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Update of the Distribution, Biomass, and Length Frequencies of *Illex illecebrosus* in Divisions 4VWX from Canadian Research Vessel Surveys, 1970-1983

by

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Introduction

Standardized groundfish surveys have been conducted on the Scotian Shelf by Fisheries Research Branch, Department of Fisheries and Oceans, since 1970. Squid (Illex illecebrosus) distribution and abundance in relation to abiotic factors such as temperature and depth have been described from the survey data by several authors (Scott, 1978; Dufour, 1979; Koeller, 1980; Mohn, 1981). The present report updates earlier efforts by including survey data from 1981-1983.

Updating of the time series will also facilitate review of current TAC levels, since the TAC being applied under the present management regime is in part based on historical biomass estimates from the groundfish survey series for the years 1970-1979.

Methods

Halliday and Kohler (1971) have described the stratified random sampling design used in the surveys. These surveys have been conducted in July of each year with additional surveys in the spring (February and March 1970-1974, and 1979 to present) and fall (October to November since 1978). As yet, the only 1983 data available are from the July survey. During the 1981-1983 period, for which this report updates the time series, the survey was being transferred from the R/V A.T. Cameron to her replacement vessels, the R/V Lady Hammond (1982) and the R/V Alfred Needler (1983). Between 1970 and 1981 the R/V A.T. Cameron conducted the survey with a Yankee 36 trawl. Since 1982 a "Western IIA" trawl has been used. The codend of both trawls had a 0.5" mesh liner.

To effect conversion to the new vessels, comparative fishing tows were made during the July stratified random survey in 1979-1981 with the R/V Lady Hammond using a Western IIA trawl. In 1983, comparative fishing tows were conducted between the R/V Lady Hammond and the R/V Alfred Needler, with both using the Western IIA trawl. The results from comparative fishing have been used to standardize the data time series to the smaller Yankee 36 trawl (see Appendix 1).

The measurements and other computations used in the following analysis are as described in Koeller (1980).

Results and Discussion

Distribution

Figure 1 illustrates the July squid distribution and abundance for the years 1970-1983. There is significant interannual variation in the generally widespread distribution. Squid are always present along the Shelf edge in July. In years of low abundance their distribution appears to be restricted largely to the Shelf edge, the outer areas of the Banks, and the LaHave and Emerald Basin areas (e.g. 1970-1975, 1978, 1980, 1982, 1983). In 1978 and 1980 some concentrations were encountered at the mouth of or within the Bay of Fundy. In some years of low abundance, the distribution may be even more restricted and/or discontinuous (e.g. 1970, 1973, 1980, 1982, 1983). In years of higher abundance, squid distribute themselves more evenly over the Shelf and into the Bay of Fundy (e.g. 1976, 1979, 1981). The latter pattern was also observed for 1977, except that squid were absent from the Bay of Fundy.

These generalized patterns suggest that in years of low density there may be little intraspecific competitive pressure along the Shelf edge and a tendency for squid to remain in the area after the juvenile migration from the off-Shelf Slope water.

It is noteworthy that prior to 1975 and after 1979 the frequency of large catches (>100 kg) was greatly reduced.

Biomass levels

Table 1 gives statistics from the 14-year time series. Some interesting points include: the estimated biomass in 9 of the years is less than 20,000 t; the other years (1975-1977, 1979, and 1981) are anomalously high, being at minimum a full order of magnitude greater than the lowest year (1970); the percentage of tows where squid occurred increased to above 59% during the period 1976-79, and was generally significantly higher than for other years in the series.

For those years in which spring and fall survey data are available (Table 2), the same pattern in biomass levels is seen (with the exception of spring 1982). Data for the three survey periods, while indicating an increase in mean length throughout the year, also suggest that in some years (1979-1981) either residual squid from the previous year (or possibly summer-spawned squid from the previous year) form a major component of the early-season biomass. The levelling out or decrease sometimes seen in mean lengths during the July survey period suggests a protracted period of emigration to the Shelf area.

The fall survey data indicate that in some years (1978-1980) there is still a large biomass remaining on the Shelf in late season despite the impact of a large-scale international fishery. However, the numbers per tow decline sharply as a result of fishery removals, natural mortality, and emigration from the Shelf.

A positive correlation between bottom temperature and squid abundance has been noted by all earlier-cited authors, and most have noted a relationship between bottom temperature and mean squid length. A reexamination of these relationships for the period 1970-1979 and also with inclusion of the more recent survey data gives positive but somewhat weaker correlations (Table 3).

Length frequency

The length frequency distributions (Fig. 2) are of several forms. In most years the distribution is unimodal; but in some, such as 1970 and 1982, a second mode (8-9 cm) is apparent. Multimodal size distributions have been reported from U.S. research surveys in the middle Atlantic to Georges Bank region and interpreted as evidence of a protracted spawning period by the previous adult squid population (cohort) in some years, especially 1974, 1975, and 1978 (Lange and Sissenwine, 1981). Other surveys on the Scotian Shelf in late August and September have indicated the presence of similar cohorts of small squid in the years 1980-1982 (Dupouy and Derible, 1983).

Diurnal changes in catch-rates

The tendency for aggregation of squid near the bottom during hours of daylight renders them more susceptible to capture by the bottom trawl. Mohn (1981) has described diurnal variability in catchability for squid by examining six 4-hour periods. In the present report the impact of vertical dispersion on squid catch rates during hours of darkness is assessed by distinguishing two 12-hour periods (daylight - 08:00-19:59 h; dark - 20:00-07:59 h) using summer survey data for the 1970-1983 series (Table 4). The data indicate that daylight catch-rates are on average about more than twice (2.4) those of dark hours. The ratio of day/night catch-rates are, however, highly variable, occasionally being very high as in 1975 (26.7) or in the case of 1973 being less than unity (0.6).

If the relationship is assumed constant, a correction can be applied to accommodate the "underrepresented" catches of the nighttime tows. While the ratio throughout the time series is highly variable, application of a correction factor of 2.4, to nighttime catch-rates based on the mean, would improve the estimates of biomass in 11 of the 14 years.

The inclusion of the correction factor increases the biomass estimates by a multiplier ranging between 1 and 2 (Table 4). The impact of the factor appears to be independent of abundance level since it is variable both in years of high and of low abundance.

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Table 1. Summer survey statistics for squid from the Scotian Shelf, 1970-1983.

Year	Mean		Biomass Est. (x 10^3 t)	Weighted Mean Length (cm)	% Tows With Squid	No. of Tows	Mean Bottom Temperature (°C)	Mean Sampling Date (Julian)
	No./Tow	Wt/Tow (kg)						
1970	5.6	0.40	1.89	14.8	35.1	143	5.3	201
1971	25.9	2.66	14.74	16.4	53.6	110	6.0	193
1972	8.1	0.88	3.22	16.6	42.5	146	5.7	187
1973	8.3	1.17	8.92	18.5	38.1	134	5.6	205
1974	11.6	1.66	9.50	18.4	42.5	153	5.8	203
1975	35.4	4.10	24.61	17.3	44.1	143	5.4	208
1976	187.9	35.27	203.73	20.5	82.2	135	6.8	206
1977	51.3	9.81	46.59	19.3	59.0	144	6.5	201
1978	19.5	2.66	11.20	18.5	59.2	142	5.7	202
1979	73.6	11.00	70.32	19.8	74.8	147	6.4	199
1980	16.3	1.43	10.78	16.9	44.1	145	6.2	199
1981	23.9	3.18	27.22	18.5	52.0	150	6.4	197
1982	5.5 (18.0)	0.43 (1.40)	3.29 (10.71)	16.5	50.7	150	5.4	202
1983	28.4 (57.0)	0.78 (1.57)	5.69 (10.54)	13.1	29.0	145	5.6	198

N.B. - values in parenthesis are the computed results whereas the adjacent numbers have been corrected as in Appendix 1.

Table 2. Spring and fall survey statistics for squid from the Scotian Shelf, 1970-1982.

Year	Mean No./Tow	Mean Wt./Tow (kg)	Biomass Est. (x 10^3 t)	Weighted Mean Length (cm)	% Tows With Squid	No. of Tows	Mean Bottom Temperature (°C)	Mean Sampling Date (Julian)
Spring:								
1970	0.0	0.0	0.0	-	0.0	28	6.5	76
1971	0.1	0.0	0.0	10.5	5.4	37	6.7	82
1973	0.0	0.0	0.0	-	0.0	31	2.4	26
1974	0.2	0.0	0.0	12.0	8.3	12	8.3	67
1979	0.2	0.03	0.36	19.7	7.8	116	4.3	79
1980	0.1	0.0	0.0	18.6	3.8	106	5.1	76
1981	0.3	0.07	0.30	20.3	10.2	118	4.6	65
1982	5.4	0.33	0.72	15.8	7.7	130	4.3	73
Fall:								
1978	4.6 (15.1)	1.3 (4.2)	3.30 (10.75)	22.5	72.8	81	5.8	331
1979	26.8 (87.2)	8.7 (28.2)	29.37 (95.75)	23.9	87.3	126	7.1	302
1980	6.9 (22.4)	1.9 (6.3)	9.35 (30.48)	22.2	57.1	140	6.2	286
1981	5.3 (17.3)	0.4 (1.3)	1.73 (5.63)	20.2	58.3	127	7.7	285
1982	1.3 (4.2)	0.2 (0.5)	0.89 (2.89)	20.8	46.9	145	6.1	282

N.B. - Surveys above conducted prior to 1978 were performed by the A.T. Cameron (Yankee 36) and those since by the Lady Hammond (Western IIA)

- Values in parenthesis are computed results whereas the adjacent numbers have been corrected by Appendix 1.

Table 3. Correlation coefficients for squid biomass and squid mantle length with bottom temperature.

	Squid Biomass		Squid Mantle Length	
	1970-1979	1970-1983	1970-1979	1970-1983
Bottom Temperature	0.7998	0.7106	0.7785	0.6774

Table 4. Mean squid catch rate (kg/tow) for daytime (08:00-19:59 h) and nighttime (20:00-07:59 h) tow and biomass estimates incorporating the diurnal factor.

Year	Catch Rate (kg/tow)			Day/Night Ratio	Biomass (x 10 t)	
	Day	Night	Pooled		Uncorrected	Corrected
1970	0.6	0.2	0.4	3.00	1.89	2.11
1971	4.9	0.6	2.7	8.17	14.74	17.33
1972	1.2	0.5	0.9	2.40	3.22	5.33
1973	0.9	1.5	1.2	0.60*	8.92	17.71
1974	1.8	1.5	1.7	1.20*	9.50	17.51
1975	8.0	0.3	4.1	26.67	24.61	25.62
1976	46.4	24.0	35.3	1.93	203.73	304.86
1977	15.1	3.8	9.8	3.97	46.59	54.34
1978	2.7	2.6	2.7	0.96*	11.20	14.09
1979	15.2	7.0	11.0	2.17	70.32	98.06
1980	2.5	0.4	1.4	6.25	10.78	12.39
1981	4.1	2.4	3.2	1.71	27.22	41.40
1982	2.6	0.3	1.4	8.67	3.29	3.56
1983	2.1	0.9	1.6	2.33	5.69	7.33
Pooled (all years):						
Mean (kg/yr)	542.6	226.4	768.9			
Std. Dev.	833.2	420.1	1,242.2			
Mean (kg/tow)	0.55	0.23	0.39			

* Years when 2.4 correction factor would not likely improve biomass estimate.

GROUNDFISH SURVEYS

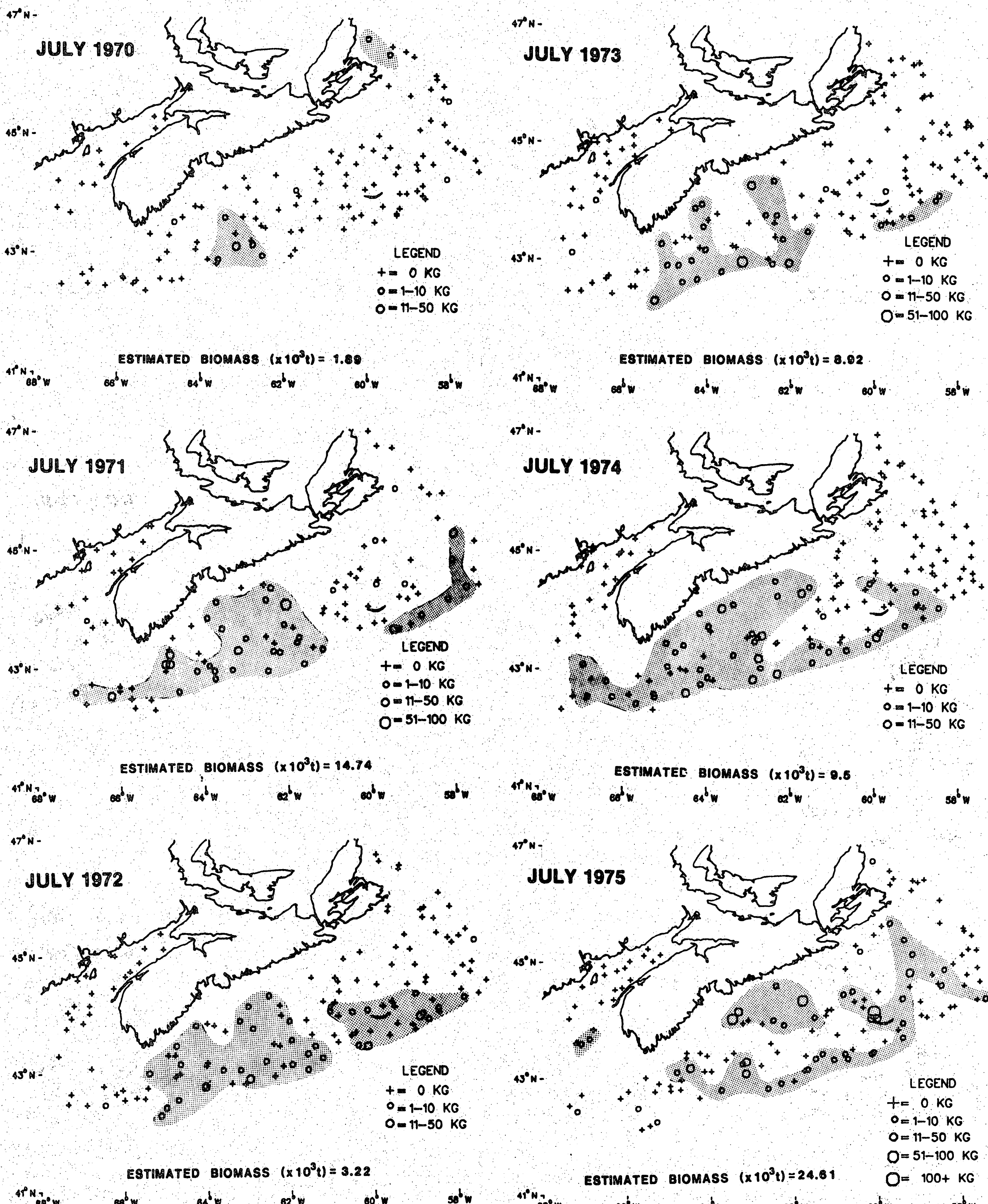


Fig. 1. Distribution of squid catches (kg/tow) on the Scotian Shelf during July 1970–83. Areas of apparent concentration are shaded.

GROUNDFISH SURVEYS

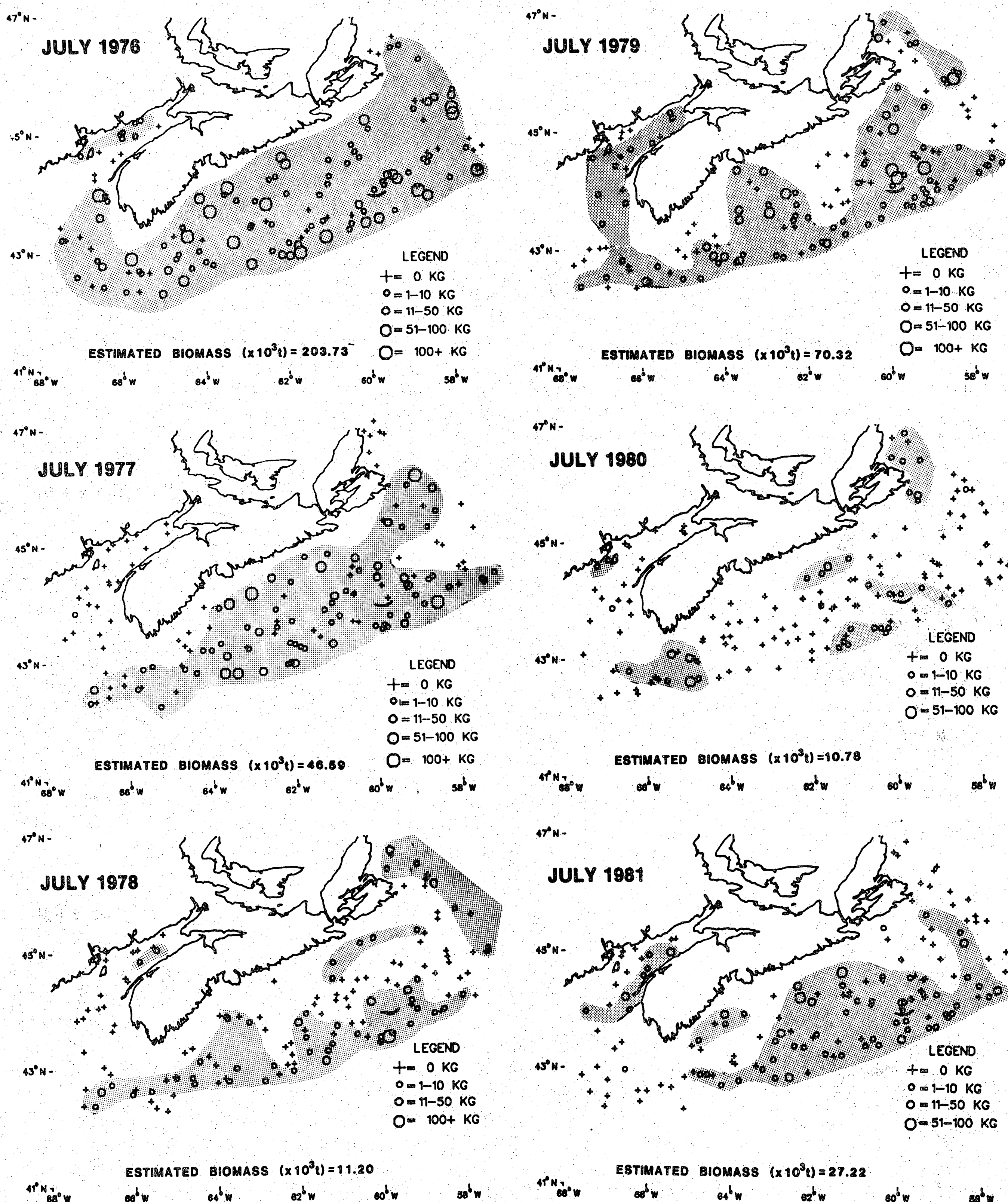
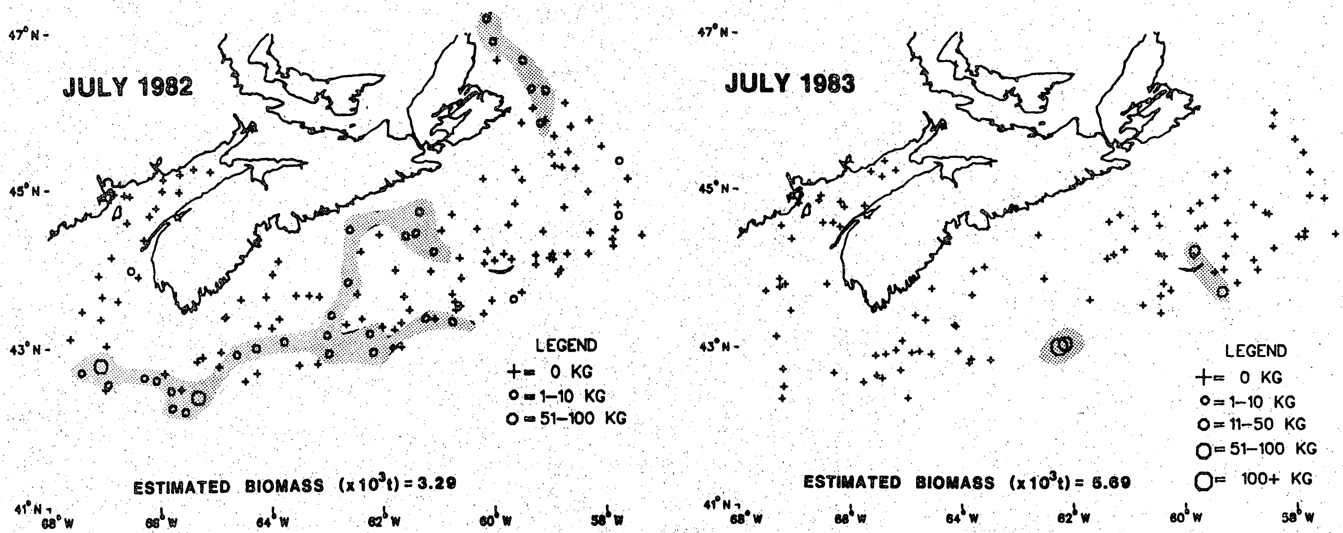


Fig. 1. (continued).

GROUNDFISH SURVEYS



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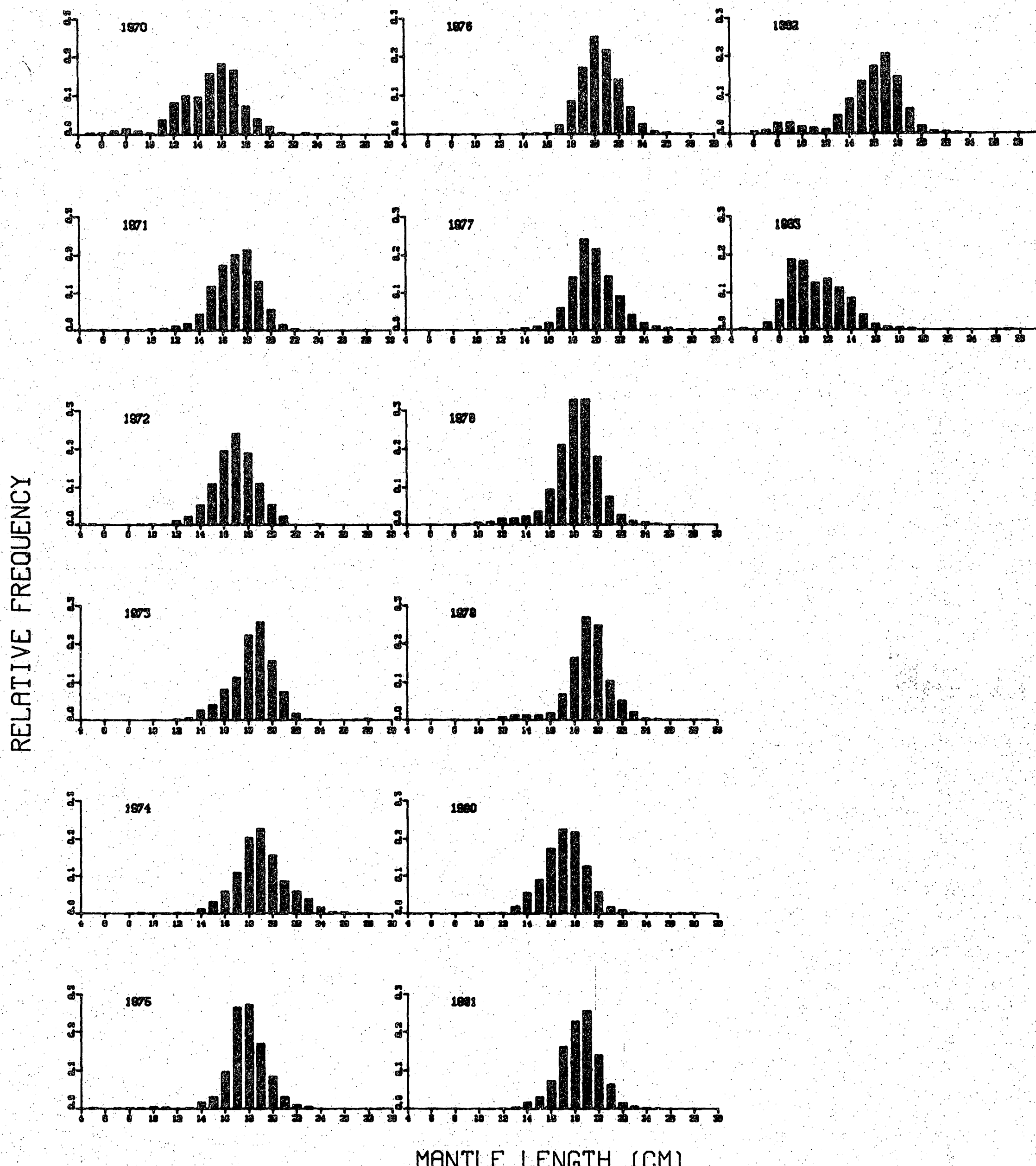

Fig. 2 Length frequency distributions of *Illex illecebrosus* on the Scotian Shelf in July 1970-83.

Appendix 1. Standardization of bottom trawls from stratified random and comparative fishing surveys.

Year	Vessel	Gear	No. Tows	$\overline{X}$ Squid Tow	$\overline{X}$ Squid Length (cm)
1979	A.T. Cameron	Yankee 36	58	29.9	18.9
	Lady Hammond	Western IIA	58	84.5	18.5
1980	A.T. Cameron	Yankee 36	126	17.7	17.2
	Lady Hammond	Western IIA	126	43.5	17.2
1981	A.T. Cameron	Yankee 36	108	19.5	18.8
	Lady Hammond	Western IIA	108	87.6	18.8
1979-81	A.T. Cameron	Yankee 36	292	20.8	18.3
(pooled)	Lady Hammond	Western IIA	292	67.8	18.2
1983	Alfred Needler	Western IIA	80	7.5	13.3
	Lady Hammond	Western IIA	80	12.2	13.0

The trawl conversion factors used in Tables 1 and 2 are as follows:

i) Yankee 36 (A.T. Cameron) vs Western IIA (Lady Hammond)
$= 20.8 \div 67.8 = 0.3068$

ii) Western IIA (Lady Hammond) vs Western IIA (Alfred Needler)
$= 12.2 \div 7.5 = 1.6267$

iii) Western 11A (Alfred Needler) vs Yankee 36 (A.T. Cameron)
$= 1.6267 \times 0.3068 = 0.4990$

To correct 1982 and 1983 estimates to a Yankee 36 (Cameron) trawl the factors are: Lady Hammond (1982) = 0.3068
Alfred Needler (1983) = 0.4990