Northwest Atlantic Fisheries Organization

Serial No. N062

NAFO SCR Doc. 80/II/30

SPECIAL MEETING OF SCIENTIFIC COUNCIL - FEBRUARY 1980

Growth and Maturation Patterns of the Short-finned Squid (*Illex illecebrosus*) on the Scotian Shelf

by

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INTRODUCTION

The short-finned squid Illex illecebrosus has recently become a very important commercial species, and commercial landings in the northwest Atlantic have escalated by many fold since 1974 (Table 1). There is need to improve and develop new approaches to management of the fishery, but this has been seriously handicapped by the lack of sufficient information on the basic biology of the species. A literature survey shows that the life cycle of the species is not completely described, although two hypotheses are current (Squires, 1967; Mesnil, 1977). The major constraint is that adult animals migrate from their summer and fall feeding grounds on the Continental Shelf to unknown areas in the winter to spawn. They are next seen in the spring when a new generation returns.

Biological information on the species during their residency on the Shelf has been accumulating during recent years. Aspects such as maturation (Mercer, 1973a; Amaratunga and Durward, 1979; Durward et al., 1979) and food and feeding (Squires, 1957; Mercer and Paulmier, 1974; Amaratunga, 1979; Ennis and Collins, 1979; Vinogradov and Noskov, 1979; O'Dor et al., 1979) have been documented. It is recognized here that such biological studies, augmented with further studies during their residency on the Shelf, could provide a valuable basis to develop models for the fishery (Amaratunga, 1979). The primary objective of this study is to describe growth and maturation of I. illecebrosus and define realistic biological parameter values toward this purpose.

Before proceeding, however, it is necessary to recognize some major features of I. illecebrosus. I. illecebrosus is widely distributed in the northwest regions of the Atlantic Ocean. During a plankton survey in this study, I. illecebrosus larvae and juveniles were recorded for the first time in the Gulf Stream, seaward of the Scotian Shelf between March 7 and May 22, 1979. These records, compiled with data from various sources (Roper and Lu, 1979; Roper et al., 1969; Lu, 1973; Clarke, 1966) show distribution (Figure 1) from Labrador and Newfoundland to central Florida. This constitutes a variation of climatic conditions from arctic to virtually tropical. There are biological variations associated with distribution. Population studies on the Scotian Shelf and northeastward usually report a unimodal length frequency distribution (Amaratunga et al., 1978; Squires, 1957), whereas multimodal distributions (usually three size groups) are common southwestward (A.T. Lange, pers.

comm.; Mesnil, 1977). These distributional differences have resulted in two main hypotheses for a life cycle. Squires (1967) proposed an annual cycle with a protracted breeding season while Mesnil (1977) proposed more elaborate long and short cycles that cross one one another. It is noteworthy that during the fishing season I. illecebrosus distribution is along the landward skirt of the Gulf Stream. Their distribution in Nova Scotia (Amaratunga et al., 1978) and Newfoundland (Squires, 1957) waters is usually limited to the warmest period of the year, from spring (April to May) to late fall (as late as December), although their local distribution and abundance may vary connsiderably from year to year. Hence, in this report three years of data obtained mainly from the Scotian Shelf are analysed.

MATERIALS AND METHODS

The biological data base for this study dates back to early 1977, when detailed studies on I. illecebrosus were undertaken. The data sources comprised of i) International Observer Program in which observers placed on international fishing vessels routinely collected length-frequency data and, when possible, obtained samples of frozen animals for detailed biological analyses in the laboratory. ii) Joint multinational research cruises which provided detailed biological data: July 20 to September 13, 1977 - R.V. Shirane Maru - survey to determine bycatch associated with Illex in bottom trawls; June 3 to July 4, 1978 - R.V. Shirane Maru - early-season mesh selectivity and biology study; October 16 to November 15, 1978 - R.V. Shirane Maru - late-season mesh selectivity, biology, and distribution study; July 9 to July 31, 1978 - A.T. Cameron - groundfish cruise; February 1 to June 2, 1979 - RTM Belogorsk - biology and distribution study; June 13 to June 29, 1979 - Lady Hammond - biology and distribution study; July 5 to July 15, 1979 - A.T. Cameron and Lady Hammond - groundfish cruise; October 23 to November 29, 1979 - Hakurei Maru - emigration and biology study; December 11 to December 20, 1979 - Lady Hammond - biology and distribution study.

All data, with the exception of Gulf Stream larval surveys between March 7 and May 22, 1979 on the Belogorsk cruises, were collected offshore on the Scotian Shelf, mainly from bottom trawls and occasionally from midwater trawls. While the International Observer Program data were from random samples collected in the commercial fishery, research cruise data were from random stratified surveys. In 1977, the International Observer Program obtained length-frequency data of unsexed animals accurate to the nearest 10 mm, but in subsequent data the animals were sexed and measured to the nearest 5 mm. Other morphometric data were collected according to the standard procedure described by Amaratunga and Durward (1979).

The length-frequency data (especially from the International Observer Program) were analysed with no consideration given to mesh selection (Amaratunga et al., 1979; Clay, 1979). However, data collected in June, 1978, and October/November, 1978, consisted of total samples from covered nets in the selectivity experiments, while gear in research cruises usually had small meshes. Length-frequencies were grouped by sex and by week to obtain means and standard deviations (Table 2). Growth curves were fitted (Figure 2) to the data applying the von Bertalanffy equation $L_t = L_\infty(1-e^{-Kt})$. Approximately 1,750 larval and juvenile I. illecebrosus captured in the Gulf Stream survey were analysed separately and treated separately.

Male maturity assessed by visual criteria (Amaratunga and Durward, 1979) are staged as follows: Stage 1 - immature, Stage 2 - maturing, Stage 3 - mature, and Stage 4 - spent. Female maturity stages determined from the ratio of nidamental gland length to mantle length (Amaratunga and Durward, 1979) are characterized as follows: Stages 1 and 2 - thin, transparent to translucent nidamental glands (immature), Stage 3 - nidamental gland translucent to opague (maturing), Stage 4 - nidamental gland white, oviducts forming, Stage 5 - eggs in oviducts (mature). Ogives of representative stages of maturation were plotted (Figures 3 and 4) and referred to the growth curves to determine progression of maturation through the season.

RESULTS

Since length-frequencies were obtained from both fresh and frozen samples, the effect of freezing was tested on 1978 research cruise samples. At 95% confidence limits, no significant differences were noted between sample mean lengths.

Length frequency distributions compiled by sex by week typically showed normal distributions with a consistent single modal class progressing through the season. However, inconsistent modes were also apparent. Subtle modal classes were sometimes noted at various regions of the distributions, sometimes close to the major modal class. Especially in early and late season, distributions were often skewed (larger S.D. in Figure 2) and modes were sometimes apparent at considerably different sizes. The males usually had a narrower size range than females.

Figure 2 shows fitted growth curves for the three years studied. The first three samples (April) of 1977 consisted of 17, 57, and 91 animals respectively, which ranged from 100 mm to 280 mm with no further details available. Since these samples probably represented an admixture of small recruits and larger stragglers from the previous year's spawners, they were not used in the fit. While early 1978 samples did not contain large individuals, similar data points in 1979 (juvenile samples were from the Gulf Stream) in Figure 2 were also not used to fit the curve. Equation parameters are given in Table 3.

The juvenile samples were collected between March 18 and May 19, 1979. Table 4 shows average measurements from the morphometric analyses performed. The animals ranged from 1.6 mm to 120 mm in length and there was considerable size variation between individual samples (Table 4). The 1978 samples provided a complete data set for length and maturity and hence were used to trace maturity on the growth curve (Figure 3). Ogives were constructed for male maturity Stages 1 to 3, and length at 50% (L_{50}) for Stage 1 was 156 mm early in June. Stage 2 had L_{50} at 209 mm in late September and Stage 3 at 228 mm in late November. Stage 3, referred to as mature, has the visual criterion that spermatophoric sac contains spermatophores (Amaratunga and Durward, 1979). Ogives constructed for 1979 male maturity stages (Figure 4) show L_{50} for Stages 1, 2, and 3 at 146, 188, and 228 mm respectively. When referred to the fitted growth curve the L_{50} for each stage corresponded to end of March, mid July, and end of October respectively.

Ogives were constructed for 1978 female maturity Stages 2, 3, and 4 (Figure 3). L_{50} for Stage 2 (immature) was 174 mm in late June. Stage 3, when maturation is activated by gonadotrophic hormone (Durward et al., 1979), had L_{50} at 250 mm in early December. Stage 4, when nidamental glands and oviducts are turning white and approaching maturity, had L_{50} at 271 mm in early February, 1979. Ogives constructed for 1979 females included Stage 1 (Figure 4). L_{50} for each successive stage of 140, 195, 258, and 267 mm respectively, when referred to the fitted growth curves, corresponded to early May, beginning of July, late November, and mid to late December respectively.

DISCUSSION

Length-frequency distributions typically seen in this study concur with previous reports for stocks on the Scotian Shelf, Newfoundland inshore, and Grand Banks (Squires, 1957). Length-frequency samples of this study constituted a conglomerate of trawls that could have originated anywhere on the Shelf and lasted varying lengths of time. Thus, the data base was not sensitive to determine any discrete regional variations, and in fact provided a good representation of pooled data. The unimodal distributions consistently seen on the Scotian Shelf are similar to the homogeneity in length distributions at Newfoundland reported by Squires (1957, 1967).

The inconsistent modal classes apparent in some weeks are probably the result of sample variations when distributional patterns of the stocks, such as schooling, become apparent. For example, juveniles in the Gulf Stream exhibited discrete groupings with significantly different mean sizes from one group to another (Table 4). However, when each week's data were combined, length frequencies showed normal distributions and the means fitted well with the growth curve (Figure 2).

Indeed, schooling has been observed in the laboratory (O'Dor et al., 1979) and in the field (Bennett, 1978). An offshore jigging survey has in fact shown that two separate schools of squid may exist in close proximity (T. Rowell and T. Amaratunga, 1979 unpublished data), each school having narrow length-frequency distributions but with quite different modes and sex ratios to each other. This evidence is further supported by the fact that cannibalism (presumably large squid feeding on smaller ones as seen in the laboratory, [O'Dor et al., 1979]) would discourage large size disparities within schools. Mercer (1973b) reported similar multimodal classes, but those which could be followed throughout the season in a given area in Newfoundland. He suggested this to be the presence of mixed age groups within a single year-class which could relate to a protracted spawning season. The skewness in the size frequency distributions and the presence of multimodal classes in the present study are also supportive of the protracted breeding season proposed by Squires (1967). While these discrete modes may exist and periodically become apparent, it is necessary to recognize that the overall stock portrays the progression of a single mode. This is significantly different to the multimodal conditions seen by Mesnil (1977) and Tibbetts (1975), especially in the more southern areas.

In the von Bertalanffy curves (Figure 2) the constant t_0 (the hypothetical age at which the animal would have had zero length) must be considered as quite artificial because adult growth patterns differ from earliest ages (Beverton and Holt, 1957). However, both t_0 and L_∞ (the greatest possible length the animal can attain) provided valuable estimations.

Growth curves of all three years (Figure 2) showed general similarities in that mean sizes of animals by the end of August were similar to each other. The 1977 and 1979 animals first observed on the Shelf in May were smaller than those of 1978. Hence, slower growth and a flattened curve is apparent for the 1978 animals.

The 1977 data which were recorded at 10 mm intervals until mid July resulted in t_0 at end of February, 1977 for males and end of January, 1977 for females. This represented growth from 0 mm to about 125 mm in about 95 days, which appears to be too rapid. L_∞ derived from the more reliable region of the fit shows more realistically males very close to asymptotic size and females about 30 mm below asymptote in November, 1977. The 1978 data were apparently more suitable for fitting the curve. Asymptotic lengths (278 mm for males and 347 mm for females) from the fit tend to fall in the higher size ranges of the animals seen in November. Estimated t_0 is in late December, 1977, which relates well to 1977 growth curves and represent growth from 0 mm to 125 mm in about 130 days.

The 1979 growth curves lacked data points from September to mid October (these data were not available at the time this report was prepared). Estimated L_∞ of 248 mm for males was reasonable and close to the asymptotic length. This was 16 mm longer than 1977 animals and 31 mm smaller than 1978 animals. Estimated L_∞ of 294 mm for females was also reasonable and was the same as for 1977 but considerably smaller than 1978 animals. The 1979 t_0 of late February was slightly late related to the 1978 growth curve, and also represented a rapid growth from 0 mm to about 130 mm in about 80 days.

Both 1978 and 1979 growth curves were used to study maturation patterns (Figures 3 and 4). Maturation is a complex somatic and physiological process progressing in a continuum; but in males, visually detectable stages are valuable parameters to demarcate different phases of maturation. The "mature" male stage (Amaratunga and Durward, 1979) used in this study describes an early state of maturation (Durward et al., 1979). The transition into this phase is critical in that males enterring it will soon be ready to breed. L_{50} for this stage at 228 mm in both 1978 and 1979 relate to late November and end of October respectively, with only about a two- to three-week difference from one to the other. This stage then also relates to an imminent emigration phase (Caddy, 1979) from the fishing grounds to the spawning grounds. This is represented as Phase 3 in Figure 5, using 1978 growth curves as an example. The flattened growth curve of 1978 is reflected by delays in Stages 1 and 2 in relation to 1979.

Female staging is less subjective, but the nidamental gland length:mantle length ratio is not a sensitive measure in early stages (1 and 2) (Durward et al., 1979). However, Stage 2 in both years had comparable dates. Stage 3, when maturation is activated by gonadotropic hormones, is important and is well defined (Figures 3 and 4). This critical stage had 50% maturity in early December 1978 and late November 1979, a little later than the corresponding Stage 3 in males. It is proposed here that Stage 3 in females also relates to an imminent emigration phase (Figure 5).

The next two stages toward maturity in females should proceed at an increasing rate (Durward et al., 1979). This is apparent in Stage 4 of 1979 but more than two months lapse before 50% reach Stage 4 in 1978. Stage 4 had representative samples of only 156 and 100 animals respectively in each year (and Stage 5 had one and three animals respectively). Hence, precision of L_{50} is in question. However, when 1978 maturities are compared with t_0 for the 1979 growth curve, the predicted time for female maturity in February seems reliable.

Caddy (1979) developed a model to analyze mortality of an I. illecebrosus population during its residency on the Scotian Shelf by incorporating components of immigration and emigration. The model required separation points (within ± two weeks) of the three phases (Figure 5). The data presented in this paper permit this separation between Phases 1 and 2, as discussed above. Further factors support the suggestion that Stage 3 initiates emigration: i) During the course of November 1979, percent males in the population dropped from 44% to 26% (males mature earlier than females). ii) During November the growth curves record a decrease in mantle length, suggesting that larger animals have moved out. iii) Exhaustive research surveys have resulted in the capture of very few specimens of spent males (Stage 4) or Stage 4 and 5 females.

Phase 1 was determined by the mean sizes of animals first captured on the Scotian Shelf.

ACKNOWLEDGEMENTS

I wish to extend my thanks to Mr. Ian McQuinn, Ms. Michelle Roberge, and Mr. Jamie Young for their hard work in data collection, computer analyses, and support work; Ms. Sharon LeBlanc, Mr. Dave Chaisson, and Ms. Maureen Butler for their efforts in compiling this report.

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TABLE 1. Nominal catches (metric tons) of *Illex illecebrosus* in the ICNAF area from 1974 to 1978.

Year	ICNAF Subareas				
	2	3	4VWX	Total 2-4	Total 5-6
1974	31	17	389	437	11653[a]
1975		3764	13993	17757	13790[a]
1976		11254	30510	41764	27717[a]
1977	6	32748[b]	47199[b]	79953[b]	24792[b]
1978		45472[b]	53118[b]	98590[b]	17695[b]

[a] Excludes catches which have not been reported for *Illex* and *Loligo* separately.

[b] Preliminary data.

Table 2. Weekly mean mantle lengths, S.D., and numbers of <u>Illex illecebrosus</u> on the Scotian Shelf for the years 1977, 1978, and 1979.

Week		Male			Female		
		Mean mantle length	Standard deviation	Numbers	Mean mantle length	Standard deviation	Numbers
6	1977	-	-	-	-	-	-
	78	-	-	-	-	-	-
	79	205.0	7.1	4	227.5	20.2	4
7	77	-	-	-	-	-	-
	78	-	-	-	-	-	-
	79	-	-	-	-	-	-
8	77	-	-	-	-	-	-
	78	-	-	-	-	-	-
	79	234.0	14.3	194	208.9	17.3	284
9	77	-	-	-	-	-	-
	78	-	-	-	-	-	-
	79	180.8	17.0	30	198.5	25.2	42
10	77	-	-	-	-	-	-
	78	-	-	-	-	-	-
	79*	24.4	6.3	79	24.4	6.3	79
11	77	-	-	-	-	-	-
	78	-	-	-	-	-	-
	79*	21.1	3.8	234	21.1	3.8	234
12	77	-	-	-	-	-	-
	78	-	-	-	-	-	-
	79*	30.6	5.8	156	30.6	5.8	156
13	77	-	-	-	-	-	-
	78	-	-	-	-	-	-
	79	-	-	-	-	-	-
14	77*	171.8	38.3	17	171.8	38.3	17
	78	-	-	-	-	-	-
	79*	39.9	4.1	140	39.9	4.1	140
15	77*	159.1	38.0	57	159.1	38.0	57
	78	-	-	-	-	-	-
	79*	61.6	7.8	88	61.6	7.8	88
16	77*	150.3	22.6	91	150.3	22.6	91
	78	-	-	-	-	-	-
	79	-	-	-	-	-	-
17	77*	129.6	13.5	1246	129.6	13.5	1246
	78	149.4	9.2	39	149.7	9.9	45
	79	-	-	-	-	-	-
18	77*	132.6	27.2	419	132.6	27.2	419
	78	136.5	12.7	50	135.4	12.9	50
	79	-	-	-	-	-	-
19	77*	150.4	22.8	935	150.4	22.8	935
	78	150.1	15.0	167	155.3	20.2	243
	79	132.1	9.7	317	140.7	19.1	321
20	77*	159.2	20.6	1158	159.2	20.6	1158
	78	157.7	10.4	88	161.4	14.7	135
	79	131.6	14.4	1306	137.8	19.5	1262
	*	58.1	17.6	57	58.1	17.6	57
21	77*	160.8	18.4	1291	160.8	18.4	1291
	78	150.9	12.5	180	157.0	13.7	218
	79	142.3	13.8	566	145.8	16.2	498
22	77*	175.4	21.2	1359	175.4	21.2	1359
	78	159.6	15.7	28	168.4	17.3	19
	79	153.8	15.6	2262	162.0	21.6	2721

Table 2. (Cont'd)

Week		Male			Female		
		Mean mantle length	Standard deviation	Numbers	Mean mantle length	Standard deviation	Numbers
23	77*	167.9	22.3	1915	167.9	22.3	1915
	78	150.7	13.1	3212	154.0	15.9	2829
	79	172.9	14.4	103	181.0	19.2	92
24	77*	188.1	21.5	5282	188.1	21.5	5282
	78	153.9	18.5	2644	161.2	23.2	2377
	79	166.6	17.9	354	179.0	23.4	462
25	77*	191.9	23.4	6629	191.9	23.4	6629
	78	157.6	15.0	1710	162.5	19.6	1581
	79	164.7	18.3	754	167.4	22.5	497
26	77*	202.1	18.8	1864	202.1	18.8	1864
	78	159.8	15.9	2968	163.0	20.2	2605
	79	178.7	29.6	736	192.0	25.3	657
27	77*	193.3	17.5	4305	193.3	17.5	4305
	78	166.2	13.8	629	169.7	19.0	592
	79	187.0	13.4	192	195.7	18.1	193
28	77*	191.2	19.0	3348	191.2	19.0	3348
	78	167.3	16.8	495	174.4	17.8	534
	79	190.9	15.2	727	198.4	19.2	498
29	77*	204.9	14.6	5451	204.9	14.6	5451
	78	184.4	16.0	336	186.6	18.3	252
	79	196.9	16.9	586	200.1	18.0	577
30	77	205.2	11.7	424	210.5	11.3	272
	78	194.9	12.8	781	204.2	14.4	564
	79	198.6	13.9	564	210.4	20.5	571
31	77	207.9	12.6	783	214.1	16.1	417
	78	191.5	13.1	301	201.9	16.8	235
	79	204.4	12.0	343	211.5	14.5	263
32	77	207.0	10.9	782	216.1	15.2	619
	78	196.7	10.8	392	201.6	15.7	252
	79	209.3	14.3	158	212.1	15.8	142
33	77	208.8	11.1	961	220.7	17.7	739
	78	194.5	16.9	418	202.3	21.5	302
	79	213.3	11.1	270	222.3	15.3	119
34	77	216.1	10.4	219	222.8	16.4	228
	78	207.4	9.5	224	213.6	13.7	174
	79	224.7	12.8	258	233.0	16.4	143
35	77	216.2	10.0	1130	226.9	16.0	720
	78	209.0	11.5	361	220.2	15.7	289
	79						
36	77	215.6	10.4	1374	231.5	19.6	1014
	78	212.1	8.2	158	215.8	10.6	109
	79						
37	77	216.5	10.9	999	233.9	18.2	421
	78	220.5	9.7	44	225.2	21.0	56
	79						
38	1977	223.6	10.5	176	239.5	15.4	124
	78	220.9	9.9	217	234.2	16.5	185
	79						
39	77	-	-	-	-	-	-
	78	222.0	10.6	629	236.8	16.2	672
	79						
40	77	-	-	-	-	-	-
	78	222.0	7.4	41	240.8	14.0	32
	79						
41	77	-	-	-	-	-	-
	78	219.9	10.0	405	231.5	10.1	392
	79						

Table 2. (Cont'd)

Week		Male			Female		
		Mean mantle length	Standard deviation	Numbers	Mean mantle length	Standard deviation	Numbers
42	77	-	-	-	-	-	-
	78	225.5	21.9	891	241.2	31.6	999
	79						
43	77	225.0	4.1	7	250.5	16.6	21
	78	226.6	18.8	1359	245.1	20.9	1524
	79	230.8	13.1	642	255.9	19.7	967
44	77	237.5	3.5	2	271.5	17.5	20
	78	232.0	10.4	1126	256.4	21.8	1206
	79	231.2	11.1	1488	258.9	19.9	1829
45	77	230.0	2.9	7	255.7	14.6	23
	78	227.7	26.0	2707	249.6	35.5	2879
	79	230.4	11.0	968	259.9	17.7	1549
46	77	222.8	10.6	67	251.0	21.4	100
	78	227.4	11.3	545	245.3	19.2	719
	79	230.1	11.0	128	247.6	15.4	238
47	77	222.9	6.9	12	254.1	14.6	58
	78	220.7	9.6	125	242.6	17.4	106
	79	227.0	12.3	282	251.6	18.0	549
48	77	-	-	-	-	-	-
	78	-	-	-	-	-	-
	79	231.7	10.9	437	261.4	16.1	1200
49	77	-	-	-	-	-	-
	78	202.5	21.1	47	217.0	25.3	47
	79						
50	79	225.0	13.5	107	256.0	19.6	216
51	79	226.6	9.8	103	245.0	16.8	117

*Unsexed

Table 3. Growth curve parameters for 1977, 1978, and 1979 from the fitted curve of the equation $L_t = L_\infty[1-e^{-K(t-t_o)}]$

	1977		1978		1979	
	♂	♀	♂	♀	♂	♀
L_∞ (mm)	231.9	293.2	278.0	346.9	247.9	293.9
t_o (in weeks)	+9.4	+5.4	-0.1	-2.5	+9.2	+8.2
K	0.106	0.052	0.036	0.025	0.074	0.056

Table 4. Mean lengths of juvenile _Illex illecebrosus_ samples, giving dates and locations of capture.

Date	Location		# of squid measured	Mean length (mm)	Mean length (mm) by week
	Latitude	Longitude			
March 1 (9)	40°04'	65°38'	35	20.6	20.6
March 16 (11)	39°52'	63°47'	33	21.1	19.4
March 17 (11)	40°36'	64°33'	38	17.6	
March 19 (12)	42°00'	65°11'	15	63.2	42.7
	41°43'	64°02'	2	27.5	
March 20 (12)	41°01'	63°21'	1	36.0	
March 21 (12)	40°23'	62°35'	182	30.9	
	40°53'	61°32'	31	33.6	
March 28 (13)	40°17'	59°15'	144	32.2	27.2
March 29 (13)	40°11'	59°12'	3	27.0	
	40°00'	59°03'	2	18.0	
March 30 (13)	39°41'	58°33'	4	25.5	
April 1 (14)	39°43'	56°58'	140	23.9	35.7
April 2 (14)	40°34'	57°41'	204	35.7	
April 3 (14)	41°06'	58°38'	85	16.4	
	41°50'	59°23'	64	55.3	
April 4 (14)	42°06'	58°03'	22	57.5	
April 5 (14)	41°44'	57°38'	65	53.3	
	41°00'	56°47'	149	49.7	
April 6 (14)	40°17'	55°58'	8	23.5	
	39°33'	55°06'	196	44.8	
April 7 (14)	38°50'	54°16'	34	26.4	
April 9 (15)	40°58'	55°00'	240	63.0	64.5
April 12 (15)	42°13'	54°52'	1	73.0	
May 14 (20)	40°33'	62°18'	5	72.6	63.5
May 15 (20)	40°53'	62°20'	8	74.5	
May 18 (20)	40°39'	59°35'	11	53.3	
May 19 (20)	41°06'	59°42'	21	53.4	

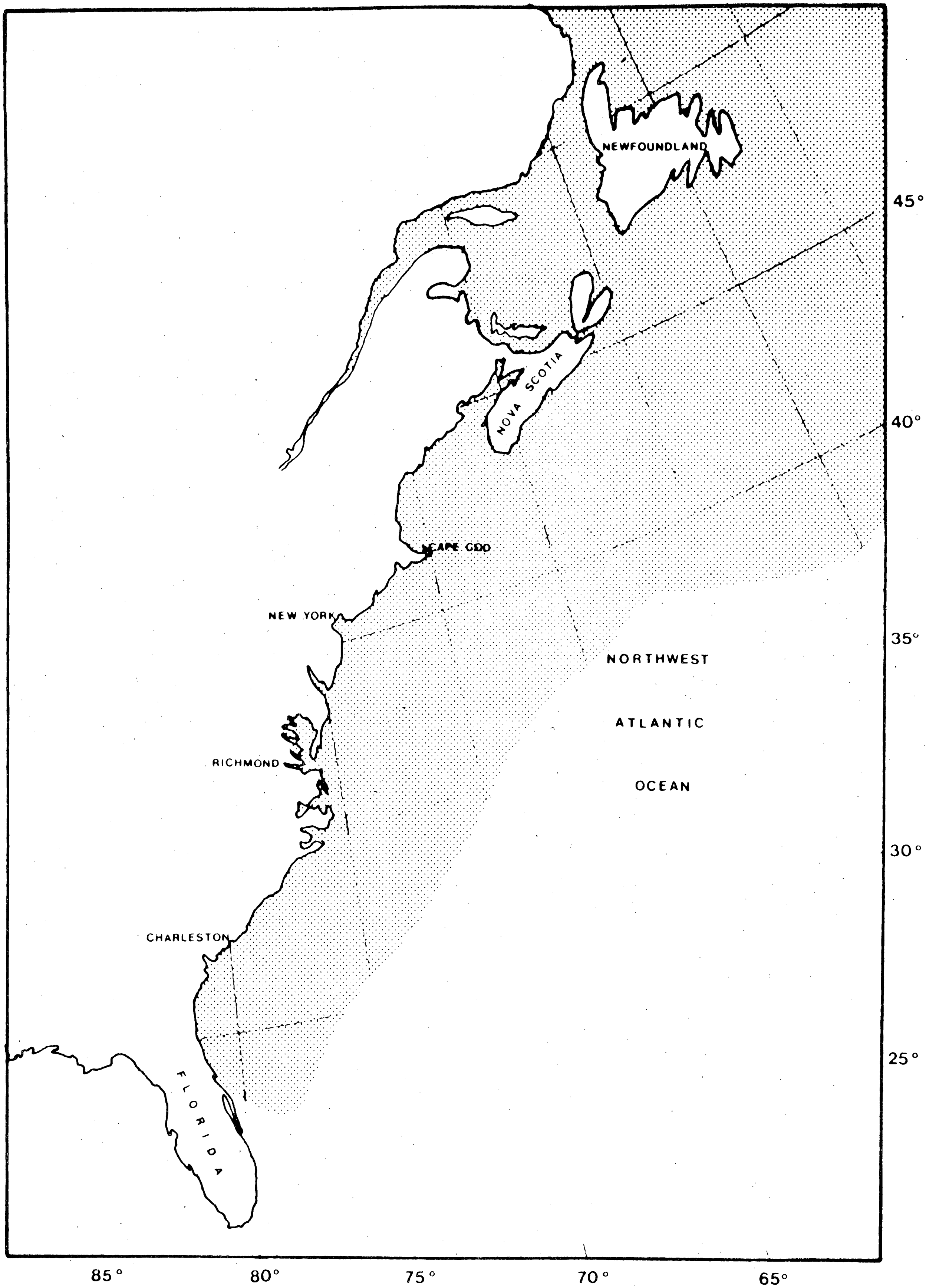

Figure 1. Known distribution (shaded area) of Illex illecebrosus in the northwest Atlantic region.

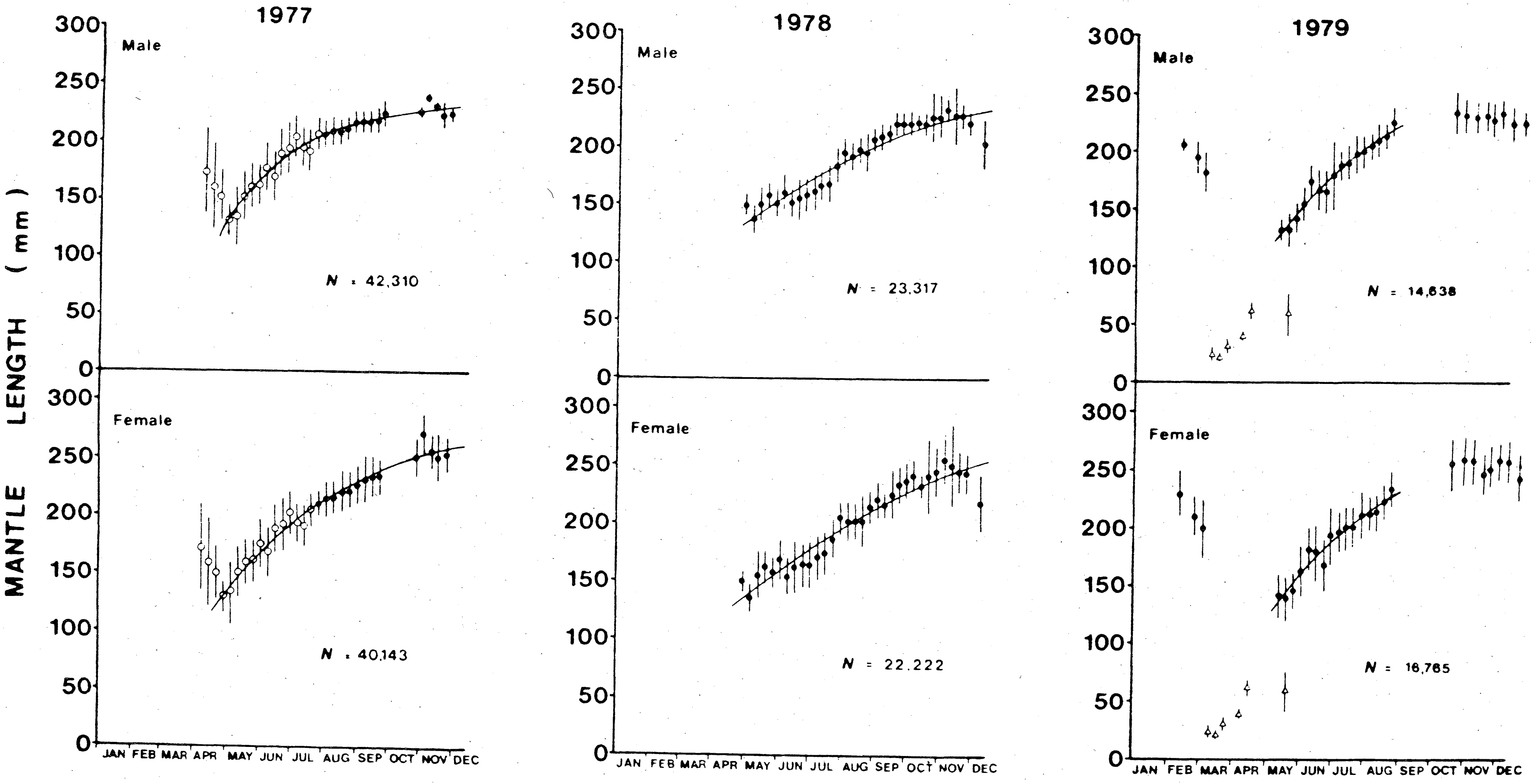

Figure 2. Growth curves fitted with von Bertalanffy equation $L_t = L_\infty(1-e^{-Kt})$ to length-frequency data of *Illex illecebrosus* from 1977, 1978, and 1979 (N.B. ○ - unsexed; ● - sexed; △ - samples obtained from Gulf Stream; verticle bars - 1 S.D.

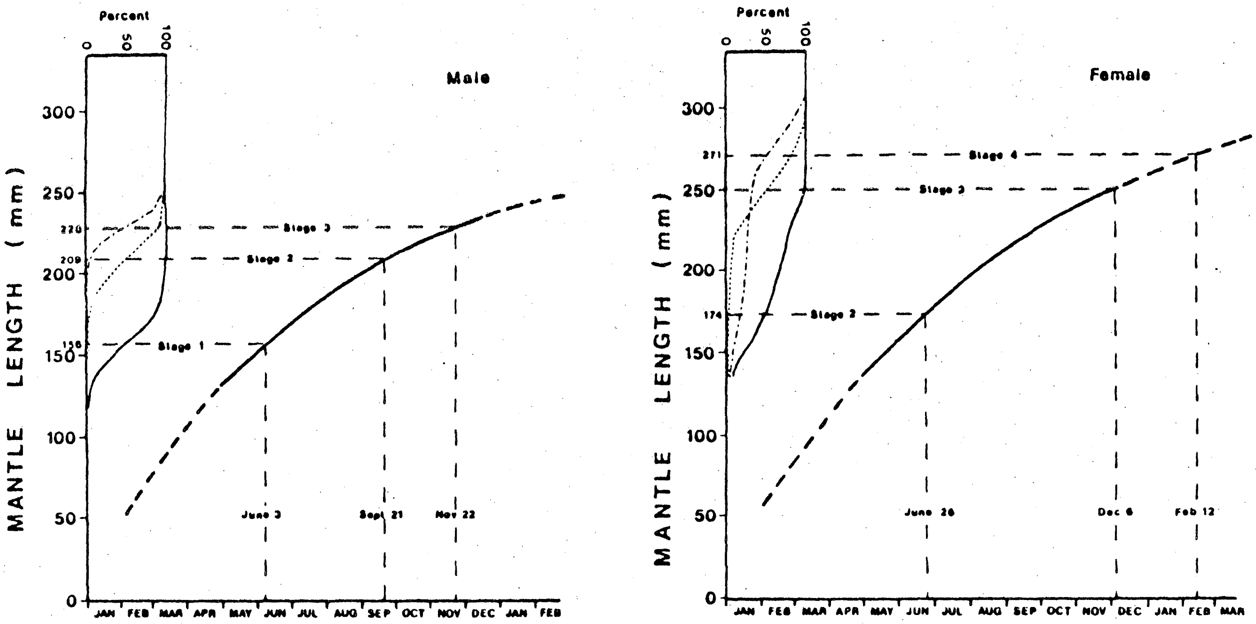

Figure 3. Maturity stage ogives plotted onto the 1978 fitted growth curves for male and female *Illex illecebrosus* to show lengths and dates at 50% maturity.

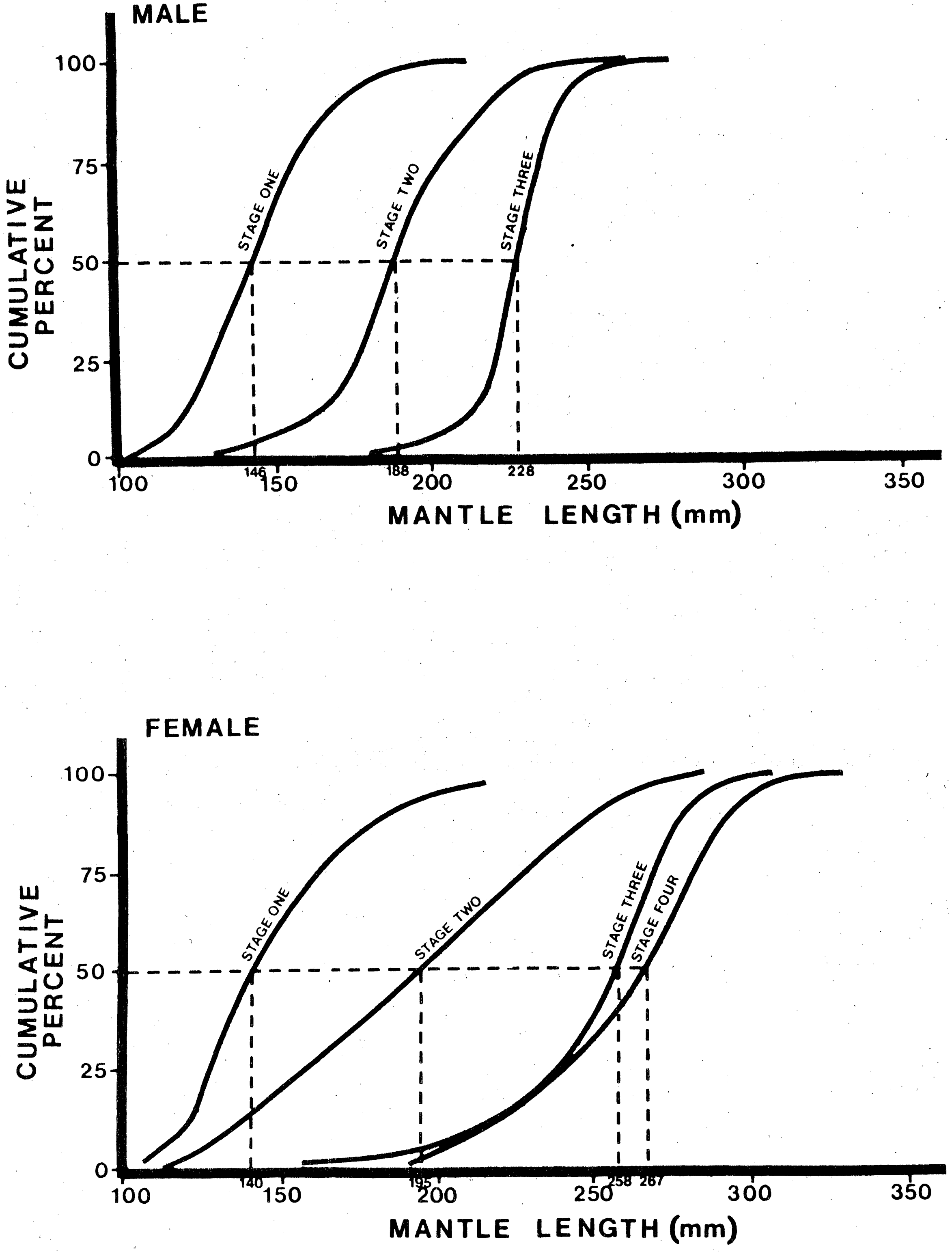

Figure 4. Maturity stage ogives for 1979 data.

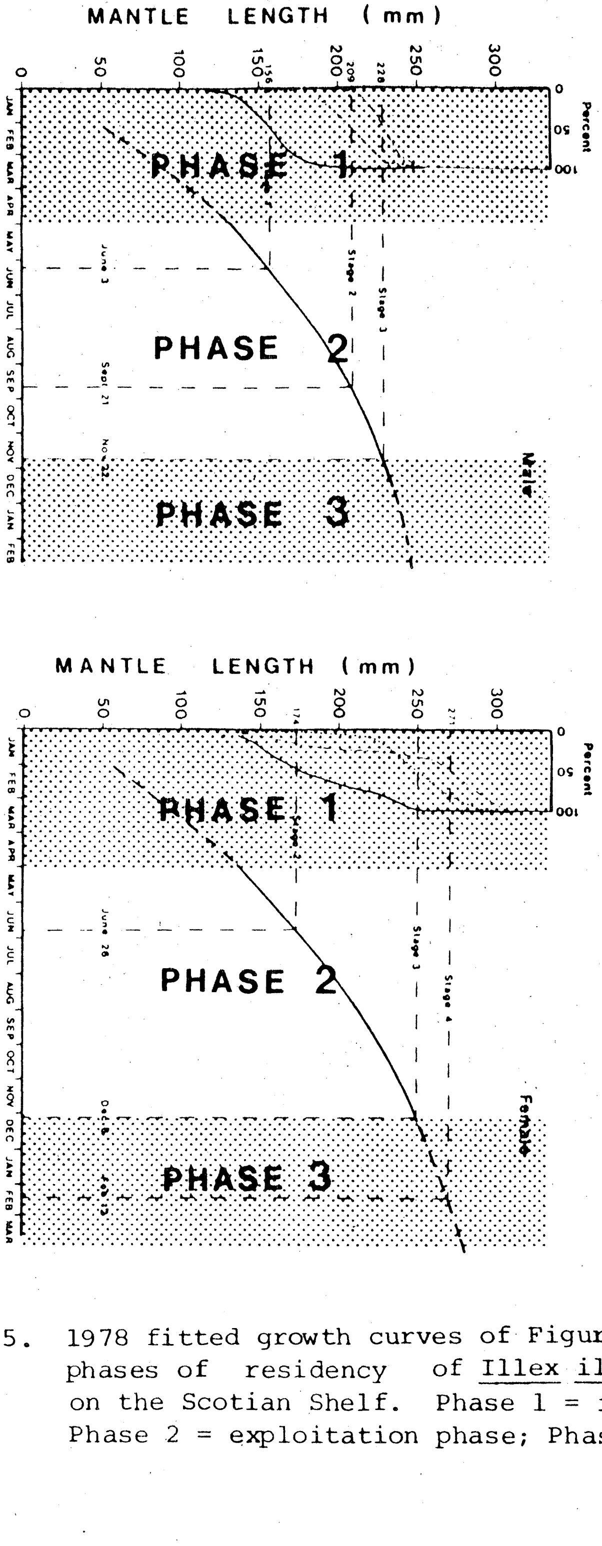

Figure 5. 1978 fitted growth curves of Figure 3 showing three phases of residency of <u>Illex illecebrosus</u> population. on the Scotian Shelf. Phase 1 = immigration phase; Phase 2 = exploitation phase; Phase 3 = emigration phase.