RESTRICTED

International Commission for the Northwest Atlantic Fisheries

Serial No. 3323
(D.c.3)

ICNAF Res.Doc. 74/87

ANNUAL MEETING - JUNE 1974

# Distribution and biological characteristics of the Short-finned Squid (Illex illecebrosus) on the continental shelf of Subareas 3 and 4 in May-June, 1973.

by

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## Introduction

Offshore fisheries for squid continue to expand in the Northwest Atlantic and preliminary figures indicate total landings of 48,092 metric tons for 1973 in the Convention Area and Statistical Area 6. The increased offshore landings of 7961 tons of Illex illecebrosus in Subareas 3 and 4 accounted for 93 per cent of landings of the species in these two subareas which have traditionally supported inshore squid fisheries.

The Canada Department of the Environment has been conducting a long-term program to study the distribution, biology and population dynamics of the species and, as part of this program, has conducted a series of offshore squid surveys (Mercer, 1973a). In 1972 the St. Pierre laboratory of the Institut Scientifique et Technique des Pêches Maritimes instituted a squid research program. The vessel Cryos was assigned for one month of the spring of 1973 and, rather than duplicate research efforts, scientists from both agencies collaborated in this cruise. This report summarizes part of the data obtained.

## Materials and Methods

### Survey method

All sets were made during daylight hours at standard depths assigned at 25 fath (46 m) intervals from 50 to 150 fath (91 to 274 m) on fixed transects as previously employed by Mercer (1973a). A total of 77 sets was made from May 12 to June 3 using a No. 41 otter trawl with a 31.2 m headline and a 17.7 m groundline equipped with steel bobbins. Mesh sizes in the wings were 140 mm and in the codend 50 mm stretched. Four sets were made with a shrimp trawl.

### Hydrography

Surface temperatures were taken and bathythermograph casts run 0 to 270 m for each set except in the case of replicated sets. Temperatures about 4 m off bottom were obtained using Knudsen bottles with attached mercury thermometers.

### Squid lengths, maturities, and stomach contents

Dorsal mantle lengths were measured to the nearest half-centimetre from the anterodorsal margin of the mantle to the apex of the tail fin. Maturities were classified according to the scale given by Mercer (1973b). Stomach contents were identified and an index of fullness, modified after that used by Trauberg (1969), was calculated as follows:

$$\text{Index of fullness} = \frac{\text{weight of stomach contents}}{\text{weight of squid}} \times 1000.$$

## Results and Discussion

### Distribution and abundance

Largest catches were obtained on the continental slope of Georges Bank, Browns Bank and Western Bank in depths 88 to 273 m, bottom temperatures 8.8 to 13.6°C (Fig. 2); the most taken in a single set was estimated at 5680 specimens in 9.9°C at 181 to 189 m on Western Bank. Except for single specimens in 3.0 and 4.8°C south of Sable Island no squid were taken in those sets on the Scotian Shelf where bottom temperatures were less than 5°C.

Catches on the Grand Bank and St. Pierre Bank were low, the largest being on southern St. Pierre Bank and along the northern part of the southwest slope of the Grand Bank in 5.0 to 5.8°C (Fig. 3); the largest catch comprised only 62 specimens. The few specimens taken at the southern tip and on the southern part of the southwest slope of the Grand Bank where colder bottom temperatures prevailed may have been taken pelagically in surface layers where temperatures exceeded 6°C.

Results recorded here are in accord with the observations of Mercer (1973a) who concluded that, in spring, the species concentrates at the edge of the continental shelf in waters generally warmer than 5°C in areas where vertical dispersal and horizontal movement to shallower zones on the shelf are impeded by overlying cold arctic water.

### Squid size and depth

Large squid catches at different depths were made in three areas (Table 1) and these are compared below for data grouped in 1 cm and 0.5 cm classes.

Georges Bank. With data grouped in cm classes male mantle lengths in Z-332 showed a strong positive skew, the mode being at 14 cm; analysis by 0.5 cm classes resolved the distribution into two modal classes at 13.75-14.25 and 15.25 cm. In contrast Z-334 males were unimodal and rather more leptokurtic in the plot by 0.5 cm classes and the coefficient of variation was lower (Table 1); the mode was at 14.75 cm. The plot by 1 cm groups resulted in a more platykurtic distribution peaking at 14-15 cm.

Female mantle lengths in Z-332 also showed a strong positive skew when grouped in 1 cm classes, the mode being at 14 cm, while a plot by 0.5 cm classes again resolved this into two components peaking at 14.25 and 15.25 cm. The coefficient of variation was higher than that found in the unimodal, leptokurtic distribution in Z-334 which peaked at 14.75 cm.

Browns Bank. In plots by 0.5 cm classes the ranges and modes for male squid were 10.75-13.75-16.25 cm and 11.25-14.25-17.25 cm for Z-326 and Z-328 respectively, both distributions being leptokurtic (the latter more so) and the former negatively skewed with a higher coefficient of variation and significantly lower mean size (Table 1).

Ranges and modes for females were 11.25-14.25-17.25 cm and 11.75-14.25-16.75 cm for Z-326 and Z-328 respectively, the kurtosis, skew and variability being as described for males but the mean sizes not being significantly different. Plots by 1 cm classes showed the same configuration.

Western Bank. In plots by 0.5 cm groups Z-357 males were unimodal, slightly positively skewed, and moderately leptokurtic with the mantle length range and mode being 11.75-14.75-17.25 cm. The range for Z-362 males was 11.25-16.75 cm and the distribution was somewhat more platykurtic at 13.25-14.25 cm although the coefficients of variation were similar (Table 1). Mean sizes were significantly different. Grouping in 1 cm classes resulted in modal classes at 15 and 14 cm for Z-357 and Z-362 respectively, the skews in the two distributions being opposite.

Females were unimodal, leptokurtic and strongly positively skewed with ranges and modes being 11.75-14.75-18.25 cm and 12.25-13.75-17.25 cm for Z-357 and Z-362 respectively. The coefficient of variation was higher and the mean size significantly higher for the former sample. Grouping in 1 cm classes indicated a similar distribution.

Squid size and area

Since few squid were taken on the Grand Bank and St. Pierre Bank all length composition data were combined by 0.5 cm classes. The distribution of male squid was found to be bimodal, the range being 9.25-16.25 cm with modes at 13.25 and 14.25 cm. Females were unimodal, the range and mode being 9.25-13.75-18.25 cm. Grouping by 1 cm classes smoothed the distributions, females being leptokurtic with a peak at 14 cm and mean length 13.65 cm and males being more platykurtic with a modal class at 13-14 cm and mean length 13.50 cm.

Composite frequencies for the Nova Scotian Shelf and Georges Bank indicated unimodal distributions with ranges and modes of 10.75-14.25-18.25 and 10.25-14.25-21.25 cm for males and females respectively; mean lengths were 14.30 and 14.57 cm for males and females respectively.

A two-tailed t test indicated significant differences in mean length between areas for both sexes ($P < .001$) with squid on the Scotian Shelf and Georges Bank being the larger. This is the opposite of the pattern which obtained in three of four previous surveys (Mercer, 1973a).

Females were found to be significantly larger than males in pooled samples for Georges Bank and the Scotian Shelf ($P < .001$) but no significant between sex difference was demonstrated for pooled samples on the Grand Bank and St. Pierre Bank ($P > 0.1$).

Maturities and sex ratios

A single mature fertilized female with mantle length 30.5 cm and ova measuring 0.9 x 0.6 mm was taken on Browns Bank in 184 to 185 m. Two 21 cm females taken on La Have Bank had slightly enlarged nidamental glands (38 to 40 mm long) and ova diameter 0.35 mm. All remaining females were immature. The only previous published account of maturing or mature females in this area is that of Squires (1957) who reported ova diameters of 0.83 and 1.00 mm for two specimens taken on the Grand Bank in May, 1953.

Five males of mantle lengths 14 to 16 cm from the southern part of the Nova Scotian Shelf and Georges Bank were classified as maturing stage I. All other males were immature. Mercer (1973a) has previously reported male maturities to be farther advanced on the Nova Scotian Shelf than on the Newfoundland Shelf in spring.

The $X^2$ test was applied to test deviation from a 50:50 sex ratio in all large catches and also to compare sex ratios between sets where more than one large catch was obtained on the same transect (Table 1). Deviation from a 50:50 ratio was found for single sets on Georges Bank, Browns Bank and Western Bank and males predominated in each case. Between-set comparisons yielded significant differences only on Browns Bank where males were more prevalent in the deeper set.

Stomach contents

The average index for all analyzed stomachs is 24.3, with a maximum of 137.6 (full stomach) and a minimum of 1.1 (empty stomach). This index varies among areas and stations (Table 2). Stomachs were half full on La Have Bank (Z-324), and one-quarter full or less in other areas at the times of sampling.

In most of cases, the ground and partly digested food is difficult to identify. Nevertheless, several species, mostly planktonic, were distinguished. Stomach contents in the Nova Scotian area differed from those in the Grand Bank area in diversity and identity (Table 3). Amphipods (34.3%) and copepods (28.3%) were the most important food components by incidence off Nova Scotia while euphausids (61.4%) were predominant off Newfoundland (Table 4).

Off Nova Scotia we frequently observed the copepods Euchirella rostrata and Candacia armata, the amphipods Phronima atlantica and Parathemisto sp., the pteropod Limacina retroversa and also the Decapoda Natantia and young fishes. Observations on the copepods are interesting as the species Calanus finmarchicus and Pseudocalanus minutus elongatus predominate in the plankton, but rarely occur in stomach contents. The squids thus seem to feed selectively.

On the Newfoundland banks, the squid were found to be feeding primarily on euphausids, especially on Meganyctiphanes norvegica; this is consistent with the studies of Squires (1957). Finally, we have noted a frequency of cannibalism approximating that reported by Mercer (1965) in specimens of 16-21 cm length.

## Acknowledgements

We would like to acknowledge the collaboration of H. Loreal, J. P. Berthomé, J. C. Poulard and P. W. Collins as members of the scientific party of the cruise and Mr. Collins also for assistance in compiling tables and figures.

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Table 1. Variation of squid size and sex ratio with depth as observed on Cryos Mission Encornet, May-June, 1973. The $X^2$ test was applied in the comparison of sex ratios and the t test (2-sided) for mean sizes.

| Area and Set No. | Depth (Meters) | No. M | No. F | Prob 50:50 | Prob diff | Males Mean ML | Males St. Dev. | Males V | Males t | Males P | Females Mean ML | Females St. Dev. | Females V | Females t | Females P |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Georges Bank | | | | | | | | | | | | | | | |
| Z-332 | 269-273 | 286 | 285 | .90<P<.95 | .1<P<.2 | 14.5227 | .9969 | 6.8644 | .6859 | .4<P<.5 | 14.7289 | 1.0558 | 7.1682 | .3046 | .7<P<.8 |
| Z-334 | 181-185 | 344 | 291 | .02<P<.05 | | 14.4738 | .7922 | 5.4733 | | | 14.7534 | .8670 | 5.8766 | | |
| Browns Bank | | | | | | | | | | | | | | | |
| Z-326 | 139 | 199 | 228 | .1<P<.2 | .001<P<.01 | 13.6847 | 1.0278 | 7.5106 | 4.7016 | <.001 | 14.3070 | 1.0405 | 7.2727 | .3274 | .7<P<.8 |
| Z-328 | 175-184 | 235 | 181 | .001<P<.01 | | 14.0670 | .6492 | 4.6151 | | | 14.2776 | .6886 | 4.8229 | | |
| Western Bank | | | | | | | | | | | | | | | |
| Z-357 | 88-90 | 279 | 267 | .5<P<.7 | .3<P<.5 | 14.8504 | .9188 | 6.1870 | 10.9090 | <.001 | 15.0627 | 1.1039 | 7.3287 | 10.7308 | <.001 |
| Z-362 | 181-189 | 314 | 267 | .05<P<.1 | | 14.0478 | .8718 | 6.2060 | | | 14.1433 | .8610 | 6.0877 | | |

Table 2. Specific diversity and average index of stomach contents for squid sampled at various stations.

| Location and station number | Depth (meters) | Time (AST) | Number of stomachs examined | Average index of fullness | Number of species |
|---|---|---|---|---|---|
| Browns Bank | | | | | |
| Z-324 | 138 | 0948-0952 | 20 | 61.0 | 7 |
| Z-326 | 139 | 1306-1336 | 50 | 17.0 | 10 |
| La Have Bank | | | | | |
| Z-343 | 139 | 1045-1115 | 25 | 19.1 | 13 |
| Western Bank | | | | | |
| Z-357 | 90 | 0646-0716 | 50 | 13.0 | 11 |
| Z-362 | 189 | 1334-1404 | 45 | 24.3 | 14 |
| St. Pierre Bank | | | | | |
| Z-398 | 181 | 1035-1105 | 20 | 23.3 | 2 |
| Z-402 | 260 | 1725-1755 | 21 | 29.9 | 10 |
| Whale Bank | | | | | |
| Z-426 | 145 | 0910-0940 | 20 | 33.5 | 2 |
| Z-428 | 180 | 1106-1136 | 20 | 25.9 | 3 |

Table 3. Percentages of squid stomachs examined which contained the given species.

| Species \ Set No. | Z-324 | Z-326 | Z-343 | Z-357 | Z-362 | Z-398 | Z-402 | Z-426 | Z-428 |
|---|---|---|---|---|---|---|---|---|---|
| Sagitta sp. | | 2 | 12 | 2 | 4 | | 5 | | |
| Limacina retroversa | | 2 | 32 | 10 | 42 | | | | |
| Limacina helicoides | | 2 | | | 2 | | 5 | | |
| Illex illecebrosus | 5 | 2 | | 16 | 4 | | 10 | | |
| Conchoecia obtusata | | | 16 | | | | | | |
| Euchirella rostrata | 25 | | 60 | 82 | 98 | | 19 | | |
| Candacia armata | | | 24 | | 42 | | 29 | | |
| Pareuchaeta norvegica | | | 4 | 6 | | | | | |
| Calanidae sp. | | | 12 | 2 | 2 | | | | |
| Other Copepoda | | | | 10 | 2 | | | | |
| Isopoda | 5 | | | | 2 | | | | |
| Parathemisto sp. | 10 | 8 | 8 | 12 | 4 | | 19 | | 5 |
| Phronima atlantica | 80 | 90 | 32 | | 7 | 25 | | | |
| Vibilia sp. | 10 | 6 | 4 | | | | | | |
| Other Amphipoda | | | | 50 | 42 | | | | |
| Euphausiidae | | 4 | 8 | 4 | | 100 | 10 | 100 | 100 |
| Spirontocaris sp. | | | | | | | 24 | | |
| Other Decapoda | 45 | 22 | 56 | | 18 | | 33 | | |
| Teleostei | | 24 | 20 | 26 | 24 | | 10 | 5 | 5 |

Table 4. Numbers of stomachs examined and frequency of occurrence of the principal taxa in squid stomach contents.

| | Browns Bank | | | | La Have Bank | | Western Bank | | | | Nova Scotian | | St Pierre Bank | | | | Whale Bank | | | | Newfoundland | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Z-324 | | Z-326 | | Z-343 | | Z-357 | | Z-362 | | Shelf Total | | Z-398 | | Z-402 | | Z-426 | | Z-428 | | Shelf Total | |
| | N | % | N | % | N | % | N | % | N | % | N | % | N | % | N | % | N | % | N | % | N | % |
| Chaetognatha | | | 1 | 2 | 3 | 12 | 1 | 2 | 2 | 4 | 7 | 2 | | | 1 | 5 | | | | | 1 | 1 |
| Pteropoda | | | 2 | 4 | 8 | 32 | 5 | 10 | 19 | 42 | 34 | 9 | | | 1 | 5 | | | | | 1 | 1 |
| Cephalopoda | 1 | 5 | 1 | 2 | | | 8 | 16 | 2 | 4 | 12 | 3 | | | 2 | 10 | | | | | 2 | 2 |
| Ostracoda | | | | | 4 | 16 | | | | | 4 | 1 | | | | | | | | | | |
| Copepoda | 5 | 25 | | | 18 | 72 | 45 | 90 | 44 | 98 | 112 | 28 | | | 9 | 43 | | | | | 9 | 9 |
| Isopoda | 1 | 5 | | | | | | | 1 | 2 | 2 | 1 | | | | | | | | | | |
| Amphipoda | 20 | 100 | 49 | 98 | 12 | 48 | 31 | 62 | 24 | 53 | 136 | 34 | 5 | 25 | 4 | 19 | | | 1 | 5 | 10 | 10 |
| Euphausiidae | | | 2 | 4 | 2 | 8 | 2 | 4 | | | 6 | 2 | 20 | 100 | 2 | 10 | 20 | 100 | 20 | 100 | 62 | 61 |
| Decapoda (natantia) | 9 | 45 | 11 | 22 | 14 | 56 | | | 8 | 18 | 42 | 11 | | | 12 | 57 | | | | | 12 | 12 |
| Teleostei | | | 12 | 24 | 5 | 20 | 13 | 26 | 11 | 24 | 41 | 10 | | | 2 | 10 | 1 | 5 | 1 | 5 | 4 | 4 |

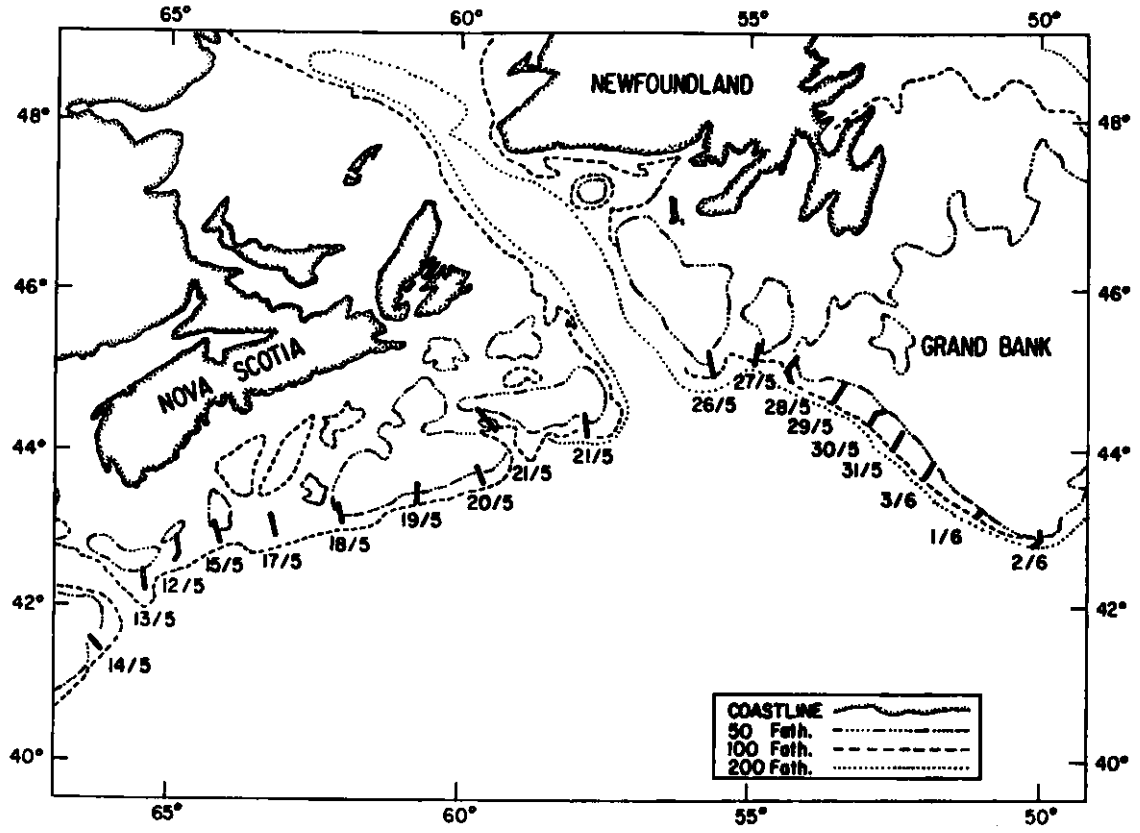


Fig. 1. Locations and fishing dates for transects discussed in this paper.

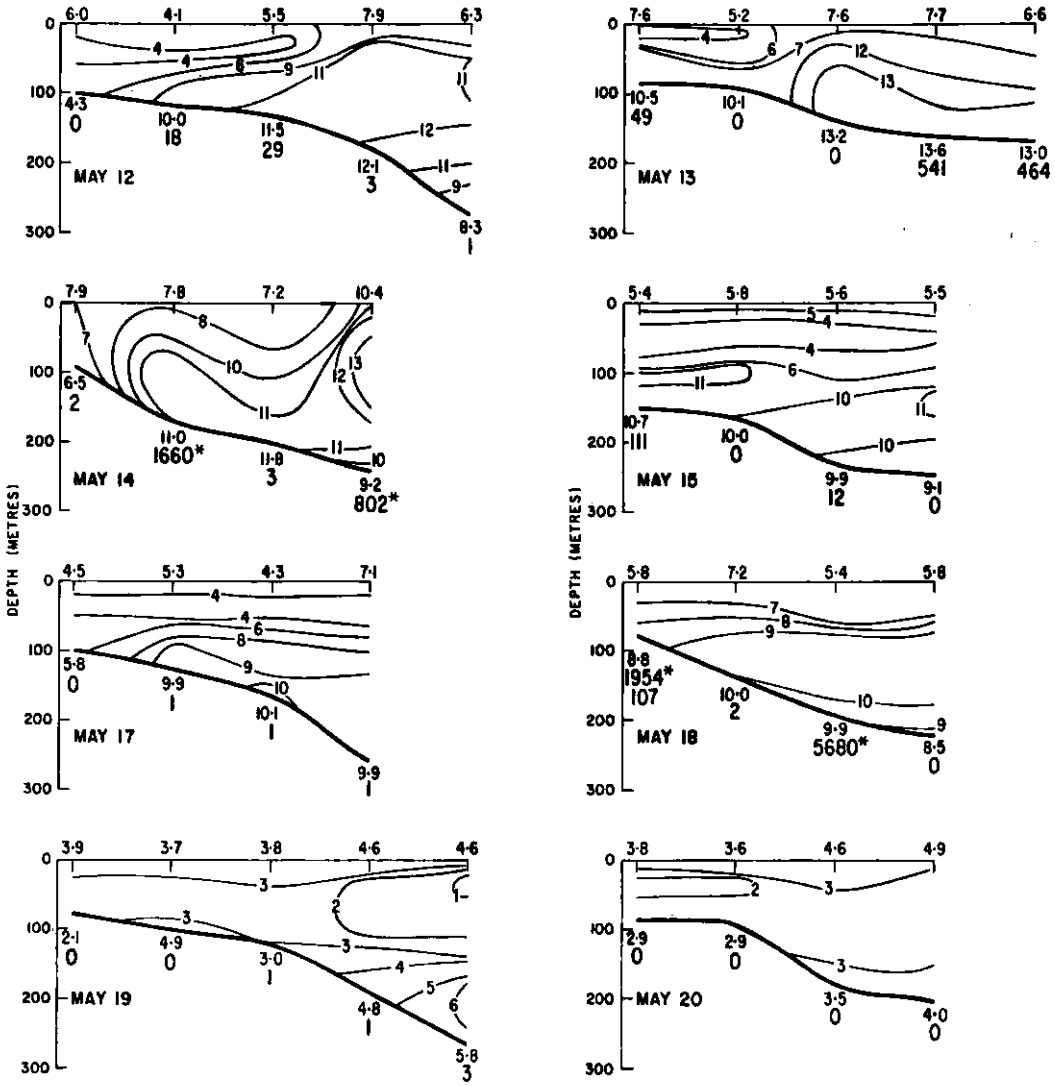


Fig. 2. Temperature profiles along Nova Scotian Shelf transects the locations of which are indicated in Fig. 1. Numbers below the bottom temperatures indicate numbers of squid taken in a 30-minute set; numbers with an asterisk were estimated by sub-sampling of the catch.

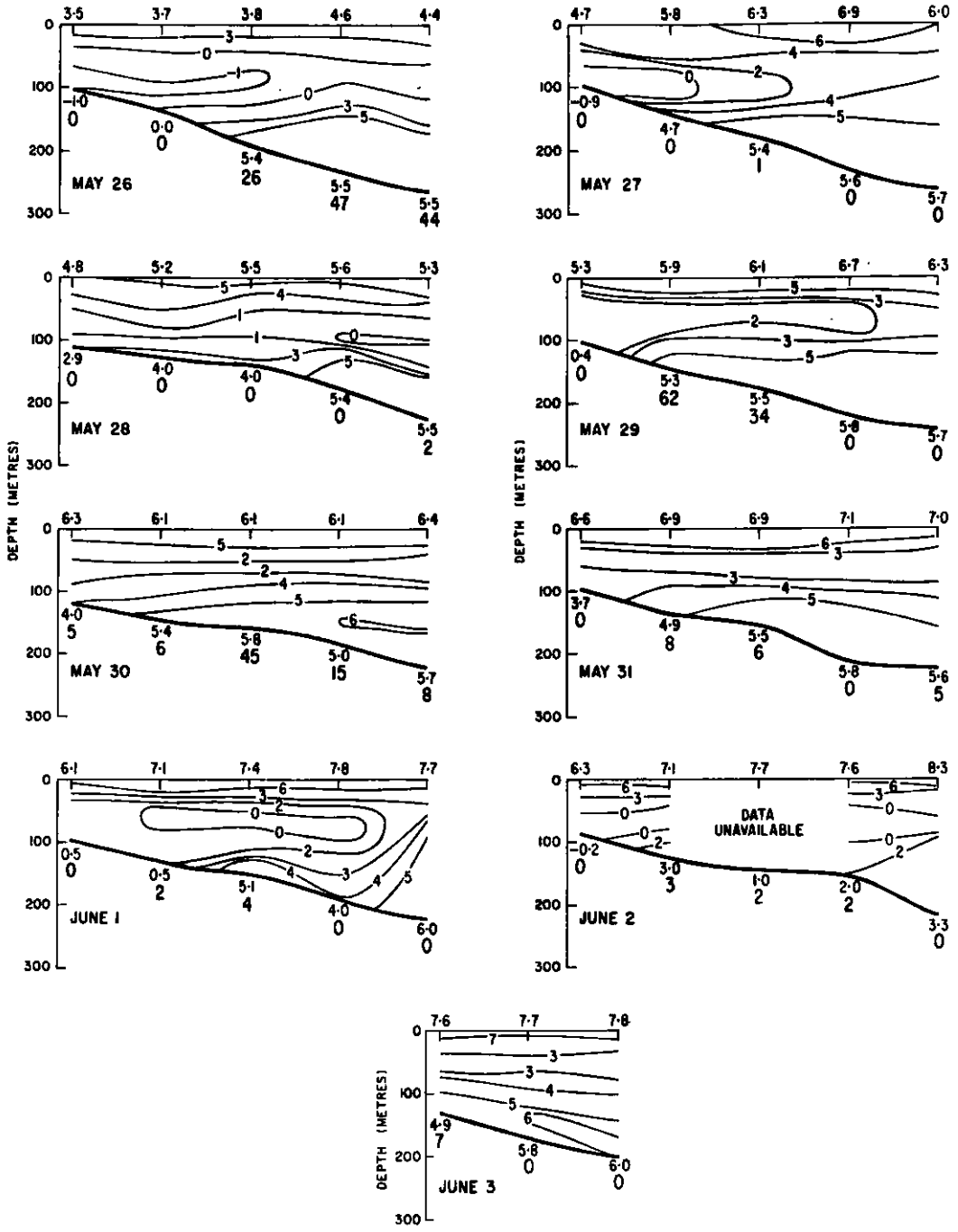


Fig. 3. Temperature profiles on St. Pierre Bank and the Grand Bank for transects of which the locations are indicated in Fig. 1. Numbers below the bottom temperatures indicate numbers of squid taken in a 30-minute set.

## Appendix

Length frequencies of squid samples discussed in the text and composite frequencies for A) Georges Bank and the Nova Scotian Shelf and B) Grand Bank and St. Pierre Bank.

| | Set No. | Z-332 | | Z-334 | | Z-326 | | Z-328 | | Z-357 | | Z-362 | | A | | B | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Length | (cm) | M | F | M | F | M | F | M | F | M | F | M | F | M | F | M | F |
| 9 | 8.75 | | | | | | | | | | | | | | | | |
| | 9.25 | | | | | | | | | | | | | | | 1 | 1 |
| 10 | 9.75 | | | | | | | | | | | | | | | 1 | |
| | 10.25 | | | | | | | | | | | | | | 1 | 1 | |
| 11 | 10.75 | | | 2 | | 4 | | 1 | | | | | | 9 | 1 | 3 | 2 |
| | 11.25 | | | | | 6 | 2 | | | | | 1 | | 8 | 2 | 5 | 8 |
| 12 | 11.75 | | | | | 7 | 7 | 1 | 1 | 1 | 1 | 1 | | 11 | 9 | 4 | 4 |
| | 12.25 | 1 | 1 | | | 7 | 8 | 1 | | 1 | 1 | 6 | 3 | 22 | 18 | 13 | 12 |
| 13 | 12.75 | 8 | 3 | 4 | 2 | 13 | 8 | 6 | 4 | 6 | 6 | 12 | 13 | 61 | 46 | 18 | 14 |
| | 13.25 | 32 | 19 | 21 | 13 | 32 | 16 | 25 | 16 | 11 | 11 | 69 | 42 | 208 | 136 | 34 | 23 |
| 14 | 13.75 | 56 | 55 | 57 | 37 | 49 | 28 | 73 | 38 | 26 | 21 | 70 | 72 | 364 | 279 | 24 | 41 |
| | 14.25 | 56 | 59 | 91 | 65 | 42 | 54 | 74 | 57 | 52 | 38 | 71 | 64 | 419 | 373 | 31 | 27 |
| 15 | 14.75 | 43 | 42 | 103 | 72 | 29 | 52 | 39 | 39 | 61 | 59 | 50 | 29 | 351 | 323 | 20 | 19 |
| | 15.25 | 47 | 48 | 40 | 55 | 7 | 32 | 13 | 22 | 50 | 46 | 14 | 21 | 188 | 243 | 5 | 10 |
| 16 | 15.75 | 22 | 29 | 17 | 26 | 1 | 14 | 2 | 3 | 46 | 29 | 10 | 15 | 105 | 130 | 3 | 4 |
| | 16.25 | 13 | 11 | 4 | 10 | 2 | 5 | | | 15 | 24 | 6 | 7 | 44 | 64 | 2 | 2 |
| 17 | 16.75 | 3 | 6 | 3 | 9 | | 1 | | 1 | 9 | 22 | 4 | | 23 | 41 | | |
| | 17.25 | 2 | 6 | 1 | | | 1 | | | 1 | 4 | | 1 | 5 | 15 | | |
| 18 | 17.75 | 2 | 4 | | 1 | | | | | | 4 | | | 4 | 9 | | |
| | 18.25 | 1 | 2 | 1 | | | | | | | 1 | | | 2 | 6 | | 1 |
| 19 | 18.75 | | | | | | | | | | | | | | | | |
| | 19.25 | | | | 1 | | | | | | | | | | 1 | | |
| 20 | 19.75 | | | | | | | | | | | | | | | | |
| | 20.25 | | | | | | | | | | | | | | | | |
| 21 | 20.75 | | | | | | | | | | | | | | | | |
| | 21.25 | | | | | | | | | | | | | | 2 | | |
| 22 | 21.75 | | | | | | | | | | | | | | | | |
| | 22.25 | | | | | | | | | | | | | | | | |
| | . | | | | | | | | | | | | | | | | |
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| | . | | | | | | | | | | | | | | | | |
| | . | | | | | | | | | | | | | | | | |
| 30 | 29.75 | | | | | | | | | | | | | | | | |
| | 30.25 | | | | | | | | | | | | | | 1 | | |
| Totals | | 286 | 285 | 344 | 291 | 199 | 228 | 235 | 181 | 279 | 267 | 314 | 267 | 1824 | 1700 | 165 | 168 |