Captura por lance contra captura por tiempo de remolque. Las barras verticales indican las desviaciones estándar $\pm$.

Figura 6 Perfiles de las variaciones diurnas de la intensidad de luz media, distribución vertical del krill, captura por lance y captura por tiempo de remolque. La captura por tiempo de remolque está estandarizada a la captura media por tiempo de remolque durante las horas del día (0600-1800 hrs), lo cual se presenta en la figura de la derecha. El sombreado indica el período de presencia frecuente de cardúmenes superficiales.

Figura 7 Captura por tiempo de remolque y trayectorias remolcadas en el transcurso de tres períodos sucesivos en el área H2. C/T = captura (toneladas) por 10 minutos de remolque; C/H = captura (toneladas) por lance; C/D = captura (toneladas) por día.

Figura 8 Variaciones en la composición de tallas entre lances consecutivos. El área sombreada de cada histograma representa la proporción de hembras (véase el texto). El área O se indica en la figura A-4.

Figura 9 Histogramas de frecuencia de tallas durante la temporada. El área sombreada representa la proporción de hembras (véase el texto).

Figura A-1 Trayectoria de la expedición (30 de diciembre - 6 de enero).

Figura A-2 Trayectoria de la expedición (6 - 31 de enero).

Figura A-3 Trayectoria de la expedición (31 de enero - 1° de febrero).

Figura A-4 Trayectoria de la expedición (2 de febrero - 16 de marzo).

Заголовки к таблицам

Таблица 1 Возможные способы обработки криля после различных режимов питания.

Таблица 2 Сравнение качественных характеристик криля из района Земли Уилкса с крилем моря Скотия.

Таблица 3 Причины перемены курса судна в поисках новых промысловых районов.

Таблица 4 Относительная частота использования того или иного метода обнаружения скоплений (в %).

Таблица 5	Данные по каждому промысловому району.
Таблица 6	График работы "Зуйо-мару №2" в районе Земли Уилкса, 1985/86 г.

Подписи к рисункам

Рисунок 1 Частотное распределение размеров скоплений, облавливавшихся в каждом промысловом районе.

Рисунок 2 Маршрут плавания "Зуйо-мару №2" в сезоне 1985/86 г. Очерчены границы промысловых участков.

Рисунок 3 Район вокруг H2, где с сезона 1983/84 г. по сезон 1986/87 г. производился вылов криля японскими промысловиками. ● указывает исходную позицию при каждом тралении.

Рисунок 4 Схема, полученная сетевым регистратором в момент облова скопления самой высокой плотности. За 14 минут траления было выловлено двадцать тонн криля. Абсолютная плотность была оценена в 40 г/м^3.

Рисунок 5 Кривая величин соотношения "улов за траление"/"улов за определенное время траления". Вертикальные линии указывают ± стандартное отклонение.

Рисунок 6 Профили суточных изменений в средней интенсивности света, вертикальном распределении криля, величине "улов за траление" и "улов за определенное время траления". Величины "улова за определенное время траления" соотнесены со средними величинами "улова за определенное время траления в течение дня" (06.00-18.00), что показано на рисунке справа. Штриховка указывает на период времени, когда часто встречались поверхностные скопления.

Рисунок 7 Улов за определенное время траления и маршруты траления для трех последовательных промежутков времени в районе H2. C/T - улов (в тоннах) за 10 минут траления, C/H - улов (в тоннах) за траление, C/D - улов (в тоннах) за день.

Рисунок 8 Изменения в размерном составе между последовательными тралениями. Заштрихованные участки каждой гистограммы указывают на относительное количество особей женского пола (см. текст). Район O показан на Рисунке A-4.

Рисунок 9 Гистограммы ассортимента длин за сезон. Заштрихованный участок указывает на относительное количество особей женского пола (см. текст).