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DATA ON THE SHRIMP (*Pandalus borealis*) OFF THE LABRADOR COAST

by

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INTRODUCTION

The "Solborg", a Faroese factory shrimper of the stern trawler type, with a gross tonnage of 735 t and an overall length of 57 m, fished shrimp (Pandalus borealis) off Labrador, specifically in the Hopedale and Cartwright Channels (Fig. 1), from September 21 to December 31, 1978. It conducted three fishing trips on behalf of the Quebec company "Fruits de mer de l'Est du Québec Inc." of Matane, as part of a "joint venture", with an observer from Environment Canada on board.

The first author of this publication participated in the second fishing expedition from October 28 to December 5. Observations were made on the technical and scientific aspects of the fishery. This document is a report on the results on fishing effort, catches and their nyctimeral variations, length frequency distributions and incidental catches.

A more detailed report will be issued later.

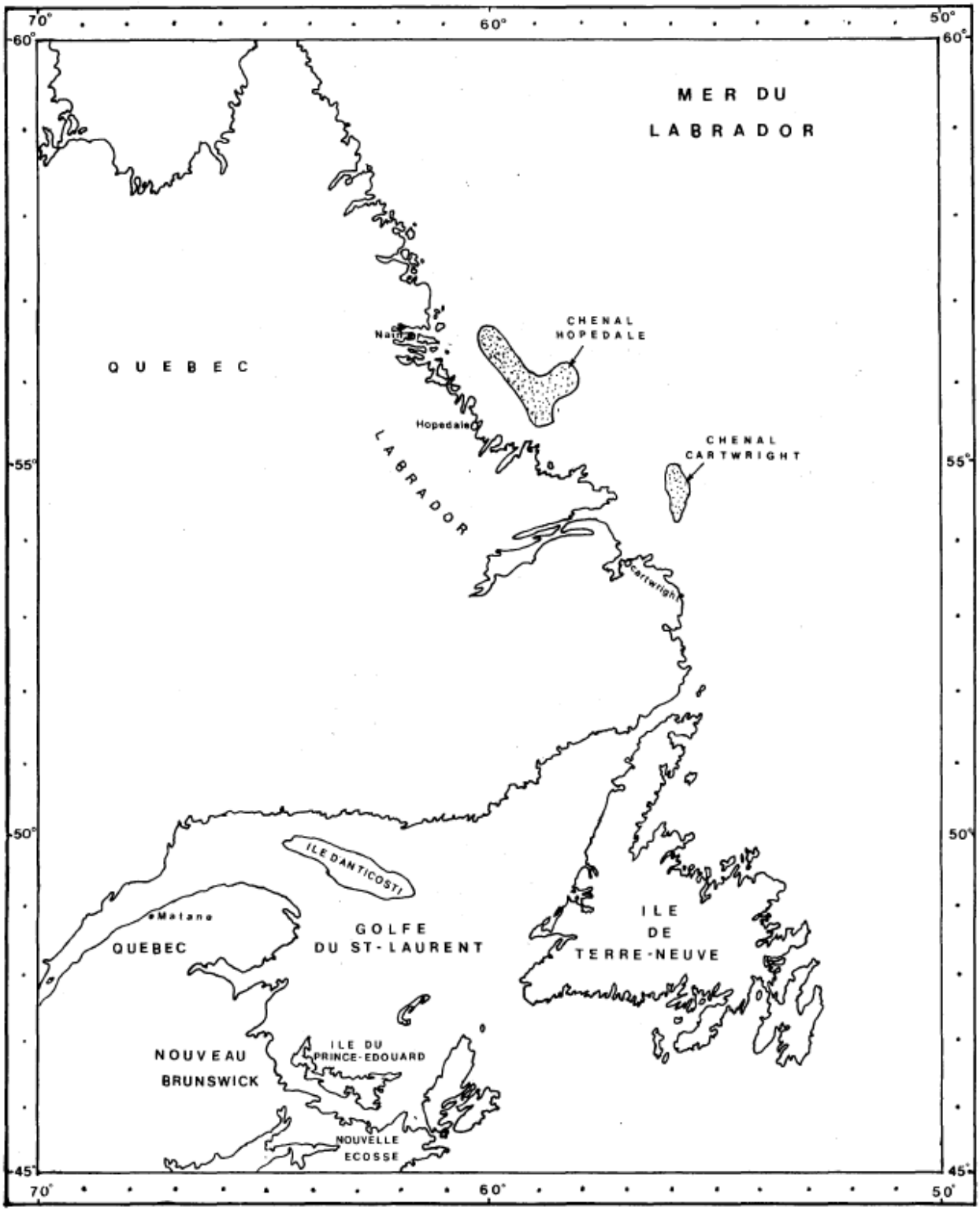

Fig. 1. Main shrimp fishing grounds; off the Labrador coast.

MATERIAL AND METHODS

The "Solborg" used a shrimp trawl with a 2000 mesh with a 61.6 m footrope and a 51.5 m headrope. The cod-end mesh when extended had a dimension of 43 mm. The average trawling speed was 2.5 knots and a haul lasted between 4 and 6 hours.

During the second trip, samples were taken from 70 of the 109 hauls made. Each sample consisted of 300 to 500 shrimp. Sampling was performed while the catch, after been dumped into the tanks, was being transported by conveyor to graders.

On the one hand, we measured the cephalothorax length of ovigerous shrimp, and on the other, that of non-ovigerous shrimp and determined the total weight of these two categories. The measurements were made to the nearest 0.1 mm and for analysis individual specimens were grouped into classes with 0.5 mm intervals. In addition, we froze several samples so that we could determine the gender ratio in the laboratory, and also measured incidental catches. Finally, we obtained detailed data on the catches and fishing effort, these data were combined with those we obtained on the 1st and 3rd trips.

CATCHES AND CATCHES PER UNIT EFFORT

The total number of fishing days of the "Solborg" off Labrador was 80, including 61 in the Hopedale Channel (Fig. 2-4) and 19 in the Cartwright Channel (Fig. 5).

Table I provides a general overview of catches and fishing efforts. The catch data did not include shrimp that were rejected (about 6%) because they were too small or damaged.

Throughout the trip, the yield in the Cartwright Channel was not very high (315 kg/h); in contrast, it was very high in the Hopedale Channel, double the yield of the former (635 kg/h) during the 1st and 2nd trips and even three times higher (916 kg/h) during the third trip. One of the factors contributing to the high yield was certainly excellent organization of fishing activities on board the "Solborg": these continued night and day, without dead time between hauls, regardless of the weather and even despite winds that at times blew at up to 80 miles an hour.

Cartwright Channel

Directly after its arrival from the Faroe Islands, the "Solborg" began to fish in this area on September 21. The average daily yields were very variable (Fig. 6).

TABLE I CATCHES AND CATCHES PER UNIT EFFORT

-	1st trip		2nd trip	3rd trip	-
FISHING AREA	**CARTWRIGHT**	**HOPEDALE**	**HOPEDALE**	**HOPEDALE**	**TOTAL**
Period	**Sept. 21 – Oct. 9**	**Oct 10 – Oct. 21**	**Nov. 2 – Nov. 29**	**Dec. 11 – Dec. 31**	**-**
Fishing days	**19**	**12**	**28**	**21**	**80**
Fishing hours	**345**	**239.75**	**566.16**	**400.5**	**1550.5**
Catch (mt)	**111.30**	**154.02**	**354.09**	**361.87**	**981.23**
$\bar{X}$ **catch (t/d)**	**5.86**	**12.84**	**12.65**	**17.23**	**12.27**
$\bar{X}$ **of yields kg/h**	**314.86**	**636.94**	**634.31**	**916.42**	**636.42**

This cannot be explained by the vessel's movements or by variations in the depth of fishing areas, because the "Solborg" fished in a narrow corridor with a depth varying only between 400 and 500 m. However, it could be explained by movements of the shrimp due to the concentration of the fishing fleet in a specific location and because of variations in hydrological factors.

However, even discounting the first three days spent finding the best fishing grounds, during which the yield was very low, it was noted that the mean daily catches remained fairly low (very few trawls above 500 kg/h) (Fig. 6), despite the efficiency of the vessel. In addition, during the last eight days of the trip, the yields decreased slightly, which explains why the "Solborg" left early after the October 10 before the official end of fishing, set for October 18 in this area.

The fishing results of the "Solborg" seem to match those reported by Sandeman (1978) for the year 1977 in the same area. In fact, the average kg/h yields obtained by the "Solborg" starting from September 21 (315 kg/h) were virtually the same as those for September of the previous year.

However, the fishing capacity of the "Solborg", which is certainly higher than other shrimpers/factory ships, makes it difficult to compare its yield with those obtained in 1977.

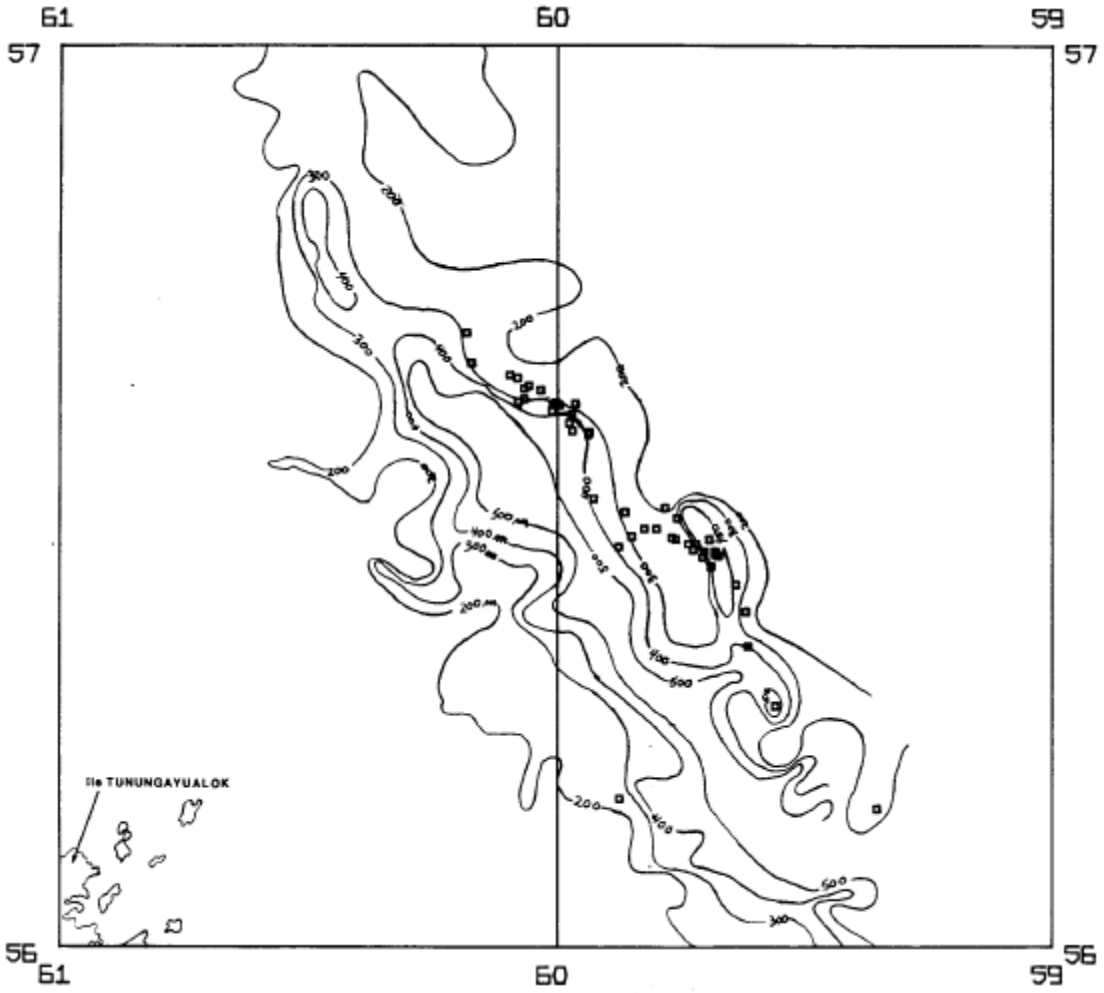

Fig. 2. Trawling stations of the Solborg between October 10 and 21, 1978 in the Hopedale Channel (Division 2H, ICNAF). Each square represents the start of a haul.

* The isobaths of the navigational charts (L,D-8047 and L,D-8048) have been slightly modified because they did not always correspond to our observations on board.

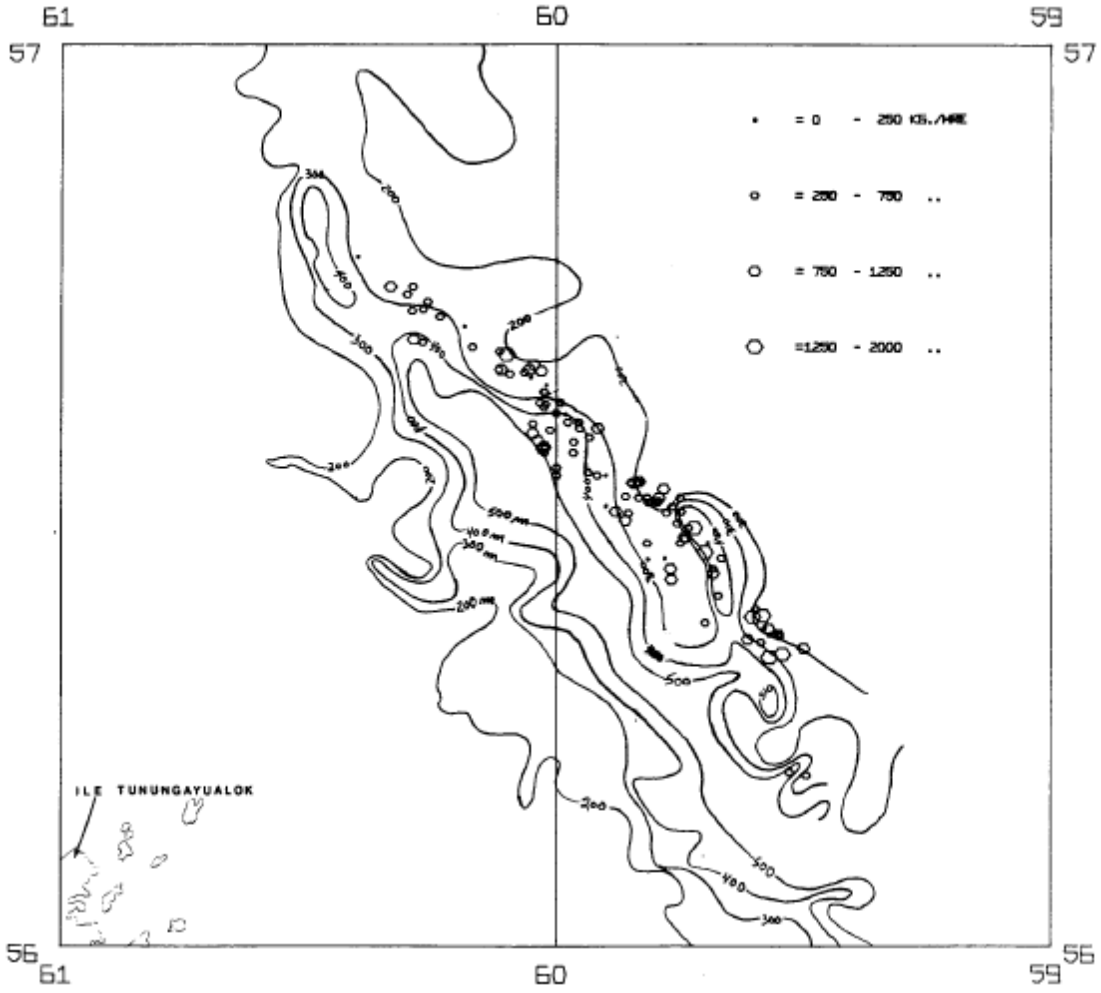

Fig. 3. Trawling stations of the Solborg between November 2 and 29, 1978 in the Hopedale Channel (Division 2H, ICNAF). Each hexagon represents the start of a haul and its yield (kg/h).

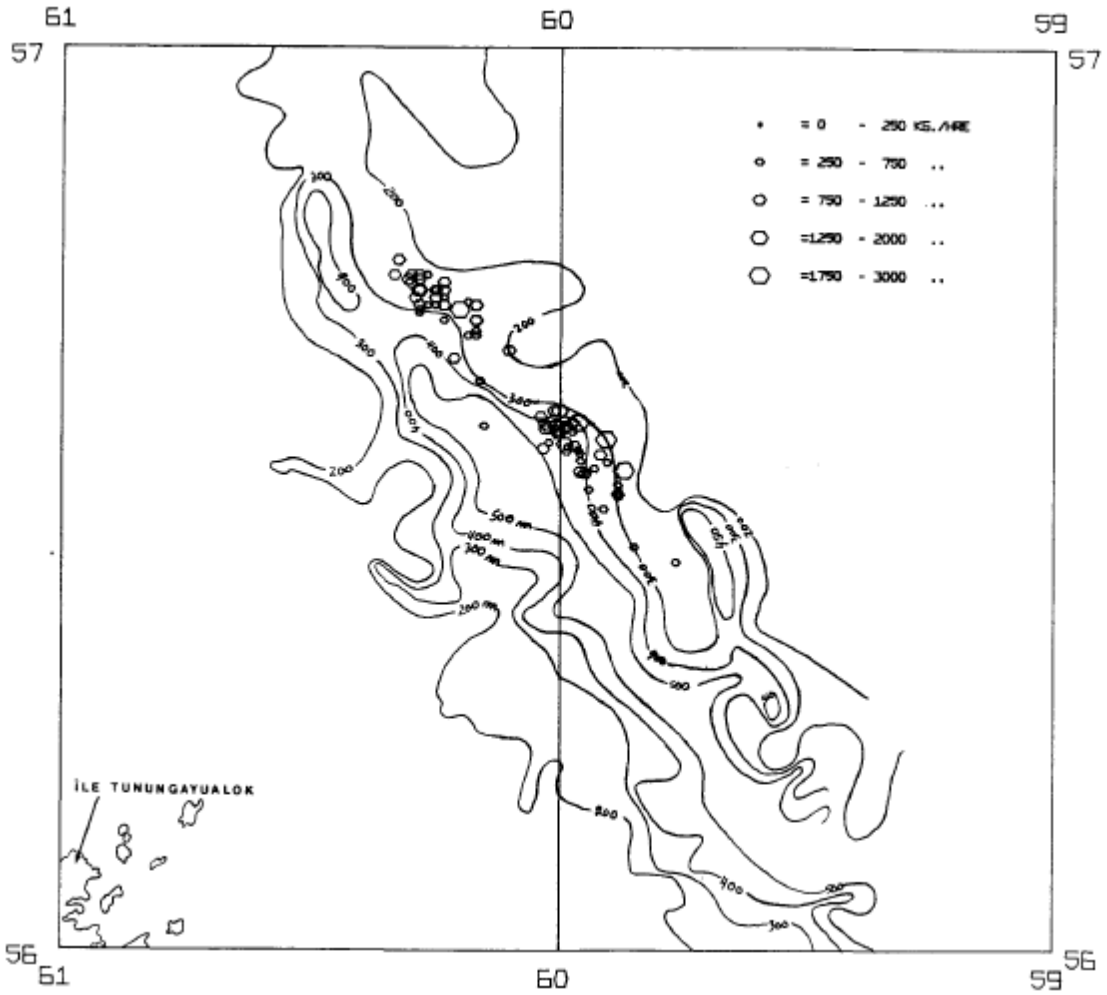

Fig. 4. Trawling stations of the Solborg between December 11 and 31, 1978 in the Hopedale Channel (Division 2H, ICNAF). Each hexagon represents the start of a haul and its yield (kg/h).

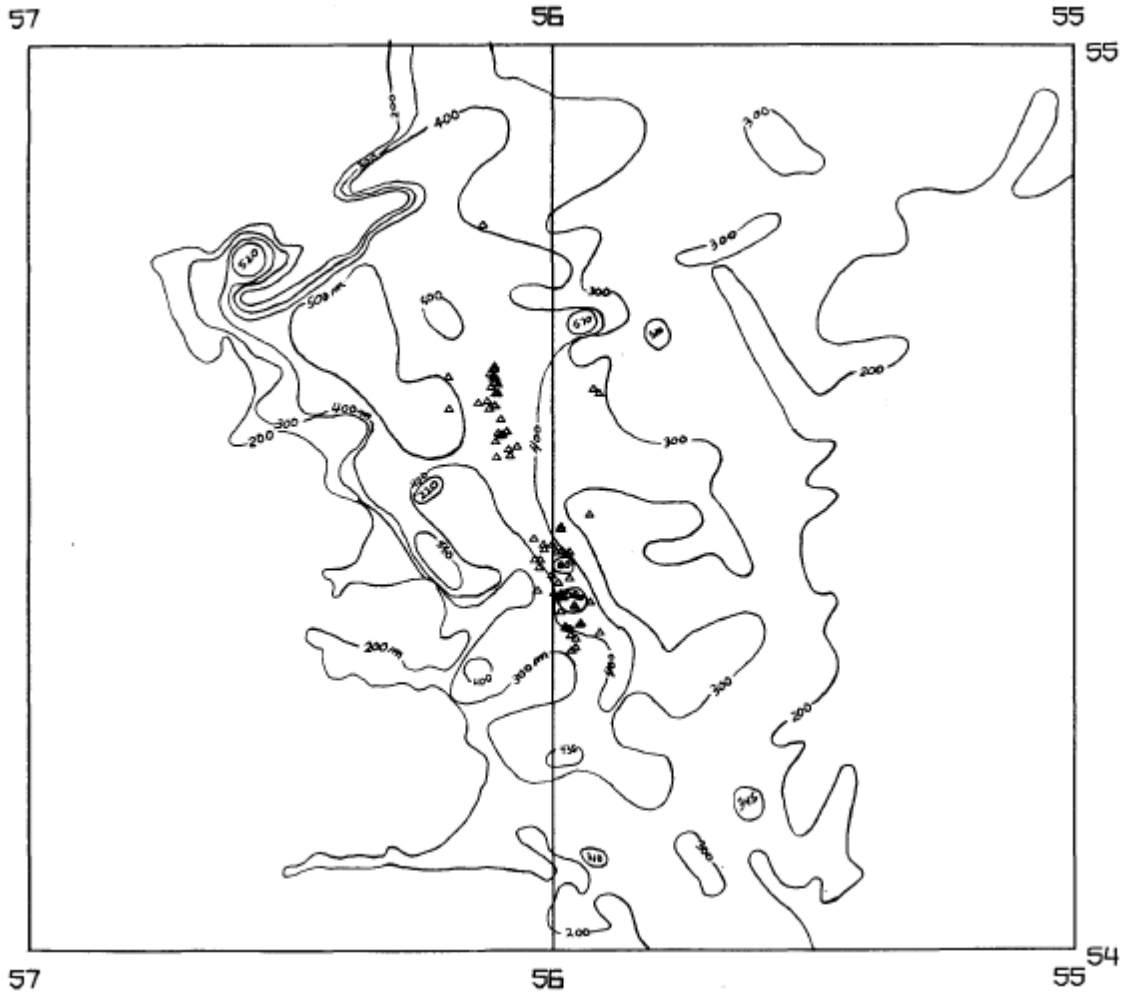

Fig 5. Trawling station of the Solborg between September 21 and October 9, 1978 in the Cartwright Channel (Division 2J, ICNAF). Each triangle represents the start of a haul.

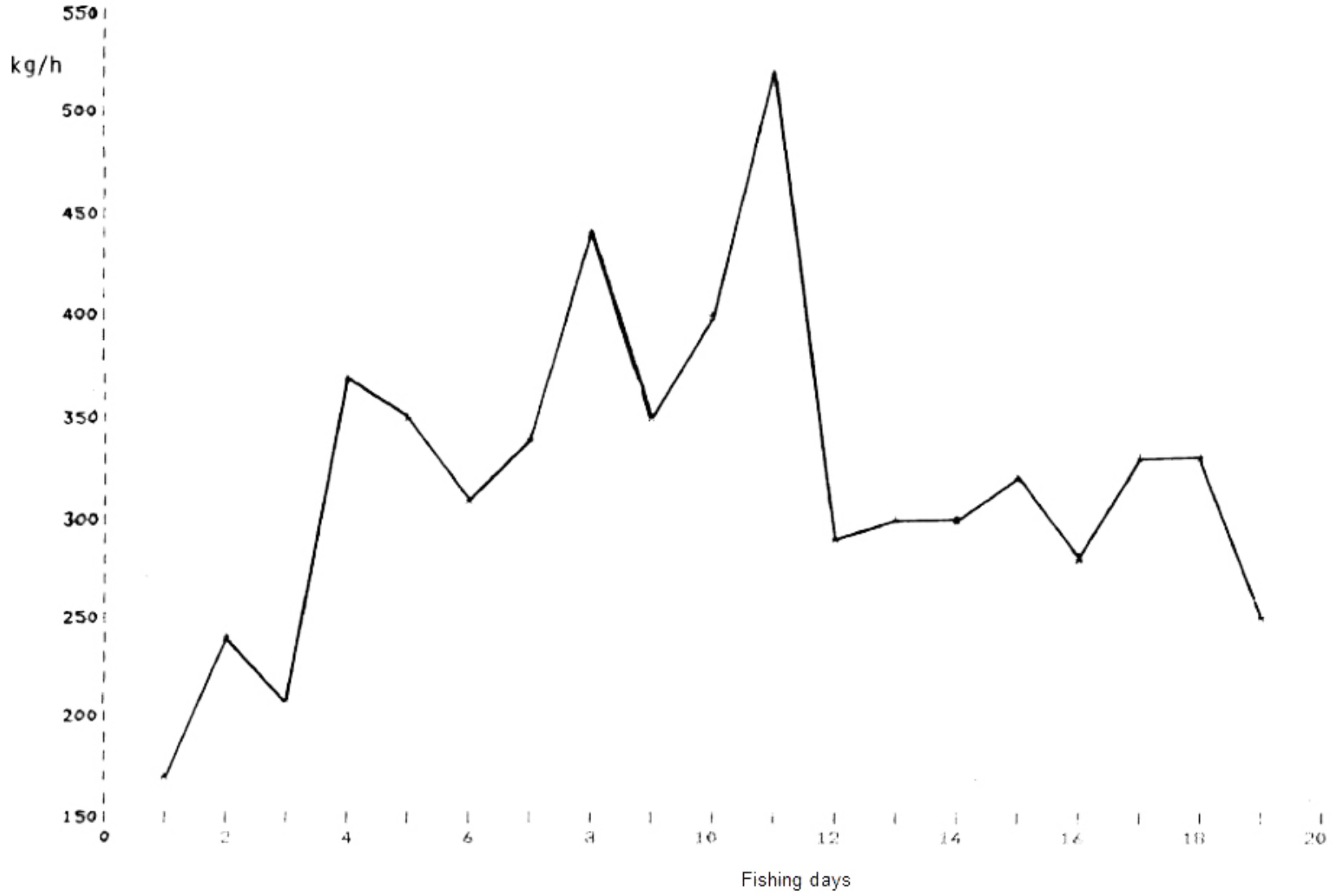

Fig. 6. Daily average yields (kg/h) obtained by the "Solborg" in the Cartwright Channel (Division 2J, ICNAF) from September 21 to October 9, 1978.

The similarity of yields obtained by the entire fishing fleet in 1977 and 1978 in corresponding periods shows that there have not been significant fluctuations in abundance in the shrimp stock in the Cartwright Channel from 1977 to 1978.

Hopedale Channel

The Solborg began fishing in this area on October 10, while other vessels had been operating there since the end of July. This fishing area is more extensive than the Cartwright area and bathymetry of fished sea floor is much more variable (250 to 520 m).

Fig. 7 shows the chart of daily average yields obtained over three trips. It is noticeable that these yields varied considerably. At the very start of the first trip, they were not high (approximately 580 kg/h), which could be explained by the vessel searching for the best fishing locations. However, they then increased considerably.

On the second trip, they remained high for a about week. The average level of catches then decreased and stabilized between 500 and 600 kg/h for about 15 days; this was probably due to the cumulative effect of the fishing effort of six or seven boats working in the same area. During the last three days of this trip, the boat searched for better fishing grounds and found these at greater depths.

During the third trip, the trawling stations were more numerous in the north of the channel and the hauls were generally conducted at greater depths, which could explain the very high yields. As for the mean yield of 2,156 kg/h obtained on the last day in shallow waters, this could be explained by a migration of ovigerous shrimp from the depths of the channel to the channel's East slope.

Figure 8 summarizes the variations in weekly yields on the three trips. A sharp drop is apparent during the second trip, and a striking rise during the 3rd.

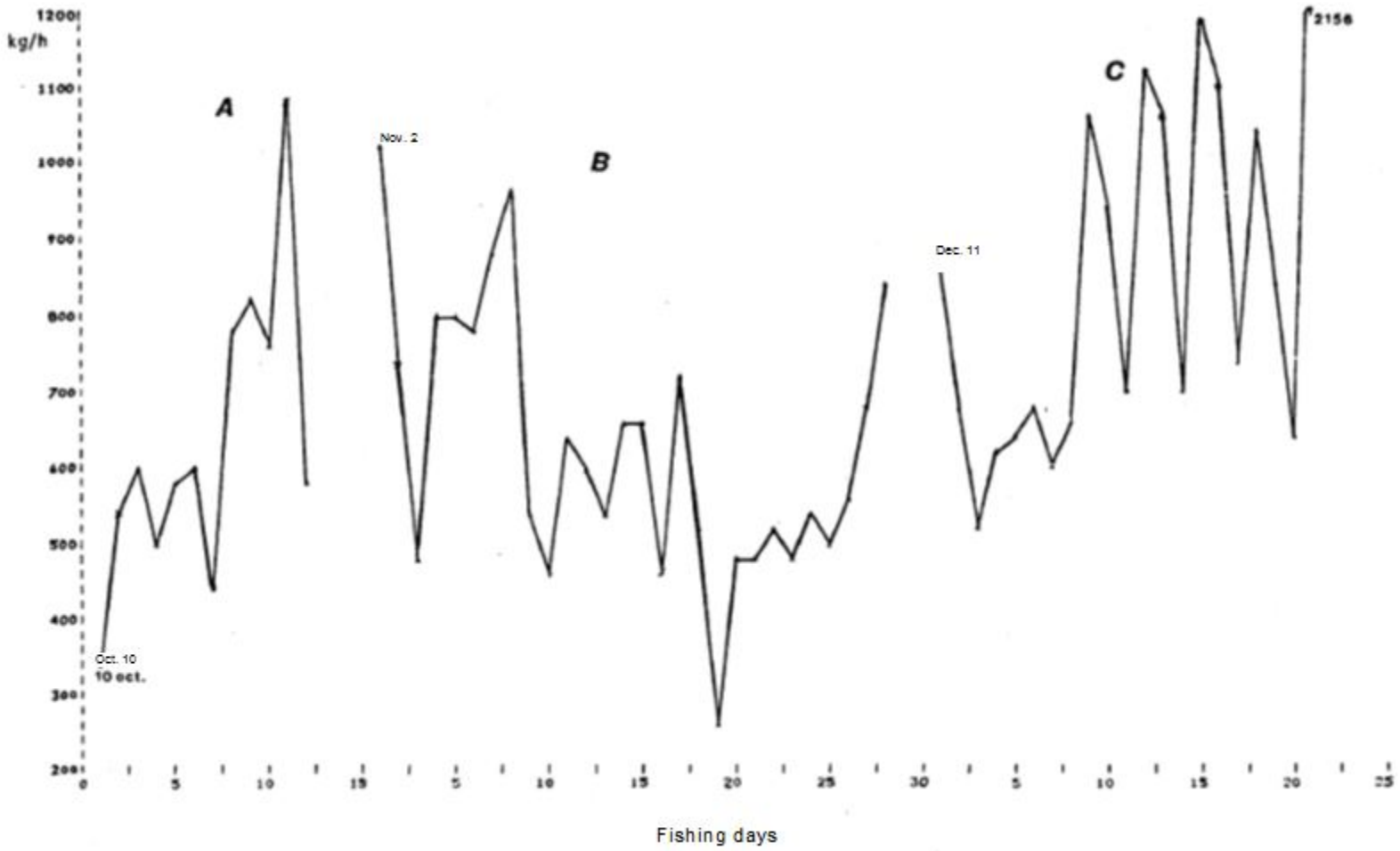

Fig. 7. Daily average yields (kg/h) obtained by the "Solborg" in the Hopedale Channel (Division 2H, ICNAF). The letters A, B, C indicate the three consecutive trips of the "Solborg."

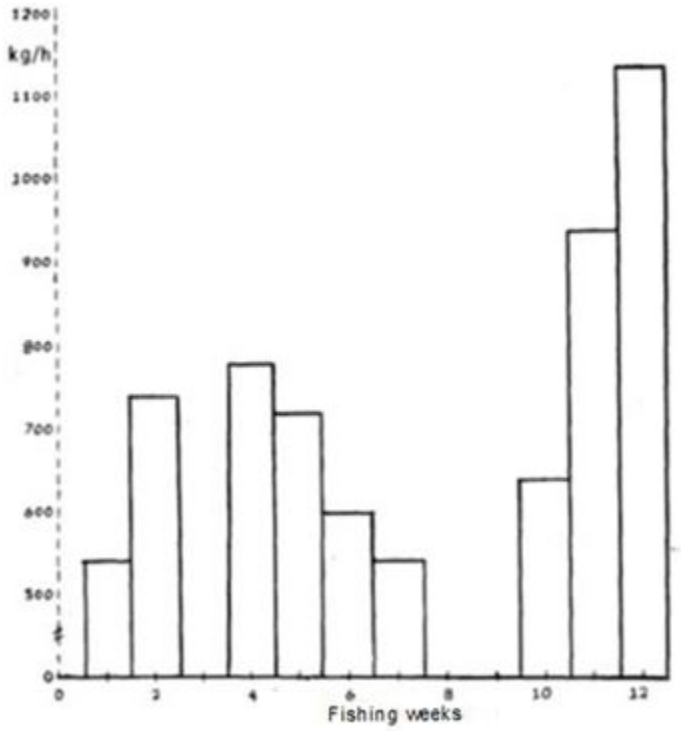

Fig. 8. Average weekly yields (kg/h) from October 9, 1978 to December 31, 1978 for three consecutive trips of the "Solborg."

YIELDS ACCORDING TO DEPTH

Fig. 9 and 10 show the mean yields obtained by the "Solborg" over three trips according to depth.

In the Cartwright Channel, at depths of between 200 and 450 m, the mean yields were very low, not rising above 208 kg/h. Between 450 and 550 m, the yields were higher but were still low compared to those obtained in the Hopedale Channel.

Mean yields in the Hopedale Channel during the first trip were the highest at depths between 250 and 300 m (822 kg/h). In the other depth classes, yields remained steady at around 500 kg/h.

During the second trip, average yields were the same order of magnitude at all depths from 200 to 550 m, ranging from 530 to 768 kg/h.

In general, the yields of the 3rd trip were much higher than those of the 2nd trip: at depths between 250 and 300 m, they were 2,156 kg/h, while they never exceeded 800 kg/h during the second trip.

At depths of 300 to 450 m, yields were 900 to 1,000 kg/h, compared with 500 to 600 kg/h during the 2nd trip.

During the 3rd trip, the vessel moved to the northwest and there were more trawling stations at greater depths (comparison of Fig. 2 and 3). The higher yields could be explained by the lower fishing effort in the new area. On the other hand, the hypothesis of shrimp movement to greater depths was also plausible.

It is also apparent that yields vary inversely with depth: thus the lowest yields (525 kg/h) were obtained at greater depths (500 to 550 m) and highest (2,156 kg/h) at the shallowest depths.

Regarding the exceptional performance on the last day of the trip of 2,156 kg at the shallow depth of 250 to 300 m, this may be attributable to the migratory movements of ovigerous females which move from the great depths to the shallower East slope of the Hopedale Channel in the spring to spawn. A similar phenomenon occurs in the Northern Gulf of St. Lawrence (J. Fréchette, pers. comm.). We have no data to confirm that this migration also occurs on the West slope of the channel.

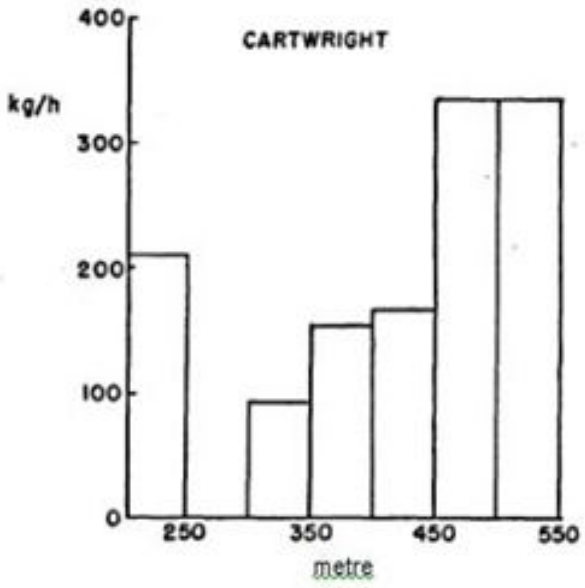

Fig. 9. Average yields (kg/h) according to depth, obtained by the Solborg in the Cartwright Channel.

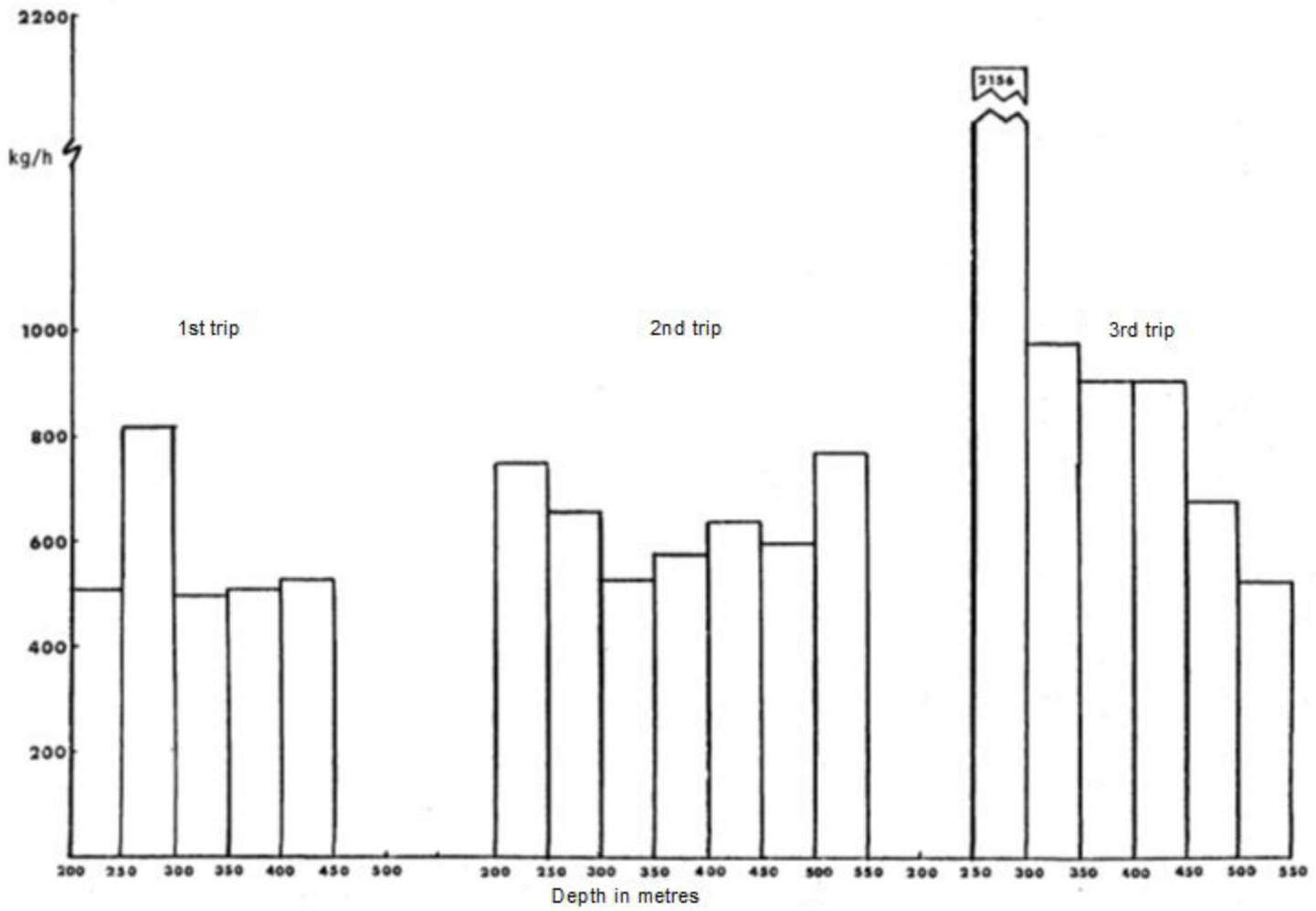

Fig. 10. Mean yields (kg/h) according to depth, obtained by the Solborg in three consecutive trips to the Hopedale Channel.

NYCTIMERAL VARIATION OF CATCHES

Several authors have previously demonstrated that there is a nyctimeral variation in the mean shrimp catch in northerly waters (Smidt, 1978, Carlsson et al., 1978, Jones and Parsons, 1978), with a maximum yield during the day and a minimum at night. The difference between these two yields varies according to the season.

The results obtained by us in Hopedale and Cartwright areas show, on the one hand, that yields (kg/h) of hauls performed at the same time of day vary considerably. They also show that the nyctimeral variation (Fig. 11 and 12) is comparable to that obtained by the authors cited above.

In the Cartwright area, this variation is quite significant. Thus, the Solborg fished in a rather limited area and at a relatively constant depth (400 to 550 m) (Fig. 5), which largely eliminated variations due to the size and depth of fishing area.

In the Hopedale area, the results obtained during the third trip seem to show the shrimp moving to greater depths in mid-December (350 to 450 m), and with a possible movement of ovigerous females toward shallower depths (250 to 300 m) at the end of the month. These two movements have a significantly effect on the variations, making them so aberrant compared with those of the other two trips that we discounted these results in the variation study. Thus the nyctimeral variation in mean yields of the first two trips in the Hopedale area was quite similar to that for the Cartwright area, even though the fishing area is more extensive and the depths more varied.

The free-hand curve was sketched and the day-night correction factors calculated; around 1.36 for Cartwright and 1.56 for Hopedale. These figures are quite similar to those obtained by Horsted in the Davis Strait, but significantly lower than those obtained by Smidt, Berenboim et al., Jones and Parsons for the same area (see Jones and Parsons 1978). When the correction factors for estimates of biomass were applied; "background noise", i.e. extraneous components such as variations due to the extent and depth of fishing area and others, had to be eliminated to the extent possible from the major causes of nyctimeral variations in the shrimp population.

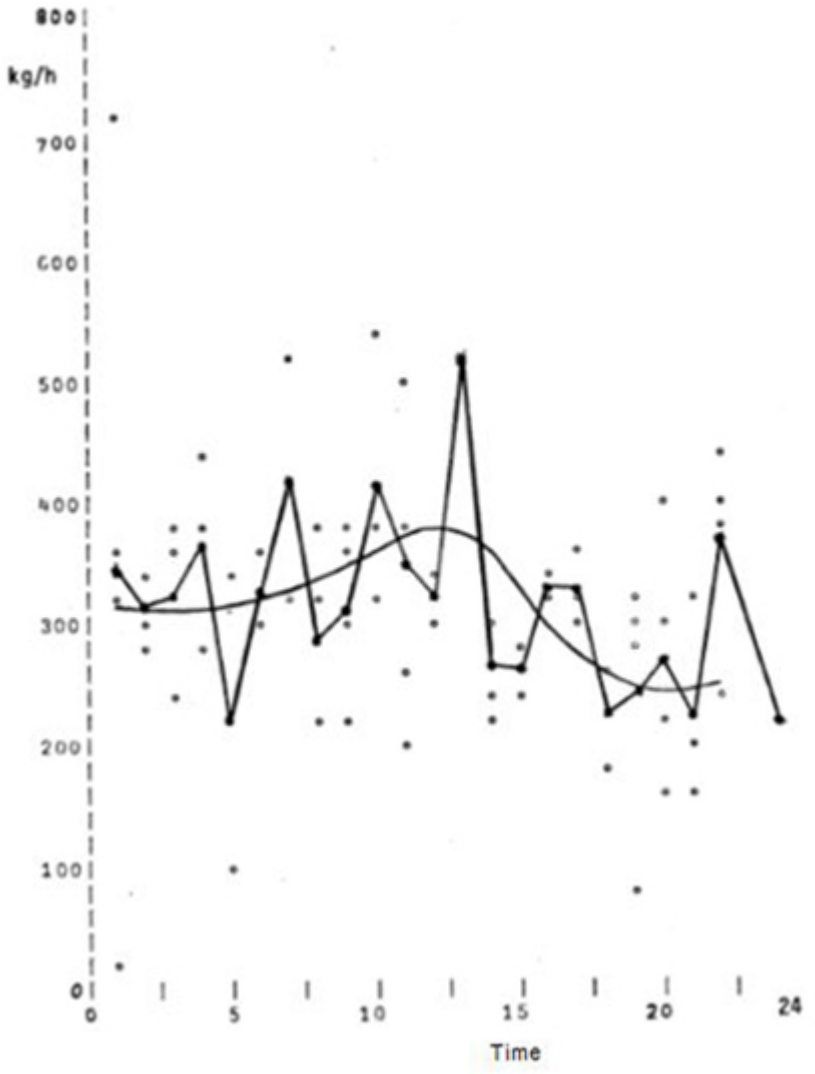

Fig. 11 Free-hand curve of nyctimeral variations in average yield (kg/h) obtained by the Solborg in the Cartwright Channel between September 21 and October 9, 1978. Each circle indicates a haul.

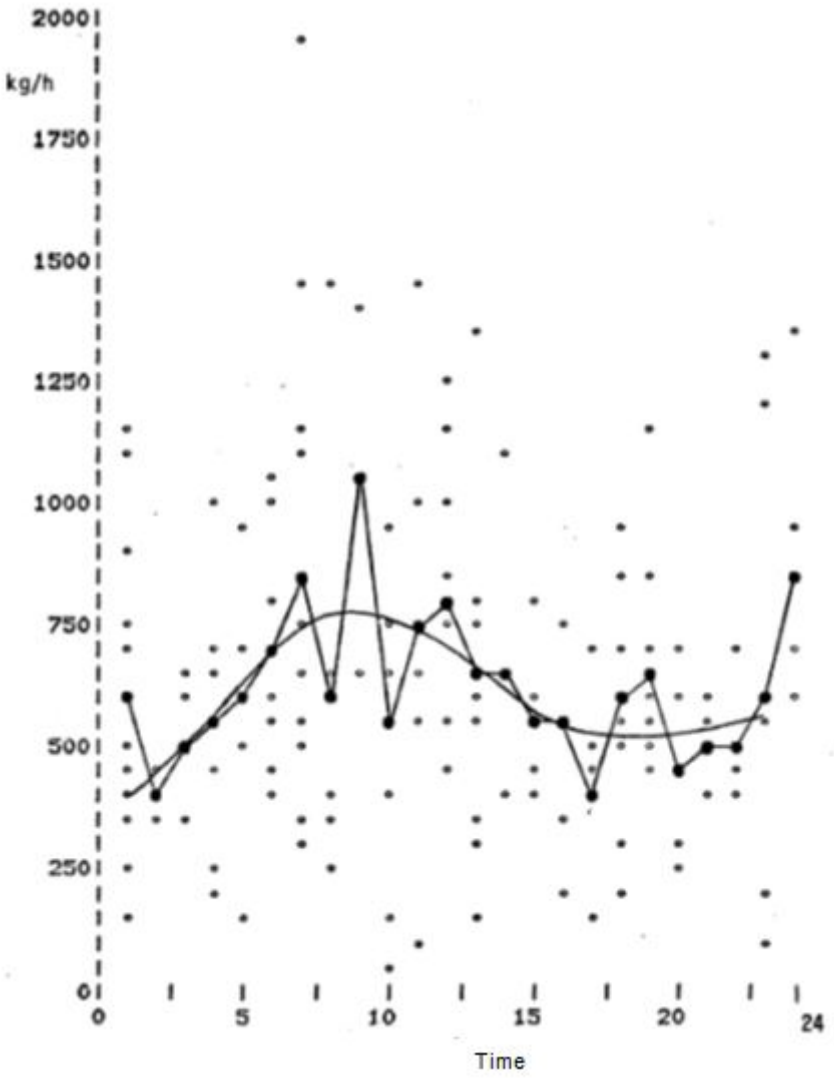

Fig.12. Free-hand curve of nyctimeral variations in average yield (kg/h) obtained by the Solborg in the Hopedale Channel from October 10 to November 29, 1978. Each circle indicates a haul.

DISTRIBUTIONS OF SHRIMP LENGTH FREQUENCIES

Fig. 13A shows the overall size frequency distribution in the Hopedale Channel for the period from November 2 to 29. Four age classes can be identified quite clearly.

Due to trawl selectivity (stretched mesh gauge is 43 mm), the average size and abundance of Class I is distorted (phenomenon previously observed by Ultang and Øynes 1978). As a result, the average size of around 17 mm is certainly well above the actual size and abundance that can be seen on the frequency distribution histogram (Fig. 13a, b and c) is not representative of the real abundance.

Class II is dominant in terms of relative abundance with a mode of 20 mm.

Class III has a mode of 24 mm.

Class IV+ (possible accumulation of several age classes), which is much less abundant than the others, reached its mode at 27 mm. This low abundance could be explained by a combination of the following factors: less abundant recruitment for classes III and IV (probably a very important factor), natural mortality and mortality due to fishing (as the latter is a very recent phenomenon in the Hopedale Channel, this factor is probably of minor significance). The low abundance could indicate that class III ovigerous females have only one clutch since they have largely disappeared from the class IV.

For comparison purposes, Table II shows the modes of the frequency distributions for three areas at approximately the same time of year, without taking into account the reasons for differences contained.

TABLE II. COMPARISON OF THE MODES OF FREQUENCY DISTRIBUTION FOR THREE DIFFERENT AREAS.

Area	Month	Modes mm				References
Davis Strait	Sept.-Oct. 1977	12.9	17.9	23.1	29.5	Minet et al. 1978
Hopedale Channel	Nov. 1978	14-15	20	24	27	Axelsen et al. 1979
Gulf of St. Lawrence	Sept.-Oct. 1971-74	15*	19*	23*	26*	Simard et al. 1975

* (3-year average).

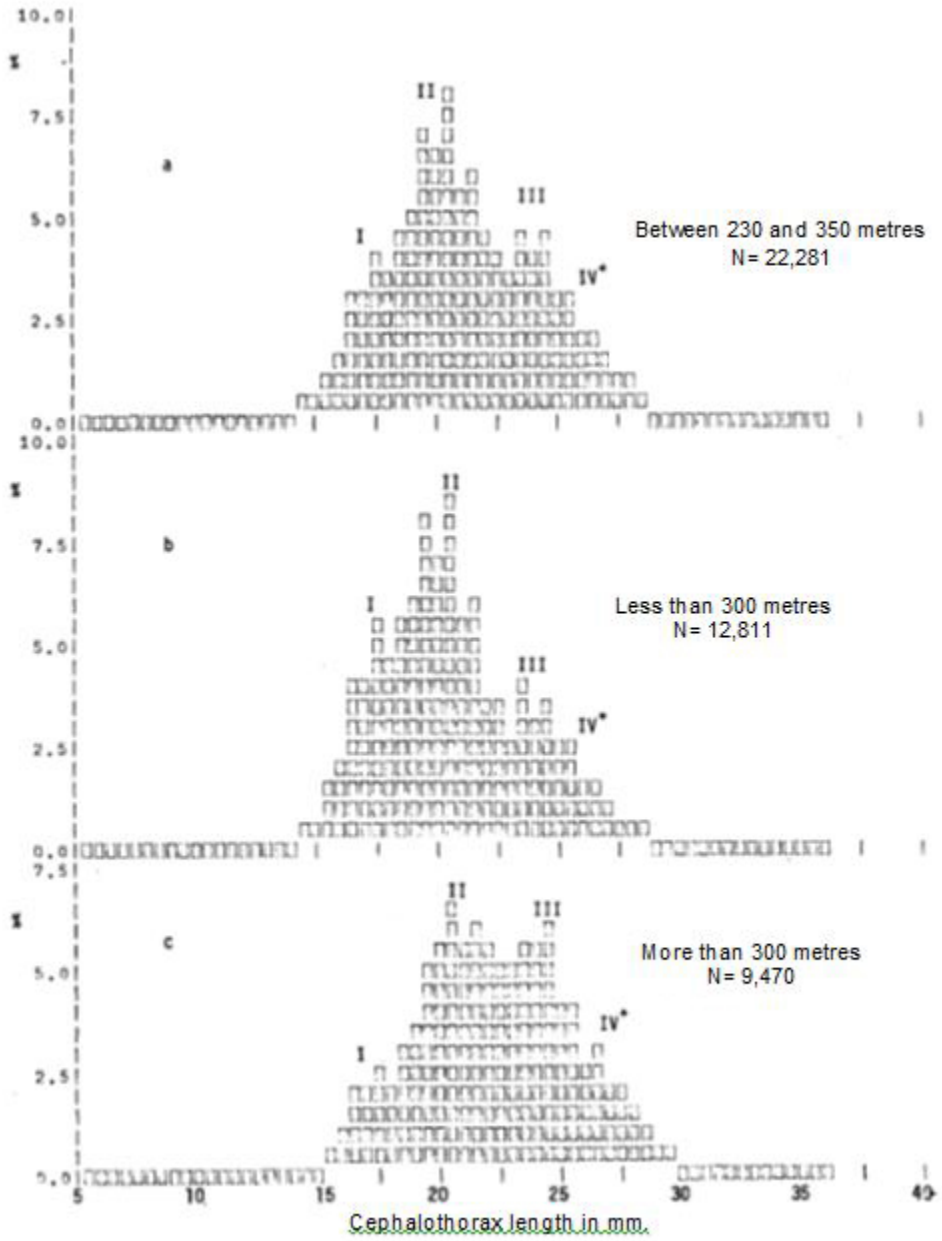

Fig. 13. Frequency distribution *Pandalus borealis* in relation to depth.

DISTRIBUTIONS OF SIZE FREQUENCIES WITH DEPTH

Fig. 13B shows that the population of Pandalus borealis in the Hopedale Channel at depths of less than 300 m largely consists of class I and II individuals and with a lower number of class III and IV individuals. It should be noted that class II is predominant at all depths.

Fig. 13C shows that at depths of more than 300 m, although classes I and II are still present, class III becomes more significant and that class IV also begins to peak. This distribution is similar to that obtained by Labonté and Fréchette (1978).

It may therefore be concluded that ovigerous females, which are of a large size, can be found in the greater depths (except in the period in which they migrate to shallower depths, see p. 17) as is shown by Table III.

TABLE III. PERCENTAGE OF OVIGEROUS FEMALES ACCORDING TO DEPTH

Depth m	total % of ovigerous females
250-300	23.6
300-350	46.9
350-400	48.0
400-450	49.0
450-500	52.9

FREQUENCY DISTRIBUTIONS BY SEX

Fig. 14 shows a frequency distribution by sex, based on a limited number of samples. It is apparent that the modes of these distributions practically coincide with those of Fig. 13a. Almost 92% of females are ovigerous in this period, reflecting, as for the majority of stocks of this species, an annual reproductive cycle.

On the histogram, it can be seen that the male - female overlap is located in the period when shrimp have a cephalothorax length ranging from 20 to 23 mm, which corresponds to the transition from class II to class III. As this species is protandric (sequentially hermaphroditic), it is at this time that the transition from male to female occurs.

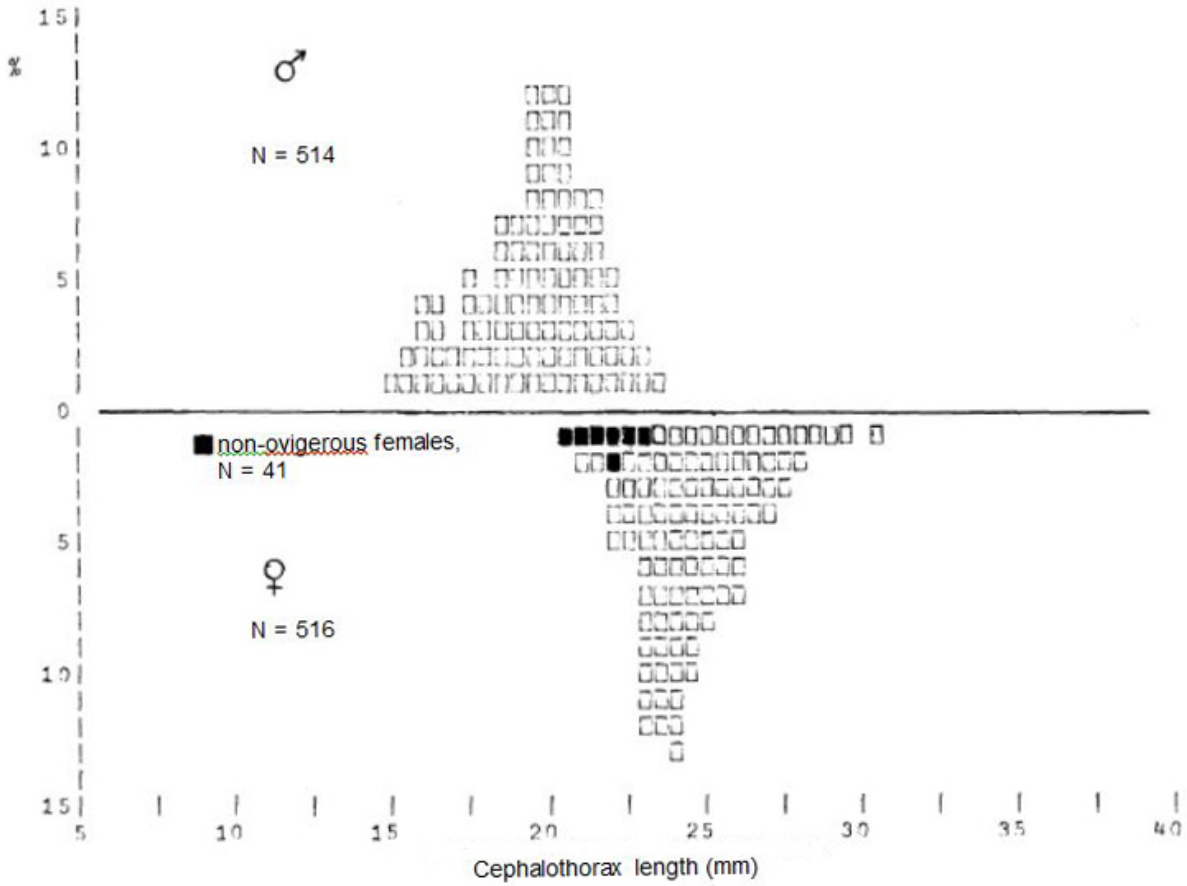

Fig. 14. Frequency distributions by sex of *Pandalus borealis*

INCIDENTAL CATCHES ASSOCIATED WITH SHRIMP FISHING

Incidental catches are inevitable in shrimp fishing due to the small mesh size at the cod-end of the trawl (43 mm). The incidental catches were not kept, except in limited quantities for consumption on board. We performed some body measurements on specimens and some observations on these incidental catches. We thus estimated that they accounted for roughly 25% of the total catch weight. The incidental catch mainly consisted of the commercially exploited species of rockfish (Sebastes marinus mentella) and Greenland halibut (Reinhardtius hippoglossoides), cod (Gadus morhua) and occasionally some Atlantic halibut (Hippoglossus hippoglossus). It should be noted that the rockfish and Greenland halibut were found in almost all hauls. The non-commercially exploited species consisted almost entirely of eelpouts, which were always abundant.

Both rockfish, generally of a small size (10 to 20 cm), as well as Greenland halibut (10 to 40 cm) had 2 distinct modes in their distributions (Fig. 15). The proportion of small individuals of these two species was large compared to that of large individuals. But neither of these distributions is necessarily a good representation of the whole population due to the low trawling speed, as large size individuals had the opportunity to escape. This phenomenon has also been observed in the Gulf of St. Lawrence (Axelsen et al. 1977).

The frequency distribution of cod was narrow (Fig. 15) and its average specimen length was 50.2 cm. At the start of the second trip of the "Solborg", we noticed that it was present in small quantities, but then suddenly it appeared to become very concentrated. This concentration would explain its abundant presence in the trawl, despite the low trawling speed. The cod had probably come down from the Nain Bank because of changes in temperature. It was mainly found at depths between 220 and 280 m. It was undoubtedly in search of food at this point, as is apparently demonstrated by the 200 cod stomachs examined, which only contained shrimp.

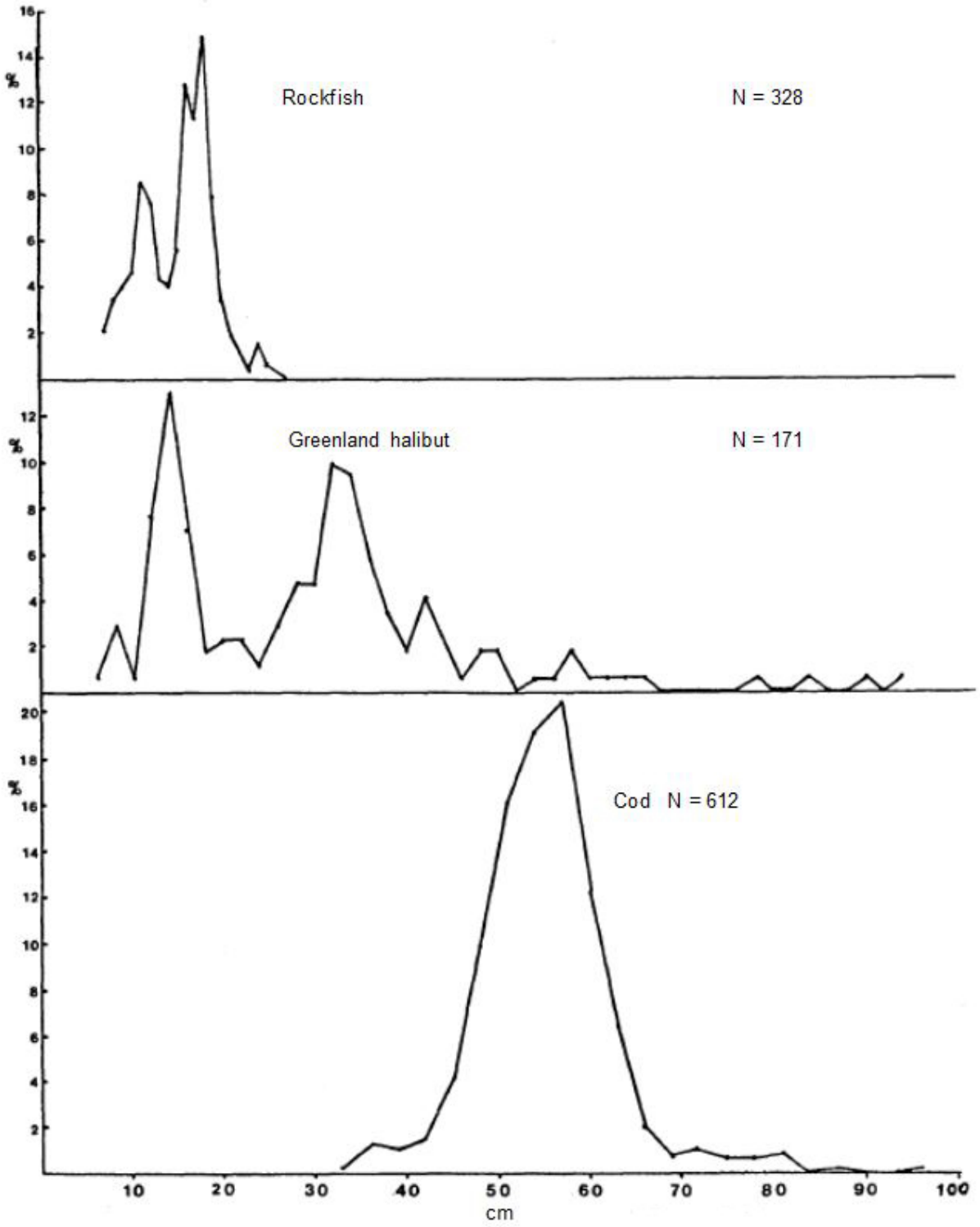

Fig.15. Size frequency distribution of rockfish (*Sebastes marinus mentella*), cod (*Gadus morhua*) and Greenland halibut (*Reinhardtius hippoglossoides*) in the Hopedale Channel, in November 1978.

CONCLUSIONS

On the basis of the data obtained on-board the "Solborg", we were able to conclude that:

- the average yield in the Cartwright Channel in September – October was 315 kg/h, while in the Hopedale Channel in October – November it was 635 kg/h and in December 916 kg/h.
- there is a nyctimeral variation with a maximum yield during the day and a minimum yield at night in both fishing areas.
- there is a possible migration of ovigerous females at the end of December from the bottom of the depression toward the East slope of the channel.
- at this time of year, there were four age classes with the following modes: 14-15 mm, 20 mm, 24 mm and 27 mm. Class II is predominant.
- around 92% of females are ovigerous in November, which is evidence of an annual reproductive cycle.
- the percentage of ovigerous females of the total number of shrimp increases with depth.

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