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Biological Characteristics and Biomass Estimates of the Squid (*Illex illecebrosus*) on the Scotian Shelf (Div. 4VWX) in Late Summer, 1983

by

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#### Introduction

A squid survey of the Scotian Shelf (NAFO Div. 4VWX) was carried out from August 30 to October 3 on board the French R/V Cryos (stern trawler Class 5). A concurrent survey was carried out by the Canadian R/V Alfred Needler from September 12 to 29. The Cryos survey was a continuation of the annual assessment surveys conducted by France since 1980, and the Alfred Needler survey was in part designed to complement the assessment survey by providing additional coverage of deeper strata along the Shelf edge. Other aspects of the Alfred Needler survey not reported here involved offshore tagging of squid and mid-water trawling between the Shelf edge and Gulf stream.

This paper presents data collected on abundance, size distribution, and maturity stages of <u>Illex</u> <u>illecebrosus</u> and relates these to prevailing hydrographic conditions. A biomass estimate is also provided by stratum and comparisons are made with observations from the 1980-1982 surveys.

## Materials and Methods

Cryos

The gear used was a Lofoten trawl with the following specifications: 31.2 m headrope, 17.7 footrope, and 50 mm stretched mesh in the codend. Of the 137 tows made during the survey, 129 were used to estimate biomass, the remaining sets being either in deeper water, outside of the strata, or incomplete because the trawl was damaged on the bottom. After each tow an XBT was cast. Additionally, four hydrographic sections were made normal to the Shelf edge.

On the surveyed area (Fig. 1a), the stations were distributed randomly using the stratification scheme proposed by Halliday and Kohler (1971) and recommended by NAFO for Divisions 4VWX. The 22 strata surveyed were limited to depths ranging from 50 fm (92 m) to 200 fm (366 m). Three additional stations were made on the slope of the Shelf between 420 m and 480 m to provide further information on squid at greater depths.

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Tows were of standard duration (30 minutes), and the area swept by the trawl, which is assumed to be constant, has been calculated on the basis of a horizontal opening of 13.5 m at the wings, with a vessel speed of 3.5-4 knots. This results in an areal coverage per standard tow of 0.015 square nautical miles (0.05 km<sup>2</sup>).

After each tow, the catch was sorted by species, the total guantity of squid was weighed, and where numbers were sufficient, a representative subsample (200 individuals per set) was analyzed. Detailed morphometrics, by sex, were carried out on 50 individuals (maturity stage, mantle length to the half-centimeter, weight, stomach and caecum fullness, food type, and parasite occurrence and location). An additional 150 individuals were analyzed by sex for only maturity stage, mantle length, and weight. Maturity scales were as defined by Amaratunga and Durward (1979) except that Stage 0 for males was combined with Stage 1.

### Alfred Needler

The gear used was a Western IIA bottom trawl with a codend mesh size of 90 mm and a codend liner of 19 mm stretched mesh. Thirty minute tows were conducted at 82 stations (Fig. 1b). At each station, surface and bottom temperatures and salinity were determined by hydro casts. XBT casts were made twice in each longitudinal bin (see stratification below).

The area to be surveyed was divided into five longitudinal bins (<59°W, 59°-61°W, 61°-63°W, 63°-65°W, 65°W) and four depth strata as follows:

Stratum	Depth Range					
	m	fm				
I II III IV	18.3-91.5 91.5-183 183-366 366-915	10.2-51 51-102 102-203 203-508				

Although ten possible station locations were randomly selected within each longitude bin/depth stratum cell, the stations fished were concentrated in the two deeper strata on the Shelf edge.

The processing of the catch at each station consisted of the following: after sorting, the catch was weighed by species; detailed morphometrics were done on a subsample of 50 Illex, and length-frequency measurements by sex were conducted on other species in the catch.

#### Results and Discussion

In this paper, the Alfred Needler data have been used to supplement the Cryos data only where gear differences were clearly of little importance.

Geographical distribution relative to hydrographic conditions

During the Cryos cruise 1,328 kg of squid were caught. The mean catch per 30-minute tow was 10 kg or 70 individuals. <u>Illex</u> <u>illecebrosus</u> were found in 110 of the 129 tows (85%). Although squid were captured throughout the area surveyed, the best yields were obtained along the edge of the Shelf between the area to the south of Emerald Bank and to the south of Browns

Bank (Fig. 2, 3a, 3b). In this western area the highest catches were 447 kg and 167 kg at between 150 m and 170 m in Stratum 72 and 86 kg at 200 m in Stratum 78. In the other strata yields were below 18 kg per tow except for one catch of 124 kg in Stratum 53, to the south of Sable Island at 200 m depth. The bottom temperatures observed with the four best tows were in the range of  $6.3^{\circ}$ -10.3°C.

The Alfred Needler survey (Fig. 3c) captured only 43 kg of squid, with the mean catch per tow being 1 kg or 6 individuals. Squid were found in only 43 of 82 tows (52%), with a higher frequency of occurrence in the intermediate depth range (61% occurrence in 102-203 fm vs 36% in 203-508 fm). The yield was very low throughout the survey area, with only 10 stations resulting in catches of more than 10 individuals; the greatest catch was only 5 kg. Catches were more frequent and tended to be larger in the area between  $61^{\circ}$ W and  $65^{\circ}$ W in Stratum III (183-366 m). The corresponding bottom temperatures were, with one exception, in the range of  $7.2^{\circ}-8.9^{\circ}$ C. The largest catch took place with a bottom temperature of  $15.0^{\circ}$ C.

Figure 4 provides data on bottom temperatures throughout the Cryos and Alfred Needler survey areas, while Figure 5 presents temperature profiles for the inner Shelf and Shelf edge.

As in previous surveys (Dupouy, 1981; Dupouy and Minet, 1982; Dupouy and Derible, 1983), the three-layered structure of water masses on the Scotian Shelf described by Sigaev (1979) and Gomez (1979) was observed during the period of this survey.

- surface water (0-30 m depth) was generally in the range of 10°-19°C with cooler temperatures at depths over Roseway Bank, LaHave and Emerald Basins, and the Gully; salinities ranged from 29-32%.
- intermediate water (30-100 m depth) covering most of the shallower strata with low temperatures (2°-10°C) with salinities generally in the range of  $30-33\%_{oo}$ . In the deeper water (60-100 m) temperatures over most of the inner Shelf were in the 4°-7°C range, while over the outer Shelf they ranged from 2°-8°C. Temperatures were generally cooler in the near-shore areas and in the areas to the east of Emerald Bank; and

- slope water, generally at depths greater than 100 m and characterized by warmer temperatures  $(7^{\circ}-10^{\circ}C)$  and higher salinities (33-34%), stretching primarily along the Shelf edge west of Western Bank and entering into the centre of the Shelf in the Lahave and Emerald Basin area (Fig. 4, 5).

Mean bottom temperature in the 1983 Cryos survey was 7.2°C as compared to the 6.6°C observed in 1982. This increase still left bottom temperatures in 1983 up to 1.5°C lower than those reported in September 1980 and 1981 (Dupouy, 1981; Dupuoy and Minet, 1982).

In Figure 6, catch rates from the Cryos survey, in numbers of individuals, are expressed relative to bottom and minimum intermediate temperatures. The data indicate that:

- i) very few squid were caught where bottom temperatures were lower than 6°C or minimum intermediate temperatures were lower than 2°C; and
- ii) highest catch rates were observed where bottom temperature exceeded 8-9°C and intermediate temperatures exceeded 7°C.

The temperature/catch rate relationship suggested by Figure 6 is in general agreement with the results from the 1980-1982 surveys and tends to support the idea that intermediate depth temperatures may, along with bottom temperatures, influence the distribution of <u>Illex</u> over the Shelf.

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Biological characteristics of squid

The Cryos length-frequency distributions have been developed using the areal expansion method. A mean sizedistribution was calculated for each stratum and the results weighted by the surface area of the stratum. The resulting size-distributions by sex and depth interval are expressed in mean number per 30 minute tow in Figure 7a. This estimation of numbers of squid, based on the length-frequency distribution in each stratum, is less influenced by the number of tows made in each stratum than is an estimate based on numbers derived from a length-frequency distribution for the entire area surveyed.

Squid caught in this survey ranged from 5.5-29.0 cm in mantle length. The bulk of the population consisted of large animals with a modal length between 19.0-19.5 cm for males and 19.5-20.5 cm for females.

Only 269 squid were caught in the Alfred Needler survey; and as a result, size-distributions appear more irregular than in the Cryos data (Fig. 7b). In the Alfred Needler survey the codend liner mesh size was smaller than that used in the Cryos trawl. Despite this, the smallest squid caught by the Alfred Needler were larger than those caught by the Cryos, the size ranging from 12 to 29 cm. A comparison between the lengthfrequency distributions of squid caught during the two surveys in the same depth range (roughly 100-200 fm) shows a slightly smaller modal length for males caught by the Alfred Needler (18.5-19.0 cm vs 19.0-19.5 cm for the Cryos data) and a larger one for females (21.0-21.5 cm vs 20.0-20.5 cm).

In both surveys, the bulk of the population consists of large animals with mantle lengths in the range of 18-23 cm. This range is similar to that observed in 1980 (Dupouy, 1981) and 1981 (Dupouy and Minet, 1982), but the modal lengths for males and females in 1983 are smaller by roughly 2-3 cm. The 1983 modal lengths are also less than those for the deeper strata (100-200 fm) in 1982, when the length-frequency distribution was much flatter due to relatively large numbers of smaller animals. In the 1983 Cryos survey, squids smaller than 13 cm represented only 1.5% and 1.7% of males and females respectively, whereas in 1982 the length-frequency distribution was characterized, particularly in the shallower strata, by these larger numbers of small squid.

In 1983 most males were immature. In the Cryos data the maturity Stages II and III correspond only to 6.1% and 0.5% of the mean number caught per 30 minutes. Females were mainly in Stage II (87.4%), with only 7.6% in Stage I, 5% in Stage III, and no Stage IV being encountered.

In the Alfred Needler data, males were generally in maturity Stages I and II, with a higher proportion in Stage II than observed from the Cryos survey. At depths greater than 203 fm, Stage II males were much more frequently observed than elsewhere in either survey. Immature females (Stage I) were comparatively more numerous in the Alfred Needler survey (68.6% and 44% in the depth ranges of 102-203 fm and 203-508 fm respectively), although one Stage IV was observed.

Compared with previous years, sexual maturation appears to have been retarded in 1983.

## Biomass estimates

The biomass of squid present in the area surveyed was estimated using the swept area method. Assuming 100% efficiency for the trawl in capturing squid in its path, the biomass Bi along with its variance can be calculated in weight and number for each stratum by the following equations:

$$B_i = Y_i A_i / b$$

Var.  $B_i = A_i^2 \times S_i^2 / N_i b^2$ 

Where:  $\overline{Y}_{i}$  is the mean catch of Illex by tow in stratum;  $A_{i}$  is the area of Stratum i; b is the area swept by the trawl per 30 minute tow (estimated to be 0.015 sq. nautical miles); and  $S_i$  is the variance of catch per tow in Stratum i.

Since the trawl does not fish with 100% efficiency, the calculated abundance and biomass are minimum estimates of stock size.

The abundance and biomass estimates for all strata fished by the Cryos in 1983 are presented in Table 1.

The overall biomass was about 13,700 t representing 94.6 millions of individuals. In numbers, 87% occupied the 51-100 fm depth range. The standard error on the abundance and biomass indices represents about 40% of these estimates. This high variability is probably a reflection of the schooling behaviour of Illex.

Since 1980, there have been 18 strata consistently surveyed on the Scotian Shelf in each year of the program. The biomass of Illex in these 18 strata shows a large decrease from 1980 to 1983 (Table 2). The lowest indices were recorded in 1982; the level in 1983 was slightly higher but was still no more than 9% of the abundance in 1980.

Restriction of the analysis to those strata which have been sampled every year should give more comparable data for the estimation of changes in stock size. However, as noted by Lange and Sissenwine (1983), little is known about the distribution offshore and changes in geographical distribution may affect the abundance indices without necessarily reflecting overall population size.

Distribution of squid along the edge of the Shelf was more completely sampled in 1983 than in previous years. The data indicate that, in September, squid, while mainly distributed along the edge of the Shelf, were guite scarce in the deepest strata.

#### Conclusions

In 1983, as in the previous year, squid were widely distributed throughout the areas surveyed, but no large concentrations were encountered. The weighted mean number of squid caught per 30 minute tow was 70, up from the 41 of 1982, but well below the 168 and 503 of 1981 and 1980 respectively. The estimated biomass (about 13,700 t) was roughly three times as large as that of 1982 (4,600 t) but far below the levels of 1981 and 1980 (53,000 t and 153,000 t respectively).

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Depth range	! nº !	!(square miles) ! !	hauls	Number	Kg	N.thousands	W. tons	N.thousands	W. tons
	49	144 383	4. 4	0.50 3.00	0.03	5 79	0 9	! 5 ! 39	`0 4
	54 57	499 811	4 5	6.75	0.75	231	26	138	16
	60	1 344	8	24.88	3.95	2 294	364	261	113
51-100 faths (93-183 m)	62 65	2 116 2 383	10 10	7.00 121.30	0.62	1 016 19 827	90 2 223	166 13 303	1 559
	70 72	920 1 249	4	18.75	3.10	1 183 48 772	196 7 643	366 34 397	63 5483
	76	1 478 1 232	6 8	5.33 88.63	0.55	540 7 490	56 1 123	442 3 262	46 489
	!	!1 875	10	6.00	0.83			172	2/
Total	!	14 434	80	79.86	11.67	82 265	11 845	37 030	5 723
	46 51 52	491 147 345	4 2 4	0.00 34.50 1.25	0.00 6.20	! 0 ! 348 ! 30	0 63 4	! 0 ! 287 ! 15	! 0 ! 48 ! 2
	53	259	4	215.25	32.90	3 824	584	3 540	540
100-200 faths (185-366 m)	61	1 154 226	8	8.63 136.00	1.39	68 <i>3</i> 2 108	110 248	211 1 072	41
	71 78	1 004 233	6 4	13.67 239.50	2.27	941 3828	156 583	441 2 102	73 302
	82 83	1 042 532	8 5	7.13 2.20	1.05 0.30	510 80	75 11	1.33 21	21
Total	!	5 433	49	54.21	7.95	12 352	1 834	4 295	637
Overall	! ! !	! ! 19 867 !	129	70.12	! 10.26	! ! 94 617 !	! ! 13 679 !	! ! 37 278 !	! ! 5 758 !

Table	1.	- Mean	Catch	and Biomass	estimates	of Il	llex i	llecebrosus	per	stratum	in	NAFO Div.	4	۷,	W,	Х
		(R/V	Cryos	survey : Au	g.30 – Oc	t.3,	1983)	•								

Table 2. Abundance and biomass estimates for the 18 strata surveyed annually by France in the years 1980-83.

! Depth ! Level	50 - 100	faths	101 - 200	faths	Overall(50-200 faths)				
Year	Number : ! in million	Weight in tons	Number Number	! Weight ! in tons	! Number ! in million	Weight in tons			
1980	447	108 014	180	! 43 706	657	151 720			
: ! 1981	164	39 135	40	: ! 9 941	204	49 076			
1982	! 49	3 667	5	905 !	54	4 572			
1983 ·		11 819	8	! 1 239 !	90 !	13 058			

Table 2.- Evolution of biomass index in number and weight in the same strata from 1980.



Fig. 1a. Sampling strata and position of stations occupied during R/V *Cryos* survey in NAFO Div. 4VWX (Aug 30-Oct 3, 1983).



Fig. 1b. Position of on-shelf stations occupied during R/V *Alfred Needler* survey in NAFO Div. 4VWX (Sept 10-29, 1983).

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Fig. 5. Temperature profiles for the inner Shelf area (Section A) and the Shelf-edge (Section B). Each profile was computed by MEDS on the basis of all available temperature data from an 80 km wide transect as shown in Fig. 4.



Fig. 6. Mean catch-rate of *Illex illecebrosus* (in number per 30-minute tow) from the R/V *Cryos* survey related to bottom and minimum intermediate temperatures: the number of tows is indicated in each block of 1°C x 1°C and m represents the overall mean catch-rate (68 individuals per tow).

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