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Population structure of Illex illecebrosus in the Scotian Shelf fishing areas in 1977

by

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INTRODUCTION

The life cycle of Illex illecebrosus is still largely a matter of conjecture (Squires, 1967; Mesnil, 1976) because these squid disappear from areas where they are normally fished when they reproduce. The seasonal distribution, biology, and population dynamics of Illex in the northwest Atlantic has been previously studied for limited periods in each year (Mercer, 1975; Squires, 1957, 1967; Mesnil, 1976).

This paper provides a preliminary analysis of the data obtained during April to November, 1977, on the Scotian Shelf (ICNAF Subarea 4). Population structure, growth, and maturation are considered in relation to seasonality.

MATERIALS AND METHODS

Biological data for this paper were collected from cooperative research cruises with international fisheries groups, from the international observer program for 1977 and samples obtained from offshore fishing vessels. The area of concern was the Scotian Shelf in ICNAF Subarea 4. The gear used, in most cases, was the Otter trawl commonly used in the fishery.

Data Analysis

Collections and observations. Immediately after the catch was sorted by species on board, a random sample of 100 Illex was usually obtained for these analyses. Mantle length measurements of each squid were made to the nearest 0.5 cm, taken from the tip of the anterodorsal protruberance on the collar to the apex of the tail fin. Corresponding round weight measurements were taken to the nearest 5 gm. No weight corrections were made for the stomach fullness factor. The individuals were then opened along the mid-ventral line for observations on sex and maturity. Prior to July, however, the method employed recorded the total weight of the sample, and no individual weighings or sexings were done (Table 1).

Maturity stages for males were estimated using Mercer's (1973) criteria by gross visual inspections of the vas deferens, testes and spermatophoric organ. Criteria for female maturity stages were developed as the season advanced and were a combination of: a) gross visual inspections of the ovary, oviducal funnel and gland, and the nidamental gland and b) length estimations of the nidamental gland. The latter was found to fit a more accurate maturity index (Durward et al STACRES, 1978). Only preliminary observations on seasonality of the sexual maturation process are described here.

Length frequency. All lengths were grouped into 1 cm size classes and totalled into two-week periods (Table 1). These larger groupings of individuals ($\simeq$ 1000) eliminate the polymodal distributions that may result from random variations in smaller samples (Gulland, 1966) with a more precise estimation of mode. Length frequency distributions were plotted (Figure 1) for the season, and mean lengths and standard deviations were used to construct the growth curve (Figure 2).

Length-weight relationship. The length-weight relationships were determined for both sexes from the standard equation $W = aL^b$, where W = weight, L = length, and a and b are constants derived from a least squares regression (Mercer, 1973; Tibbetts, 1975). A random sample of at least 300 individuals for each sex, from the period July to November, were used to determine these constants.

Sex ratio. The percentage ratios of sexes were obtained from samples of July to November.

RESULTS

The length-frequency distributions are illustrated in Table 1 and Figure 1. Amplitudes of the distributions from April through November varied; however, a decreasing trend was noted. Unimodal distribution was characteristic of most samples early in the season. Bimodal distributions were observed in May (140 mm and 170 mm, May 5; 160 mm and 190 mm, May 30). Modes during this time (April to June) increased from 130 mm to 200 mm and the unadjusted mean mantle lengths increased from 129.7 mm to 203.4 mm. Bimodal distribution between the sexes was not apparent until August; however, differences in means were observed in late July. Mean mantle lengths of both sexes increased during the months of July through November, with little change in standard deviation of the sample; from 209.20 ± 12.39 mm to 225.42 ± 8.64 mm for males and 213.44 ± 11.43 to 254.32 ± 14.65 mm for females. This represents increases of 16.22 mm for males and 40.88 mm for females during this time period (July to November), and increases of 58.09 mm (males) and 87.02 mm (females) throughout the entire season (April to November).

Male mantle length plateaued at approximately 220 mm in September, which corresponds with onset of maturation. The female mantle length continued to increase until November, where mantle length plateaued at approximately 250 mm (Figure 2). Although growth rates have not been determined, the pattern observed (Figure 2) is very similar to that presented by Squires (1967) for Newfoundland squid.

Preliminary observations of maturity stages during the season are outlined below.

	Female Maturity (Durward et al, 1978)	Male Maturity (Mercer, 1973c)
July	immature (stage 1)	immature (stage 1)
August	immature (stage 1)	maturing (stage 1 and 2)
Sept.	immature (stage 1)	maturing (stage 2)
Oct.	maturing (stage 2 and 3)	mature (stage 3)
Nov.	maturing (stage 3)	mature (stage 3)

A detailed report on growth and maturation is in progress. The length-weight relationship for both sexes is illustrated in Figure 3, indicating that males are heavier than females at a given mantle length. The equation of the length-weight curves are:

$$W = 2.95 \times 10^{-6} L^{3.35} \text{ for females,}$$
$$W = 3.72 \times 10^{-6} L^{3.32} \text{ for males.}$$

The difference in weight between the sexes decreases as mantle length increases.

Males were numerically dominant in all samples until late season, the average sex ratio being 57:43. In the period October to November, females were dominant in the samples. The average sex ratio (57:43) from July to September, along with the length-weight relationship for each sex, was utilized to estimate the number of animals caught per 100 MT during the active Illex fishery (Amaratunga et al, 1978b).

DISCUSSION

Specimens of Illex illecebrosus collected on the Scotian Shelf were larger in mantle length (Mercer, 1973b) and differed in length-weight relationship (Mercer, 1973a) than previously reported. While the samples of other surveys were obtained in different years, it is evident that sizes of the squid observed here increased rapidly as time progressed; a pattern consistent with all previous studies on size composition in Newfoundland (Mercer and Paulmier, 1974; Mercer, 1975; Squires, 1957 and 1967), the Scotian Shelf (Mercer, 1973b; Mesnil, 1976; Efanov and Puzhakov, 1975), and Georges Bank (Efanov and Puzhakov, 1975; Tibbetts, 1975).

The analyses of size composition of squid from the Scotian Shelf in relation to time showed that it is very similar to the hypothesized life cycle of Squires (1967). The present data revealed that small squid were present on the Scotian Shelf during the spring, and increased in size towards the fall. Large specimens were noted early in April (April 4); however, accurate descriptions of this sample are not available. If these large specimens were fully mature, they would most likely be individuals from the previous year. This could be indicative of a one-year life cycle.

However, this cannot be resolved until a detailed survey is completed during the critical maturation, breeding, and spawning period which most likely occurs between the months of November to May.

The bimodal distribution observed in July/August is likely characteristic of sexual dimorphism in size, and coincides with the onset of maturation in males. Prior to this time, bimodal distribution could be attributed to: a) admixture of different age classes resulting from late spawning, b) feeding behavior (Durward, unpublished observations).

Preliminary analysis of the maturation process in relation to growth and time of year now provides more information pertaining to the life cycle. The onset of maturation in males apparently creates a modal class, for little change in the range of mantle length is observed with increasing mantle length. A possible explanation for this observation is the actual process of sexual maturation. This process is regulated by the gonadotropin hormone secreted by the optic glands (Wells and Wells, 1959). Upon receiving the appropriate environmental cues for "triggering" this system, all males, regardless of size, will begin to sexually mature. This could explain the consistency in mantle length class of the male population. The early maturation of males may also account for the changes in sex ratios observed at the end of the season (October/November). This same trend is observed in females during October/November when their onset of maturation begins (stage 3 to 4, Durward et al, 1978). Studies on captive females indicate that this process occurs regardless of size (O'Dor et al, 1977).

Although complete field data on the maturation process is not available, the Scotian Shelf population appears to have a one-year life cycle, rather than the overlapping one to two year cycle as proposed by Mesnil (1976).

SUMMARY

1. Squid ranged from 129.7 mm in April to 259.52 mm in November.
2. Mantle length increased approximately 58.09 mm for males and 87.02 mm for females throughout the season.
3. Sex ratios during the active fishing season (July to Sept.) were ≈ 57:43 (males:females).
4. Males were found to be heavier at a given mantle length than females.
5. Data supports a one-year life cycle.

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TABLE 1. Length distributions of Illex illecebrosus samples from the Scotian Shelf in 1977.
(Table continued on next page.)

Mantle Length (mm)	Period Beginning						
	Apr. 4	Apr. 18	May 2	May 16	May 30	June 13	June 27
100	-	24	35	1	-	-	-
110	-	108	103	3	2	1	-
120	7	341	121	19	3	4	-
130	15	420	198	71	19	22	-
140	16	272	249	152	52	48	3
150	8	71	204	193	138	119	5
160	4	30	118	167	266	337	12
170	4	10	137	134	234	702	28
180	7	8	88	74	187	925	99
190	6	-	57	53	210	825	187
200	5	1	37	26	131	663	224
210	4	-	12	5	70	339	157
220	4	-	6	1	27	179	120
230	2	-	-	-	16	88	84
240	4	-	-	-	3	28	34
250	1	-	-	-	1	7	14
260	0	-	-	-	-	2	6
270	1	-	1	-	-	6	-
280	1	-	1	-	-	8	-
290	-	-	-	-	-	3	-
300	-	-	-	-	-	-	-
310	-	-	-	-	-	-	-
TOTAL # of Animals	89	1285	1367	899	1359	4306	973
Mean	167.30	129.70	147.17	157.43	175.44	186.17	203.40
Mode	140	130	140	150	160	180	200
Std. Dev.	39.62	13.16	25.49	19.11	21.23	20.28	19.38
Male: Female % Ratio	unsexed	unsexed	unsexed	unsexed	unsexed	unsexed	unsexed

TABLE 1 Continued...

Mantle Length (mm)	Period Beginning													
	July 11		July 25		Aug. 8		Aug. 22		Sept. 5		Oct/Nov.		Nov. 13	
	M	F	M	F	M	F	M	F	M	F	M	F	M	F
100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
110	-	-	-	-	-	-	-	-	-	-	-	-	-	-
120	-	-	-	-	-	-	-	-	-	-	-	-	-	-
130	-	-	-	-	-	-	-	-	-	-	-	-	-	-
140	-	-	1	-	-	-	-	-	-	-	-	-	-	-
150	-	-	-	-	-	-	-	-	-	-	-	-	-	-
160	1	-	2	-	-	-	-	-	-	-	-	-	-	-
170	1	-	16	2	-	1	-	-	-	-	-	-	-	-
180	7	1	13	6	8	3	-	-	-	-	-	-	-	-
190	48	9	135	40	47	17	3	2	3	1	-	-	-	-
200	155	64	378	148	204	93	38	18	27	7	-	-	2	-
210	205	112	521	302	432	170	298	114	130	24	1	-	23	3
220	98	93	289	251	327	221	495	209	171	65	6	-	69	2
230	42	32	96	151	121	180	260	233	120	80	18	10	98	19
240	15	9	29	83	38	129	68	167	47	60	3	19	21	54
250	2	3	3	35	9	69	11	95	13	69	-	18	1	59
260	-	-	1	18	-	28	1	48	-	52	-	26	-	72
270	-	-	-	6	-	10	1	20	-	21	-	32	-	50
280	-	-	-	3	-	5	1	9	-	4	-	16	-	18
290	-	-	-	1	-	1	-	2	-	3	-	2	-	1
300	-	-	-	-	-	-	-	-	-	-	-	2	-	-
310	-	-	-	-		-	-	-	-	-	-	-	-	-
TOTAL # of Animals	574	323	1484	1046	1186	927	1176	917	511	386	28	125	214	278
Mean	209.20	213.44	208.77	218.06	213.35	224.53	220.52	231.52	221.17	238.76	228.21	259.52	225.42	254.32
Mode	210	210	210	210	210	220	220	220	220	230	230	270	230	260
Std. Dev.	12.39	11.43	12.65	16.23	11.72	17.46	10.03	16.30	11.57	18.32	6.70	16.75	8.64	14.65
Male: Female % Ratio	64.0	36.0	58.7	41.3	56.1	43.9	56.2	43.8	57.0	43.0	18.3	81.7	43.5	56.5

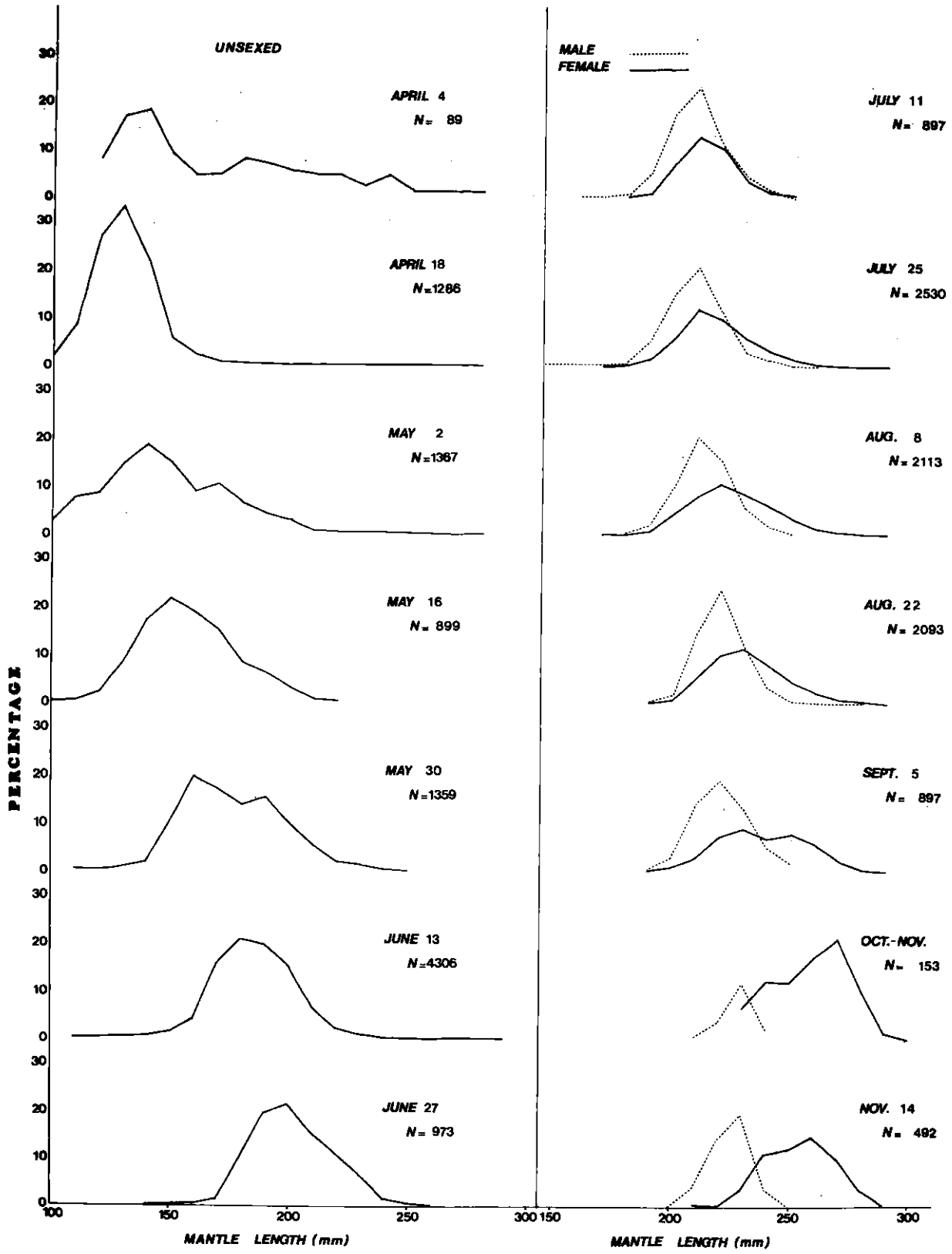

Figure 1. Length-frequency distributions of Illex illecebrosus samples from the Scotian Shelf in 1977. Numbers (N) indicate sample sizes.

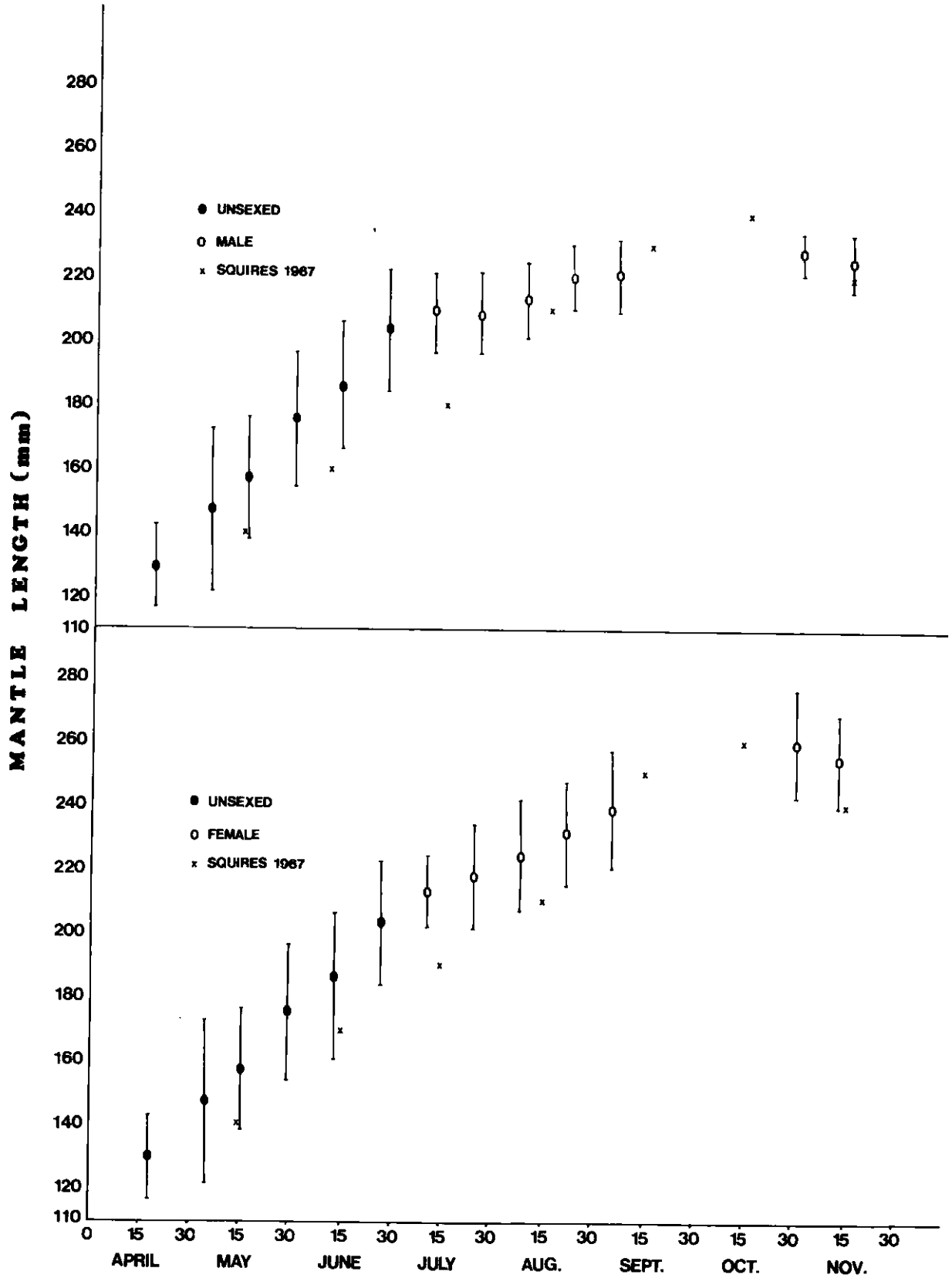

Figure 2. Growth of Illex illecebrosus from the Scotian Shelf in 1977. Circles and bars represent the mean mantle length and standard deviations.

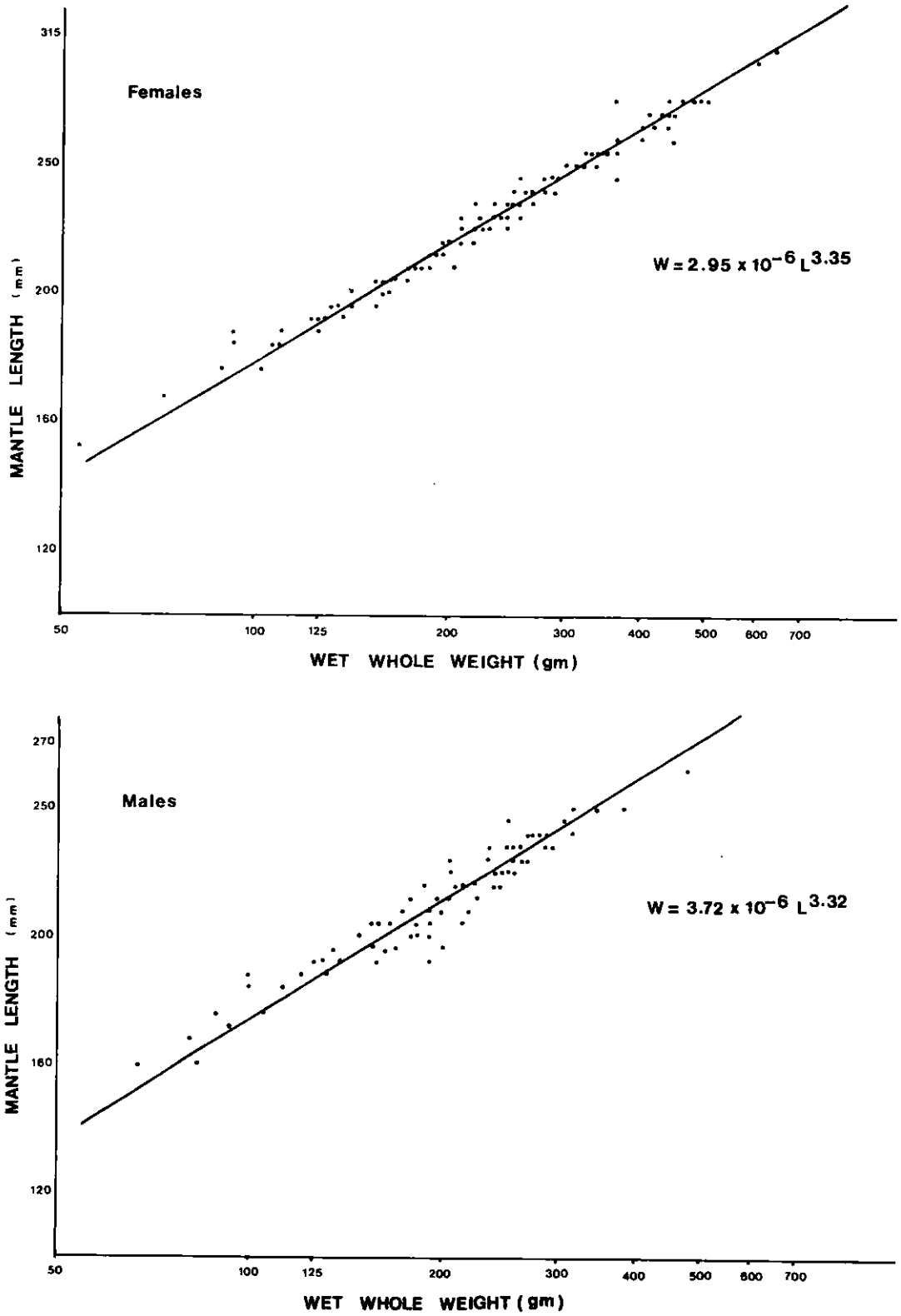

Figure 3. Length-weight relationships of the squid *Illex illecebrosus* from the Scotian Shelf in 1977.