

Dorsal Mantle Length - Total Weight Relationships
of Squid (Loligo pealei and Illex illecebrosus) from
the Northwest Atlantic, off the Coast of the United States.

by

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Introduction

Two species of squid are of commercial importance off the northeastern United States, these are: Loligo pealei (the long-finned squid) and Illex illecebrosus (the short-finned squid). Loligo is distributed primarily from Cape Hatteras to the Gulf of Maine with some seasonal occurrences in the Gulf of Mexico and as far north as New Brunswick (Summers 1969). Illex ranges from Newfoundland to Florida with commercial concentrations from the Middle Atlantic area, near Baltimore Canyon, to Newfoundland (Squires 1957). Until the late 1960's these species were taken commercially off the USA in quantities, ranging from 400 to 5,000 metric tons (MT) per year (average 1,805 MT, 1930-1967). Comparable amounts of Illex were taken annually off Newfoundland by coastal Canadian fishermen. However, with development of international fisheries in these areas catches increased rapidly in the early 1970's, reaching 56,700 MT (Loligo and Illex) in 1973, off the USA and 80,600 MT (Illex) in 1977, off Canada.

The life history and population dynamics of these two squid species, especially Illex, are not fully understood. The relationship of growth in length to increase in weight can be used, in conjunction with length-frequency samples from the commercial fishery, to convert catch in weight to catch in number. For rapid growing species, like squid, population size in numbers may be more appropriate than biomass in analyzing the status of the stocks. Mesnil (1977),

Summers (1971), and Squires (1967) present studies of the growth and life cycles of these species, but do not provide length-weight relationships. Mercer (MS 1973), provided length-weight functions for male and female Illex from Newfoundland waters, but these may not be appropriate for Illex off the US. Similar studies have not been made for Loligo.

The objectives of this study were to: (1) calculate dorsal mantle length - total weight relationships for squid (Loligo pealei and Illex Illecebrosus) from the Northwest Atlantic, off the US coast; (2) analyze differences in length-weight relationships from different areas, seasons, and years and by sex; and (3) determine the appropriate application of these relations to empirical data from the commercial fishery.

Methods and Materials

Samples of squid, both Loligo and Illex, for length-weight analysis, were collected from the Nova Scotian to Middle-Atlantic areas (Figure 1) during research vessel bottom trawl surveys conducted in 1975, 1976, and 1977 (Table 1). Standard randomly selected, depth-area stratified, bottom trawl stations (Grosslein 1969) were made and subsamples of each species of squid taken from tows in a given strata were frozen whole and returned to the Northeast Fisheries Center, Woods Hole, for analysis. These were generally, random subsamples, but in areas or seasons when few individuals in the upper or lower size ranges were obtained, length stratified random samples were used to ensure representation of the entire size range. The length data, therefore, do not represent an unbiased subsample of the survey catches.

Frozen samples were thawed prior to analysis. Dorsal mantle length was measured from the apex of the tail fin to the anterodorsal protuberance, to the nearest mm (Figure 2); total weight was measured to the nearest gram; and sex, maturity, and stomach content information was recorded. All data were audited and stored on computer files for statistical analysis.

The form of the length-weight relationships was assumed to be:

$$W = AL^b$$

where;

W = total weight (g),

L = dorsal mantle length (cm),

and A and B = coefficients of regression.

squares regressions were fitted to the linearized form of this function: $Y = a + bx$

where;

$Y = \log_e W,$

$X = \log_e L,$

$a = \log_e A,$

and b = coefficient of regression.

Various regressions were fitted, with the SPSS (1975) SCATTERGRAM sub-program, to combinations of the data, illustrating effects of sex, season, year, and area differences on the length-weight relationship. Pearson correlation coefficients (r) were calculated for each regression to measure the strength of the relationship, and the goodness of the fit of the calculated regression line to the empirical data.

One-way analyses of covariance were conducted using the program BMDP1V (BMDP, 1977), to determine the significance of differences between slopes and adjusted means of the various length-weight functions (Winer 1971).

Results

Data Collection:

A total of 5,388 Loligo and 2,798 Illex were obtained from 9 cruises during the three year study period (1975-1977). Of this total 750 Loligo and 20 Illex were of indeterminable sex and not considered in this study. There were also 3,026 Loligo and 193 Illex which were damaged during the capture or preserving process, preventing accurate measurement of weight, these were also excluded from the analysis.

The number of individuals in any sample does not, necessarily, reflect the size of the survey catches or the relative abundance of either species in any area or season. This is often a function of time available to separate and freeze the samples. Generally, however, both species are more available in autumn than in spring, and while Illex may be taken in great quantities during the summer, Loligo is usually too far inshore to be captured in an offshore survey. Loligo is most abundant in the area south of Cape Cod, and is only occasionally found north of Georges Bank, while Illex is generally more available from southern New England and Georges Bank areas, with significant catches also taken in the Gulf of Maine and Nova Scotian areas. Examples of seasonal distributions of each species, from 1977 US surveys, are presented in Figures 3 (a, b).

Statistical Summary:

Statistical summaries of Loligo and Illex length and weight data are presented in Table 2. Lengths ranged from 2.1 to 42.5 cm for Loligo and from 4.8 to 45.0 cm for Illex, with an overall average of 17.0 cm and 22.3 cm, respectively. Weights averaged 133 g and 243 g ranging from 4 to 752 g and from 3 to 861, for Loligo and Illex, respectively. Male Loligo were consistently larger (mean lengths and weights) in all areas, seasons, and years, than female Loligo; while on the average, female Illex were larger than the males of that species. The Loligo taken in the two southern areas (Middle Atlantic and Southern New England) were generally larger than those to the north; and while males were larger in spring than autumn, females seem to be larger in the autumn. Illex mean lengths decreased from north to south and increase from spring to autumn, for both sexes.

Regression parameters (a and b), standard error, and Pearson correlation coefficients (r) for Loligo and Illex length-weight relations are presented in Table 3 (a and b, respectively), by sex and overall, for each year, season, and area. Correlation coefficients indicate that generally between 76 and 96% ($r^2 \times 100$) of the variation between dorsal mantle length and total weight of Loligo may be accounted for by these regression equations. The low value for the regression of females from summer samples (64%) may possibly be explained by small sample size, and a narrow range of lengths. For Illex, between 41% and 96% of the variation is explained by the various regressions. The very low correlations for Illex in some groups (all 1977 data, males in 1975 and 1976, and all data from Georges Bank, the Gulf of Maine, and Nova Scotia) indicate

that regression equations may not always be appropriate for that species. However, examination of residuals indicated no systematic departures from the fitted equations to imply a better model. Fitted regressions were plotted for visual comparisons of the various relationships (Figures 4a-g, 5a-g).

Comparison of the length-weight relationships of male versus female Loligo, for all samples, shows a difference in weight, by sex, through the entire length range (Figure 4a). This difference is also evident when considering the relationships in each area separately (Figure 4b). Generally, females less than about 13 cm are lighter than males of the same length, while females greater than about 17 cm are heavier than the males. Length-weight relationships by year (pooled over season and area, Figure 4c), and those by season (pooled over area and year, Figure 4d) also showed differences between sexes, again with females less than 13-17 cm weighing less than males at the same lengths and those greater than that range weighing more. The summer sample shows only a slight difference between sexes. Comparisons of length-weight relationships by year, season, and area, for each sex separately and combined are shown in Figure 4e-g. Differences in each category are more evident in the male than in the female samples. Individuals of a given length, for both sexes, were lightest in summer, then spring and heaviest in the autumn, though larger females were heavier in the spring than they were later in the year. The most robust males were from the Middle Atlantic and Southern New England areas, while females from Georges Bank and Southern New England were heavier at any given length than those from the other areas. The regressions for the Gulf of Maine are not given since only five Loligo were obtained for weights.

Differences between the length-weight relationships of male and female Illex were not as consistent as those of Loligo. The overall Illex regressions (pooled over year, season, and area, Figure 5a) were visually inseparable. Though great differences were exhibited in the spring (Figure 5b) and Nova Scotian samples (Figure 5c); the relationships from the other areas and seasons were similar for each sex. Comparisons by year, season, and area, overall and for each sex separately are illustrated in Figures 5e-g. The greatest difference is exhibited by both males and females, among areas, where the Nova Scotian samples had a nearly linear length-weight relationship ($b = 0.827$ and 1.170 for males and females, respectively, and 1.242 overall).

Analyses of Covariance:

Analysis of covariance was used to test if observed differences in the regression equations of each species were statistically significant (Tables 4, 5). Differences between sexes were examined with tests of slopes and adjusted means, by pooling data over all years, areas, and seasons for each sex. Consistencies in these differences were checked by testing differences between sex within each season (data pooled over years and areas), within each area (data pooled over seasons and years), and within each year (data pooled over seasons and areas). Seasonal differences were tested, with pairwise tests of slopes and adjusted means for data combined over all areas, sexes, and years, for each season. Area and annual differences in slopes and adjusted means were tested with data pooled over years, sexes, and seasons, and over areas, sexes, and seasons, respectively.

Significant differences ($P < 0.01$) were exhibited in slopes and adjusted means between male and female Loligo (Table 4a), indicating that overall, females were heavier than males of the same length. This difference was also evident during each season, though it was only significant ($P < 0.01$) in the spring. Slopes were significantly different between sexes in most areas ($P < 0.01$), but while adjusted mean weights for females were greater in all areas this difference was significant only in Southern New England and Nova Scotia ($P < 0.01$). Significance was consistently demonstrated in tests of slopes for each year ($P < 0.01$). Tests of adjusted means were also significant in 1975 and 1977 (females again heavier), but not in 1976.

Tests between seasons (Table 4b) showed significant differences ($P < 0.01$) in adjusted means for each pair with heaviest individuals in autumn and lightest in summer. Significant differences were also evident in slopes between summer and autumn ($P < 0.05$).

Differences in Loligo length-weight regressions were also found between areas (Table 4c). Adjusted means were significantly different ($P < 0.01$) between the Middle Atlantic and all areas and between Southern New England and Nova Scotia, generally decreasing from south to north (excluding the Gulf of Maine). Significance in both slopes and adjusted means were evident only between: the Middle Atlantic and Southern New England and between Southern New England and Nova Scotia. Though the adjusted mean from Middle Atlantic samples was significantly greater than that of Southern England Loligo, the slope from the latter was greater. Larger individuals (over 19 cm) from Southern New England, generally, weighed more than those of the same length from the Middle Atlantic, while the reverse was true for individuals less than about 19 cm.

Pairwise comparisons between years produced significant results in tests of adjusted means, decreasing from 1975 to 1977. However, there was no significant difference in the slopes in any year. Therefore, although the mean sizes changed from year to year, there was no significant change in the relationship of length to weight.

Differences in length-weight regressions for Illex were not as consistent as for Loligo. Tests of adjusted means and slopes between sexes (Table 5a) revealed significant differences ($P < 0.01$) in the overall adjusted means (males heavier per unit length) but no significance in their slopes. When regressions by sex were compared within seasons, only summer samples were significantly different in both adjusted means and slopes (males heavier). Comparisons between sex, within the five areas showed significance in both slopes and adjusted means on Georges Bank (males heavier) and in the Nova Scotian area (females heavier), while adjusted means were significantly different in Southern New England ($P < 0.05$), Georges Bank ($P < 0.05$), the Gulf of Maine ($P < 0.01$), and Nova Scotia ($P < 0.01$). Differences between males and females within each year were also inconsistent. The adjusted mean of the males was greater than that of the females in each year, but this difference was only significant ($P < 0.01$) in 1976. Significant differences in slope were found only in 1977 data, with females over about 20 cm heavier per unit length, than males.

Differences in length-weight regressions due to seasons (Table 5b) were not significant for Illex. However, tests of adjusted means and slopes between most pairs of areas were (at the $P < 0.05$ level). Adjusted means were greatest in the Gulf of Maine, and less for Nova Scotia, Georges Bank, the Middle Atlantic, and Southern New England, respectively. Significance

in adjusted means at the $P < 0.01$ level were exhibited between: the Middle Atlantic and Nova Scotia; Southern New England and Georges Bank, the Gulf of Maine, and Nova Scotia; and Georges Bank and the Gulf of Maine. Tests of slopes were significant ($P < 0.01$) for all comparisons except between: Middle Atlantic and Southern New England; Middle Atlantic and the Gulf of Maine; and Southern New England and the Gulf of Maine. Therefore, the length-weight regression for Illex from the Nova Scotian area was significantly different (both adjusted means and slopes) from all other areas, exhibiting an almost linear relationship. Georges Bank Illex were also significantly different than those from other areas, with individuals greater than 25 cm weighing less than those of comparable lengths taken in other areas (except Nova Scotia).

There was a significant difference between the adjusted means in 1975 and 1976, with the mean in 1975 significantly greater than in 1976. Tests of slopes revealed significant differences ($P < 0.01$) between 1975 and 1977, and between 1976 and 1977 samples (Table 5d), however, there was no significance in tests of adjusted means between those years.

Comparisons of total calculated versus total empirical weights were made for each species, for all data and for various combinations of data (Table 6). Weights were calculated on an individual basis from sampled lengths, summed within length (cm) interval and then summed over all lengths. Percent differences were calculated between these values and those obtained by summing the individual empirical weights for the data set. Predicted weights were less than empirical weights for all comparisons, but these differences were very small, ranging from 0.08 to 6.60 percent for Loligo and from 0.17 to 5.62 percent for Illex. This indicates that the dorsal mantle length-total weight relationship produces relatively precise approximations of total empirical weight, and that the functions used for each species are fairly accurate representations of this relationship.

Discussion

Results of these analyses indicate that the weight of Loligo of a given size, differs significantly, depending on the sex of the individual. The consistency of this difference in tests within areas, seasons, and years is evidence that it is not merely a product of the statistical procedures employed. Major factors influencing differences between sexes, are the relative weight of gonads, with mature ovaries heavier than fully developed testes; differences in rates of maturation, and differential feeding during different stages of maturation and at different sizes. This study also suggests significant seasonal differences in the length-weight relationship of Loligo. A possible explanation of this is that in spring larger individuals are more mature and, therefore, heavier than later in the year; while in summer the many individuals which are not yet mature begin to feed; so by autumn individuals throughout the size range are heavier as a result of summer feeding. Area and annual differences, also shown significant for Loligo, may possibly be explained by various physical and biological factors such as temperature, nutrients, and availability of food.

Differences in length-weight relationships for various groupings of Illex were less consistent than for Loligo. Overall, tests between sexes were not significant, except in summer samples, possibly due to maturation of males, or differential feeding. Seasonal and annual differences were not significant for Illex, but area differences proved to be important. As with Loligo these are most likely due to physical and biological factors such as temperatures, nutrients, and food availability.

Conclusions

This study points out that differences in the length-weight relationships of Loligo do exist (by sex, year, season, and area) and implies a need for continual collection of data from each of these categories. Differences in Illex length-weight relationships were also significant among areas (but not between sexes, seasons, and years). However, comparisons within categories of sums of total empirical weight versus sums of total weight predicted by equations obtained for all data within a given set, indicate that the net results of using a single equation for each species is approximately as precise as using separate equations for each area, season, year, or sex. This implies that for purposes of predicting total numbers taken in a fishery from length frequency and total catch is weight data, a single equation, obtained from all samples is probably as accurate as applying different equations to catches from each area or season. These equations are: $W = 0.25662L^{2.15182}$ and $W = 0.04810L^{2.71990}$, for Loligo and Illex, respectively. However, significant changes in this relationship, for these short lived species, could occur as a result of changes in environmental factors. To monitor any such future changes sampling done during surveys should continue with data reported by sex and area, and additional samples should be taken during the inshore fishery.

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Table 1. Survey cruises used in Illex and Loligo length-weight relationship analysis.

Year	Cruise Code	Country	Season	Area
1975	753	USA	Spring	Mid-Atlantic - Nova Scotia
	758	USA	Autumn	Mid-Atlantic - Nova Scotia
1976	762	USA	Spring	Mid-Atlantic - Nova Scotia
	766	USSR	Autumn	Mid-Atlantic - Nova Scotia
	767	USA	Autumn	Mid-Atlantic - Nova Scotia
1977	771	USA	Spring	Mid-Atlantic - Nova Scotia
	774	USA	Summer	Mid-Atlantic - Nova Scotia
	775	Japan	Summer	Mid-Atlantic - Georges Bank
	778	USA	Autumn	Mid-Atlantic - Nova Scotia

Table 2a. Length-weight summary statistics for *Loligo*; by sex, and for each area, season and year.

Year	Season	Area	Dorsal mantle length						Total Weight				
			n	\bar{x}	S.D.	S.E.	Min.	Max.	\bar{x}	S.D.	S.E.	Min.	Max.
-	All Data	-	1709	170.2066	58.43553	1.413533	21.0	425.0	133.4383	91.42767	2.21160	4.0	752.0
A11	All	All	Males										
		Mid-Atlantic	409	190.8924	59.80818	2.957325	41.0	425.0	166.6308	104.2479	5.15473	4.0	734.0
		So. New England	304	196.7039	53.81042	3.08624	65.0	402.0	170.4572	99.85371	5.727004	10.0	752.0
		Georges Bank	164	173.0061	63.74359	4.977538	21.0	355.0	127.2927	90.42714	7.061172	7.0	526.0
		Gulf of Maine	3	170.6667	10.01665	5.78312	161.0	181.0	120.0	23.00	13.27906	97.0	143.0
		Nova Scotia	35	193.9714	61.40056	10.37859	98.0	310.0	133.2857	84.12161	14.21915	34.0	305.0
A11	Spring	All	388	201.6959	69.22797	3.514519	21.0	425.0	173.9227	122.0835	6.197851	7.0	752.0
	Summer		41	169.0244	46.19875	7.215032	90.0	298.0	95.82927	49.22444	7.687566	26.0	258.0
	Autumn		486	181.8086	48.62424	2.20564	41.0	340.0	153.2119	80.65131	3.658417	4.0	570.0
75	All	All	580	188.5931	60.11943	2.496323	21.0	425.0	163.9241	103.7126	4.306433	4.0	752.0
76	All	All	212	200.783	57.14859	3.924981	41.0	374.0	172.2736	95.95537	6.590241	10.0	599.0
77	All	All	123	175.5854	54.11841	4.879692	61.0	334.0	116.0488	82.82709	7.468266	9.0	460.0
			Females										
A11	All	All	697	159.9928	37.227626	1.410083	54.0	286.0	115.8293	62.83559	2.380067	7.0	435.0
		Mid-Atlantic	293	169.2423	37.53026	2.192542	54.0	286.0	130.6485	64.5405	3.770497	7.0	435.0
		So. New England	243	162.251	34.21141	2.194662	59.0	275.0	117.2346	59.97084	3.847131	10.0	394.0
		Georges Bank	124	136.7097	29.86794	2.68222	55.0	200.0	83.0	44.80145	4.023289	10.0	222.0
		Gulf of Maine	2	168.0	18.38478	13.00001	155.0	181.0	134.0	35.35535	25.0	109.0	159.0
		Nova Scotia	35	148.9143	42.70926	7.219182	70.0	227.0	97.28572	77.08994	3.03058	14.0	350.0
A11	Spring	All	299	157.6522	38.48149	2.225442	55.0	275.0	111.4114	66.74384	3.859897	10.0	435.0
	Summer		35	131.0857	14.64556	2.475552	100.0	158.0	58.39999	15.99117	2.703001	30.0	95.0
	Autumn		363	164.7080	36.30104	1.905311	54.0	286.0	125.0055	58.99672	3.096525	7.0	403.0
75	All	All	424	159.8962	39.81136	1.933411	54.0	286.0	121.9693	66.75272	3.2418	7.0	435.0
76			178	166.6292	32.43434	2.431056	59.0	270.0	118.2416	55.62306	4.169125	10.0	374.0
77			95	147.9895	30.31764	3.110524	82.0	255.0	83.90526	46.32266	4.752604	20.0	302.0

Table 3a. Regression parameters and statistics for dorsal mantle length (cm) and total weight (g) relationships of Loligo, by sex, area, season, and year.

Area	Season	Year	Sex	Intercept (a)	Slope (b)	Std. error of b	Antilog _e of a	Correlation coefficient (r)	
All	All	All	All	-1.36015	2.15182	0.2861	0.25662	0.9526	
			Males	-0.86949	1.97528	0.3196	0.41917	0.9108	
			Females	-1.78605	2.32364	0.2038	0.16762	0.9447	
	1975	All	All	-1.41009	2.18743	0.2863	0.24169	0.9594	
			Males	-0.85092	1.98020	0.3303	0.42702	0.9118	
			Females	-1.58916	2.27017	0.2221	0.20410	0.9416	
		1976	All	-1.23862	2.10357	0.2691	0.28978	0.9461	
			Males	-0.23259	1.76347	0.3192	0.79248	0.8728	
			Females	-2.20362	2.45497	0.1196	0.111040	0.9744	
	1977	All	All	-1.61568	2.19236	0.1612	0.19876	0.9712	
			Males	-1.60828	2.17591	0.1547	0.20023	0.9779	
			Females	-2.16486	2.41658	0.1507	0.11477	0.9574	
		Spring	All	All	-1.38547	2.14418	0.2736	0.25021	0.9689
				Males	-0.88956	1.96453	0.3023	0.41084	0.9332
				Females	-2.02656	2.40412	0.18585	0.13179	0.9670
	Summer	All	All	-0.78138	1.87046	0.16041	0.45777	0.9522	
			Males	-0.58210	1.79805	0.1539	0.55872	0.9568	
			Females	-0.89154	1.91773	0.1658	0.41002	0.8009	
	Autumn	All	All	-1.38983	2.18390	0.2711	0.24912	0.9358	
			Males	-0.93193	2.01763	0.3290	0.39379	0.8917	
			Females	-1.39656	2.19463	0.2230	0.24745	0.9247	
Mid-Atlantic	All	All	-1.04605	2.05558	0.2803	0.35132	0.9193		
		Males	-0.97119	2.02414	0.3154	0.37863	0.9164		
		Females	-1.37391	2.18067	0.2196	0.25312	0.9262		
So. New England	All	All	-1.77585	2.29771	0.1844	0.16934	0.9737		
		Males	-1.24814	2.10368	0.2528	0.28704	0.9305		
		Females	-2.48431	2.48431	0.1762	0.08338	0.9542		
Georges Bank	All	All	-1.31404	2.11827	0.3566	0.26873	0.9556		
		Males	-0.26677	1.73782	0.4096	0.76585	0.8755		
		Females	-1.99225	2.41504	0.1798	0.13639	0.9539		
Gulf of Maine	All	All	(1)						
		Males	(1)						
		Females	(1)						
Nova Scotia	All	All	-1.26702	2.06714	0.2491	0.28167	0.9478		
		Males	-1.01588	1.95655	0.2098	0.36208	0.9506		
		Females	-1.98178	2.36422	0.2537	0.13782	0.9433		

(1) Sample size too small to fit regression.

Table 3b. Regression parameters and statistics for dorsal mantle length (cm) and total weight (g) relationships of *Illex* by sex, area, season, and year.

Area	Season	Year	Sex	Intercept (a)	Slope (b)	Std. error of b	Antilog _e of a	Correlation coefficient (r)
All	All	All	All	-3.03444	2.71990	0.2419	0.04810	0.9259
			Males	-2.90355	2.68514	0.2753	0.05483	0.8901
			Females	-3.12432	2.74348	0.2114	0.04397	0.9272
		1975	All	-3.60800	2.91776	0.2262	0.02711	0.9547
			Males	-3.86325	3.01297	0.2407	0.02100	0.9423
			Females	-3.40628	2.84306	0.2054	0.03316	0.9607
		1976	All	-3.48898	2.86430	0.2482	0.03053	0.9654
			Males	-3.24850	2.79844	0.3193	0.03744	0.9382
			Females	-3.78275	2.95017	0.1834	0.02276	0.9678
	1977	All	-2.04101	2.40036	0.2281	0.12990	0.8489	
		Males	-1.09567	2.09151	0.2596	0.33432	0.7115	
		Females	-2.49809	2.54442	0.2166	0.08224	0.8693	
	Spring	All	All	-3.43632	2.84756	0.2506	0.03218	0.9299
			Males	-1.93149	2.32096	0.2554	0.14493	0.8101
			Females	-3.87840	2.98569	0.1965	0.02068	0.9782
	Summer	All	All	-3.85026	2.98298	0.1601	0.02127	0.9154
			Males	-5.54897	3.55229	0.1796	0.00389	0.8523
			Females	-3.65525	2.91409	0.1719	0.02586	0.9134
	Autumn	All	All	-2.90048	2.67682	0.2719	0.05500	0.9295
			Males	-2.71526	2.62456	0.3189	0.06619	0.8961
			Females	-2.95402	2.68939	0.2310	0.05213	0.9266
Mid-Atlantic	All	All	-3.25968	2.79140	0.24742	0.03840	0.9309	
		Males	-3.06027	2.73143	0.3067	0.04688	0.8579	
		Females	-3.36896	2.82290	0.2186	0.03443	0.9465	
So. New England	All	All	-3.64833	2.91003	0.2045	0.02603	0.9743	
		Males	-3.59821	2.90213	0.2285	0.02737	0.9658	
		Females	-3.72612	2.92964	0.1792	0.02409	0.9716	
Georges Bank	All	All	-2.19814	2.45559	0.2213	0.11101	0.8463	
		Males	-1.24068	2.15026	0.2345	0.28919	0.7160	
		Females	-2.71228	2.61320	0.1067	0.06639	0.8678	
Gulf of Maine	All	All	-3.39896	2.84990	0.1466	0.03341	0.8756	
		Males	-4.77169	3.31502	0.1426	0.00847	0.8520	
		Females	-5.11873	3.37266	0.1291	0.00598	0.8937	
Nova Scotia	All	All	1.67461	1.24241	0.2160	5.33671	0.7191	
		Males	2.82347	0.82687	0.2002	16.83517	0.6464	
		Females	1.95943	1.16965	0.1956	7.09528	0.6426	

Table 4a. Results of analyses of covariance of adjusted means and slopes of *Loligo* length-weight regression equations between sexes: all seasons, areas, and years combined; by season (areas and years pooled); by area (seasons and years pooled); and by year (seasons and areas pooled).

Factor	Test of adjusted means			Test of slopes		
	F-Ratio	df	Level of significance	F-Ratio	df	Level of significance
Overall	13.457	1609	P<0.01	51.300	1608	P<0.01
Season						
Spring	16.122	684	P<0.01	46.523	683	P<0.01
Summer	.001	73	n.s.	0.218	72	n.s.
Autumn	2.339	846	n.s.	5.737	845	P<0.05
Area						
Mid-Atlantic	3.302	699	n.s.	4.152	698	P<0.05
So. New England	12.502	544	P<0.01	25.187	543	P<0.01
Georges Bank	1.477	285	n.s.	23.235	284	P<0.01
Gulf of Maine(1)						
Nova Scotia	7.183	67	P<0.01	5.054	66	P<0.05
Year						
1975	12.415	1001	P<0.01	22.650	1000	P<0.01
1976	0.018	401	n.s.	47.078	400	P<0.01
1977	18.762	215	P<0.01	7.590	214	P<0.01

Overall comparison of adjusted means

	Males	Females
Adjusted mean	4.7055	4.7584
Std. error	.0094	.0108
t-test females	3.6671	P<0.01

(1) Sample size in the Gulf of Maine was inadequate for proper analysis.

P<0.01 = Significant at 1% level

P<0.05 = Significant at 5% level

n.s. = non-significant

Table 4b. Results of covariance analyses, tests of adjusted means and slopes of Loligo length-weight regression equations between seasons (areas, years, and sexes pooled), and simultaneous comparisons of adjusted means.

Seasons	Test of adjusted means			Test of slopes		
	F-Ratio	df	Level of significance	F-Ratio	df	Level of significance
Spring vs. summer	16.335	844	P<0.01	5.533	843	P<0.05
Spring vs. autumn	60.993	1629	P<0.01	1.360	1628	n.s.
Summer vs. autumn	53.887	936	P<0.01	7.163	935	P<0.01

Comparisons of Adjusted Means

	<u>Spring</u>	<u>Summer</u>	<u>Autumn</u>
Adjusted Mean	4.5358	4.4078	4.6422
Std. error	0.0097	0.0307	0.0092

t-matrix and significance levels

Spring	--		
Summer	-3.983 P<0.01	--	
Autumn	7.945 P<0.01	7.316 P<0.01	--

Table 4c. Results of analysis of covariance, tests of adjusted means and slopes of Loligo length-weight regression equations between pairs of areas (sexes, seasons, and years pooled), and simultaneous comparisons of adjusted means.

Area comparison	Test of adjusted means			Test of slopes		
	F-Ratio	df	Level of significance	F-Ratio	df	Level of significance
Mid-Atlantic vs. So. New England	9.037	1263	P<0.01	34.176	1262	P<0.01
Mid-Atlantic vs. Georges Bank	20.605	1067	P<0.01	1.785	1066	n.s.
Mid-Atlantic vs. Gulf of Maine	0.1437	705	n.s.	0.066	704	n.s.
Mid-Atlantic vs. Nova Scotia	29.764	771	P<0.01	0.010	770	n.s.
So. New England vs. Georges Bank	1.301	927	n.s.	18.713	926	P<0.01
So. New England vs. Gulf of Maine	1.258	565	n.s.	0.044	564	n.s.
So. New England vs. Nova Scotia	29.149	631	P<0.01	11.215	630	P<0.01
Georges Bank vs. Gulf of Maine	0.747	369	n.s.	0.031	368	n.s.
Georges Bank vs. Nova Scotia	4.287	435	P<0.05	0.182	434	n.s.
Gulf of Maine vs. Nova Scotia	4.396	73	P<0.05	0.085	72	n.s.

Comparisons of adjusted means

	Middle Atlantic	So. New England	Georges Bank	Gulf of Maine	Nova Scotia
Adjusted mean	4.6220	4.5796	4.5432	4.6721	4.4403
Std. error	0.0104	0.0116	0.0151	0.1222	0.0324

t-matrix (with significance level)

Mid-Atlantic	-				
So. New England	-2.7425 P<0.01	-			
Georges Bank	-4.2064 P<0.01	-1.8890 n.s.	-		
Gulf of Maine	0.4083 n.s.	0.7533 n.s.	1.0469 n.s.	-	
Nova Scotia	-5.3388 P<0.01	-4.0497 P<0.01	-2.8760 P<0.01	-1.8340 n.s.	-

Table 4d. Results of analyses of covariance tests of adjusted means and slopes of Loligo length-weight regression equations between pairs of years (sex, seasons, and areas combined), and simultaneous comparisons of adjusted means.

Comparison	Test of adjusted means			Test of slopes		
	F-Ratio	df	Level of significance	F-Ratio	df	Level of significance
1975vs1976	9.275	1501	P<0.01	2.401	1500	n.s.
1975vs1977	72.857	1304	P<0.01	0.175	1303	n.s.
1976vs1977	42.700	632	P<0.01	2.358	631	n.s.

Comparison of adjusted means

	<u>1975</u>	<u>1976</u>	<u>1977</u>
Adjusted means	4.6200	4.5649	4.4379
Std. error	0.0082	0.0135	0.0182

t-matrix and significance

1975	--		
1976	-3.4801 P<0.01	--	
1977	-9.1105 P<0.01	-5.5922 P<0.01	--

Table 5a. Results of analyses of covariance of adjusted means and slopes of *Illex* length-weight regression equations by sex: all seasons, areas and years combined; by season (area and year pooled); by area (season and year pooled); and by year (season and area pooled).

Factor	Test of adjusted means			Test of slopes		
	F-Ratio	df	Level of significance	F-Ratio	df	Level of significance
Overall	17.186	2611	P<0.01	1.353	2610	n.s.
Season						
Spring	0.718	45	n.s.	3.599	44	n.s.
Summer	25.577	999	P<0.01	30.168	998	P<0.01
Autumn	7.020	1561	P<0.01	1.140	1560	n.s.
Area						
Mid-Atlantic	2.690	692	n.s.	0.855	691	n.s.
So. New England	5.415	482	P<0.05	0.160	481	n.s.
Georges Bank	5.071	933	P<0.05	14.632	932	P<0.01
Gulf of Maine	51.376	239	P<0.01	0.049	238	n.s.
Nova Scotia	42.314	223	P<0.01	4.409	222	P<0.05
Year						
1975	6.080	453	P<0.05	3.625	452	n.s.
1976	8.495	486	P<0.01	3.361	485	n.s.
1977	0.321	1666	n.s.	25.583	1665	P<0.01

P<0.01 = Significant at 1% level
P<0.05 = Significant at 5% level
n.s. = non-significant

Table 5b. Results of analyses of covariance tests of adjusted means and slopes of Illex length-weight regression equations between seasons (years, areas and sexes pooled), including simultaneous comparisons of adjusted means.

Seasons	Test of adjusted means			Test of slopes		
	F-Ratio	df	Signifi- cance level	F-Ratio	df	Signifi- cance level
Spring vs. summer	0.909	1024	n.s.	1.410	1023	n.s.
Spring vs. autumn	1.822	1627	n.s.	0.993	1626	n.s.
Summer vs. autumn	0.122	2548	n.s.	21.396	2547	P<0.01

Comparisons of adjusted means

	<u>Spring</u>	<u>Summer</u>	<u>Autumn</u>
Adjusted mean	5.3076	5.3470	5.3503
Std. error	0.0330	0.0076	0.0060

t-matrix and significance levels

Spring	--		
Summer	1.1640 n.s.	--	
Autumn	1.2759 n.s.	0.3449 n.s.	--

Table 5c. Results of analyses of covariance, tests of adjusted means and slopes of Illex length-weight regression equations by area, (sex, seasons and years pooled) and simultaneous comparisons of adjusted means among areas.

Comparison	Test of adjusted means			Test of slopes		
	F-Ratio	df	Level of significance	F-Ratio	df	Level of significance
Mid-Atlantic vs. So. New England	5.652	1194	P<0.05	5.310	1193	P<0.05
Mid-Atlantic vs. Georges Bank	3.816	1638	n.s.	26.050	1637	P<0.01
Mid-Atlantic vs. Gulf of Maine	6.603	941	P<0.05	0.131	940	n.s.
Mid-Atlantic vs. Nova Scotia	9.957	925	P<0.01	250.813	924	P<0.01
So. New England vs. Georges Bank	12.271	1431	P<0.01	60.111	1430	P<0.01
So. New England vs. Gulf of Maine	13.956	734	P<0.01	0.204	733	n.s.
So. New England vs. Nova Scotia	13.083	718	P<0.01	401.683	717	P<0.01
Georges Bank vs. Gulf of Maine	12.393	1178	P<0.01	6.754	1177	P<0.01
Georges Bank vs. Nova Scotia	5.528	1162	P<0.05	159.471	1161	P<0.01
Gulf of Maine vs. Nova Scotia	5.102	465	P<0.05	124.460	464	P<0.01

Comparisons of adjusted means

	Middle Atlantic	So. New England	Georges Bank	Gulf of Maine	Nova Scotia
Adjusted mean	5.3363	5.3024	5.3596	5.4031	5.3810
Std. error	0.0090	0.0107	0.0078	0.0153	0.0158

t-matrix and significance

Mid Atlantic	-				
So. New England	-2.4567	-			
	P<0.05				
Georges Bank	1.9297	4.2678	-		
	n.s.	P<0.01			
Gulf of Maine	3.7088	5.3169	2.5544	-	
	P<0.01	P<0.01	P<0.05		
Nova Scotia	2.4331	4.0786	1.2238	-1.0146	-
	P<0.05	P<0.01	n.s.	n.s.	

Table 5d. Results of covariance analyses, tests of adjusted means and slopes of Illex length-weight regression equations between pairs of years (sexes, seasons and areas combines), and simultaneous comparisons of adjusted means.

Factor	Comparison	Test of adjusted means			Test of slopes		
		F-Ratio	df	Level of significance	F-Ratio	df	Level of significance
Overall	1975vs1976	7.208	960	P<0.01	0.917	959	n.s.
	1975vs1977	0.317	2132	n.s.	83.393	2131	P<0.01
	1976vs1977	1.920	2167	n.s.	86.398	2166	P<0.01

Comparisons of adjusted means for years

	<u>1975</u>	<u>1976</u>	<u>1977</u>
Adjusted mean	5.3681	5.33481	5.34670
Std. error	0.0113	0.01061	0.00589

t-matrix and significance

1975	--		
1976	-2.1761 P<0.05	--	
1977	-1.6849 n.s.	0.9759 n.s.	--

P<0.01 = Significant at 1% level

P<0.05 = Significant at 5% level

n.s. = non-significant

Table 6. Percent overall error in calculated sample weights versus empirical sample weights using length-weight functions for all data; and for annual, seasonal and area data by sex.

Area	Season	Year	Sex	Loligo		Illex			
				Number sampled	% error	Number sampled	% error		
All	All	All	All	1709	1.78	2604	1.68		
			Males	915	3.73	1073	2.08		
			Females	697	1.60	1511	1.73		
			1975	All	1088	0.74	464	1.47	
				Males	580	3.77	237	2.07	
			Females	424	1.48	219	1.57		
			1976	All	402	1.05	499	1.70	
				Males	212	2.95	185	3.18	
			Females	178	0.52	304	1.40		
			1977	All	219	1.01	1641	2.30	
				Males	123	1.28	651	0.17	
			Females	95	1.34	988	2.03		
			Spring	All	All	770	1.23	53	2.34
					Males	388	3.76	34	5.62
			Females	299	1.41	17	3.25		
			Summer		All	77	0.68	974	1.00
					Males	41	0.99	916	0.26
			Females	35	1.33	566	1.24		
			Autumn		All	862	1.45	1577	1.96
					Males	486	4.04	623	2.63
Females	363	1.50	--	--					
Mid-Atlantic		All	703	1.75	702	2.07			
		Males	409	2.07	333	2.14			
		Females	293	1.67	362	1.78			
So. New England		All	563	0.08	495	1.75			
		Males	304	3.58	217	2.63			
		Females	243	1.11	268	4.83			
Georges Bank		All	367	1.83	939	1.79			
		Males	164	6.60	378	1.86			
		Females	124	1.75	558	1.83			
Gulf of Maine		All		(2)	242	0.95			
		Males		(2)	77	0.95			
		Females		(2)	165	0.73			
Nova Scotia		All	71	2.53	226	2.46			
		Males	35	1.97	68	1.76			
		Females	35	5.11	158	1.90			

(1) Percent error=(Total empirical weight-total calculated weight)/total empirical weight.

(2) Sample size too small to fit regression,

Table 1. Survey cruises used in Illex and Loligo length-weight relationship analysis.

Year	Cruise Code	Country	Season	Area
1975	753	USA	Spring	Mid-Atlantic - Nova Scotia
	758	USA	Autumn	Mid-Atlantic - Nova Scotia
1976	762	USA	Spring	Mid-Atlantic - Nova Scotia
	766	USSR	Autumn	Mid-Atlantic - Nova Scotia
	767	USA	Autumn	Mid-Atlantic - Nova Scotia
1977	771	USA	Spring	Mid-Atlantic - Nova Scotia
	774	USA	Summer	Mid-Atlantic - Nova Scotia
	775	Japan	Summer	Mid-Atlantic - Georges Bank
	778	USA	Autumn	Mid-Atlantic - Nova Scotia

Table 2a. Length-weight summary statistics for *Loligo*; by sex, and for each area, season and year.

Year	Season	Area	Dorsal mantle length						Total Weight				
			n	\bar{x}	S.D.	S.E.	Min.	Max.	\bar{x}	S.D.	S.E.	Min.	Max.
-	All Data	-	1709	170.2066	58.43553	1.413533	21.0	425.0	133.4383	91.42767	2.21160	4.0	752.0
All	All	All	Males										
		Mid-Atlantic	409	190.8924	59.80818	2.957325	41.0	425.0	166.6308	104.2479	5.15473	4.0	734.0
		So. New England	304	196.7039	53.81042	3.08624	65.0	402.0	170.4572	99.85371	5.727004	10.0	752.0
		Georges Bank	164	173.0061	63.74359	4.977538	21.0	355.0	127.2927	90.42714	7.061172	7.0	526.0
		Gulf of Maine	3	170.6667	10.01665	5.78312	161.0	181.0	120.0	23.00	13.27906	97.0	143.0
		Nova Scotia	35	193.9714	61.40056	10.37859	98.0	310.0	133.2857	84.12161	14.21915	34.0	305.0
All	Spring	All	388	201.6959	69.22797	3.514519	21.0	425.0	173.9227	122.0835	6.197851	7.0	752.0
	Summer		41	169.0244	46.19875	7.215032	90.0	298.0	95.82927	49.22444	7.687566	26.0	258.0
	Autumn		486	181.8086	48.62424	2.20564	41.0	340.0	153.2119	80.65131	3.658417	4.0	570.0
75	All	All	580	188.5931	60.11943	2.496323	21.0	425.0	163.9241	103.7126	4.306433	4.0	752.0
76	All	All	212	200.783	57.14859	3.924981	41.0	374.0	172.2736	95.95537	6.590241	10.0	599.0
77	All	All	123	175.5854	54.11841	4.879692	61.0	334.0	116.0488	82.82709	7.468266	9.0	460.0
			Females										
All	All	All	697	159.9928	37.227626	1.410083	54.0	286.0	115.8293	62.83559	2.380067	7.0	435.0
		Mid-Atlantic	293	169.2423	37.53026	2.192542	54.0	286.0	130.6485	64.5405	3.770497	7.0	435.0
		So. New England	243	162.251	34.21141	2.194662	59.0	275.0	117.2346	59.97084	3.847131	10.0	394.0
		Georges Bank	124	136.7097	29.86794	2.68222	55.0	200.0	83.0	44.80145	4.023289	10.0	222.0
		Gulf of Maine	2	168.0	18.38478	13.00001	155.0	181.0	134.0	35.35535	25.0	109.0	159.0
		Nova Scotia	35	148.9143	42.70926	7.219182	70.0	227.0	97.28572	77.08994	3.03058	14.0	350.0
All	Spring	All	299	157.6522	38.48149	2.225442	55.0	275.0	111.4114	66.74384	3.859897	10.0	435.0
	Summer		35	131.0857	14.64556	2.475552	100.0	158.0	58.39999	15.99117	2.703001	30.0	95.0
	Autumn		363	164.7080	36.30104	1.905311	54.0	286.0	125.0055	58.99672	3.096525	7.0	403.0
75	All	All	424	159.8962	39.81136	1.933411	54.0	286.0	121.9693	66.75272	3.2418	7.0	435.0
76			178	166.6292	32.43434	2.431056	59.0	270.0	118.2416	55.62306	4.169125	10.0	374.0
77			95	147.9895	30.31764	3.110524	82.0	255.0	83.90526	46.32266	4.752604	20.0	302.0

Table 3a. Regression parameters and statistics for dorsal mantle length (cm) and total weight (g) relationships of Loligo, by sex, area, season, and year.

Area	Season	Year	Sex	Intercept (a)	Slope (b)	Std. error of b	Antilog _e of a	Correlation coefficient (r)
All	All	All	All	-1.36015	2.15182	0.2861	0.25662	0.9526
			Males	-0.86949	1.97528	0.3196	0.41917	0.9108
			Females	-1.78605	2.32364	0.2038	0.16762	0.9447
	1975		All	-1.41009	2.18743	0.2863	0.24169	0.9594
			Males	-0.85092	1.98020	0.3303	0.42702	0.9118
			Females	-1.58916	2.27017	0.2221	0.20410	0.9416
	1976		All	-1.23862	2.10357	0.2691	0.28978	0.9461
			Males	-0.23259	1.76347	0.3192	0.79248	0.8728
			Females	-2.20362	2.45497	0.1196	0.111040	0.9744
	1977		All	-1.61568	2.19236	0.1612	0.19876	0.9712
			Males	-1.60828	2.17591	0.1547	0.20023	0.9779
			Females	-2.16486	2.41658	0.1507	0.11477	0.9574
	Spring	All	All	-1.38547	2.14418	0.2736	0.25021	0.9689
			Males	-0.88956	1.96453	0.3023	0.41084	0.9332
			Females	-2.02656	2.40412	0.18585	0.13179	0.9670
	Summer		All	-0.78138	1.87046	0.16041	0.45777	0.9522
			Males	-0.58210	1.79805	0.1539	0.55872	0.9568
			Females	-0.89154	1.91773	0.1658	0.41002	0.8009
	Autumn		All	-1.38983	2.18390	0.2711	0.24912	0.9358
			Males	-0.93193	2.01763	0.3290	0.39379	0.8917
			Females	-1.39656	2.19463	0.2230	0.24745	0.9247
Mid-Atlantic		All	-1.04605	2.05558	0.2803	0.35132	0.9193	
		Males	-0.97119	2.02414	0.3154	0.37863	0.9164	
		Females	-1.37391	2.18067	0.2196	0.25312	0.9262	
So. New England		All	-1.77585	2.29771	0.1844	0.16934	0.9737	
		Males	-1.24814	2.10368	0.2528	0.28704	0.9305	
		Females	-2.48431	2.48431	0.1762	0.08338	0.9542	
Georges Bank		All	-1.31404	2.11827	0.3566	0.26873	0.9556	
		Males	-0.26677	1.73782	0.4096	0.76585	0.8755	
		Females	-1.99225	2.41504	0.1798	0.13639	0.9539	
Gulf of Maine		All	(1)					
		Males	(1)					
		Females	(1)					
Nova Scotia		All	-1.26702	2.06714	0.2491	0.28167	0.9478	
		Males	-1.01588	1.95655	0.2098	0.36208	0.9506	
		Females	-1.98178	2.36422	0.2537	0.13782	0.9433	

(1) Sample size too small to fit regression.

Table 3b. Regression parameters and statistics for dorsal mantle length (cm) and total weight (g) relationships of *Illex* by sex, area, season, and year.

Area	Season	Year	Sex	Intercept (a)	Slope (b)	Std. error of b	Antilog _e of a	Correlation coefficient (r)	
All	All	All	All	-3.03444	2.71990	0.2419	0.04810	0.9259	
			Males	-2.90355	2.68514	0.2753	0.05483	0.8901	
			Females	-3.12432	2.74348	0.2114	0.04397	0.9272	
		1975		All	-3.60800	2.91776	0.2262	0.02711	0.9547
				Males	-3.86325	3.01297	0.2407	0.02100	0.9423
				Females	-3.40628	2.84306	0.2054	0.03316	0.9607
		1976		All	-3.48898	2.86430	0.2482	0.03053	0.9654
				Males	-3.24850	2.79844	0.3193	0.03744	0.9382
				Females	-3.78275	2.95017	0.1834	0.02276	0.9678
		1977		All	-2.04101	2.40036	0.2281	0.12990	0.8489
				Males	-1.09567	2.09151	0.2596	0.33432	0.7115
				Females	-2.49809	2.54442	0.2166	0.08224	0.8693
		Spring	All	All	-3.43632	2.84756	0.2506	0.03218	0.9299
				Males	-1.93149	2.32096	0.2554	0.14493	0.8101
				Females	-3.87840	2.98569	0.1965	0.02068	0.9782
		Summer		All	-3.85026	2.98298	0.1601	0.02127	0.9154
				Males	-5.54897	3.55229	0.1796	0.00389	0.8523
				Females	-3.65525	2.91409	0.1719	0.02586	0.9134
		Autumn		All	-2.90048	2.67682	0.2719	0.05500	0.9295
				Males	-2.71526	2.62456	0.3189	0.06619	0.8961
				Females	-2.95402	2.68939	0.2310	0.05213	0.9266
Mid-Atlantic	All		All	-3.25968	2.79140	0.24742	0.03840	0.9309	
			Males	-3.06027	2.73143	0.3067	0.04688	0.8579	
			Females	-3.36896	2.82290	0.2186	0.03443	0.9465	
So. New England			All	-3.64833	2.91003	0.2045	0.02603	0.9743	
			Males	-3.59821	2.90213	0.2285	0.02737	0.9658	
			Females	-3.72612	2.92964	0.1792	0.02409	0.9716	
Georges Bank			All	-2.19814	2.45559	0.2213	0.11101	0.8463	
			Males	-1.24068	2.15026	0.2345	0.28919	0.7160	
			Females	-2.71228	2.61320	0.1067	0.06639	0.8678	
Gulf of Maine			All	-3.39896	2.84990	0.1466	0.03341	0.8756	
			Males	-4.77169	3.31502	0.1426	0.00847	0.8520	
			Females	-5.11873	3.37266	0.1291	0.00598	0.8937	
Nova Scotia			All	1.67461	1.24241	0.2160	5.33671	0.7191	
			Males	2.82347	0.82687	0.2002	16.83517	0.6464	
			Females	1.95943	1.16965	0.1956	7.09528	0.6426	

Table 4a. Results of analyses of covariance of adjusted means and slopes of Loligo length-weight regression equations between sexes: all seasons, areas, and years combined; by season (areas and years pooled); by area (seasons and years pooled); and by year (seasons and areas pooled).

Factor	Test of adjusted means			Test of slopes		
	F-Ratio	df	Level of significance	F-Ratio	df	Level of significance
Overall	13.457	1609	P<0.01	51.300	1608	P<0.01
Season						
Spring	16.122	684	P<0.01	46.523	683	P<0.01
Summer	.001	73	n.s.	0.218	72	n.s.
Autumn	2.339	846	n.s.	5.737	845	P<0.05
Area						
Mid-Atlantic	3.302	699	n.s.	4.152	698	P<0.05
So. New England	12.502	544	P<0.01	25.187	543	P<0.01
Georges Bank	1.477	285	n.s.	23.235	284	P<0.01
Gulf of Maine(1)						
Nova Scotia	7.183	67	P<0.01	5.054	66	P>0.05
Year						
1975	12.415	1001	P<0.01	22.650	1000	P<0.01
1976	0.018	401	n.s.	47.078	400	P<0.01
1977	18.762	215	P<0.01	7.590	214	P<0.01

Overall comparison of adjusted means

	Males	Females
Adjusted mean	4.7055	4.7584
Std. error	.0094	.0108
t-test females	3.6671	P<0.01

(1) Sample size in the Gulf of Maine was inadequate for proper analysis.

P<0.01 = Significant at 1% level
P<0.05 = Significant at 5% level
n.s. = non-significant

Table 4b. Results of covariance analyses, tests of adjusted means and slopes of Loligo length-weight regression equations between seasons (areas, years, and sexes pooled), and simultaneous comparisons of adjusted means.

Seasons	Test of adjusted means			Test of slopes		
	F-Ratio	df	Level of significance	F-Ratio	df	Level of significance
Spring vs. summer	16.335	844	P<0.01	5.533	843	P<0.05
Spring vs. autumn	60.993	1629	P<0.01	1.360	1628	n.s.
Summer vs. autumn	53.887	936	P<0.01	7.163	935	P<0.01

Comparisons of Adjusted Means

	<u>Spring</u>	<u>Summer</u>	<u>Autumn</u>
Adjusted Mean	4.5358	4.4078	4.6422
Std. error	0.0097	0.0307	0.0092

t-matrix and significance levels

Spring	--		
Summer	-3.983 P<0.01	--	
Autumn	7.945 P<0.01	7.316 P<0.01	--

Table 4c. Results of analysis of covariance, tests of adjusted means and slopes of Loligo length-weight regression equations between pairs of areas (sexes, seasons, and years pooled), and simultaneous comparisons of adjusted means.

Area comparison	Test of adjusted means			Test of slopes		
	F-Ratio	df	Level of significance	F-Ratio	df	Level of significance
Mid-Atlantic vs. So. New England	9.037	1263	P<0.01	34.176	1262	P<0.01
Mid-Atlantic vs. Georges Bank	20.605	1067	P<0.01	1.785	1066	n.s.
Mid-Atlantic vs. Gulf of Maine	0.1437	705	n.s.	0.066	704	n.s.
Mid-Atlantic vs. Nova Scotia	29.764	771	P<0.01	0.010	770	n.s.
So. New England vs. Georges Bank	1.301	927	n.s.	18.713	926	P<0.01
So. New England vs. Gulf of Maine	1.258	565	n.s.	0.044	564	n.s.
So. New England vs. Nova Scotia	29.149	631	P<0.01	11.215	630	P<0.01
Georges Bank vs. Gulf of Maine	0.747	369	n.s.	0.031	368	n.s.
Georges Bank vs. Nova Scotia	4.287	435	P<0.05	0.182	434	n.s.
Gulf of Maine vs. Nova Scotia	4.396	73	P<0.05	0.085	72	n.s.

Comparisons of adjusted means

	Middle Atlantic	So. New England	Georges Bank	Gulf of Maine	Nova Scotia
Adjusted mean	4.6220	4.5796	4.5432	4.6721	4.4403
Std. error	0.0104	0.0116	0.0151	0.1222	0.0324

t-matrix (with significance level)

Mid-Atlantic	-				
So. New England	-2.7425	-			
	P<0.01				
Georges Bank	-4.2064	-1.8890	-		
	P<0.01	n.s.			
Gulf of Maine	0.4083	0.7533	1.0469	-	
	n.s.	n.s.	n.s.		
Nova Scotia	-5.3388	-4.0497	-2.8760	-1.8340	-
	P<0.01	P<0.01	P<0.01	n.s.	

Table 4d. Results of analyses of covariance tests of adjusted means and slopes of Loligo length-weight regression equations between pairs of years (sex, seasons, and areas combined), and simultaneous comparisons of adjusted means.

Comparison	Test of adjusted means			Test of slopes		
	F-Ratio	df	Level of significance	F-Ratio	df	Level of significance
1975vs1976	9.275	1501	P<0.01	2.401	1500	n.s.
1975vs1977	72.857	1304	P<0.01	0.175	1303	n.s.
1976vs1977	42.700	632	P<0.01	2.358	631	n.s.

Comparison of adjusted means

	<u>1975</u>	<u>1976</u>	<u>1977</u>
Adjusted means	4.6200	4.5649	4.4379
Std. error	0.0082	0.0135	0.0182

t-matrix and significance

1975	--		
1976	-3.4801 P<0.01	--	
1977	-9.1105 P<0.01	-5.5922 P<0.01	--

Table 5a. Results of analyses of covariance of adjusted means and slopes of Illex length-weight regression equations by sex: all seasons, areas and years combined; by season (area and year pooled); by area (season and year pooled); and by year (season and area pooled).

Factor	Test of adjusted means			Test of slopes		
	F-Ratio	df	Level of significance	F-Ratio	df	Level of significance
Overall	17.186	2611	P<0.01	1.353	2610	n.s.
Season						
Spring	0.718	45	n.s.	3.599	44	n.s.
Summer	25.577	999	P<0.01	30.168	998	P<0.01
Autumn	7.020	1561	P<0.01	1.140	1560	n.s.
Area						
Mid-Atlantic	2.690	692	n.s.	0.855	691	n.s.
So. New England	5.415	482	P<0.05	0.160	481	n.s.
Georges Bank	5.071	933	P<0.05	14.632	932	P<0.01
Gulf of Maine	51.376	239	P<0.01	0.049	238	n.s.
Nova Scotia	42.314	223	P<0.01	4.409	222	P<0.05
Year						
1975	6.080	453	P<0.05	3.625	452	n.s.
1976	8.495	486	P<0.01	3.361	485	n.s.
1977	0.321	1666	n.s.	25.583	1665	P<0.01

P<0.01 = Significant at 1% level

P<0.05 = Significant at 5% level

n.s. = non-significant

Table 5b. Results of analyses of covariance tests of adjusted means and slopes of Illex length-weight regression equations between seasons (years, areas and sexes pooled), including simultaneous comparisons of adjusted means.

Seasons	Test of adjusted means			Test of slopes		
	F-Ratio	df	Signifi- cance level	F-Ratio	df	Signifi- cance level
Spring vs. summer	0.909	1024	n.s.	1.410	1023	n.s.
Spring vs. autumn	1.822	1627	n.s.	0.993	1626	n.s.
Summer vs. autumn	0.122	2548	n.s.	21.396	2547	P<0.01

Comparisons of adjusted means

	<u>Spring</u>	<u>Summer</u>	<u>Autumn</u>
Adjusted mean	5.3076	5.3470	5.3503
Std. error	0.0330	0.0076	0.0060

t-matrix and significance levels

Spring	--		
Summer	1.1640 n.s.	--	
Autumn	1.2759 n.s.	0.3449 n.s.	--

Table 5c. Results of analyses of covariance, tests of adjusted means and slopes of Illex length-weight regression equations by area, (sex, seasons and years pooled) and simultaneous comparisons of adjusted means among areas.

Comparison	Test of adjusted means			Test of slopes		
	F-Ratio	df	Level of significance	F-Ratio	df	Level of significance
Mid-Atlantic vs. So. New England	5.652	1194	P<0.05	5.310	1193	P<0.05
Mid-Atlantic vs. Georges Bank	3.816	1638	n.s.	26.050	1637	P<0.01
Mid-Atlantic vs. Gulf of Maine	6.603	941	P<0.05	0.131	940	n.s.
Mid-Atlantic vs. Nova Scotia	9.957	925	P<0.01	250.813	924	P<0.01
So. New England vs. Georges Bank	12.271	1431	P<0.01	60.111	1430	P<0.01
So. New England vs. Gulf of Maine	13.956	734	P<0.01	0.204	733	n.s.
So. New England vs. Nova Scotia	13.083	718	P<0.01	401.683	717	P<0.01
Georges Bank vs. Gulf of Maine	12.393	1178	P<0.01	6.754	1177	P<0.01
Georges Bank vs. Nova Scotia	5.528	1162	P<0.05	159.471	1161	P<0.01
Gulf of Maine vs. Nova Scotia	5.102	465	P<0.05	124.460	464	P<0.01

Comparisons of adjusted means

	<u>Middle Atlantic</u>	<u>So. New England</u>	<u>Georges Bank</u>	<u>Gulf of Maine</u>	<u>Nova Scotia</u>
Adjusted mean	5.3363	5.3024	5.3596	5.4031	5.3810
Std. error	0.0090	0.0107	0.0078	0.0153	0.0158

t-matrix and significance

Mid Atlantic	-				
So. New England	-2.4567	-			
	P<0.05				
Georges Bank	1.9297	4.2678	-		
	n.s.	P<0.01			
Gulf of Maine	3.7088	5.3169	2.5544	-	
	P<0.01	P<0.01	P<0.05		
Nova Scotia	2.4331	4.0786	1.2238	-1.0146	-
	P<0.05	P<0.01	n.s.	n.s.	

Table 5d. Results of covariance analyses, tests of adjusted means and slopes of Illex length-weight regression equations between pairs of years (sexes, seasons and areas combines), and simultaneous comparisons of adjusted means.

Factor	Comparison	Test of adjusted means			Test of slopes		
		F-Ratio	df	Level of significance	F-Ratio	df	Level of significance
Overall	1975vs1976	7.208	960	P<0.01	0.917	959	n.s.
	1975vs1977	0.317	2132	n.s.	83.393	2131	P<0.01
	1976vs1977	1.920	2167	n.s.	86.398	2166	P<0.01

Comparisons of adjusted means for years

	<u>1975</u>	<u>1976</u>	<u>1977</u>
Adjusted mean	5.3681	5.33481	5.34670
Std. error	0.0113	0.01061	0.00589

t-matrix and significance

1975	--		
1976	-2.1761 P<0.05	--	
1977	-1.6849 n.s.	0.9759 n.s.	--

P<0.01 = Significant at 1% level

P<0.05 = Significant at 5% level

n.s. = non-significant

Table 6. Percent overall error in calculated sample weights versus empirical sample weights using length-weight functions for all data; and for annual, seasonal and area data by sex.

Area	Season	Year	Sex	Loligo		Illex			
				Number sampled	% error	Number sampled	% error		
All	All	All	All	1709	1.78	2604	1.68		
			Males	915	3.73	1073	2.08		
			Females	697	1.60	1511	1.73		
			1975	All	1088	0.74	464	1.47	
				Males	580	3.77	237	2.07	
			1976	Females	424	1.48	219	1.57	
				All	402	1.05	499	1.70	
			1977	Males	212	2.95	185	3.18	
				Females	178	0.52	304	1.40	
			1977	All	219	1.01	1641	2.30	
				Males	123	1.28	651	0.17	
			Spring	All	Females	95	1.34	988	2.03
					All	770	1.23	53	2.34
			Summer	All	Males	388	3.76	34	5.62
					Females	299	1.41	17	3.25
			Autumn	All	All	77	0.68	974	1.00
					Males	41	0.99	916	0.26
			Autumn	All	Females	35	1.33	566	1.24
					All	862	1.45	1577	1.96
			Mid-Atlantic	All	Males	486	4.04	623	2.63
Females	363	1.50			--	--			
So. New England	All	All	703	1.75	702	2.07			
		Males	409	2.07	333	2.14			
Georges Bank	All	Females	293	1.67	362	1.78			
		All	563	0.08	495	1.75			
Gulf of Maine	All	Males	304	3.58	217	2.63			
		Females	243	1.11	268	4.83			
Nova Scotia	All	All	367	1.83	939	1.79			
		Males	164	6.60	378	1.86			
Nova Scotia	All	Females	124	1.75	558	1.83			
		All		(2)	242	0.95			
Nova Scotia	All	Males		(2)	77	0.95			
		Females		(2)	165	0.73			
Nova Scotia	All	All	71	2.53	226	2.46			
		Males	35	1.97	68	1.76			
Nova Scotia	All	Females	35	5.11	158	1.90			

(1) Percent error=(Total empirical weight-total calculated weight)/total empirical weight.

(2) Sample size too small to fit regression,

Figure 1. Survey strata (A) and areas (B) used in length-weight regression analyses for squid.

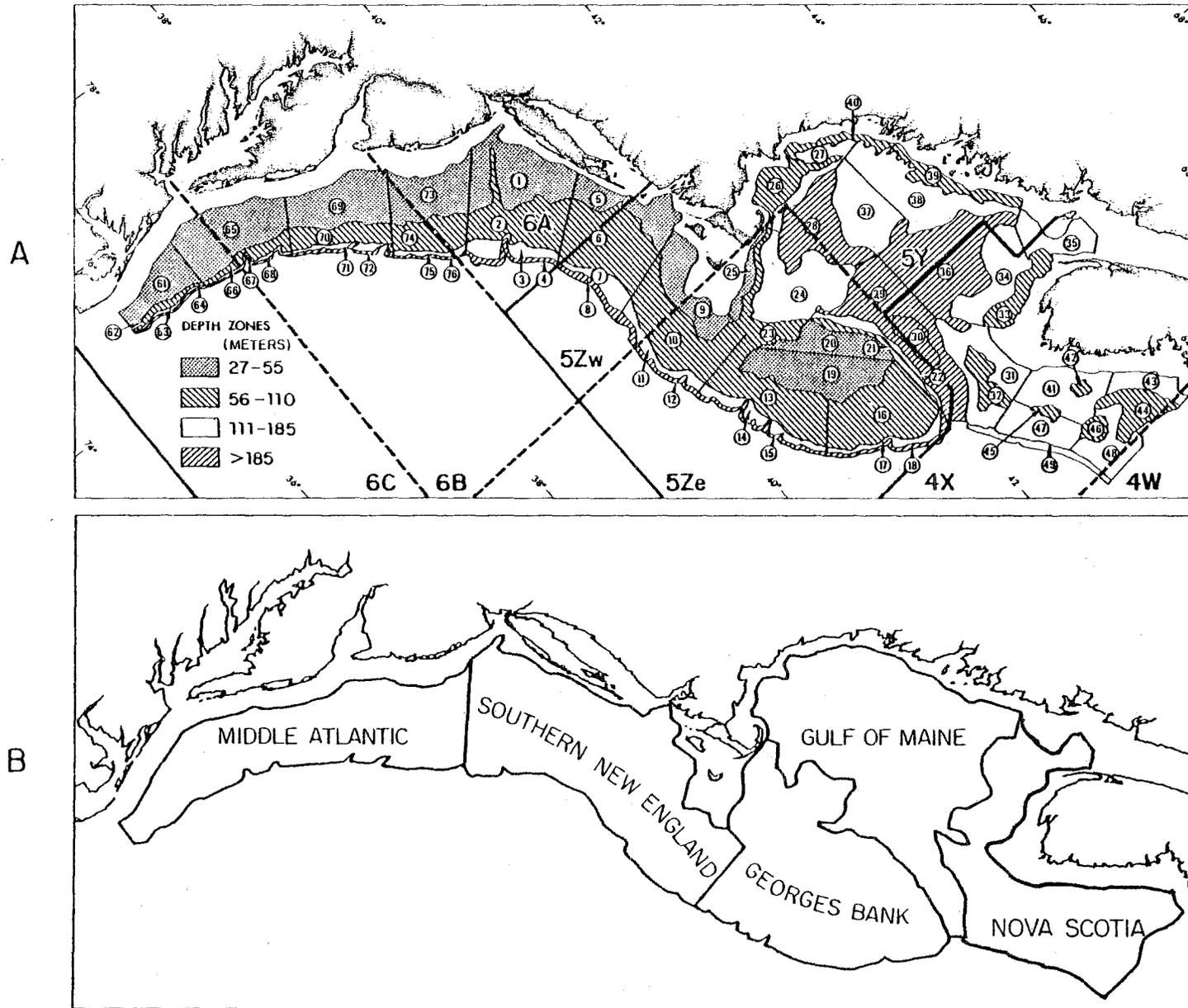
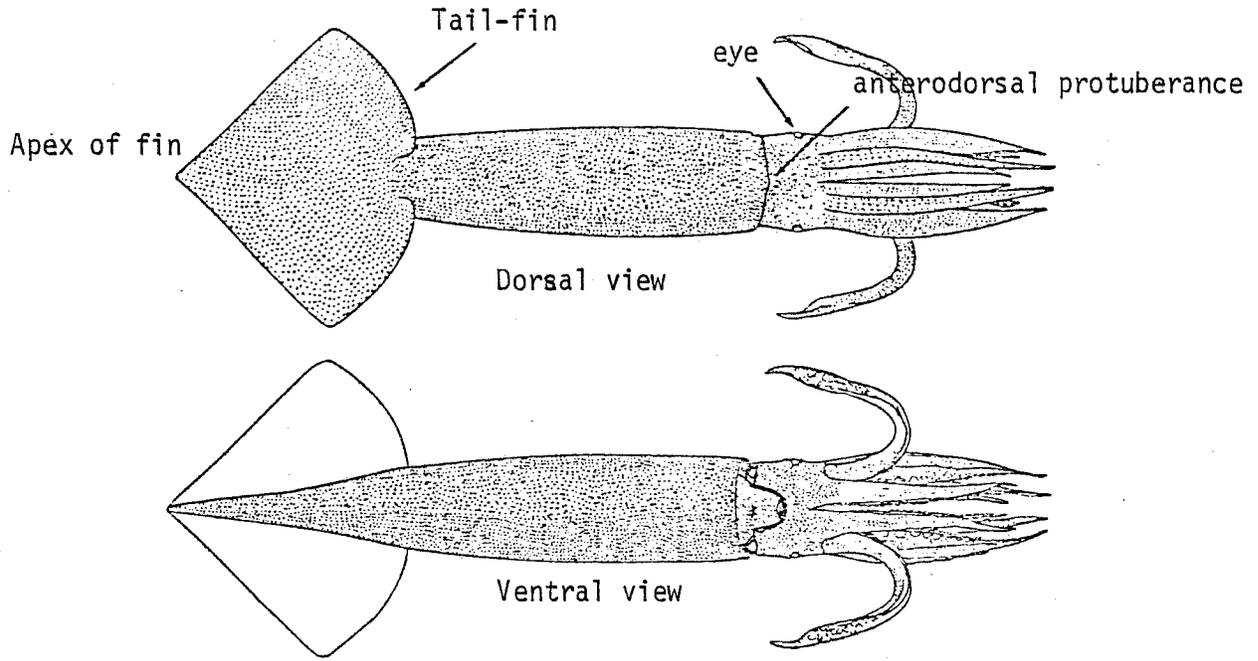
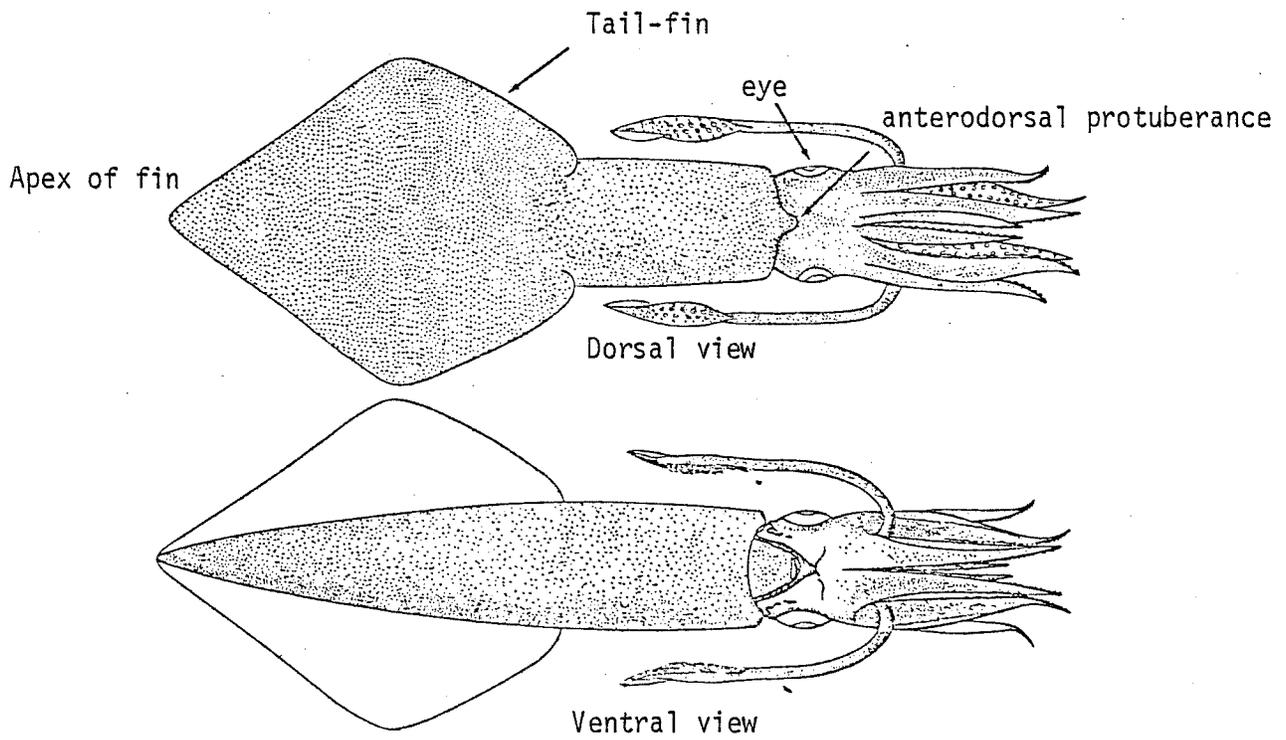


Figure 2. Dorsal mantle length measurements for squid, *Loligo* and *Illex*.



ILLEX SHORT-FINNED SQUID



LOLIGO LONG-FINNED SQUID

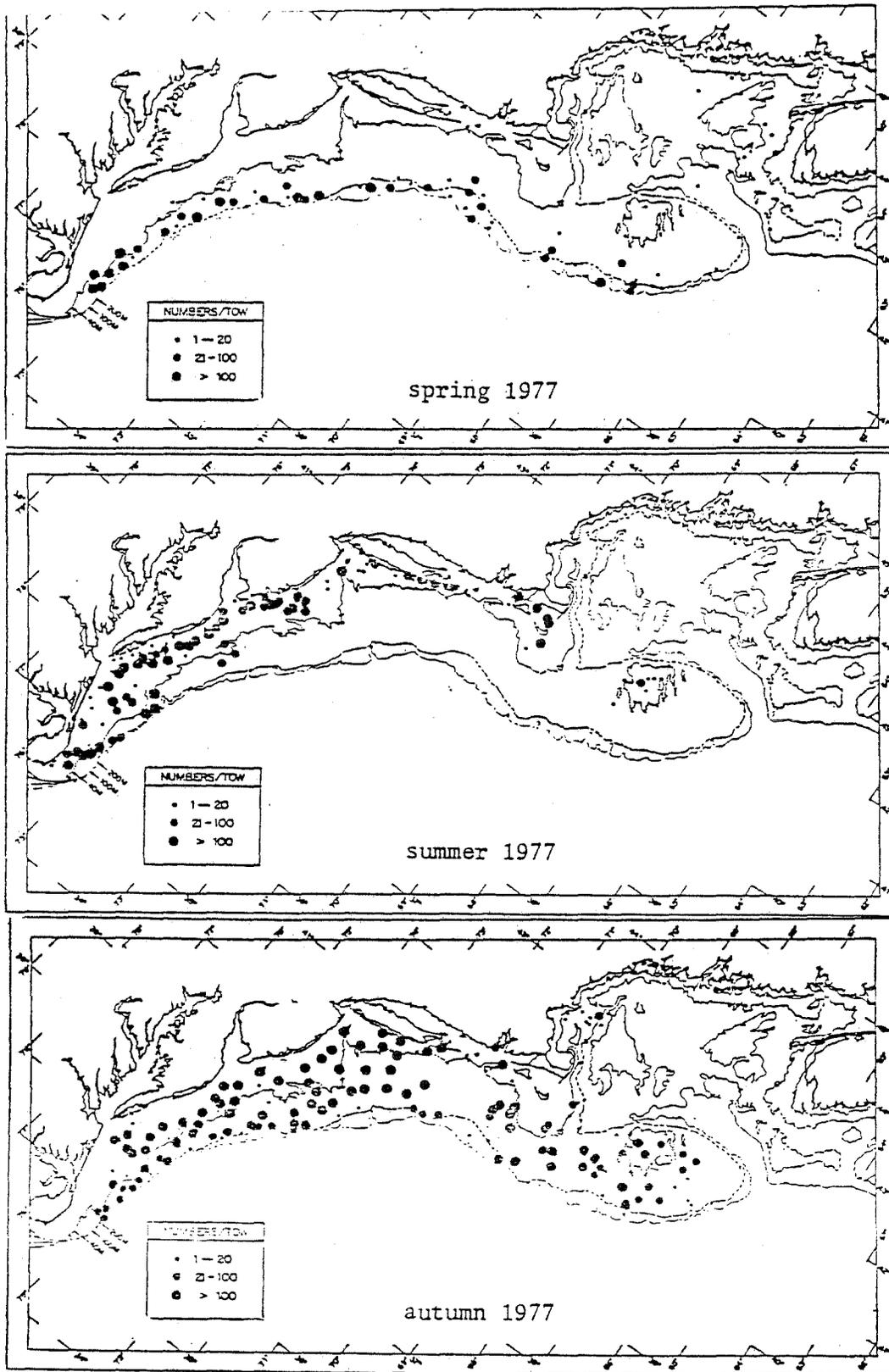


Figure 3a. Distribution of *Loligo pealei*. Locations of stations where *Loligo* were taken, during 1977 U.S.A. bottom trawl surveys, by season.

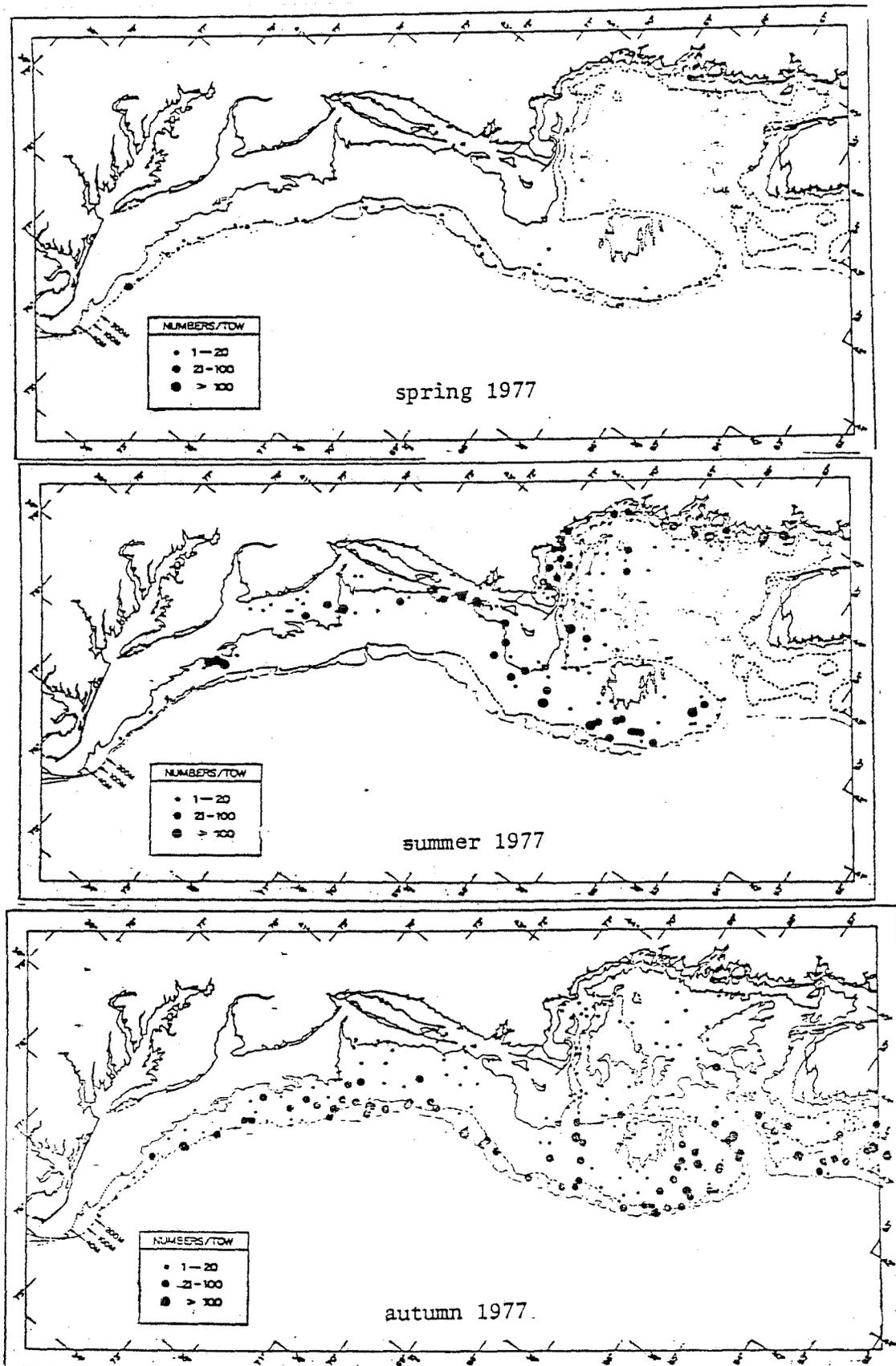


Figure 3b. Distribution of *Illex illecebrosus*. Locations of stations where *Illex* were taken, during 1977 U.S.A. bottom trawl surveys, by season.

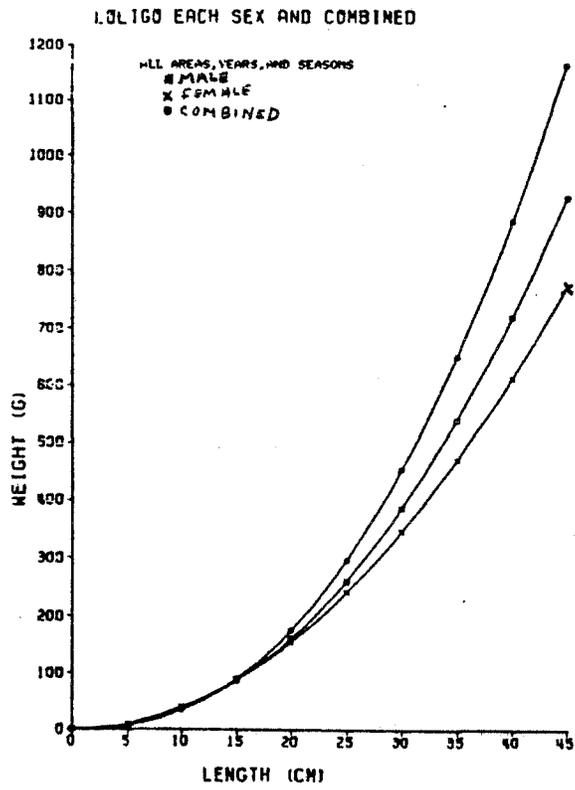
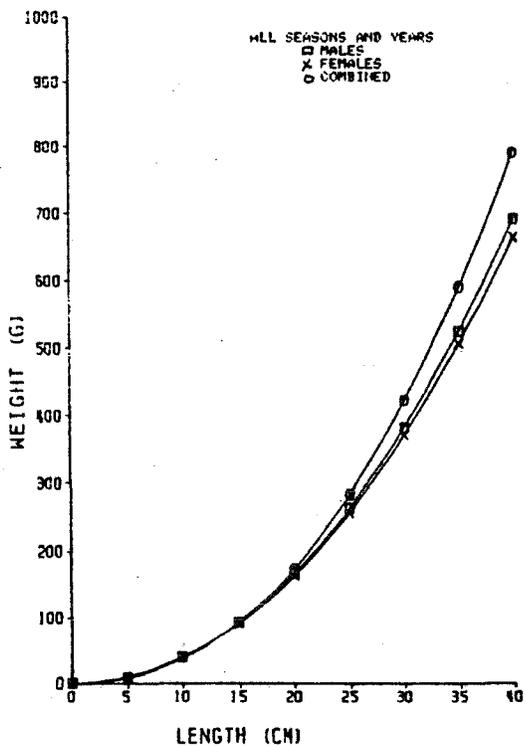
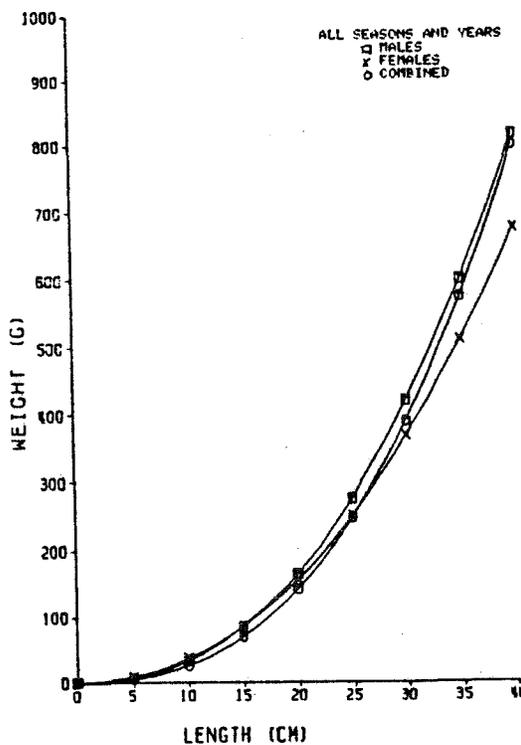


Figure 4a. Loligo length-weight relationships by sex: all areas, years and seasons.

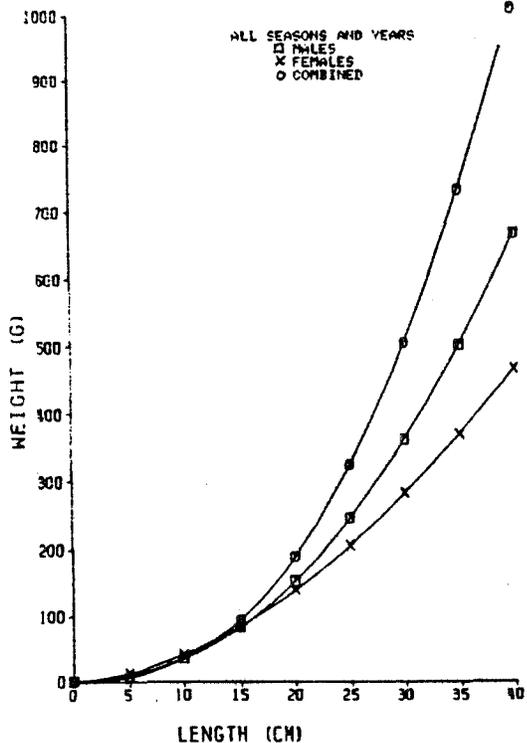
LOLIGO MIDDLE ATLANTIC, EACH SEX AND COMBINED



LOLIGO SOUTHERN NEW ENGLAND, EACH SEX AND COMBINED



LOLIGO GEORGES BANK, EACH SEX AND COMBINED



LOLIGO NOVA SCOTIA, EACH SEX AND COMBINED

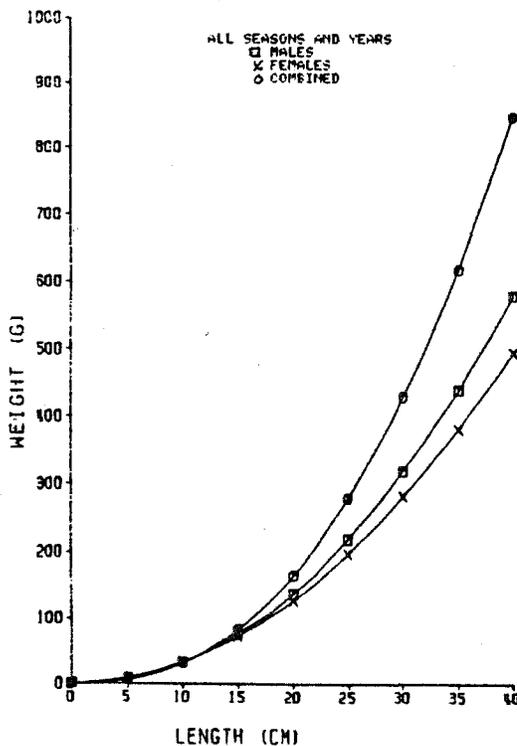
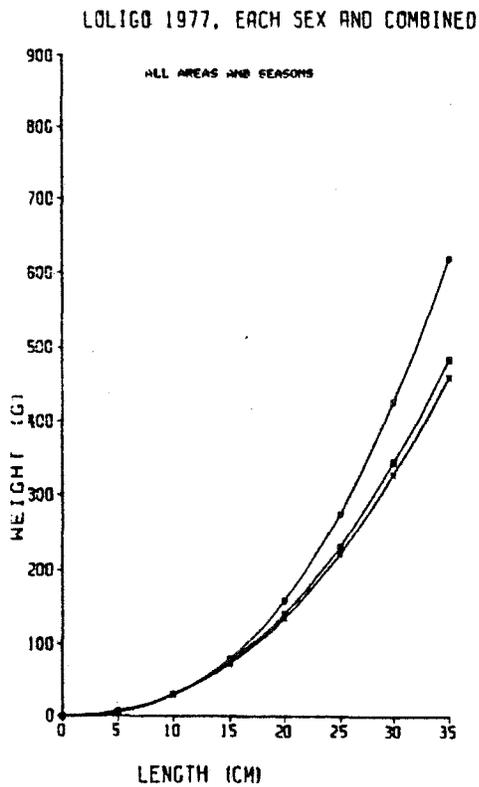
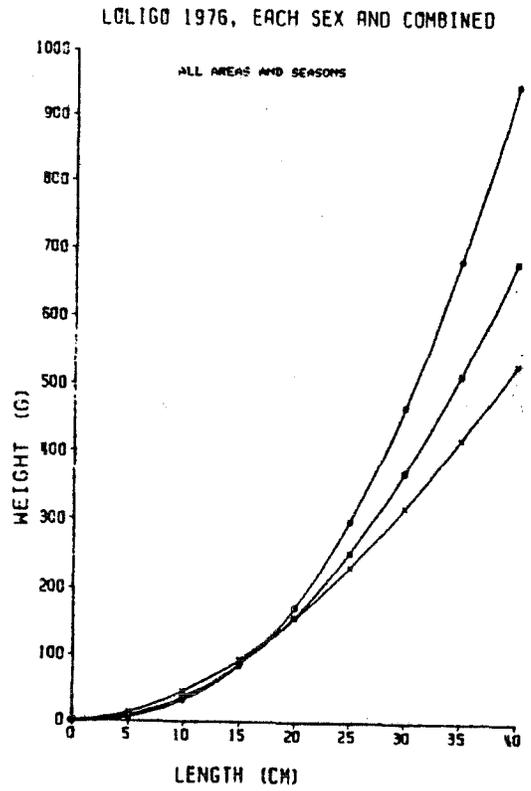
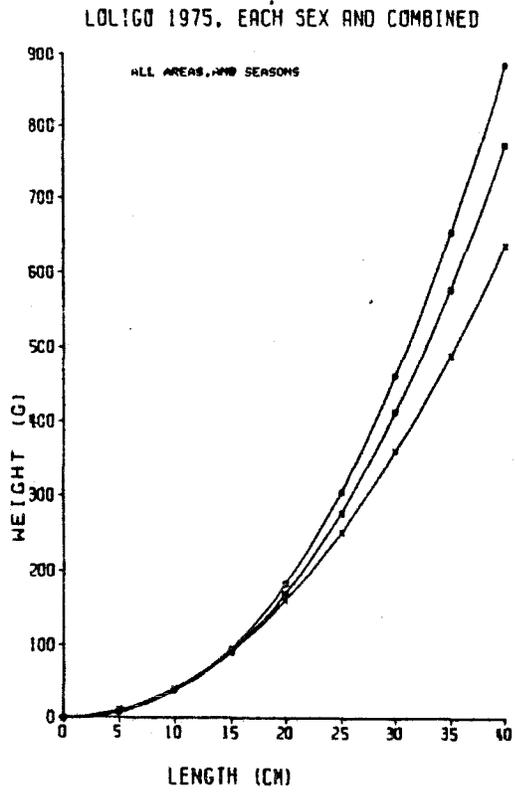


Figure 4b. Loligo length-weight relationships by sex; each area: all seasons and years.



● male
 x female
 ○ combined

Figure 4c. Loligo length-weight relationships by sex, each year: all areas and seasons.

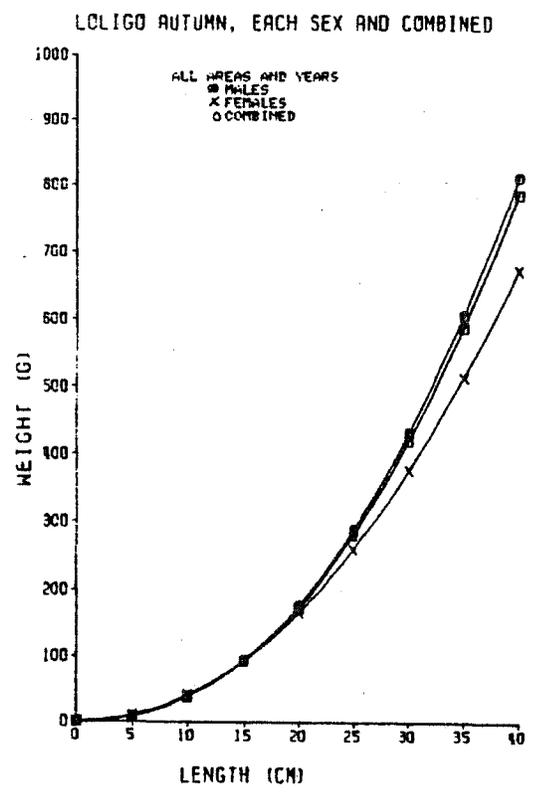
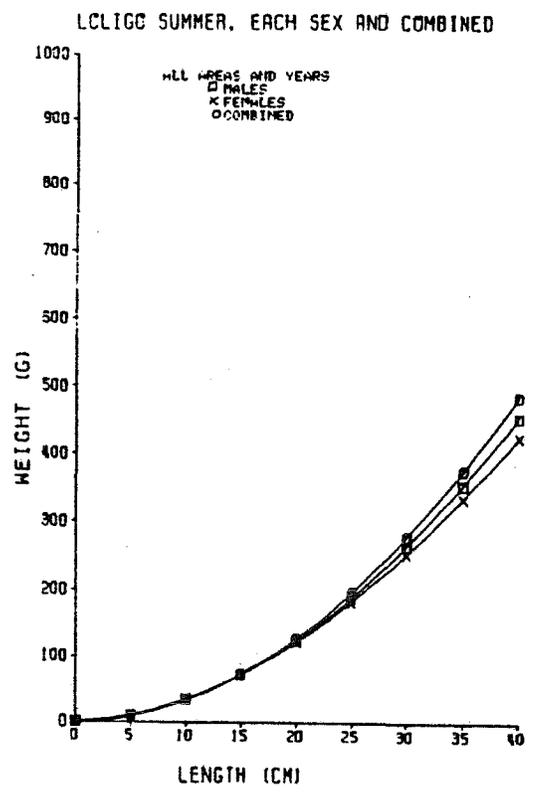
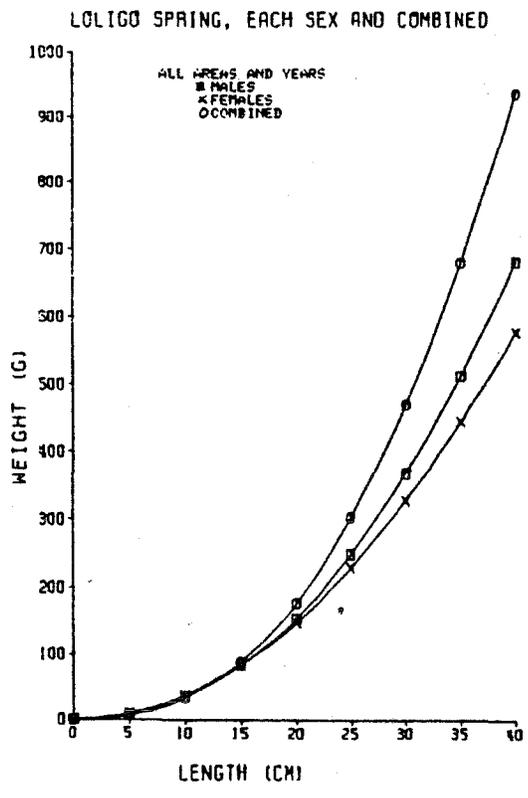


Figure 4d. Loligo length-weight relationships by sex, each season: all areas and years.

LOLIGO EACH SEASON

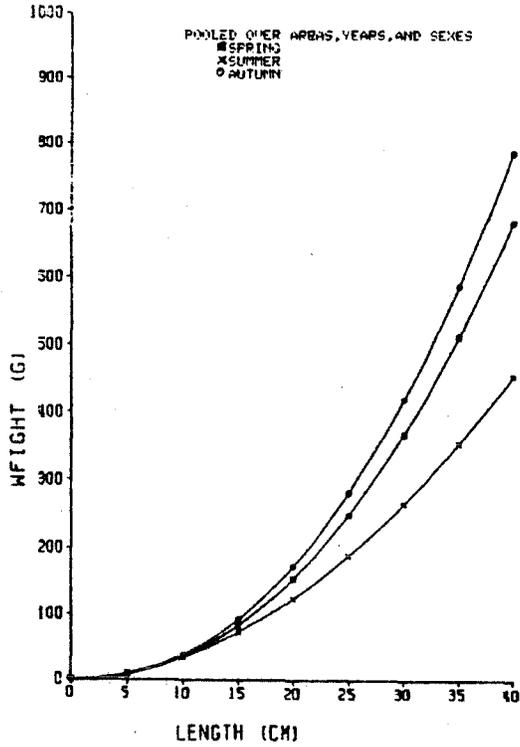
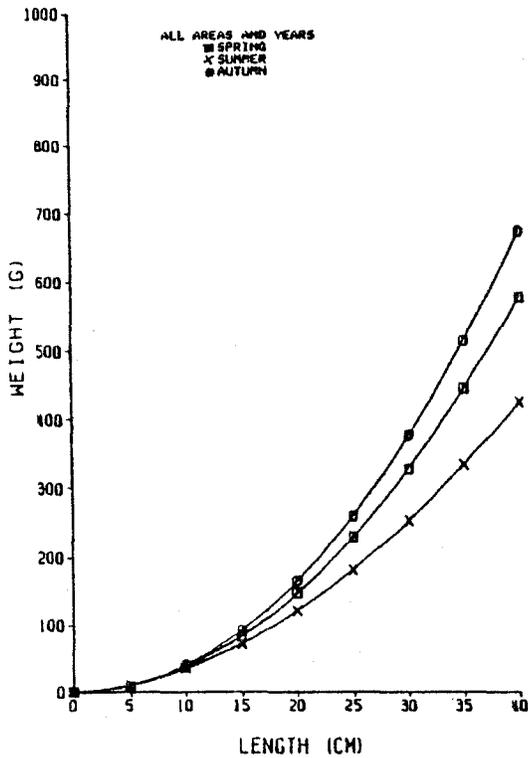
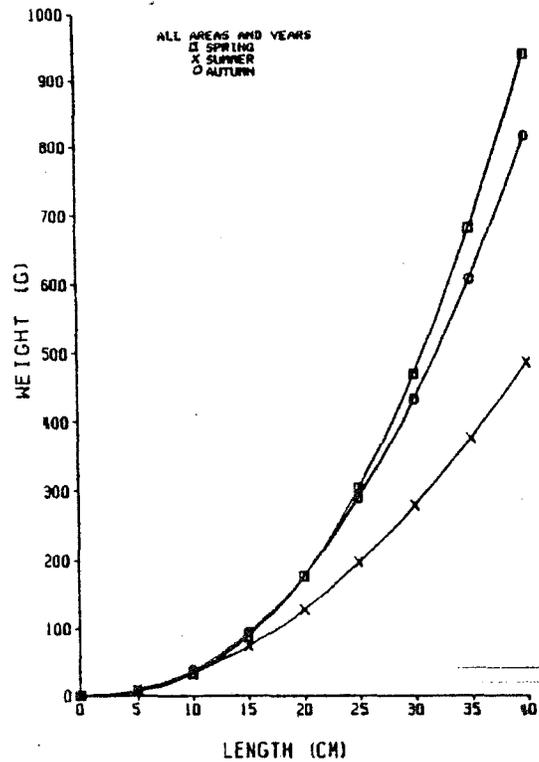


Figure 4e. Loligo length-weight relationships by season; each sex; all areas and years.

LOLIGO MALES, EACH SEASON



LOLIGO FEMALES, EACH SEASON



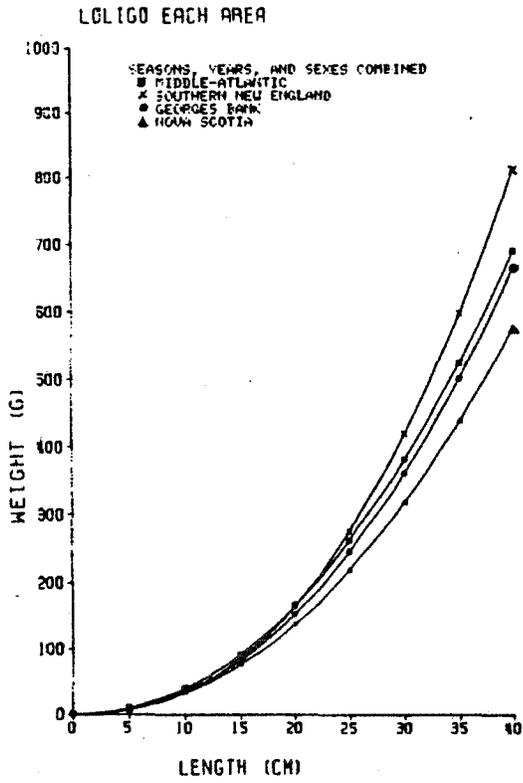
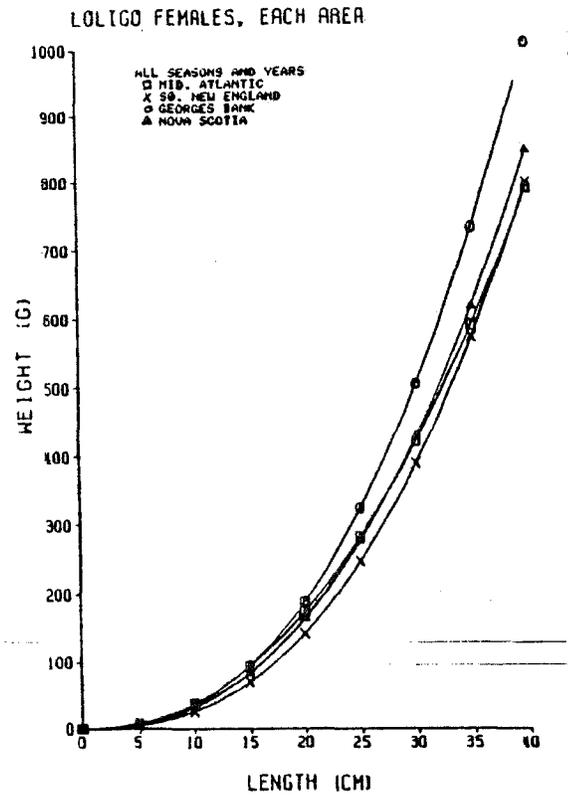
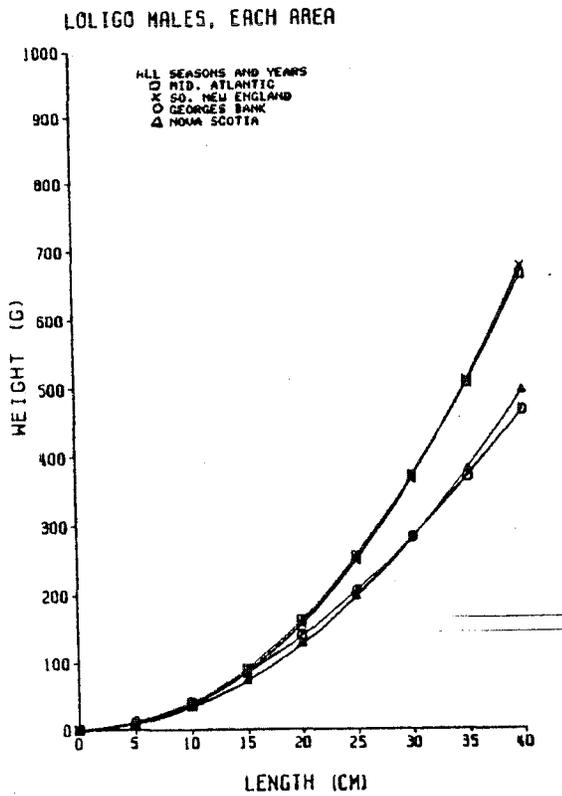


Figure 4f. Loligo length-weight relationships by area, each sex; all seasons and years.



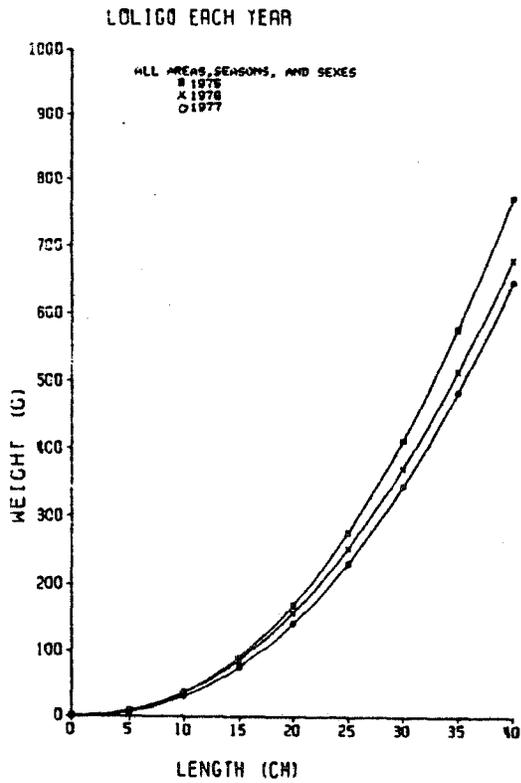
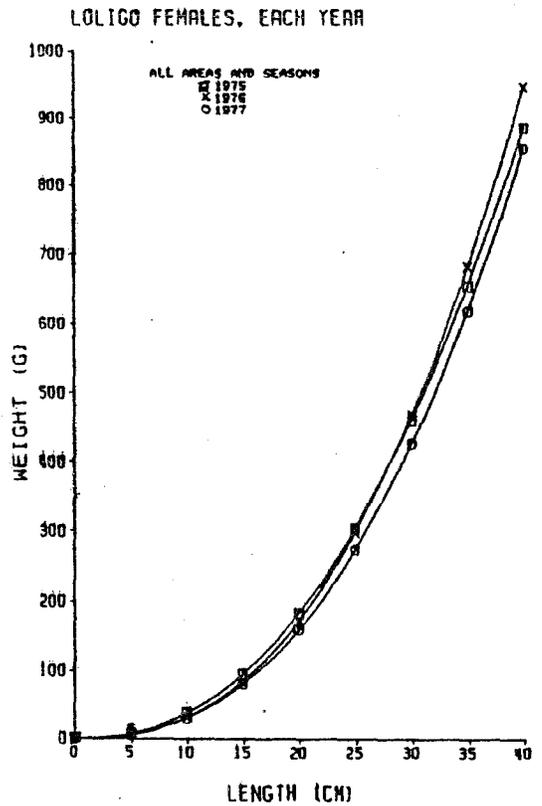
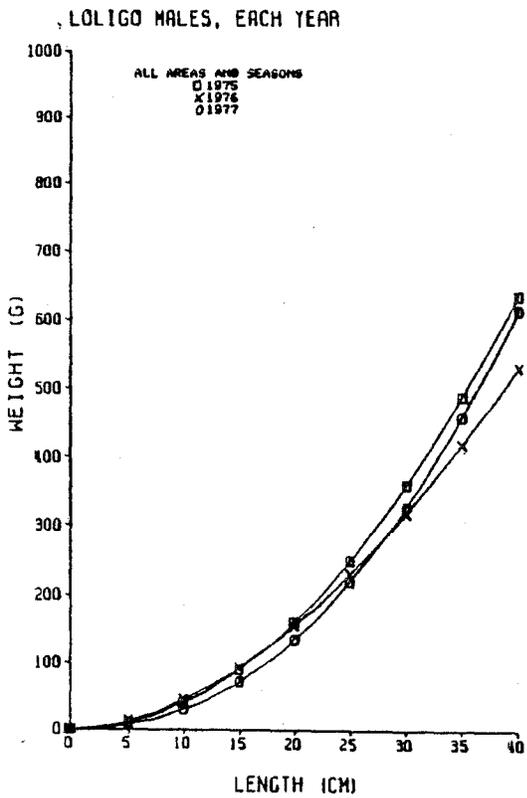


Figure 4g. Loligo length-weight relationships by year, each sex; all areas and seasons



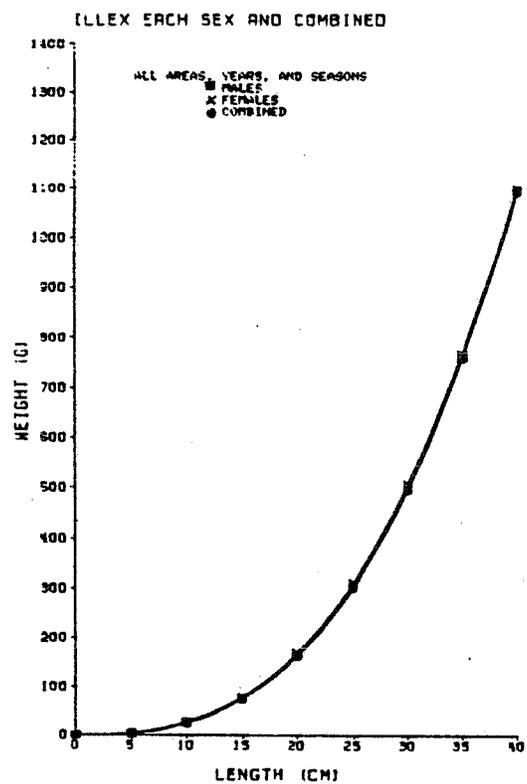
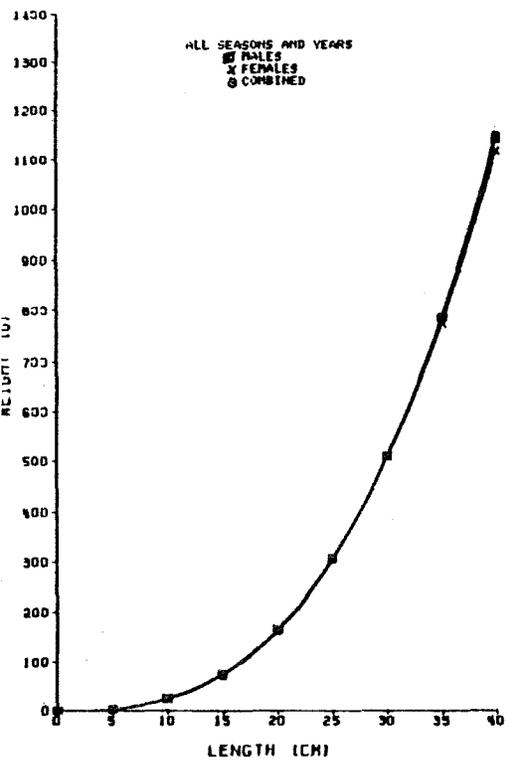
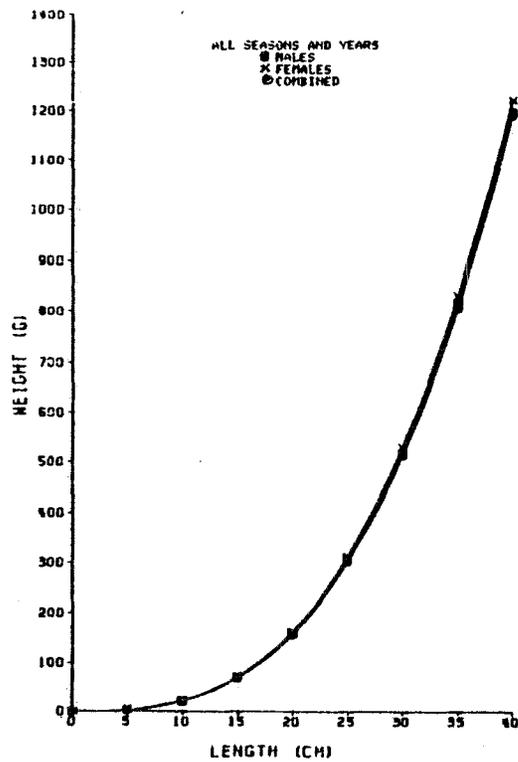


Figure 5a. Illex length-weight relationships by sex: all areas, years and seasons.

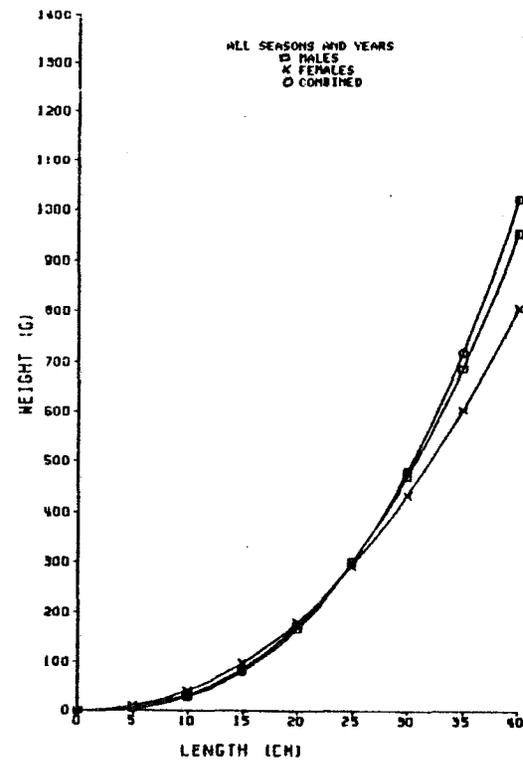
ILLEX, MIDDLE ATLANTIC, EACH SEX AND COMBINED



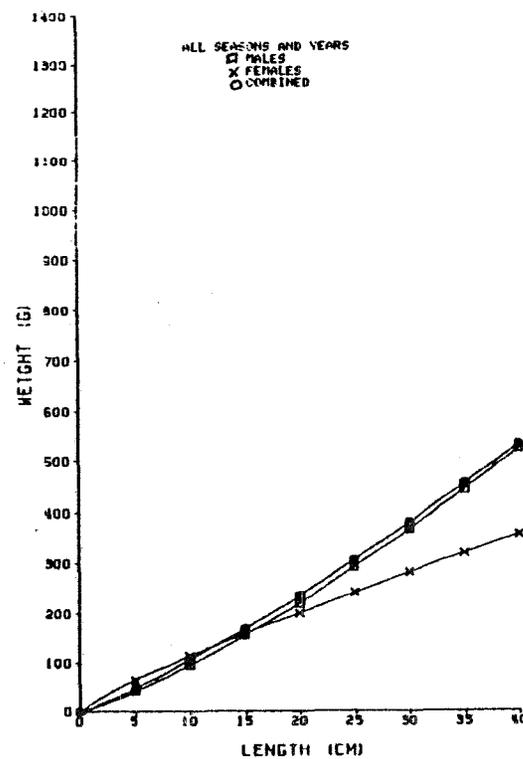
ILLEX SOUTHERN NEW ENGLAND, EACH SEX AND COMBINED



ILLEX GEORGES BANK, EACH SEX AND COMBINED



ILLEX NOVA SCOTIA, EACH SEX AND COMBINED



ILLEX GULF OF MAINE, EACH SEX AND COMBINED

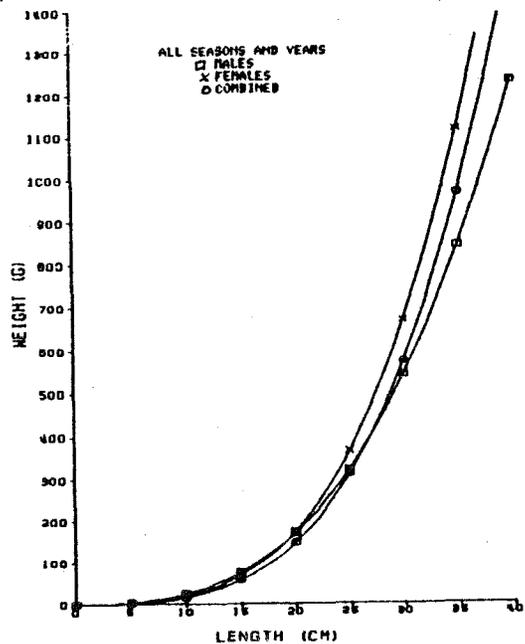


Figure 5b. Illex length-weight relationships by sex; each area: all seasons and years.

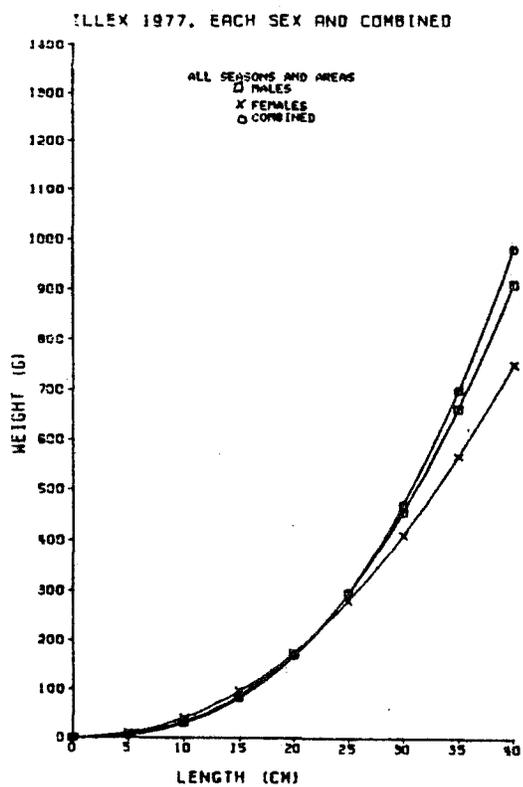
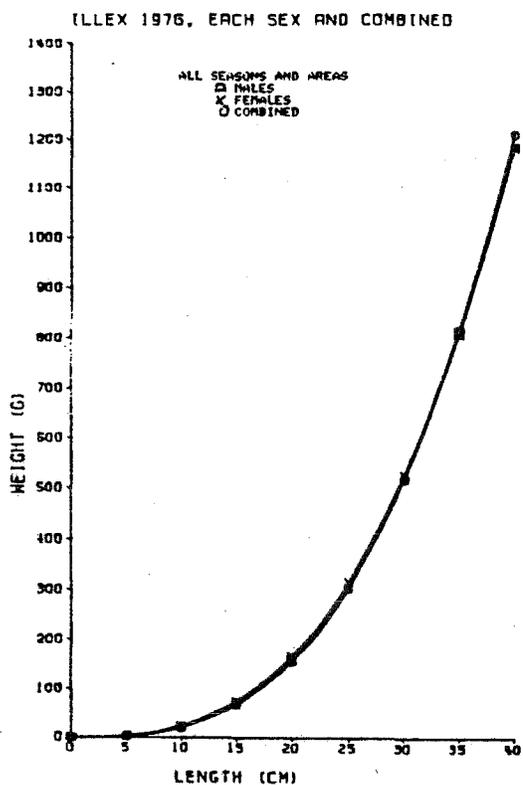
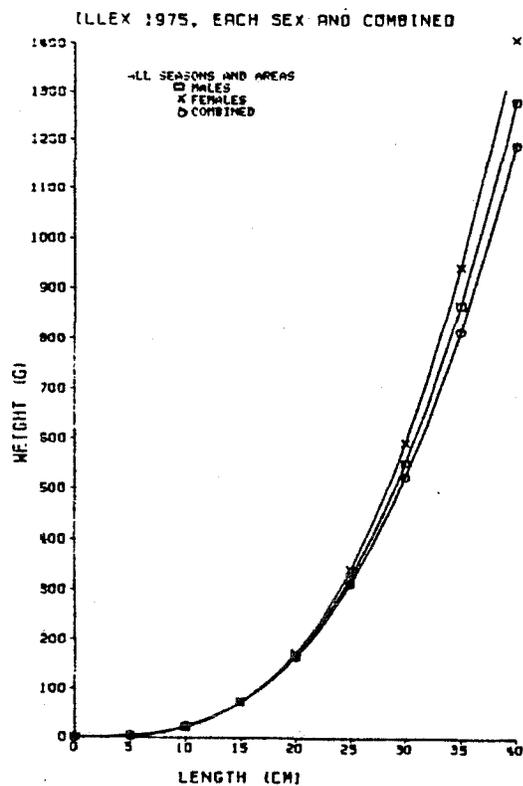


Figure 5c. Illex length-weight relationships by sex, each year: all areas and seasons.

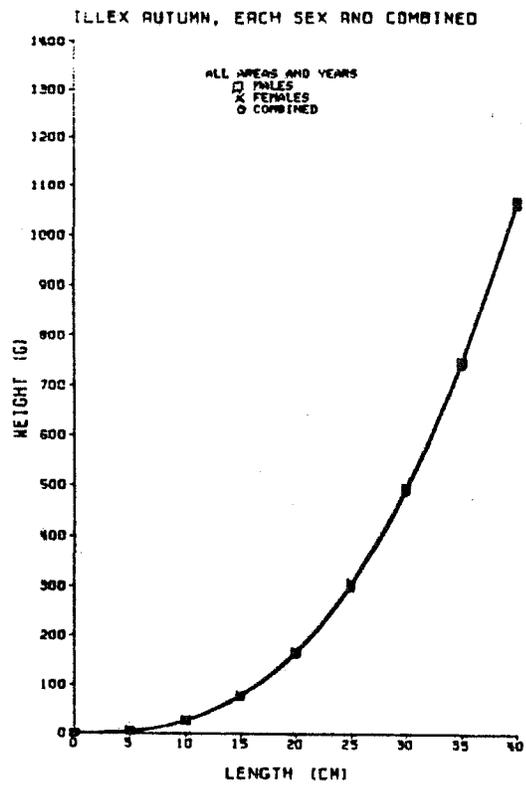
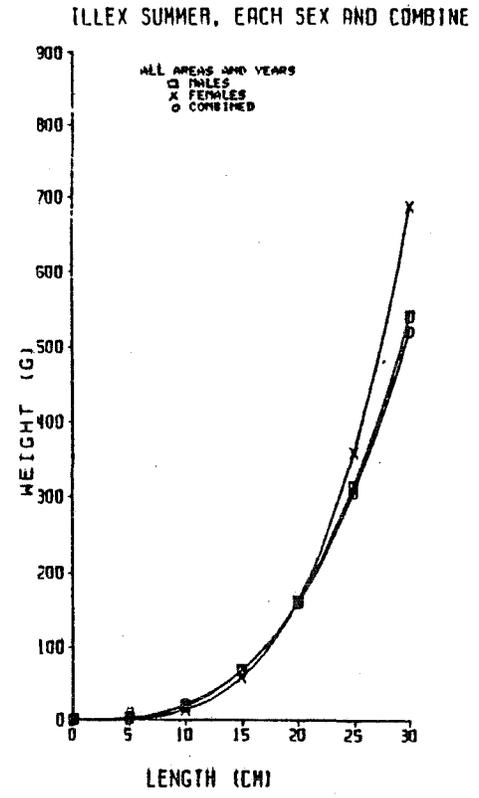
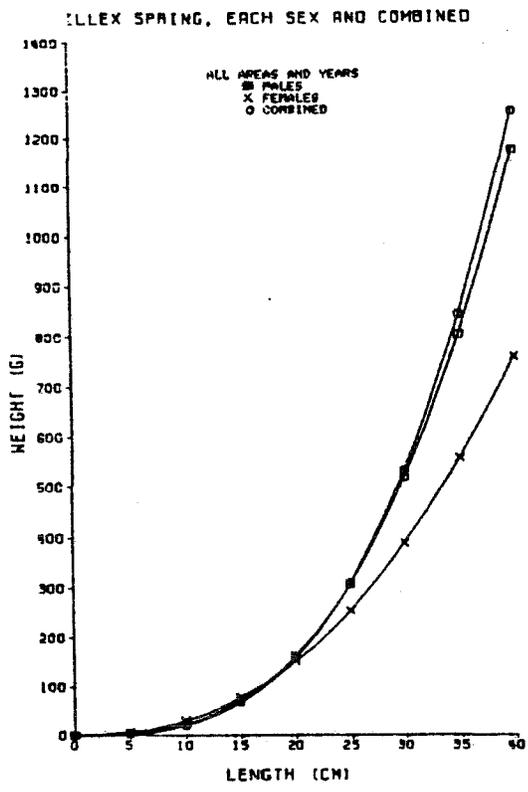


Figure 5d. Illex length-weight relationships by sex, each season: all areas and years.

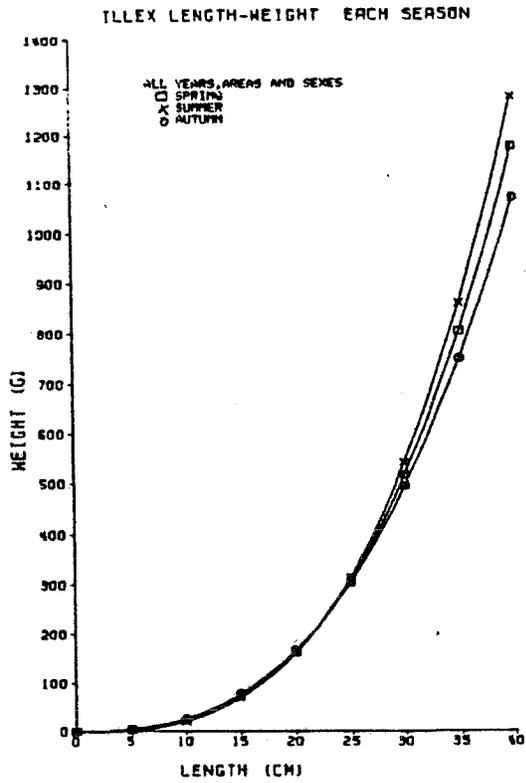
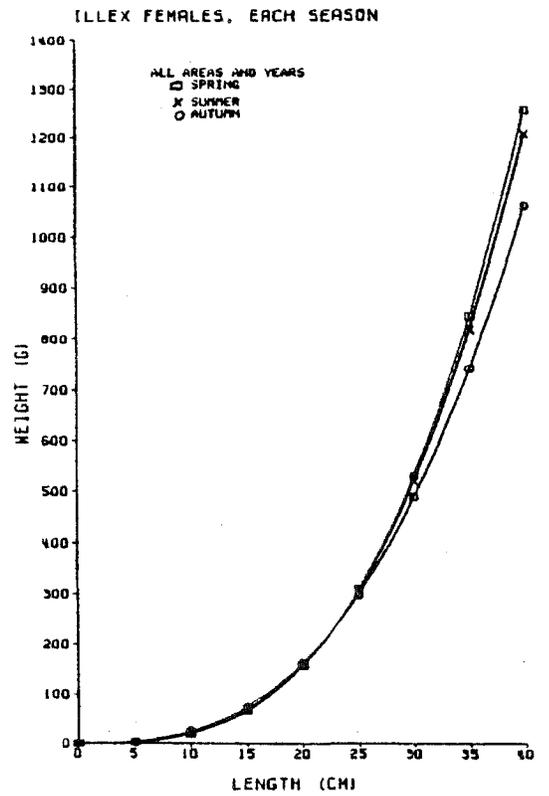
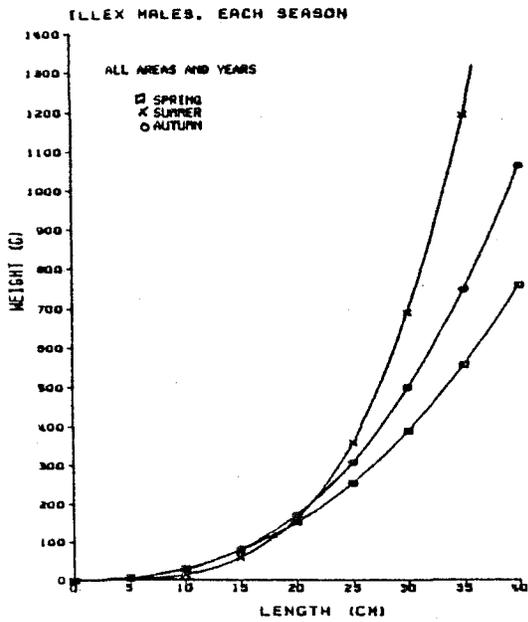


Figure 5e. Illex length-weight relationships by season; each sex; all areas and years.



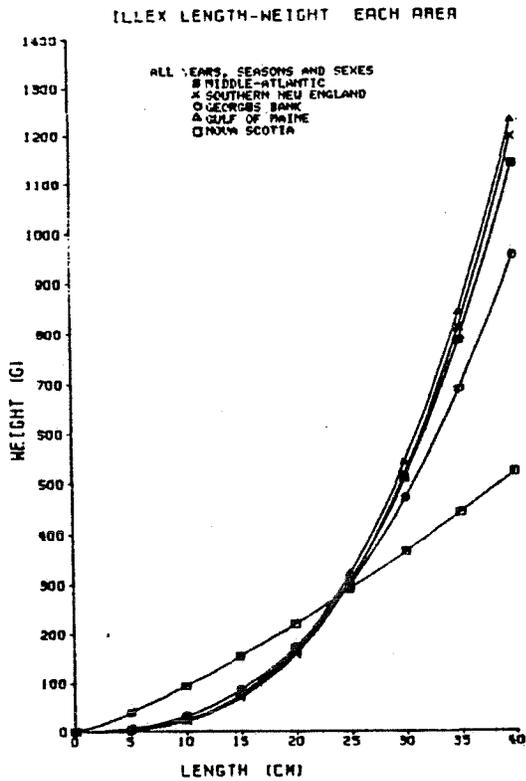
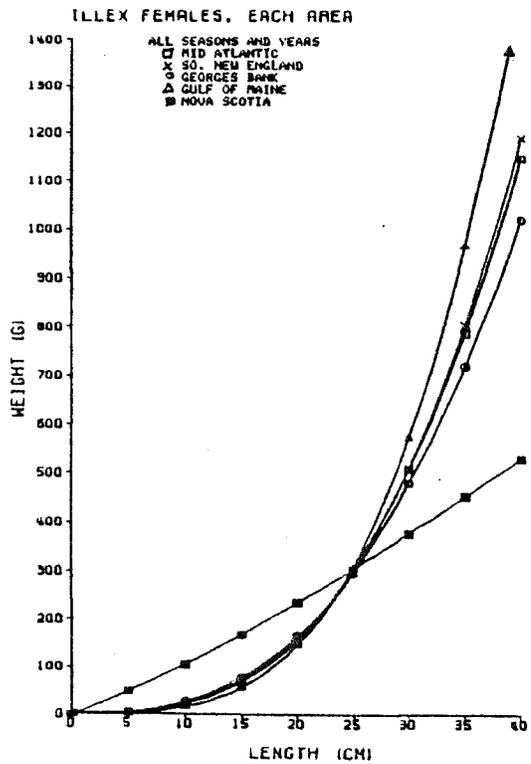
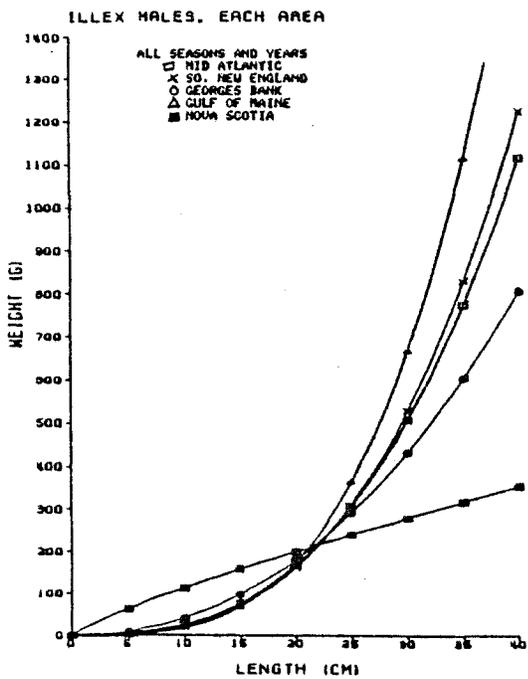


Figure 5f. Illex length-weight relationships by area, each sex; all seasons and years.



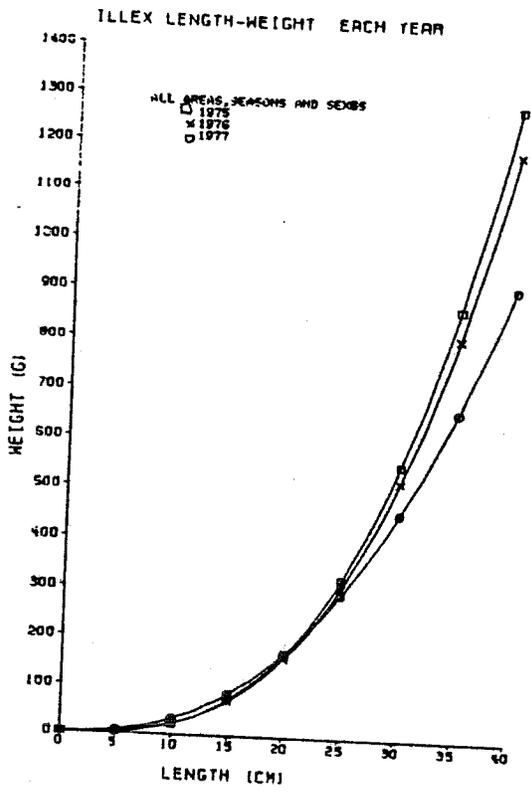


Figure 5g. Illex length-weight relationships by year, each sex; all areas and seasons.

