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NOAA Technical Report NMFS SSRF—745

Dorsal Mantle Length—Total Weight Relationships of Squids *Loligo pealei* and *Illex illecebrosus* From the Atlantic Coast of the United States

Anne M. T. Lange and Karen L. Johnson

March 1981

U.S. DEPARTMENT OF COMMERCE
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National Marine Fisheries Service

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Richard A. Frank, Administrator
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Terry L. Leitzell, Assistant Administrator for Fisheries

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Dorsal Mantle Length—Total Weight Relationships of Squids *Loligo pealei* and *Illex illecebrosus* from the Atlantic Coast of the United States

ANNE M. T. LANGE AND KAREN L. JOHNSON[1]

ABSTRACT

Length-weight data were collected from the Northwest Atlantic, for two commercially important species of squid, *Loligo pealei* and *Illex illecebrosus*, during nine research vessel cruises between 1975 and 1977. These data, in total and by year, sex, season, and area of capture, were fit to length-weight relationships of the form $W = aL^b$. Analyses of covariance indicate that for each species, differences exist between relationships determined for each area. For *L. pealei*, differences also exist between sex and among years and seasons. However, comparisons of sums of total observed 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 about as precise as using separate equations for each sex, area, season, and year. These equations are: $W = 0.25662L^{2.15182}$ for *L. pealei* and $W = 0.04810L^{1.71990}$ for *I. illecebrosus*.

INTRODUCTION

Two species of squid—the long-finned squid, *Loligo pealei*, and the short-finned squid, *Illex illecebrosus*—are of commercial importance off the northeastern United States. *Loligo pealei* is distributed primarily from Cape Hatteras to the Gulf of Maine with some seasonal occurrence in the Gulf of Mexico and as far north as New Brunswick (Summers 1969). Commercial concentrations of *L. pealei* are found primarily from Cape Cod to about Baltimore Canyon. *Illex illecebrosus* 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 United States in quantities ranging from 400 to 5,000 t (metric tons) per year (average 1,805 t for 1930-67). Comparable amounts (<5,000 t) of *I. illecebrosus* 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 t (*L. pealei* and *I. illecebrosus*) in 1973 off the United States and 80,600 t (*I. illecebrosus*) in 1977 off Canada.

The life history and population dynamics of these two squid species, especially *I. illecebrosus*, 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. Population size in number may be more appropriate than biomass in analyzing the status of the squid stocks, since individuals increase weight so rapidly. Mesnil (1977), Summers (1971), and Squires (1967) presented studies of the growth and life cycles of these species but did not provide length-weight relationships. Mercer (1973)[2] provided length-weight functions for male and female *I. illecebrosus* from Newfoundland waters, but these may not be appropriate for *I. illecebrosus* off the United States. Similar studies had not been made for *L. pealei.*

The objectives of this study were to: 1) calculate dorsal mantle length-total weight relationships for *Loligo pealei* and *Illex illecebrosus* from the northwest Atlantic off the U.S. 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 (i.e., is a single relationship appropriate for all areas, seasons, and sexes, or must several functions be used to adequately represent the population?).

METHODS

Samples of *L. pealei* and *I. illecebrosus,* for length-weight analysis, were collected from the Nova Scotian to Middle Atlantic areas (Fig. 1) during research vessel bottom trawl surveys conducted in 1975-77 (Table 1). Standard bottom tows, based on a stratified random sampling design (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 Laboratory, Woods Hole, Mass., 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

Table 1.—Survey cruises in the northwest Atlantic in which *Illex illecebrosus* and *Loligo pealei* were obtained for length-weight 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

[1]Northeast Fisheries Center Woods Hole Laboratory, National Marine Fisheries Service, NOAA, Woods Hole, MA 02543.

[2]Mercer, M. C. 1973. Length-weight relationship of the ommastrephid squid, *Illex illecebrosus* (LeSueur). Annu. Meet. Int. Comm. Northwest Atl. Fish. 1973, Res. Doc. 72, Serial 3024. [Mimeogr.]

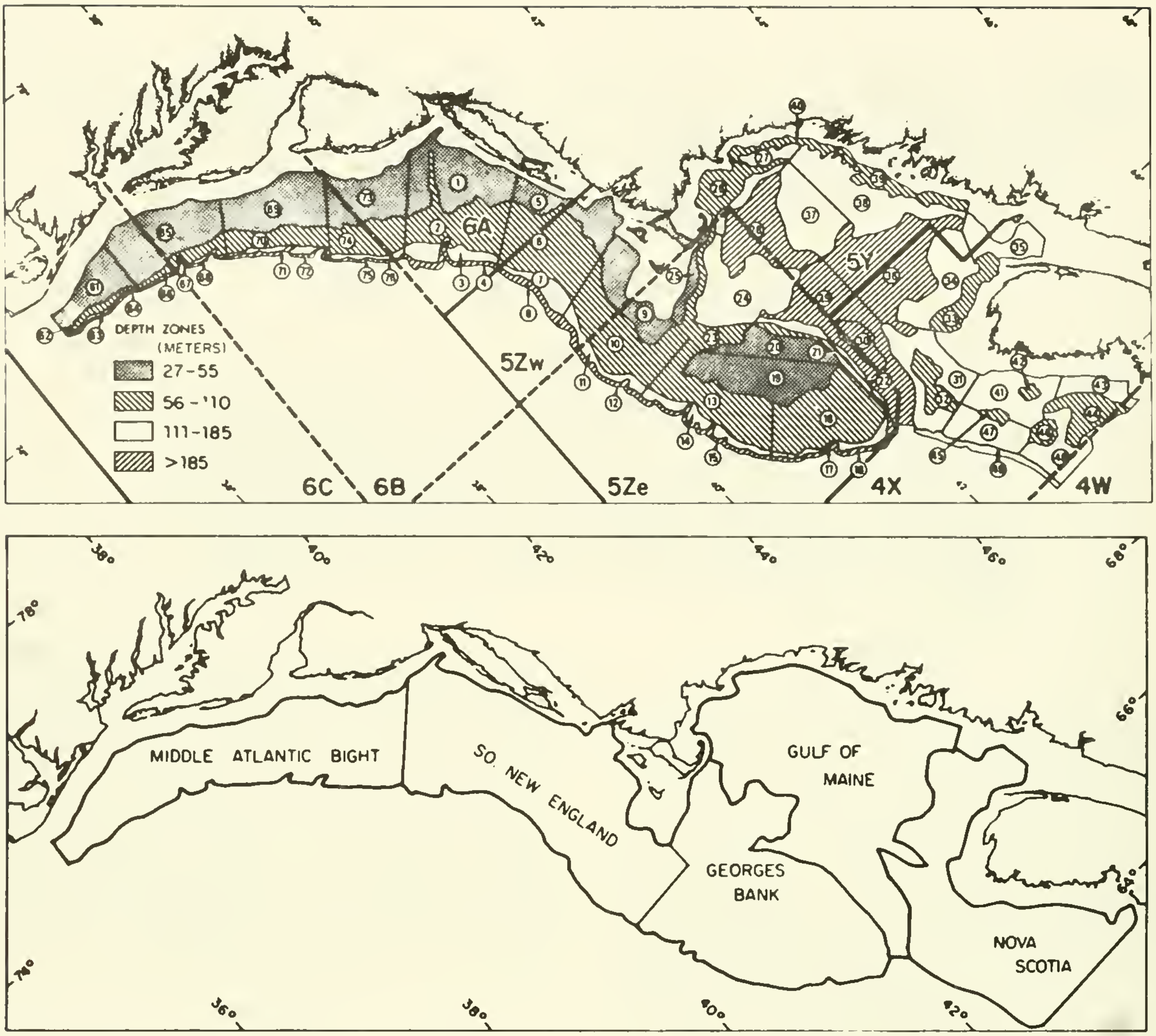


Figure 1.— The northwest Atlantic area, considered in length-weight regression analyses for squid, showing (A) survey strata (strata numbers circled) and ICNAF (International Commission for the Northwest Atlantic Fisheries) Divisions (such as 5Zw) and (B) geographical areas.

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 millimeter (Fig.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),
A and b = coefficients of regression.

Least squares regressions were fitted to the linearized form of this function:

$$Y = a + bx$$

where $Y = \log_e W$,
$X = \log_e L$,
$a = \log_e A$,
b = coefficient of regression.

Various regressions were fitted, with the Statistical Package for the Social Sciences (SPSS) (Nie et al. 1975) SCATTERGRAM subprogram, 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 Biomedical Computer Programs (BMDP) (Dixon and Brown

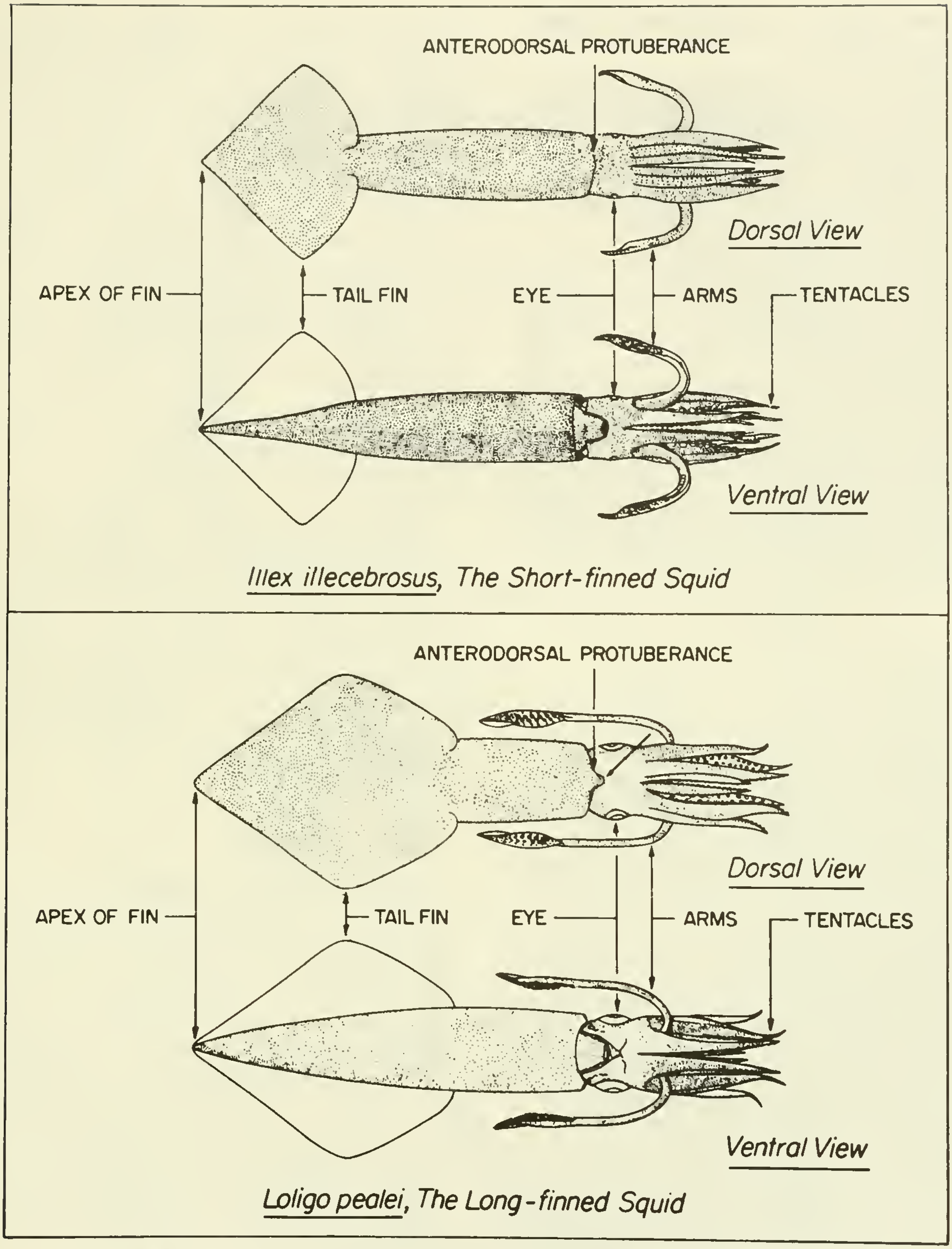


Figure 2.— Dorsal and ventral views of the squid, *Loligo pealei* and *Illex illecebrosus*, and features used for length measurements.

1977), BMDPIV, to determine the significance of differences between slopes and adjusted means of the various length-weight functions (Winer 1971).

A total of 5,388 *L. pealei* and 2,798 *I. illecebrosus* were obtained from nine cruises during the 3-yr study period (1975-77). Of this total, 750 *L. pealei* and 20 *I. illecebrosus* were of indeterminable sex and not considered in this study. There were also 3,026 *L. pealei* and 193 *I. illecebrosus* which were damaged during the capture or preserving process, preventing accurate measurement of weight; these were also excluded.

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, season, or year. 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 *I. illecebrosus* may be taken in great quantities during the summer, *L. pealei* is usually too far inshore to be captured in an offshore survey. *Loligo pealei* are most abundant in the area south of Cape Cod and are only occasionally found north of Georges Bank, while *I. illecebrosus* are 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 from U.S. surveys in 1977 are presented for *L. pealei* and *I. illecebrosus* in Figures 3 and 4.

RESULTS

Statistical Summary

Statistical summaries of *L. pealei* and *I. illecebrosus* length and weight data are presented in Table 2. Lengths ranged from 2.1 to 42.5 cm for *L. pealei* and from 4.9 to 45.0 cm for *I. illecebrosus,* with an overall average of 17.0 and 22.3 cm. Weights averaged 133 and 243 g, ranging from 4 to 752 g and from 3 to 861 g, for *L. pealei* and *I. illecebrosus.* Male *L. pealei* were consistently larger (mean lengths and weights) in all areas, seasons, and years, than female *L. pealei;* while on the average, female *I. illecebrosus* were larger than the males of that species. Size comparisons, for each species, between areas and seasons were not made, since not all samples were random with respect to length.

Regression parameters (a and b), standard errors of estimates, and Pearson correlation coefficients (r) for *L. pealei* and *I. illecebrosus* length-weight relations are presented in Table 3, 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 *L. pealei* 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 (35 individuals) and a narrow range of lengths. For *I. illecebrosus*, between 41% and 96% of the variation is explained by the various regressions. The relatively low correlations for *I. illecebrosus* in some groups (all 1977 data, males in 1977 and in spring, and all data from Georges Bank, the Gulf of Maine, and Nova Scotia) indicate that regression equations may not always be adequate for that species. However, examinations of residuals about the regression lines, plotted against predicted $\log_e$ weights indicated no systematic departures from the fitted equations which would imply a better model.

Comparison of the length-weight relationships of male versus female *L. pealei*, for all samples, shows a difference in weight, by sex, through the entire length range. This difference is also evident when considering the relationships in each area separately. 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) and those by season (pooled over area and year) also showed differences between sexes, again with females <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, indicate that 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 than 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 the weight of only five *L. pealei* were obtained.

Differences between the length-weight relationships of male and female *I. illecebrosus* were not as consistent as those of *L. pealei.* The overall *I. illecebrosus* regressions (pooled over year, season, and areas) were almost identical. Though great differences were exhibited between sexes in the spring and Nova Scotian samples, 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, indicate that 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 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). In the analyses, the H_0 the adjusted means are equal, is based on the prior assumption that the slopes are equal. Significance in the test of equality of slopes indicate differences in the populations, and the H_0 is not tested. Differences between sexes were examined with tests of slopes and adjusted means, 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 data combined over all areas, sexes, and years, for each season. Area and annual differences were tested with data pooled over years, sexes, and seasons, and over areas, sexes, and seasons.

Significant differences ($P \leq 0.05$) were exhibited in slopes between male and female *L. pealei* (Table 4a), with the slope of the female equation significantly greater than for the males. This difference was also significant during the spring and autumn, and in each area, and year. In each case, the slope of the female regression was significantly larger than for the males.

Tests between seasons (Table 4b) showed significant differences in slopes between spring and summer and between sum-

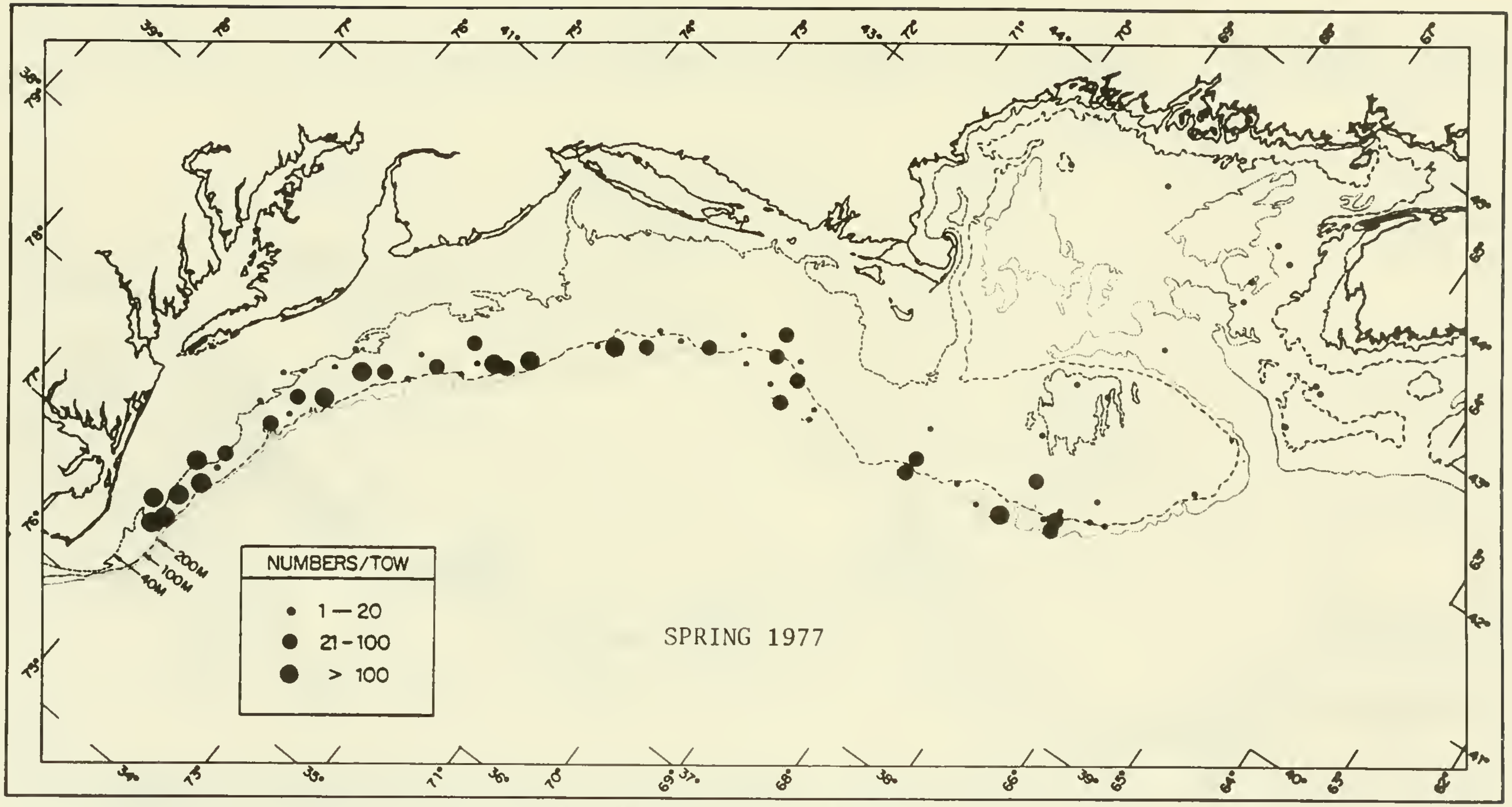


Figure 3.— Seasonal (spring, summer, autumn) geographic distributions of *Loligo pealei* catches from U.S. bottom trawl surveys in the northwest Atlantic, 1977.

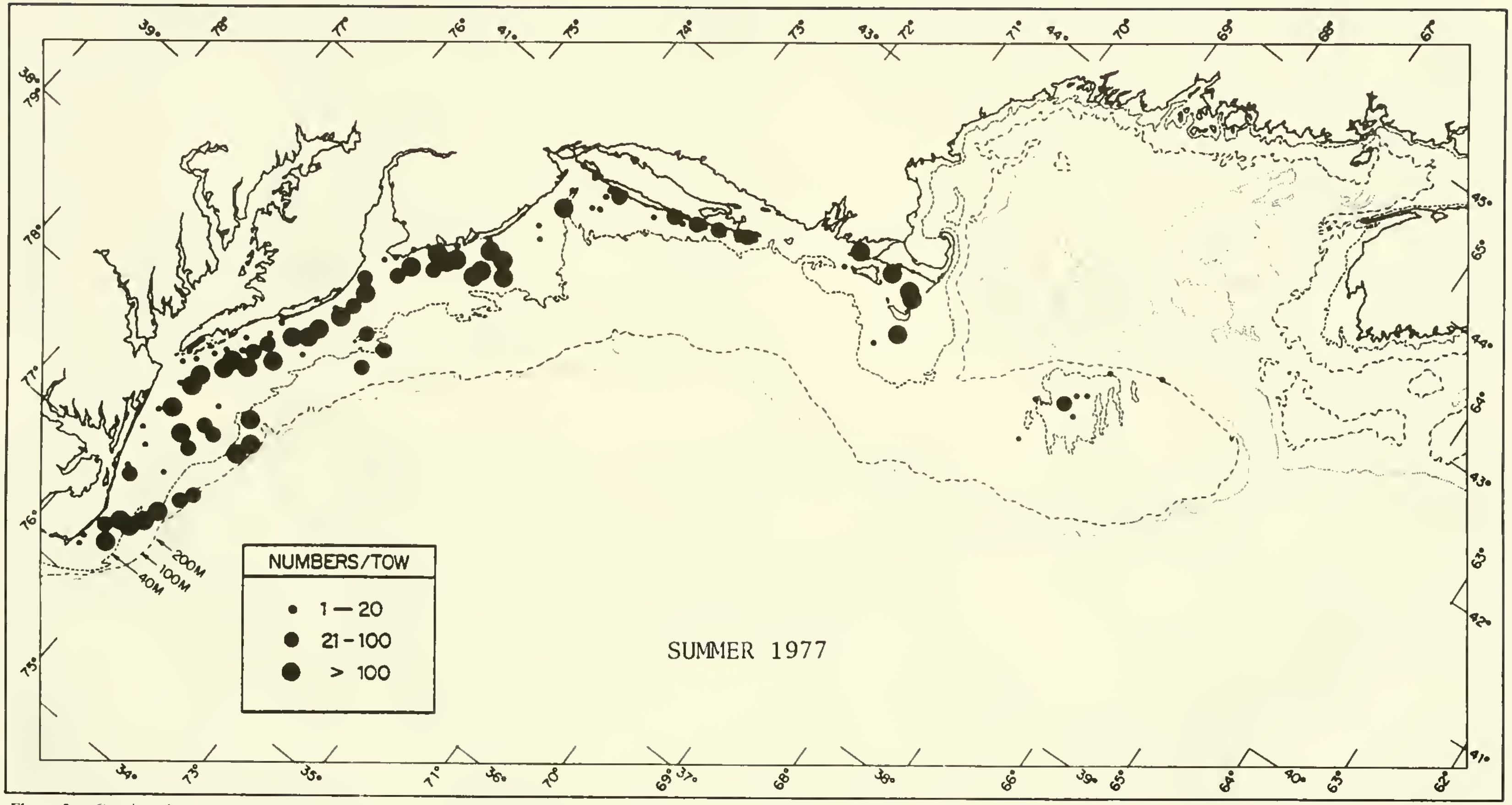
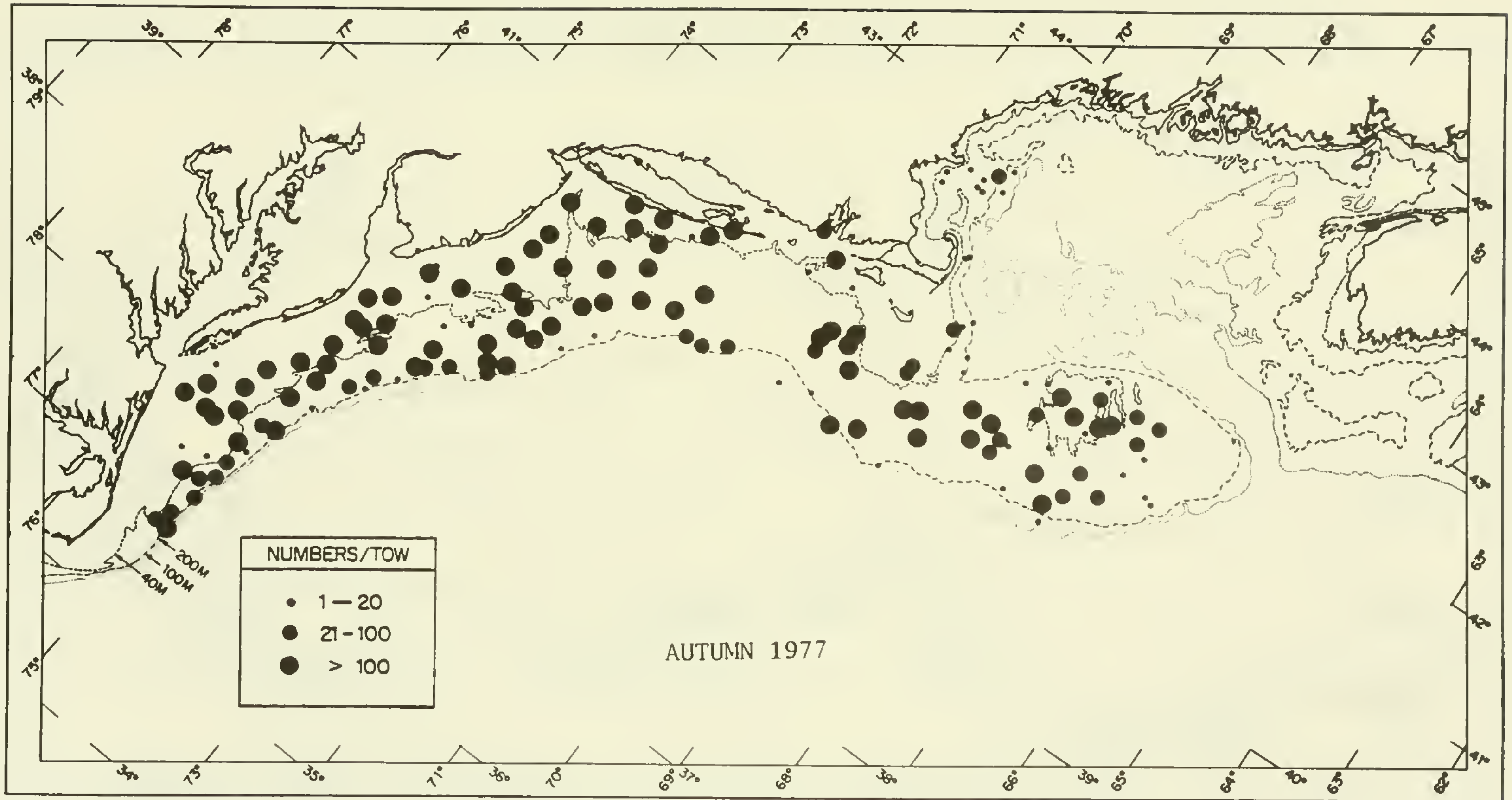


Figure 3.—*Continued.*



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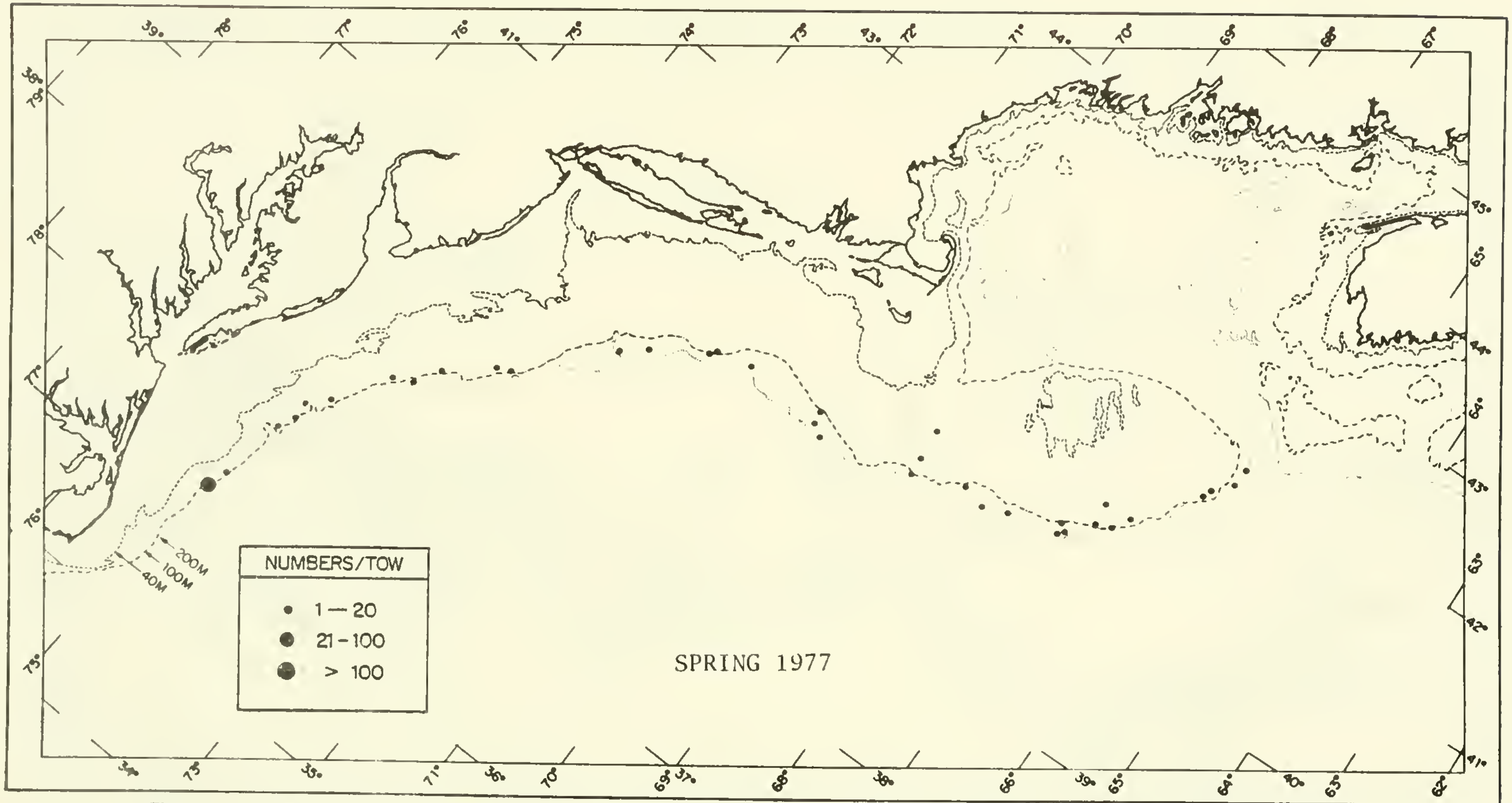
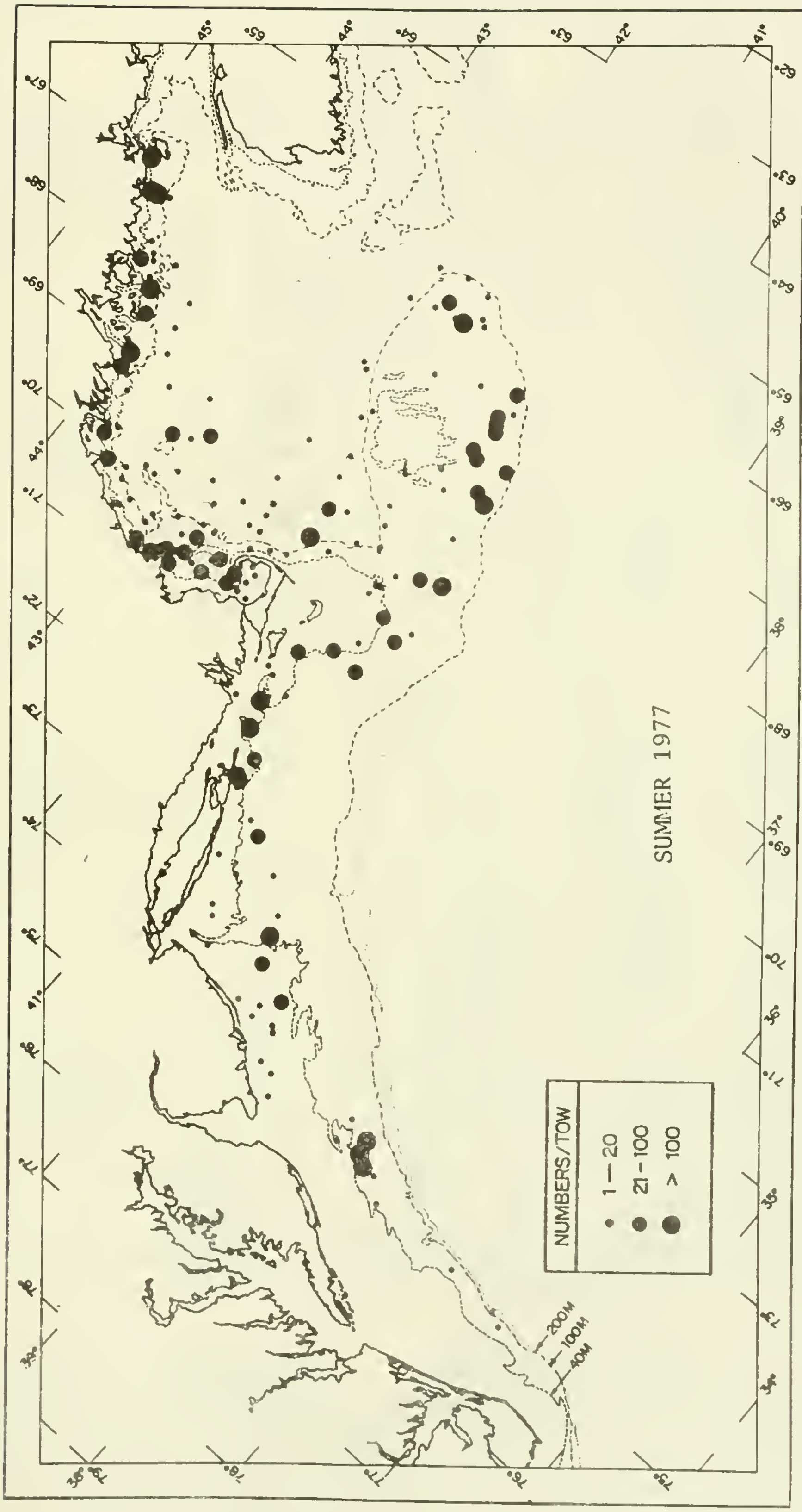


Figure 4.—Seasonal (spring, summer, autumn) geographic distributions of *Illex illecebrosus* catches from U.S. bottom trawl surveys in the northwest Atlantic, 1977.



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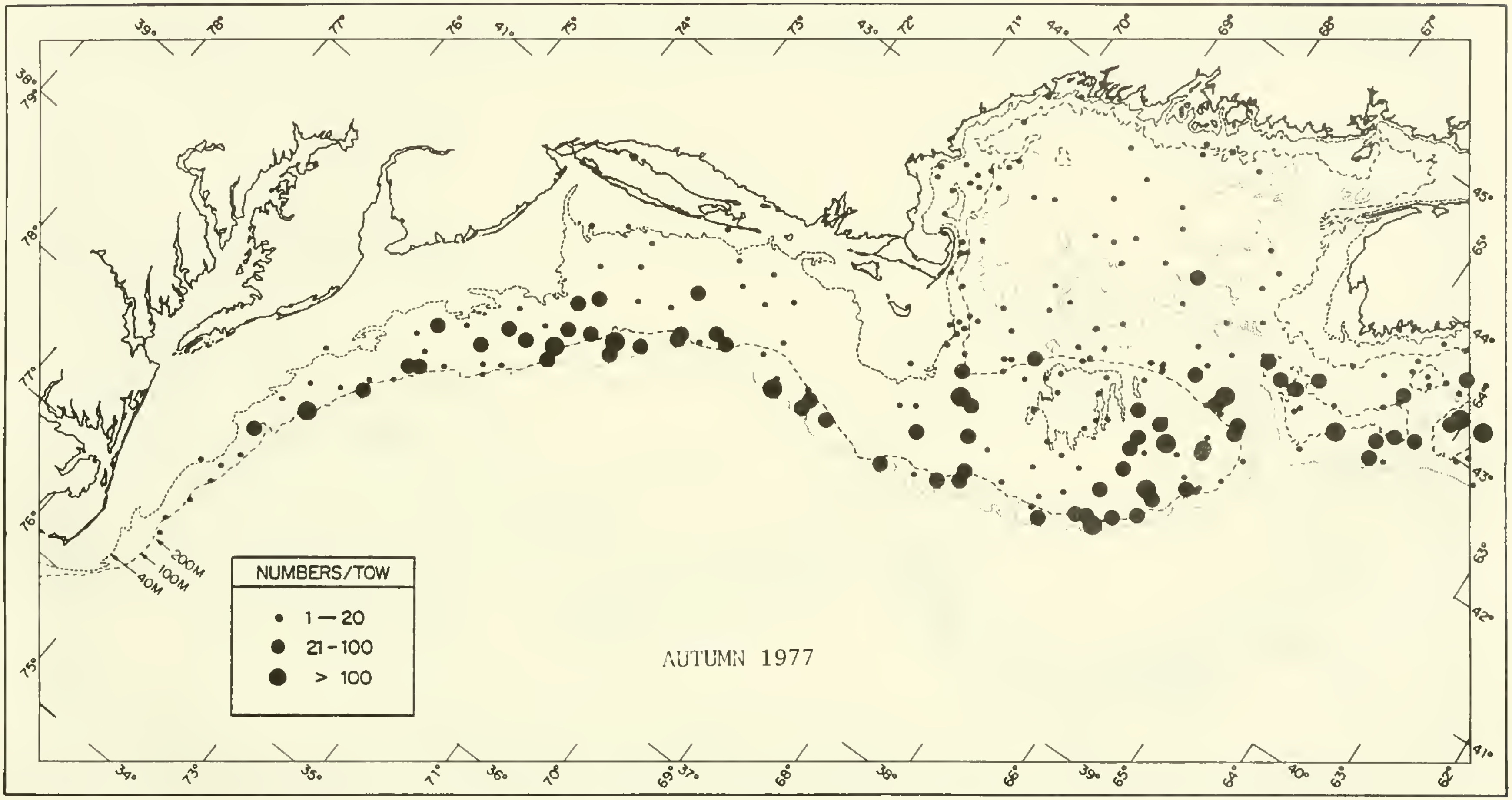

Figure 4.—*Continued.*

Table 2.—Length-weight summary statistics for northwest Atlantic squid, *Loligo pealei* and *Illex illecebrosus*, by sex, area, season, and year.

Species and sex	Year	Season	Area	Dorsal mantle length (mm)						Total weight (g)				
				n	$\bar{x}$	SD	SE	Min.	Max.	$\bar{x}$	SD	SE	Min	Max.
Loligo pealei:														
		All Data		1,709	170.2066	58.43553	1.413533	21.0	425.0	133.4383	91.42767	2.21160	4.0	752.0
Males	All	All	All	915	190.2590	61.58830	2.036046	21.0	425.0	159.4230	100.7944	3.332161	4.0	752.0
			Mid-Atlantic	409	190.8924	59.80818	2.957325	41.0	425.0	166.6308	104.2479	5.15473	4.0	734.0
			S. 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
	1975	All	All	580	188.5931	60.11943	2.496323	21.0	425.0	163.9241	103.7126	4.306433	4.0	752.0
	1976	All	All	212	200.783	57.14859	3.924981	41.0	374.0	172.2736	95.95537	6.590241	10.0	599.0
	1977	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
			S. 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
	1975	All	All	424	159.8962	39.81136	1.933411	54.0	286.0	121.9693	66.75272	3.2418	7.0	435.0
	1976	All	All	178	166.6292	32.43434	2.431056	59.0	270.0	118.2416	55.62306	4.169125	10.0	374.0
	1977	All	All	95	147.9895	30.31764	3.110524	82.0	255.0	83.90526	46.32266	4.752604	20.0	302.0
Illex illecebrosus:														
		All Data		2,605	222.5766	40.73985	0.7982071	49.0	450.0	243.19	108.8574	2.132819	3.0	861.0
Males	All	All	All	1,074	204.0978	33.55382	1.023858	49.0	450.0	196.7197	95.02876	2.899700	4.0	209.0
			Mid-Atlantic	333	192.6877	31.55191	1.729034	75.0	254.0	164.1892	71.72276	3.930386	8.0	391.0
			S. New England	217	192.5069	43.09842	2.925711	49.0	285.0	168.9309	86.65753	5.882696	4.0	430.0
			Georges Bank	379	215.0607	25.76859	1.323644	120.0	450.0	220.4617	58.56674	3.008372	26.0	397.0
			Gulf of Maine	77	223.5584	14.55865	1.662531	161.0	250.0	258.052	60.58702	6.904531	87.0	373.0
			Nova Scotia	68	213.8235	28.77963	3.490043	65.0	277.0	215.2647	47.823875	5.799496	50.0	402.0
	All	Spring	All	34	172.8235	26.97751	4.626604	128.0	241.0	118.6471	51.7903	8.881963	47.0	253.0
		Summer		417	209.6906	19.74397	0.9668665	120.0	269.0	200.4149	59.33192	2.905497	4.0	428.0
		Autumn		623	202.0610	39.55093	1.584575	49.0	450.0	195.488	83.51697	3.346037	4.0	428.0
	1975	All	All	237	196.1266	38.63312	2.50949	92.0	285.0	186.7722	93.99959	6.105929	16.0	397.0
	1976	All	All	185	190.3297	44.57156	3.276966	49.0	265.0	171.8811	87.65227	6.444323	4.0	428.0
	1977	All	All	652	210.9018	25.09465	0.9827825	120.0	450.0	204.4985	61.08788	2.392385	26.0	430.0
Females	All	All	All	1,511	237.0735	37.97983	0.9770589	52.0	343.0	280.002	113.331	2.915523	4.0	861.0
			Mid-Atlantic	362	222.8149	44.52104	2.339974	80.0	343.0	245.8232	125.4576	6.593907	10.0	794.0
			S. New England	268	225.8552	47.19168	2.882691	52.0	311.0	252.5933	133.1323	8.132354	4.0	861.0
			Georges Bank	558	242.7867	29.46974	1.247553	82.0	301.0	290.2581	99.05467	4.193318	11.0	738.0
			Gulf of Maine	165	252.5152	18.81023	1.464374	185.0	316.0	330.3696	90.3768	7.035824	78.0	713.0
			Nova Scotia	158	252.2975	28.24924	2.247388	110.0	303.0	315.9810	74.4052	5.919359	139.0	523.0
	All	Spring	All	17	131.0588	48.73341	11.33293	80.0	266.0	146.1176	117.7810	28.56609	10.0	408.0
		Summer		556	231.1799	23.78857	1.220907	139.0	290.0	247.3452	92.63647	3.928661	51.0	547.0
		Autumn		938	241.5821	41.17207	1.344316	52.0	343.0	295.8582	120.4033	3.931305	4.0	861.0
	1975	All	All	219	219.5434	47.2823	3.195042	82.0	316.0	244.9173	132.1029	8.926682	11.0	713.0
	1976	All	All	304	242.523	44.75668	2.566972	52.0	343.0	305.6777	131.5025	7.542185	4.0	861.0
	1977	All	All	988	239.2834	31.87256	1.104001	80.0	303.0	279.8787	100.0517	3.183069	10.0	738.0

mer and autumn, with summer samples indicating smaller slopes than either of the other seasons. Significant differences were also evident in adjusted means between summer and autumn.

Differences in *L. pealei* length-weight regressions were also found between areas (Table 4c). The slope from the southern New England regression was significantly greater than that of the Mid-Atlantic, Georges Bank, and Nova Scotia areas, indicating statistical difference between each of these regression pairs. Comparisons revealed that adjusted means from the Mid-Atlantic area were significantly greater than from Georges Bank or Nova Scotia, while the mean from the Nova Scotia regression was also significantly less than from both Georges Bank and the Gulf of Maine. There were no statistical differences in regressions for the Mid-Atlantic and Gulf of Maine; southern New England and the Gulf of Maine, and Georges Bank and the Gulf of Maine.

Pairwise comparisons between years (Table 4d) produced no significant difference in the slopes in any year. However, there

Table 3.—Regression parameters and statistics for dorsal mantle length (cm) and total weight (g) relationship of northwest Atlantic *Loligo pealei* and *Illex illecebrosus*, by sex, area, season, and year.

Species	Area	Season	Year	Sex	Intercept (a)	Slope (b)	SE of b	Correlation coefficient (r)
Loligo pealei:								
	All	All	All	All	-1.36015	2.15182	0.2861	0.95
				Males	-0.86949	1.97528	0.3196	0.91
				Females	-1.78605	2.32364	0.2038	0.94
			1975	All	-1.41009	2.18743	0.2863	0.96
				Males	-0.85092	1.98020	0.3303	0.91
				Females	-1.58916	2.27017	0.2221	0.94
			1976	All	-1.23862	2.10357	0.2691	0.95
				Males	-0.23259	1.76347	0.3192	0.87
				Females	-2.20362	2.45497	0.1196	0.97
			1977	All	-1.61568	2.19236	0.1612	0.97
				Males	-1.60828	2.17591	0.1547	0.98
				Females	-2.16486	2.41658	0.1507	0.96
		Spring	All	All	-1.38547	2.14418	0.2736	0.97
				Males	-0.88956	1.96453	0.3023	0.93
				Females	-2.02656	2.40412	0.1859	0.97
		Summer		All	-0.78138	1.87046	0.1604	0.95
				Males	-0.58210	1.79805	0.1539	0.96
				Females	-0.89154	1.91773	0.1658	0.80
		Autumn		All	-1.38983	2.18390	0.2711	0.94
				Males	-0.93193	2.01763	0.3290	0.89
				Females	-1.39656	2.19463	0.2230	0.92
	Mid-Atlantic			All	-1.04605	2.05558	0.2803	0.92
				Males	-0.97119	2.02414	0.3154	0.92
				Females	-1.37391	2.18067	0.2196	0.93
	Southern New England			All	-1.77585	2.29771	0.1844	0.97
				Males	-1.24814	2.10368	0.2528	0.93
				Females	-2.48431	2.48431	0.1762	0.95
	Georges Bank			All	-1.31404	2.11827	0.3566	0.96
				Males	-0.26677	1.73782	0.4096	0.88
				Females	-1.99225	2.41504	0.1798	0.95
	Gulf of Maine			All	–	–	–	–
				Males	–	–	–	–
				Females	–	–	–	–
	Nova Scotia			All	-1.26702	2.06714	0.2491	0.95
				Males	-1.01588	1.95655	0.2098	0.95
				Females	-1.98178	2.36422	0.2537	0.94
Illex illecebrosus:								
	All	All	All	All	-3.03444	2.71990	0.2419	0.93
				Males	-2.90355	2.68514	0.2753	0.89
				Females	-3.12432	2.74348	0.2114	0.93
			1975	All	-3.60800	2.91776	0.2262	0.95
				Males	-3.86325	3.01297	0.2407	0.94
				Females	-3.40628	2.84306	0.2054	0.96
			1976	All	-3.48898	2.86430	0.2482	0.97
				Males	-3.24850	2.79844	0.3193	0.94
				Females	-3.78275	2.95017	0.1834	0.97
			1977	All	-2.04101	2.40036	0.2281	0.85
				Males	-1.09567	2.09151	0.2596	0.71
				Females	-2.49809	2.54442	0.2166	0.87
		Spring	All	All	-3.43632	2.84756	0.2506	0.93
				Males	-1.93149	2.32096	0.2554	0.81
				Females	-3.87840	2.98569	0.1965	0.98
		Summer		All	-3.85026	2.98298	0.1601	0.92
				Males	-5.54897	3.55229	0.1796	0.85
				Females	-3.65525	2.91409	0.1719	0.91
		Autumn		All	-2.90048	2.67682	0.2719	0.93
				Males	-2.71526	2.62456	0.3189	0.90
				Females	-2.95402	2.68939	0.2310	0.93
	Mid-Atlantic	All		All	-3.25968	2.79140	0.2474	0.93
				Males	-3.06027	2.73143	0.3067	0.86
				Females	-3.36896	2.82290	0.2186	0.95
	Southern New England			All	-3.64833	2.91003	0.2045	0.97
				Males	-3.59821	2.90213	0.2285	0.97
				Females	-3.72612	2.92964	0.1792	0.97
	Georges Bank			All	-2.19814	2.45559	0.2213	0.85
				Males	-1.24068	2.15026	0.2345	0.72
				Females	-2.71228	2.61320	0.1067	0.87

Table 3.—Continued.

Species	Area	Season	Year	Sex	Intercept (a)	Slope (b)	SE of b	Correlation coefficient (r)
	Gulf of Maine			All	–3.39896	2.84990	0.1466	0.88
				Males	–4.77169	3.31502	0.1426	0.85
				Females	–5.11873	3.37266	0.1291	0.89
	Nova Scotia	•		All	1.67461	1.24241	0.2160	0.72
				Males	2.82347	0.82687	0.2002	0.65
				Females	1.95943	1.16965	0.1956	0.64

[1]Sample size too small to fit regression.

were significant results in tests of adjusted means, decreasing from 1975 to 1977.

Differences in length-weight regressions for *I. illecebrosus* were not as consistent as for *L. pealei*. Overall, the adjusted mean was significantly greater for female than for male *I. illecebrocus* (Table 5a.). The slope of the male regression was significantly greater than the female's during the summer, indicating statistical differences in the two regression lines, for that season, while in autumn the adjusted mean of females was greater than for males. There was no significant difference between regressions of either sex during the spring. Significant differences in the slope of male and female regressions from the Georges Bank and Nova Scotian areas indicate statistical differences between sex in both these areas. The Mid-Atlantic area is the only area that did not exhibit statistical significance in adjusted means between sexes. In all other areas females were significantly larger than males. When compared by year, slopes of male and female *I. illecebrosus* were only significantly different in 1977, but in both 1975 and 1976, adjusted means for females were statistically greater than for males.

Differences in length-weight regressions due to seasons (Table 5b) were only significant for *I. illecebrosus* between the summer and autumn, with the slope of the summer regression greater than in autumn.

Tests of slopes were significant for all area comparisons (Table 5c) except between the Mid-Atlantic and the Gulf of Maine and between southern New England and the Gulf of Maine, implying statistical differences between length-weight regressions from all other areas. However, the adjusted mean from the Gulf of Maine was also significantly greater than those from either the Mid-Atlantic or the southern New England areas, in pairwise comparisons.

Tests of slopes revealed significant differences between 1975 and 1977 and between 1976 and 1977 samples (Table 5d), indicating that separate equations were appropriate for these areas. The 1975 adjusted mean was significantly greater than that of 1976.

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 consistently less than empirical weights due to bias in linearization by log transformations. These differences were very small, ranging from 0.08% to 6.60% for *L. pealei* and from 0.17% to 5.62% for *I. illecebrosus*. 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 *L. pealei* 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, with females developing over a longer time interval than males; and differential feeding during different stages of maturation and at different sizes (Vinogradov and Noskov 1979). This study also suggests significant seasonal differences in the length-weight relationship of *L. pealei*. 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 *L. pealei,* 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 *I. illecebrosus* were less consistent than for *L. pealei.* 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 *I. illecebrosus*, but area differences proved to be important. As with *L. pealei* these differences are most likely due to physical and biological factors such as temperatures, nutrients, and food availability.

CONCLUSIONS

This study indicates that differences in the length-weight relationships of *Loligo pealei* (by sex, year, season, and area) and of *Illex illecebrosus* among areas (but not between sexes, seasons, and years) do exist. 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 new 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

Table 4.—Analysis of covariance of adjusted means and slopes of *Loligo pealei* length-weight regressions.

		Test of adjusted means			Test of slopes	
		Adjusted means	df	F-ratio[1]	df	F-ratio[1]
a. Between sexes: all seasons, areas, and years combined; by seasons (area and year pooled); by area (season and year pooled); and by year (season and area pooled).						
Seasons						
Overall			N/A[2]		1,608	51.300**
Season:	Spring		N/A		683	46.523**
	Summer		73	0.001 n.s.	72	0.218 n.s.
	Autumn		N/A		845	5.737*
Area:	Mid-Atlantic		N/A		698	4.152*
	Southern New England		N/A		543	25.187**
	Georges Bank		N/A		284	23.235**
	Gulf of Maine[3]		—		—	—
	Nova Scotia		N/A		66	5.054*
Year:	1975		N/A		1,000	22.650**
	1976		N/A		400	47.078**
	1977		N/A		214	7.590**
b. Between seasons: areas, years, and sexes pooled.						
Factor						
Spring						
	vs. Summer		N/A		843	5.533*
Spring		4.5358				
	vs. Autumn	4.6422	1,629	60.993**	1,628	1.360 n.s.
Summer						
	vs. Autumn		N/A		935	7.163**
c. Between pairs of areas: sexes, seasons, and years pooled.						
Area comparison						
Mid-Atlantic						
	vs. S. New England		N/A		1,262	34.176**
Mid-Atlantic		4.6220				
	vs. Georges Bank	4.5432	1,067	20.605**	1,066	1.785 n.s.
Mid-Atlantic		4.6220				
	vs. Gulf of Maine	4.6721	705	0.144 n.s.	704	0.066 n.s.
Mid-Atlantic		4.6220				
	vs. Nova Scotia	4.4403	771	29.764**	770	0.010 n.s.
S. New England						
	vs. Georges Bank		N/A		926	18.713**
S. New England		4.5796				
	vs. Gulf of Maine	4.6721	565	1.258 n.s.	564	0.044 n.s.
S. New England						
	vs. Nova Scotia		N/A		630	11.215**
Georges Bank		4.5432				
	vs. Gulf of Maine	4.6721	369	0.747 n.s.	368	0.031 n.s.
Georges Bank		4.5432				
	vs. Nova Scotia	4.4403	435	4.287*	434	0.182 n.s.
Gulf of Maine		4.6721				
	vs. Nova Scotia	4.4403	73	4.396*	72	0.085 n.s.
d. Between pairs of years: sex, seasons, and areas combined.						
Year comparison						
1975		4.6200				
	vs. 1976	4.5649	1,501	9.275**	1,500	2.401 n.s.
1975		4.6200				
	vs. 1977	4.4379	1,304	72.857**	1,303	0.175 n.s.
1976		4.5649				
	vs. 1977	4.4379	632	42.700**	631	2.358 n.s.

[1]* = $P \leq 0.05$; ** = $P \leq 0.01$; n.s. = not significant.
[2]N/A = test of adjusted means not applicable since test of slopes is significant.
[3]Sample size in the Gulf of Maine was inadequate for proper analysis.

Table 5.—Analysis of covariance of adjusted means and slopes of *Illex illecebrosus* length-weight regressions.

		Test of adjusted means			Test of slopes	
		Adjusted means	df	F-ratio[1]	df	F-ratio[1]
a. Between sexes: all seasons, areas and years combined; by seasons (area and year pooled); by area (season and year pooled); and by year (season and area pooled).						
Factor						
Overall			2,611	17.186**	2,610	1.353 n.s.
Season:	Spring		45	0.718 n.s.	44	3.599 n.s.
	Summer		N/A[2]		998	30.168**
	Autumn		1,561	7.020**	1,560	1.140 n.s.
Area:	Mid-Atlantic		692	2.690 n.s.	691	0.855 n.s.
	Southern New England		482	5.415*	481	0.160 n.s.
	Georges Bank		N/A		932	14.632**
	Gulf of Maine		239	51.376**	238	0.049 n.s.
	Nova Scotia		N/A		222	4.409*
Year:	1975		453	6.080*	452	3.625 n.s.
	1976		486	8.495**	485	3.361 n.s.
	1977		N/A		1,665	25.583**
b. Between seasons: years, areas, and sexes pooled.						
Seasons						
Spring		5.3076				
	vs. Summer	5.3470	1,024	0.909 n.s.	1,023	1.410 n.s.
Spring		5.3076				
	vs. Autumn	5.3503	1,627	1.822 n.s.	1,626	0.993 n.s.
Summer						
	vs. Autumn		N/A		2,547	21.396**
c. Between pairs of areas: sexes, seasons, and years pooled.						
Area comparison						
Mid-Atlantic						
	vs. So. New England		N/A		1,193	5.310*
Mid-Atlantic						
	vs. Georges Bank		N/A		1,637	26.050**
Mid-Atlantic		5.3363				
	vs. Gulf of Maine	5.4031	941	6.603*	940	0.131 n.s.
Mid-Atlantic						
	vs. Nova Scotia		N/A		924	250.813**
S. New England						
	vs. Georges Bank		N/A		1,430	60.111**
S. New England		5.3024				
	vs. Gulf of Maine	5.4031	734	13.956**	733	0.204 n.s.
S. New England						
	vs. Nova Scotia		N/A		717	401.683**
George Bank						
	vs. Gulf of Maine		N/A		1,177	6.754**
Georges Bank						
	vs. Nova Scotia		N/A		1,161	159.471**
Gulf of Maine						
	vs. Nova Scotia		N/A		464	124.460**
d. Between pairs of years: sex, seasons, and areas combined.						
Year comparison						
1975		5.3681				
	vs. 1976	5.3348	960	7.208**	959	0.917 n.s.
1975						
	vs. 1977		N/A		2,131	83.393**
1976						
	vs. 1977		N/A		2,166	86.398**

[1]* = $P \leq 0.05$; ** = $P \leq 0.01$; n.s. = not significant.
[2]N/A = test of adjusted means not applicable since test of slopes is significant.

Table 6.—Percentage overall error[1] in calculated sample weights of squid species versus empirical sample weights using length-weight functions for all data and for annual, seasonal, and area data by sex.

				Loligo pealei		*Illex illecebrosus*	
Area	Season	Year	Sex	Number sampled	% error	Number sampled	% error
All	All	All	All	1,709	1.78	2,604	1.68
			Males	915	3.73	1,073	2.08
			Females	697	1.60	1,511	1.73
		1975	All	1,088	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	1,641	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	1,577	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
Southern 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	–	–	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]Percentage error = (Total empirical weight-total calculated weight)/total empirical weight.
[2]Sample size too small to fit regression.

frequency and total catch in weight data, a single equation obtained from all samples is probably as accurate as applying different equations to catches from each sex, year, area, or season. These equations for *L. pealei* and *I. illecebrosus* are plotted in Figure 5. However, significant changes in this relationship, for these short-lived species, could occur as a result of changes in environmental factors.

LITERATURE CITED

W. J. DIXON (editor), and M. B. BROWN.
1977. BMDP-77, Biomedical Computer Programs, P-series. Univ. Calif. Press, 880 p. Berkeley, Calif.

GROSSLEIN, M. D.
1969. Groundfish survey program of BCF Woods Hole. Commer. Fish. Rev. 31(8-9):22-35.

MESNIL, B.
1977. Growth and life cycle of squid, *Loligo pealei* and *Illex illecebrosus*, from the northwest Atlantic. Int. Comm. Northwest Atl. Fish., Sel. Pap. 2:55-69.

NIE, N. H., C. H. HULL, J. G. JENKINS, K. STEINBRENNER, and D. H. BENT.
1975. SPSS (Statistical Package for the Social Sciences). 2d ed. McGraw-Hill Book Co., N.Y., 675 p.

SQUIRES, H. J.
1957. Squid, *Illex illecebrosus* (LeSueur), in the Newfoundland fishing area. J. Fish. Res. Board Can. 14:693-728.
1967. Growth and hypothetical age of the Newfoundland bait squid, *Illex illecebrosus illecebrosus*. J. Fish. Res. Board Can. 24:1209-1217.

SUMMERS, W. C.
1969. Winter population of *Loligo pealei* in the Mid-Atlantic Bight. Biol. Bull. (Woods Hole) 137:202-216.
1971. Age and growth of *Loligo pealei*, a population study of the common Atlantic coast squid. Biol. Bull. (Woods Hole) 141:189-201.

VINOGRADOV, V. I., and A. S. NOSKOV.
1979. Feeding of short-finned squid, *Illex illecebrosus*, and long-finned squid, *Loligo pealei*, off Nova Scotia and New England, 1974-75. Int. Comm. Northwest Atl. Fish., Sel. Pap. 5:31-36.

WINER, B. J.
1971. Statistical principles in experimental design. 2d ed. McGraw-Hill Book Co., N.Y., 907 p.

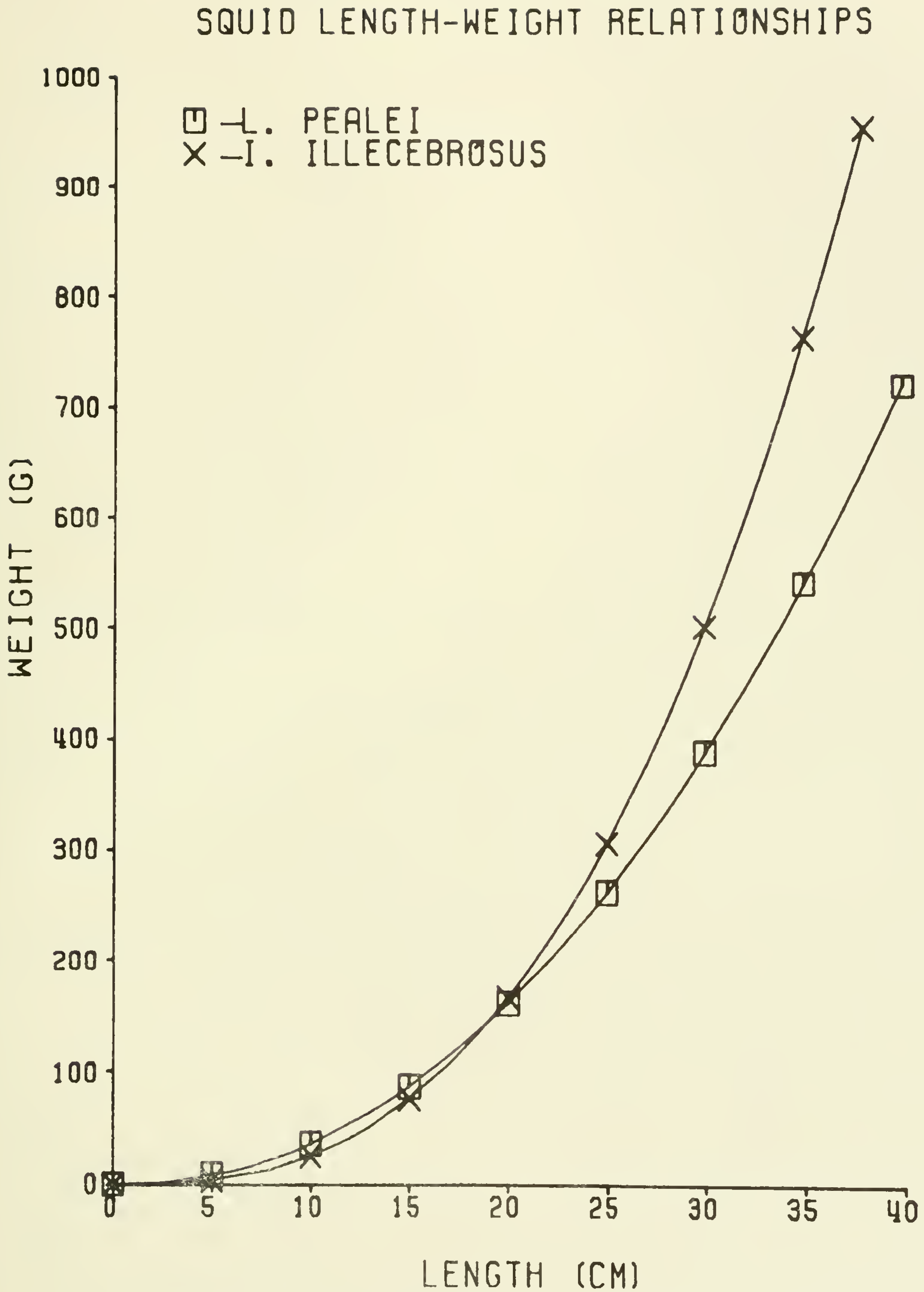

Figure 5.— Plots of squid, *Loligo pealei* and *Illex illecebrosus*, overall length-weight relationships for the northwest Atlantic, all data combined. ($W = 0.25662L^{2.15182}$ for *L. pealei* and $W = 0.04810L^{2.71990}$ for *I. illecebrosus*).

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