International Commission for the Northwest Atlantic Fisheries

Serial No. 5327

ICNAF Res. Doc. 79/II/4

SPECIAL MEETING OF STACRES - FEBRUARY 1979

# 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

Anne M. T. Lange and Karen L. Johnson

National Marine Fisheries Service
Northeast Fisheries Center
Woods Hole Laboratory
Woods Hole, Massachusetts 02543

## ABSTRACT

Length-weight data were collected from the Northwest Atlantic, for two commercially important species of squid (*Loligo pealei* and *Illex illecebrosus*) during 9 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 $W = aL^b$. Analysis of covariance indicate that differences between equations determined for each area for each species, and for each sex, year and season for *Loligo*, do exist. However, comparisons 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 about as precise as using separate equations for each sex, area, season and year.

These equations are: $W = 0.25662L^{2.15182}$ and $W = 0.04810L^{2.71990}$, for *Loligo* and *Illex*, respectively.

## 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 occurrances 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 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, 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.

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

where;

$Y = \log_e W$,

$X = \log_e L$,

$a = \log_e A$,

and b = coefficient of regression.

Various regressions were fitted, with the SPSS (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 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 Base:

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 consistantly 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.

Regression parameters (a and b), standard error or regression 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% ($r^2$ x 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 adequate 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 the weight of only five Loligo were obtained.

Differences between the length-weight relationships of male and female Illex were not as consistant 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 consistantly demonstrated in tests of slopes for each year ($P<0.01$). Tests of adjust 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.

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 which are based on geometric means were consistently less than empirical weights, 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 although differences in the length-weight relationships of Loligo (by sex, year, season, and area) and Illex (by area), do exist, comparisions 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 aera, season, year, or sex. This implies that for purposes of predicting total numbers taken in a fishery from length 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 aera or season. These equations are: $W = 0.25662L^{2.15182}$ and $W = 0.4810L^{2.71990}$, 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.

## Literature Cited

Dixon, W. J. (ed.), and M. B. Brown. 1977. BMDP-77, Biomedical Computer Programs, P-series. University of Calif. Press. Berkeley, Calif. 880 p.

Grosslein, M. D. 1969. Groundfish survey program of BCF Woods Hole. Comm. Fish. Rev. 31:22-35.

Mercer, M. C. MS1973. Length-weight relationship of the ommastrephid squid, Illex illecebrosus (Le Sueur). Annu. Meet. Int. Comm. Northw. Atlant. Fish. 1973, Res. Doc. No. 72, Serial No. 3024 (mimeo).

Mesnil, B. 1977. Growth and life cycle of squid, Loligo pealei and Illex illecebrosus, from the Northwest Atlantic. Int. Comm. Northw. Atlant. Fish., Sel. Pap. No. 2:55-69.

Nie, N. H., C. Hull, J. Jenkins, K. Steinbrenner, and D. Bent. 1975. SPSS, Statistical Package for the Social Sciences, 2nd ed. McGraw-Hill Book Co. New York. 675 pp.

Squires, H. J. 1957. Squid, Illex illecebrosus (LeSueur), in the Newfoundland fishing area. J. Fish. Res. Bd. Canada, 14(5):693-728.

Squires, H. J. 1967. Growth and hypothetical age of the Newfoundland bait squid, Illex illecebrosus. Ibid.,24(6):1209-1217.

Summers, W. C. 1969. Winter populations of Loligo pealei in the Mid-Atlantic Bight. Biol. Bull., 137:202-216.

Summers, W. C. 1971. Age and growth of Loligo pealei, a population study of the common Atlantic coast squid. Ibid., 141:189-201.

Winer, B. J. 1971. Statistical Principles in Experimental Design, 2nd ed. McGraw-Hill Book Co., New York. 907 pp.

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 n | x̄ | S.D. | S.E. | Min. | Max. | Total Weight x̄ | 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 |
| | | | | | | | | Males | | | | | |
| All | All | All | | | | | | | | | | | |
| | | Mid-Atlantic | 409 | 190.8924 | 59.80818 | 2.957326 | 41.0 | 425.0 | 166.6308 | 104.2479 | 6.15473 | 4.0 | 734.0 |
| | | So. New England | 304 | 196.7039 | 53.81042 | 3.08624 | 66.0 | 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 | 36 | 193.9714 | 61.40066 | 10.37869 | 98.0 | 310.0 | 133.2867 | 84.12161 | 14.21916 | 34.0 | 305.0 |
| All | Spring | All | 388 | 201.6959 | 69.22797 | 3.514619 | 21.0 | 425.0 | 173.9227 | 122.0835 | 6.197851 | 7.0 | 752.0 |
| | Summer | | 41 | 169.0244 | 46.19875 | 7.216032 | 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 | 3.668417 | 4.0 | 570.0 |
| 75 | All | All | 580 | 188.6931 | 60.11943 | 2.496323 | 21.0 | 425.0 | 163.9241 | 103.7126 | 4.306433 | 4.0 | 752.0 |
| 76 | All | All | 212 | 200.783 | 67.14859 | 3.924981 | 41.0 | 374.0 | 172.2736 | 96.95537 | 6.690241 | 10.0 | 599.0 |
| 77 | All | All | 123 | 175.6854 | 54.11841 | 4.879692 | 61.0 | 334.0 | 116.0488 | 82.82709 | 7.468266 | 9.0 | 460.0 |
| | | | | | | | | Females | | | | | |
| All | All | All | 697 | 169.9928 | 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 | 64.6405 | 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 | 65.0 | 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 | 65.0 | 275.0 | 111.4114 | 66.74384 | 3.859897 | 10.0 | 435.0 |
| | Summer | | 35 | 131.0857 | 14.64556 | 2.476552 | 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 | 68.99672 | 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 | | | 96 | 147.9895 | 30.31764 | 3.110524 | 82.0 | 255.0 | 83.90526 | 46.32266 | 4.752604 | 20.0 | 302.0 |

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

| | | | Dorsal mantle length | | | | | | Total weight | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | Season | Area | n | x̄ | S.D. | S.E. | Min. | Max. | x̄ | S.D. | S.E. | Min. | Max. |
| All Data | | | 2605 | 222.5766 | 40.73985 | 0.7982071 | 0.00 | 450.0 | 243.19 | 108.8574 | 2.132819 | 3.0 | 861.0 |
| **Males** | | | | | | | | | | | | | |
| | | Mid-Atlantic | 333 | 192.6877 | 31.55191 | 1.729034 | 75.0 | 254.0 | 164.1892 | 71.72276 | 3.930386 | 8.0 | 391.0 |
| | | So. New England | 217 | 192.5069 | 43.09842 | 2.925711 | 49.0 | 286.0 | 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 | 14.55866 | 1.662531 | 161.0 | 260.0 | 258.062 | 60.58702 | 6.904531 | 87.0 | 373.0 |
| | | Nova Scotia | 68 | 213.8235 | 28.77963 | 3.490043 | 56.0 | 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 | .9668665 | 120.0 | 269.0 | 200.4149 | 59.33192 | 2.905497 | 70.0 | 430.0 |
| | Autumn | | 623 | 202.0610 | 39.55093 | 1.584575 | 49.0 | 450.0 | 195.488 | 83.51697 | 3.346037 | 4.0 | 428.0 |
| 75 | All | All | 237 | 196.1266 | 38.63312 | 2.50949 | 92.0 | 285.0 | 186.7722 | 93.99959 | 6.105929 | 16.0 | 397.0 |
| 76 | | | 185 | 190.3297 | 44.57156 | 3.276966 | 49.0 | 265.0 | 171.8811 | 87.65227 | 6.444323 | 4.0 | 428.0 |
| 77 | | | 652 | 210.9018 | 26.09465 | .9827825 | 120.0 | 450.0 | 204.4985 | 61.08788 | 2.392385 | 26.0 | 430.0 |
| **Females** | | | | | | | | | | | | | |
| All | All | All | 1511 | 237.0735 | 37.97983 | .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 |
| | | So. 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 | 5.919369 | 139.0 | 523.0 |
| All | Spring | All | 17 | 181.0588 | 48.78841 | 11.83293 | 80.0 | 266.0 | 146.1176 | 117.7810 | 28.56609 | 10.0 | 408.0 |
| | Summer | | 556 | 231.1799 | 28.78857 | 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 |
| 75 | All | All | 219 | 219.5434 | 47.2823 | 3.195042 | 82.0 | 316.0 | 244.9178 | 132.1029 | 8.926682 | 11.0 | 713.0 |
| 76 | All | All | 304 | 242.523 | 44.75668 | 2.566972 | 52.0 | 343.0 | 305.6777 | 131.5025 | 7.542185 | 4.0 | 861.0 |
| 77 | All | All | 988 | 239.2834 | 31.87256 | 1.014001 | 80.0 | 303.0 | 279.8787 | 100.0517 | 3.183069 | 10.0 | 738.0 |

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 | -1.36016 | 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 | 0111040 | 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 | -1.38647 | 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 | 2.05658 | 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 | -1.99226 | 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 (d) | 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 | 0.2783 | 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 | 0.2606 | 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 | 0.2046 | 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 | 2.16026 | 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 | 16.83617 | 0.6464 |
| | | | Females | 1.95943 | 1.16965 | 0.1956 | 7.09528 | 0.6426 |

A 1

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: F-Ratio | df | Level of signifi-cance | Test of slopes: F-Ratio | df | Level of signifi-cance |
|---|---|---|---|---|---|---|---|
| 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: F-Ratio | df | Level of signifi-cance | Test of slopes: F-Ratio | df | Level of signifi-cance |
|---|---|---|---|---|---|---|
| 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

| | Spring | Summer | Autumn |
|---|---|---|---|
| Adjusted Mean | 4.5358 | 4.4078 | 4.6422 |
| Std. error | 0.0097 | 0.0307 | 0.0092 |

t-matrix and significance levels

| | Spring | Summer | Autumn |
|---|---|---|---|
| Spring | -- | | |
| Summer | -3.983<br>P<0.01 | -- | |
| Autumn | 7.945<br>P<0.01 | 7.316<br>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 F-Ratio | df | Level of significance | Test of slopes 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 F-Ratio | df | Level of signifi-cance | Test of slopes F-Ratio | df | Level of signifi-cance |
|---|---|---|---|---|---|---|
| 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

| | 1975 | 1976 | 1977 |
|---|---|---|---|
| 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 F-Ratio | df | Level of signifi-cance | Test of slopes F-Ratio | df | Level of signifi-cance |
|---|---|---|---|---|---|---|---|
| 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: F-Ratio | df | Significance level | Test of slopes: F-Ratio | df | Significance 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

| | Spring | Summer | Autumn |
|---|---|---|---|
| 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: F-Ratio | df | Level of significance | Test of slopes: 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 n.s. | 4.2678 P<0.01 | - | | |
| Gulf of Maine | 3.7088 P<0.01 | 5.3169 P<0.01 | 2.5544 P<0.05 | - | |
| Nova Scotia | 2.4331 P<0.05 | 4.0786 P<0.01 | 1.2238 n.s. | -1.0146 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.

| | | Test of adjusted means | | | Test of slopes | | |
|---|---|---|---|---|---|---|---|
| Factor | Comparison | 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

| | 1975 | 1976 | 1977 |
|---|---|---|---|
| Adjusted mean | 5.3681 | 5.33481 | 5.34670 |
| Std. error | 0.0113 | 0.01061 | 0.00589 |

t-matrix and significance

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

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

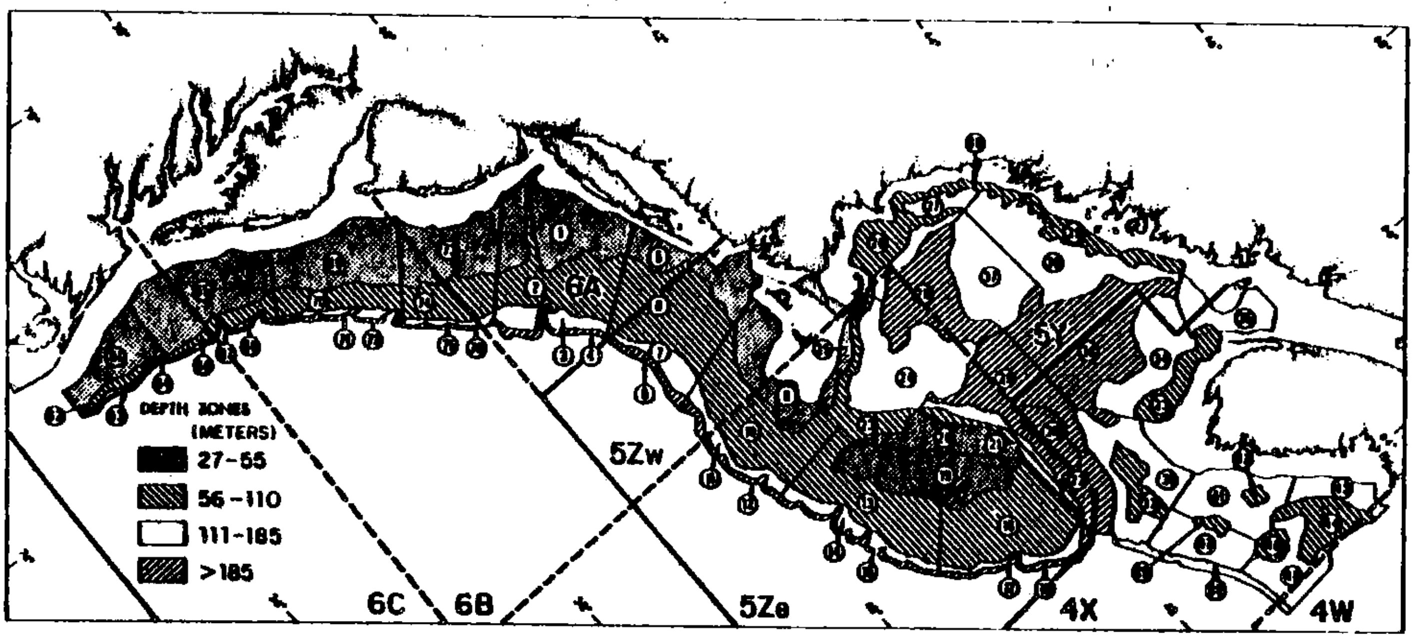
Table 6. Percent overall error in calculated sample weights versus empirical sample weights using length-weight functions for all data; and for annual, seasonal and area data by sex.

| | | | | Loligo | | Illex | |
|---|---|---|---|---|---|---|---|
| Area | Season | Year | Sex | 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 | 0.62 | 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.

A




B

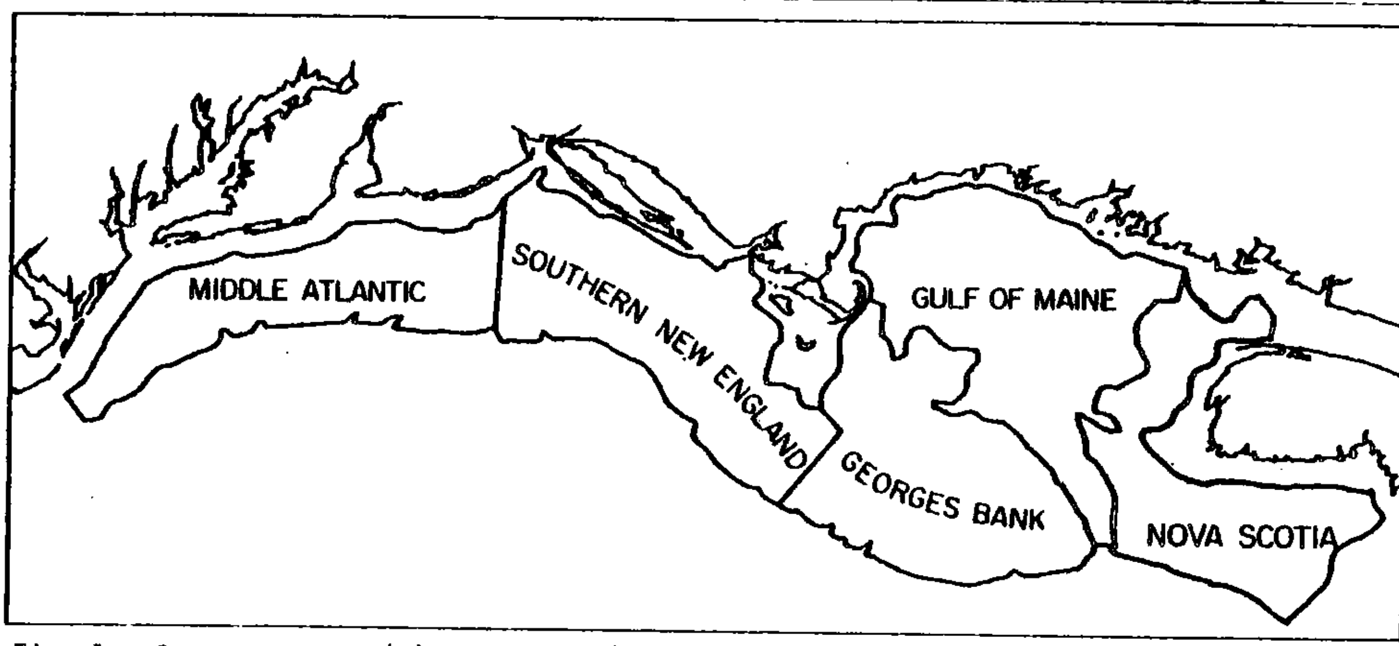
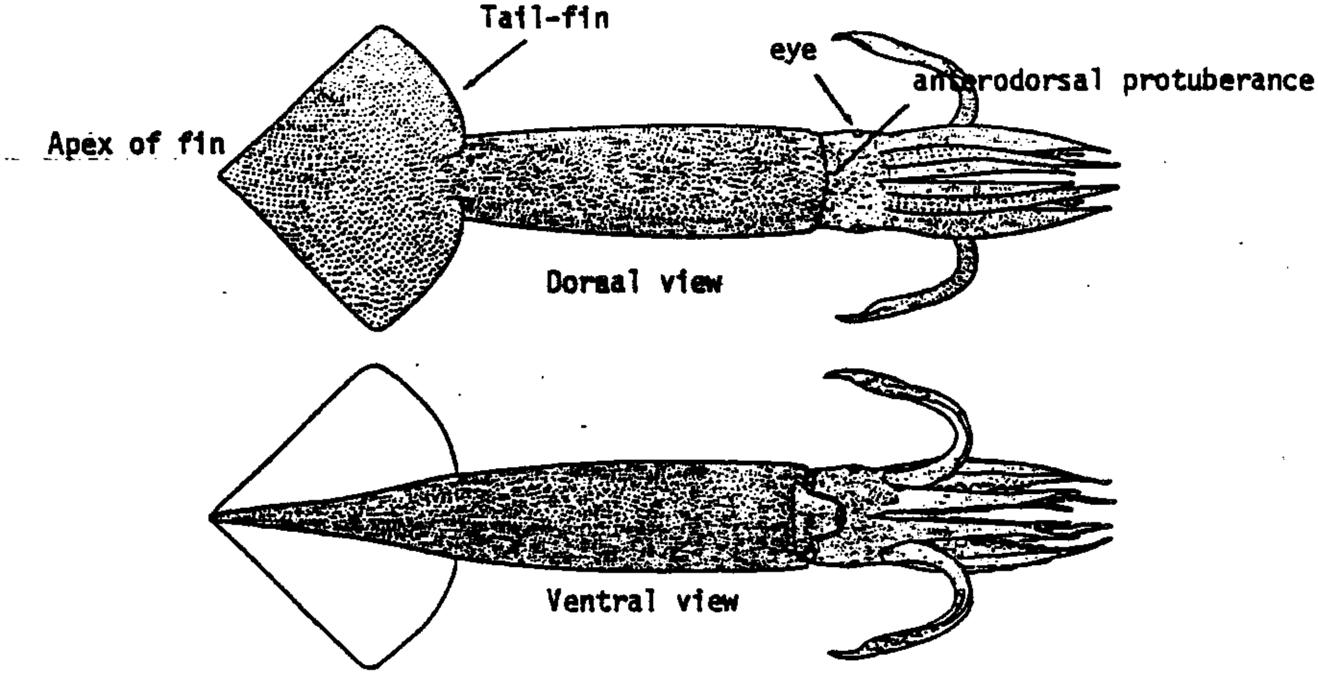
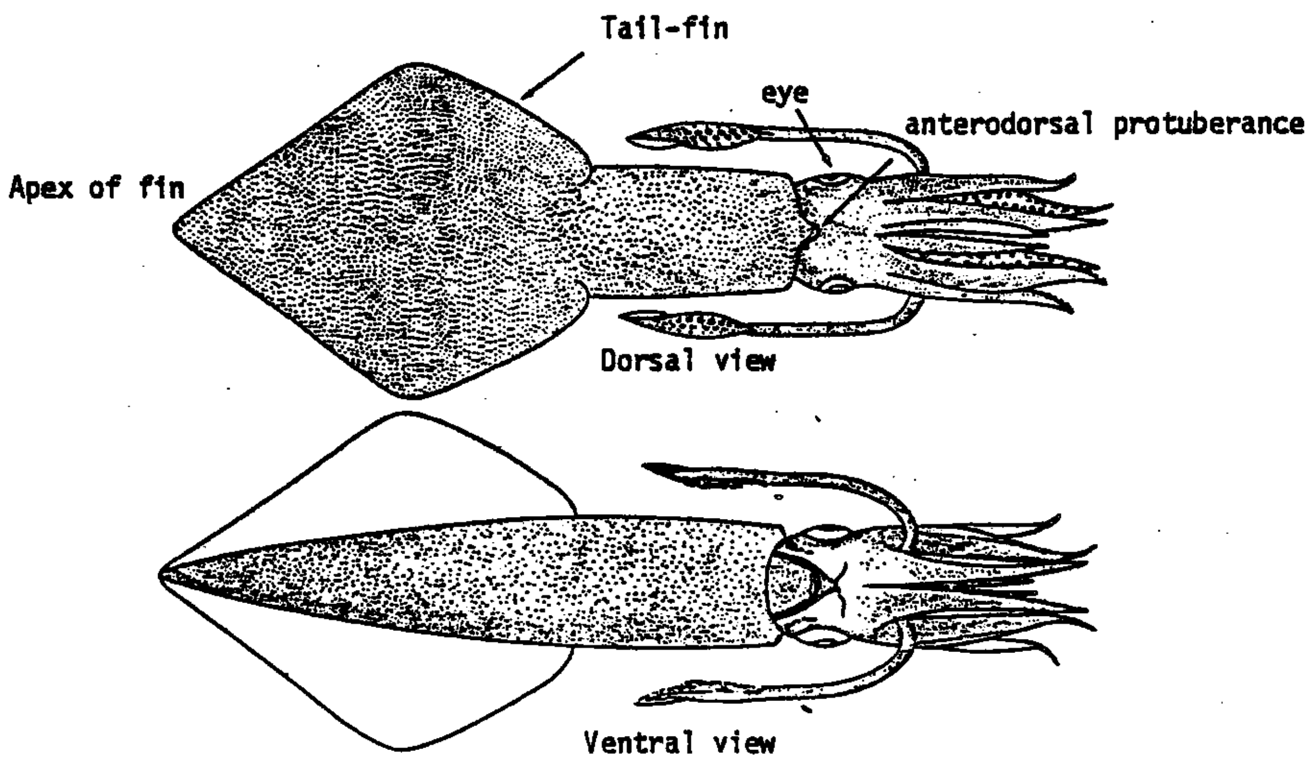



Fig. 1. Survey strata (A) and areas (B) used in length-weight regression analyses for squid.




*ILLEX* SHORT-FINNED SQUID




*LOLIGO* LONG-FINNED SQUID

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

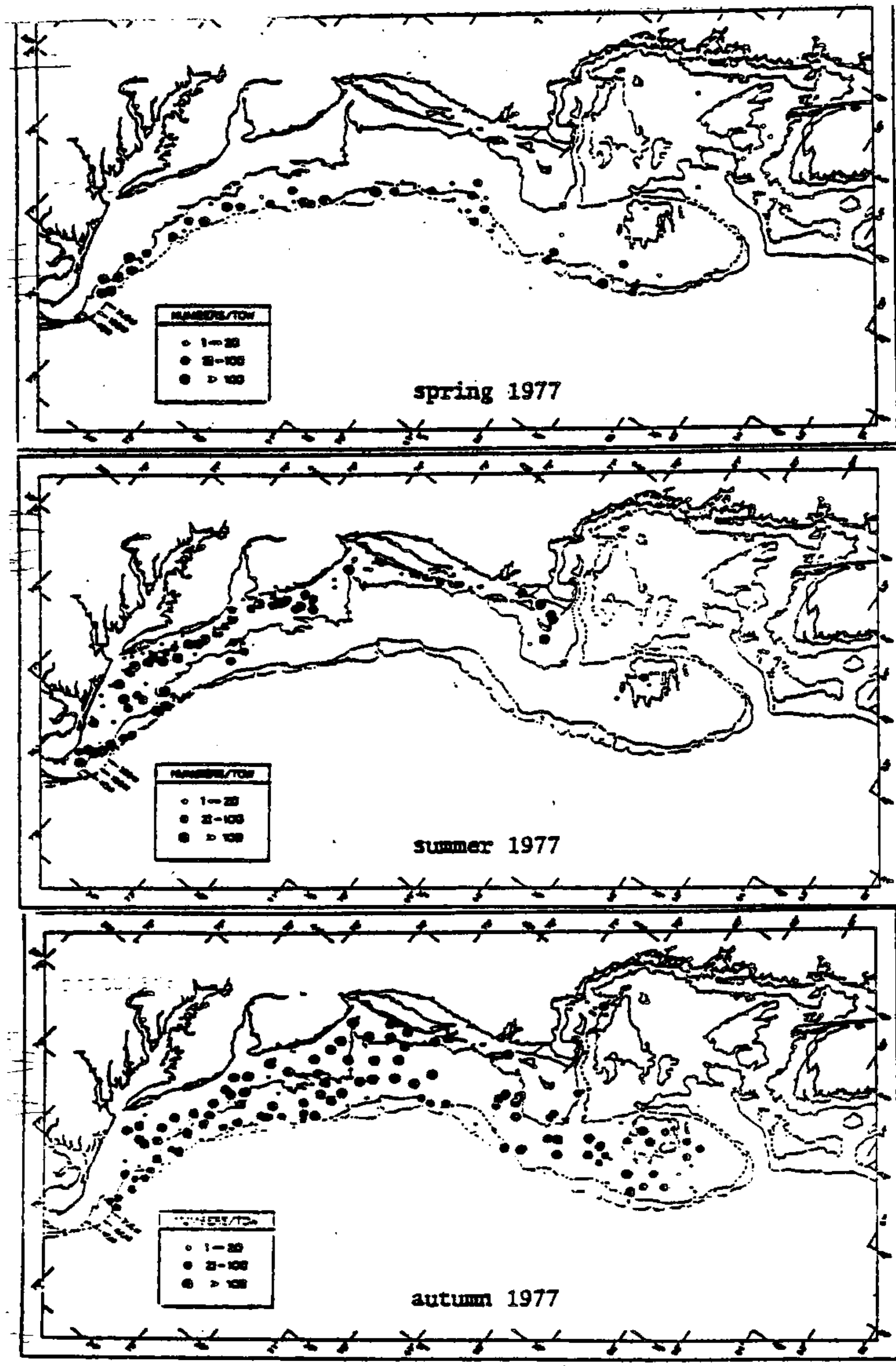



Figure 3a. Distribution of Loligo pealei. Locations of stations where Loligo were taken, during 1977 U.S.A. bottom trawl surveys, by season.

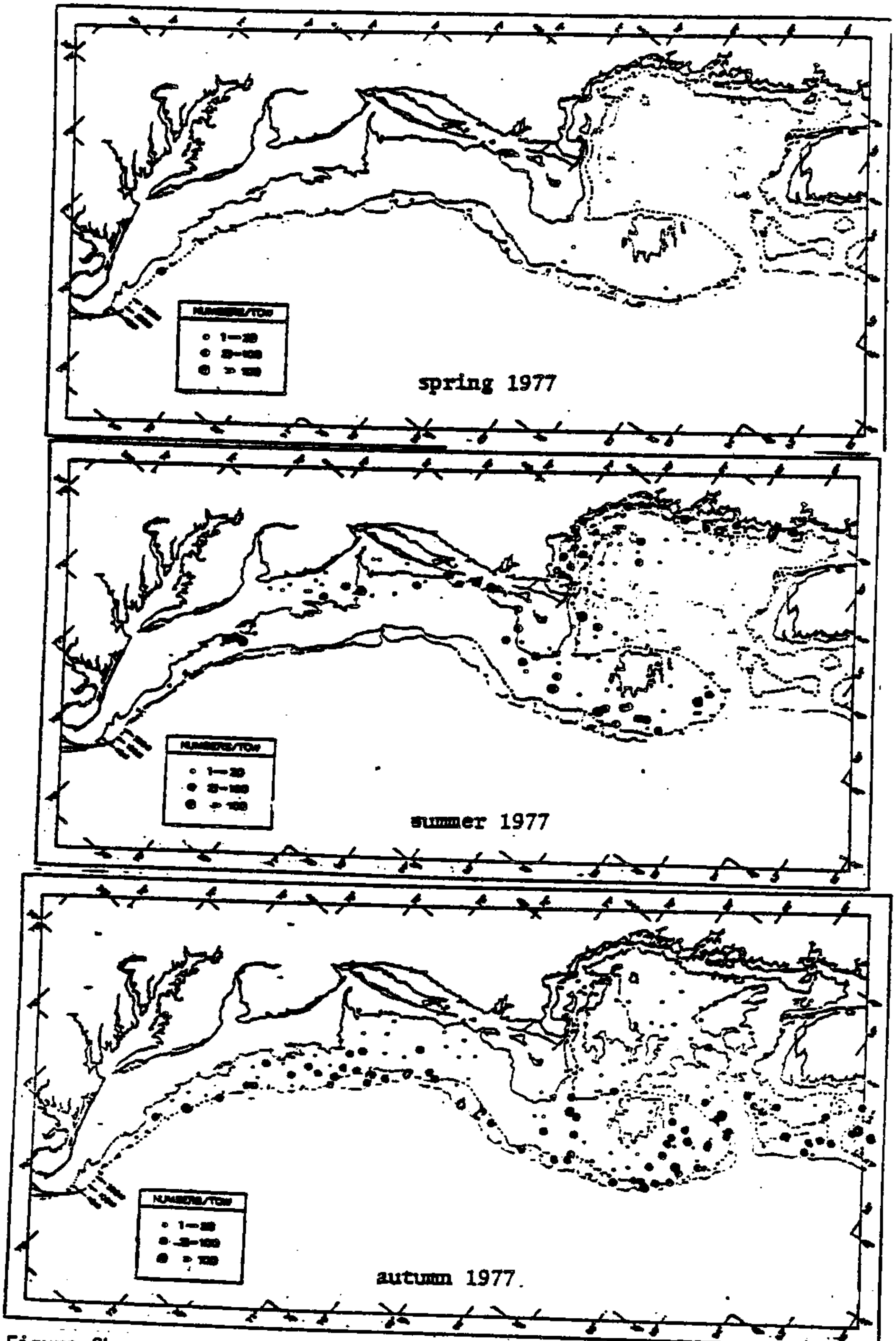



Figure 3b. Distribution of Illex illecebrosus. Locations of stations where Illex were taken, during 1977 U.S.A. bottom trawl surveys, by season.

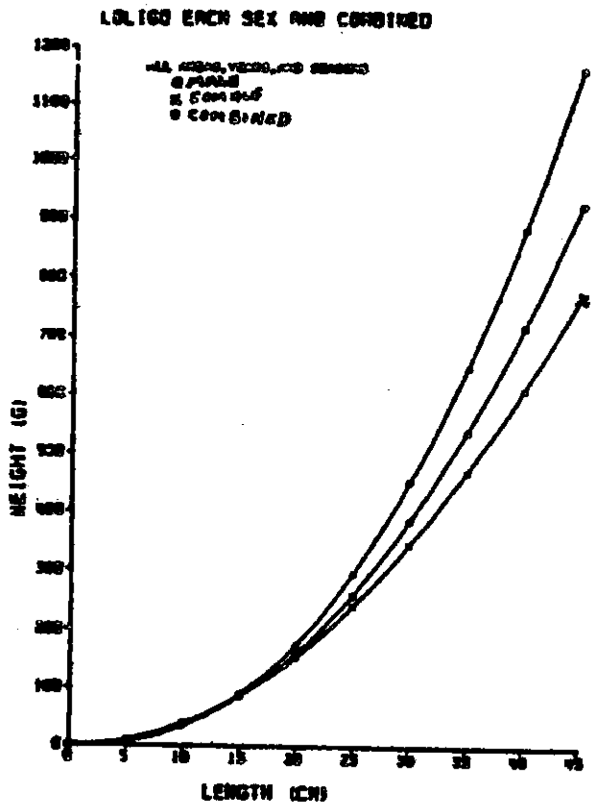



Figure 4a. <u>Loligo</u> length-weight relationships by sex: all areas, years and seasons.

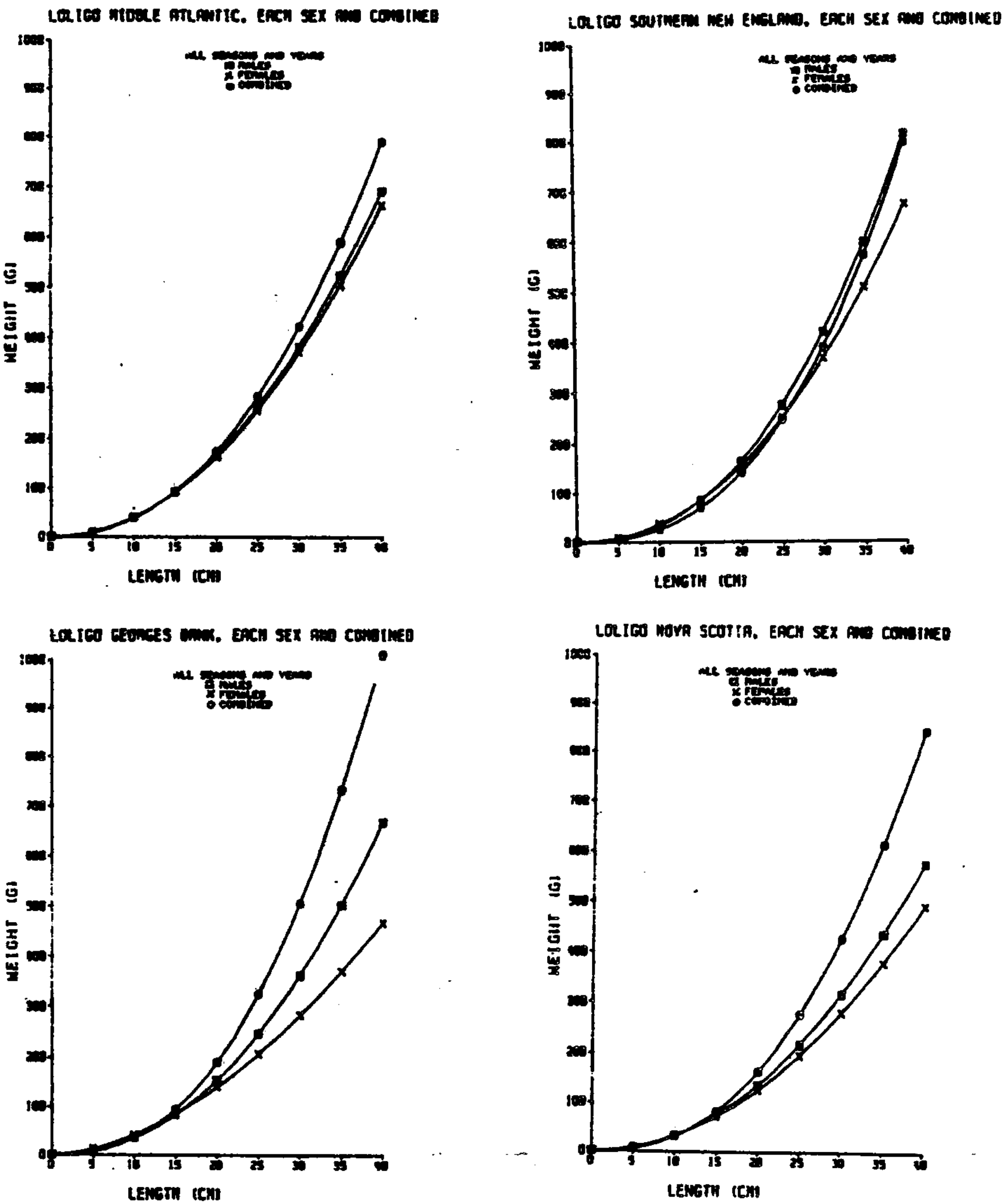
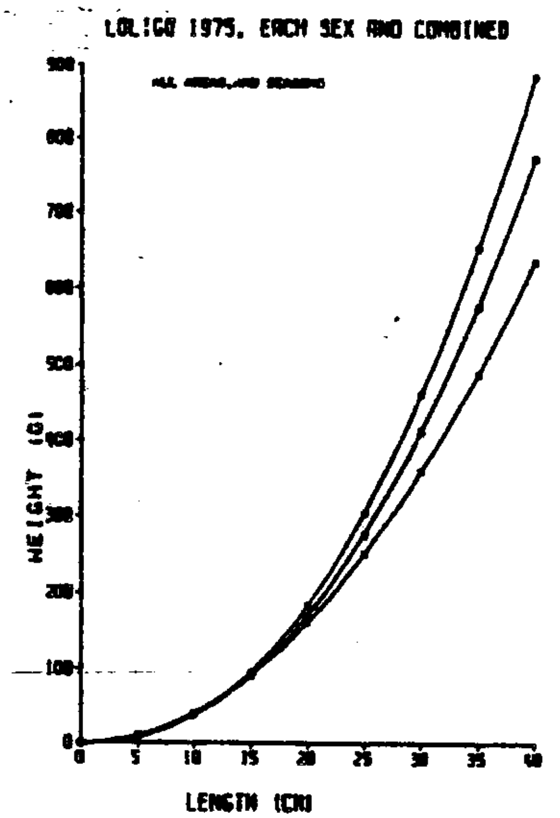
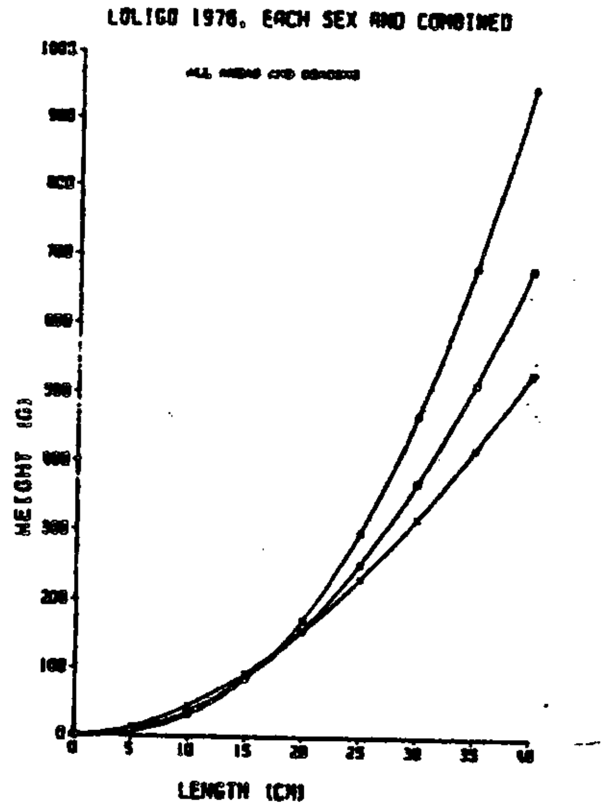



Figure 4b. *Loligo* length-weight relationships by sex; each area: all seasons and years.



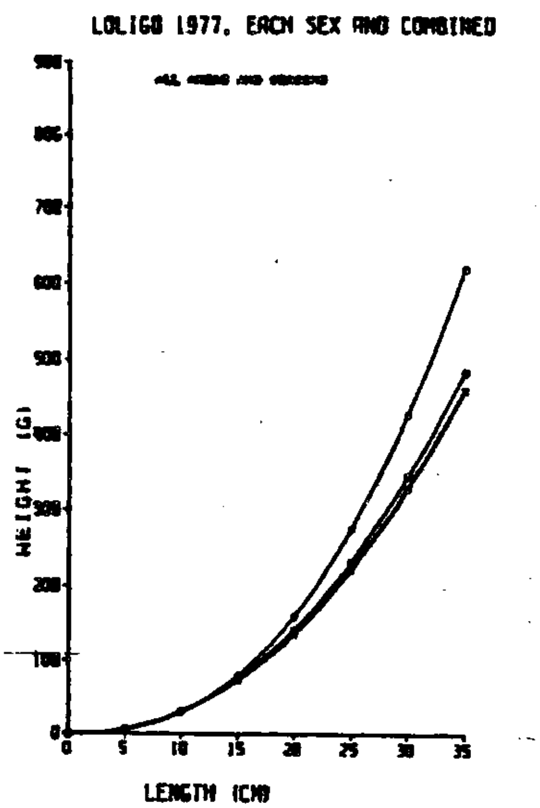
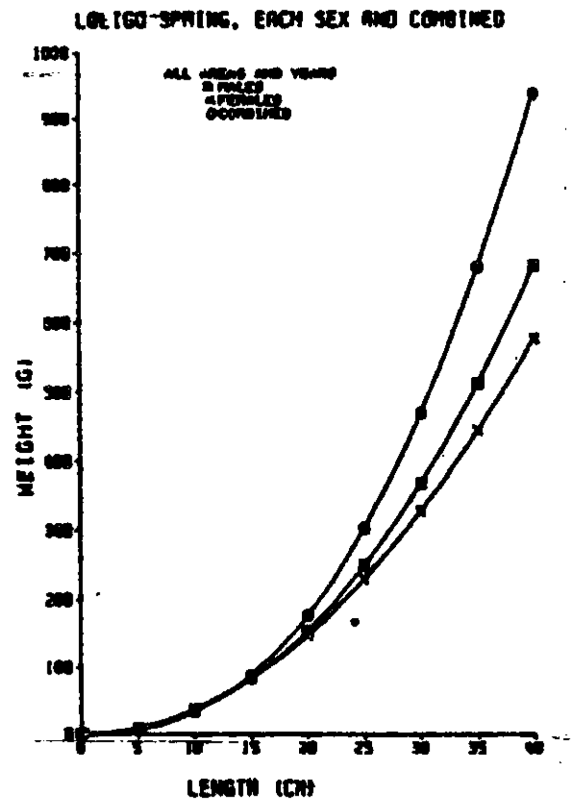
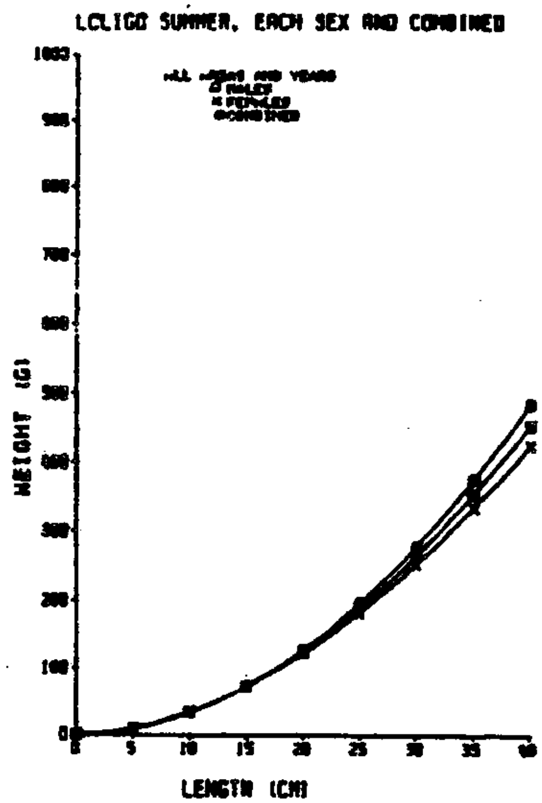






Figure 4c. *Loligo* length-weight relationships by sex, each year: all areas and seasons.



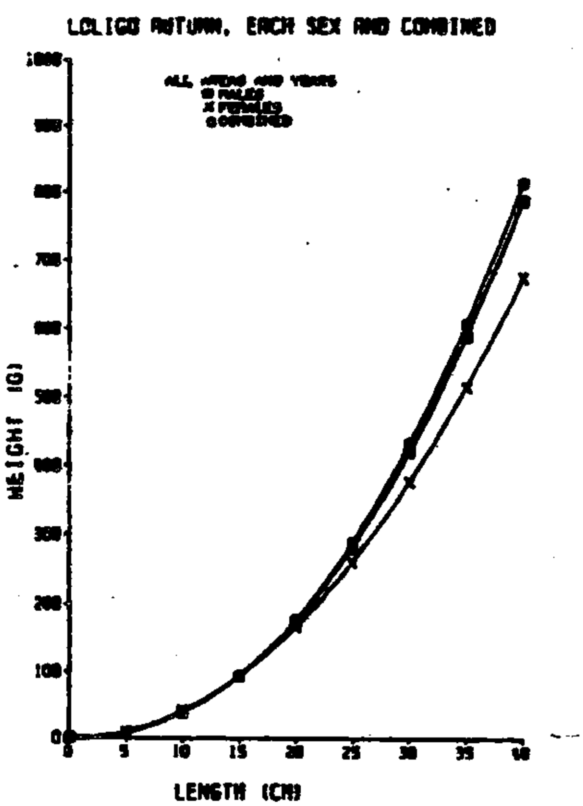




Figure 4d. _Loligo_ length-weight relationships by sex, each season: all areas and years.

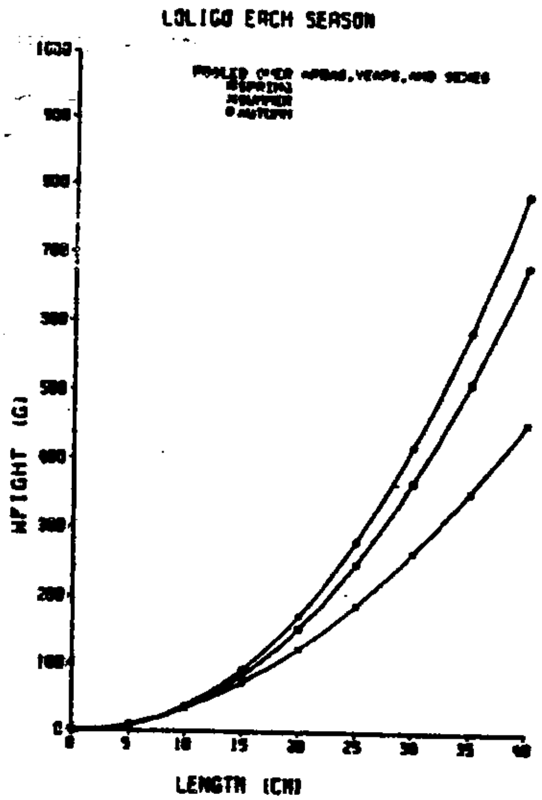
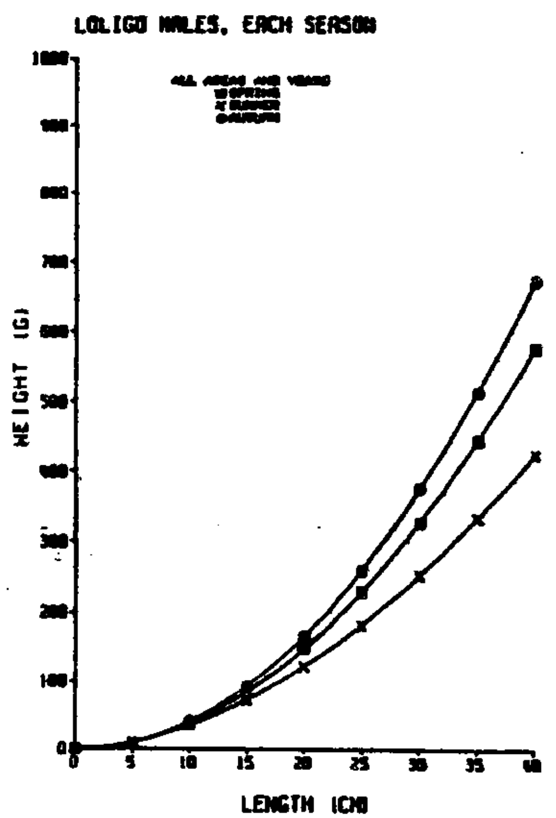
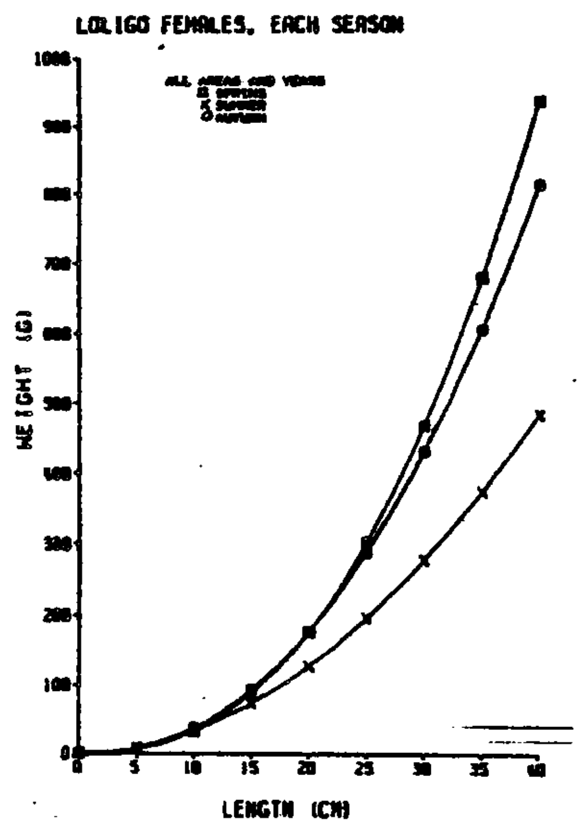



Figure 4e. Loligo length-weight relationships by season; each sex; all areas and years.



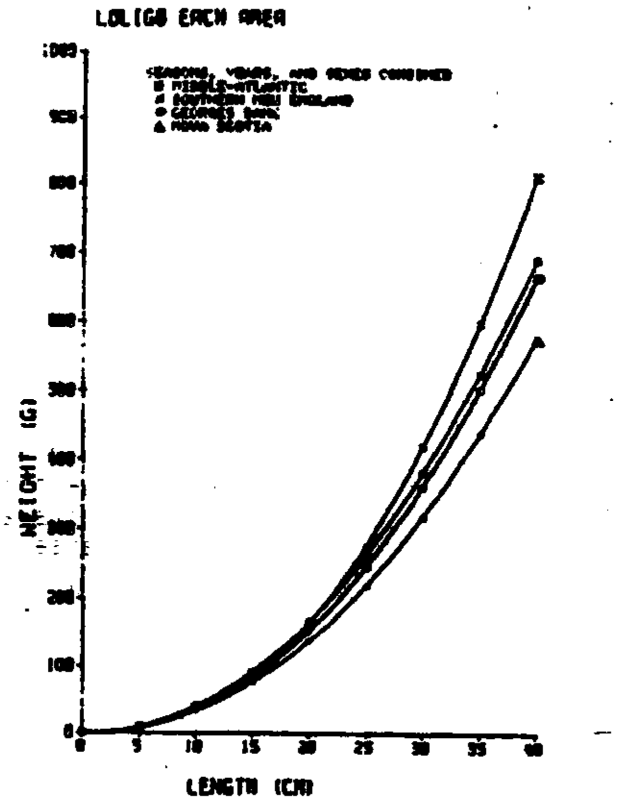
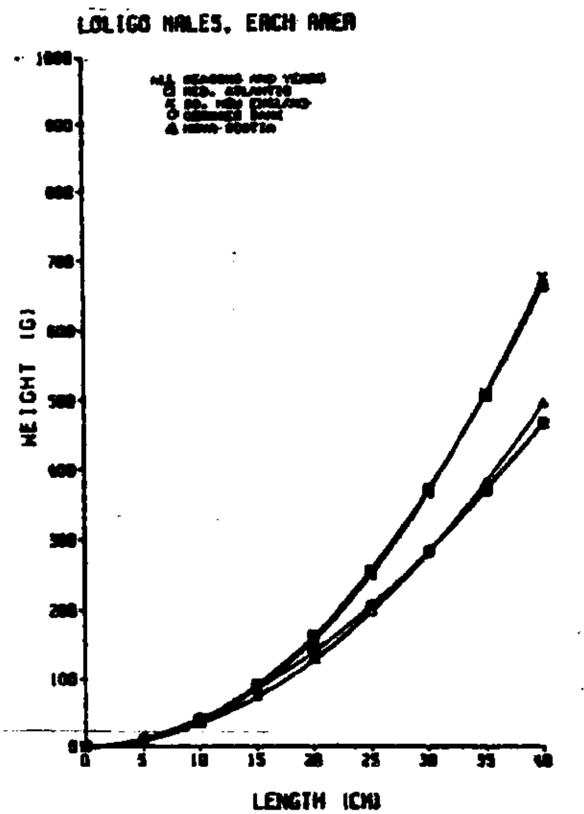
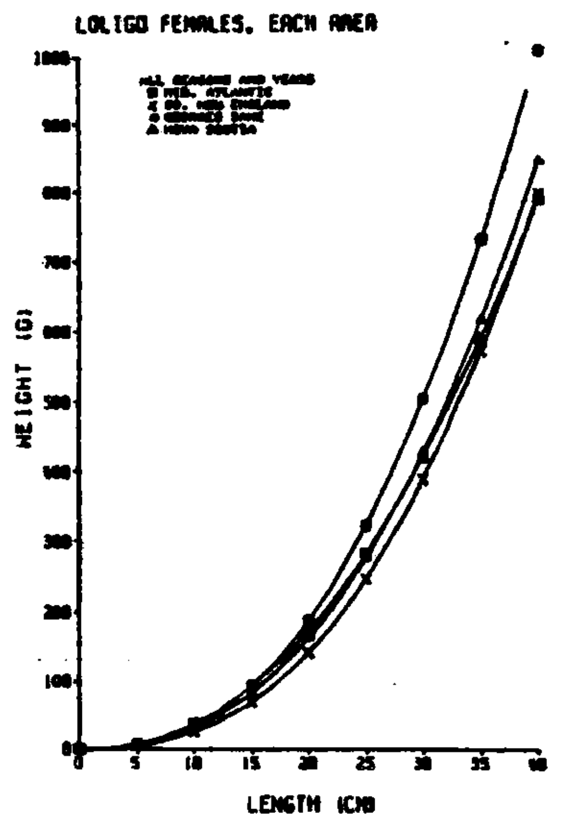



Figure 4f. *Loligo* length-weight relationships by area, each sex; all seasons and years.



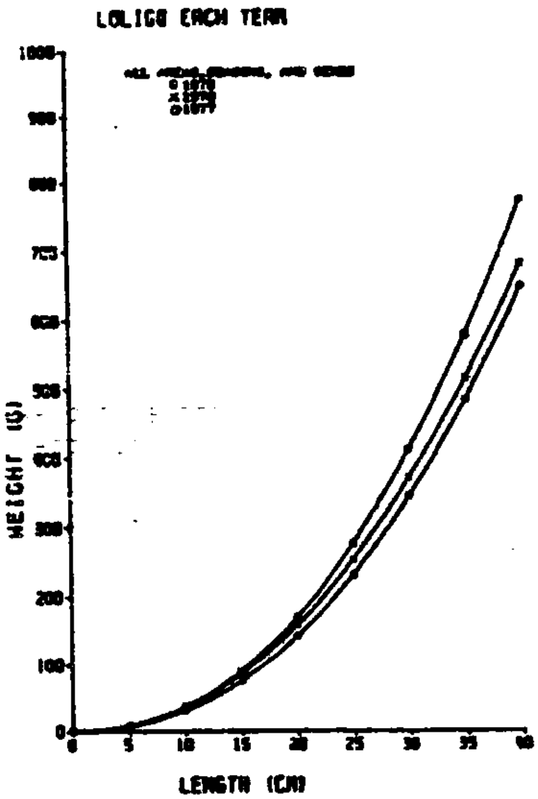
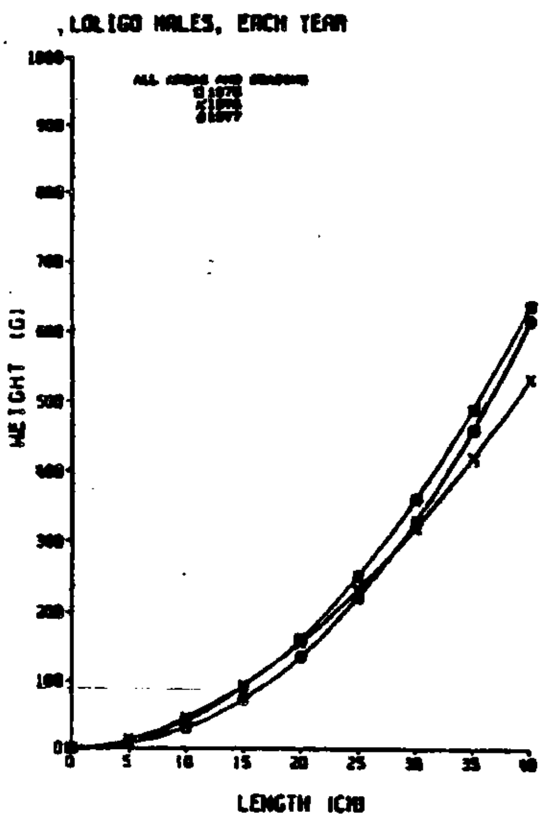
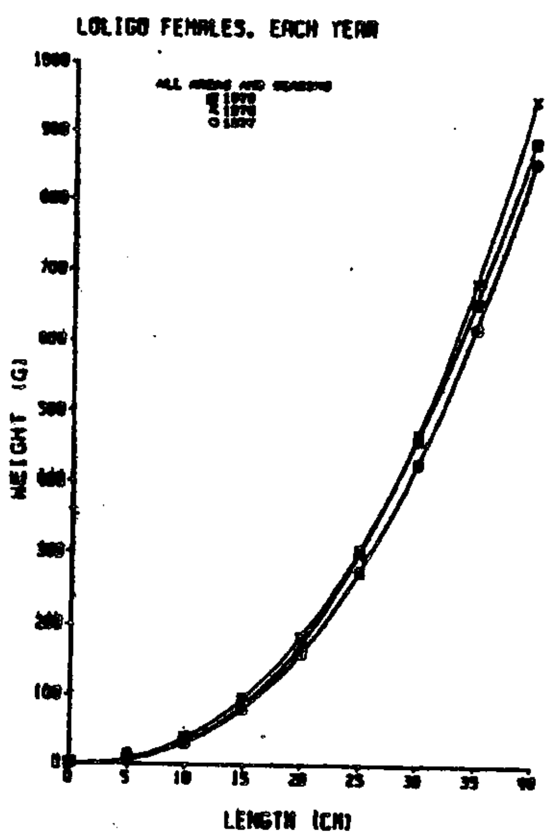



Figure 4g. Loligo length-weight relationships by year, each sex; all areas and seasons



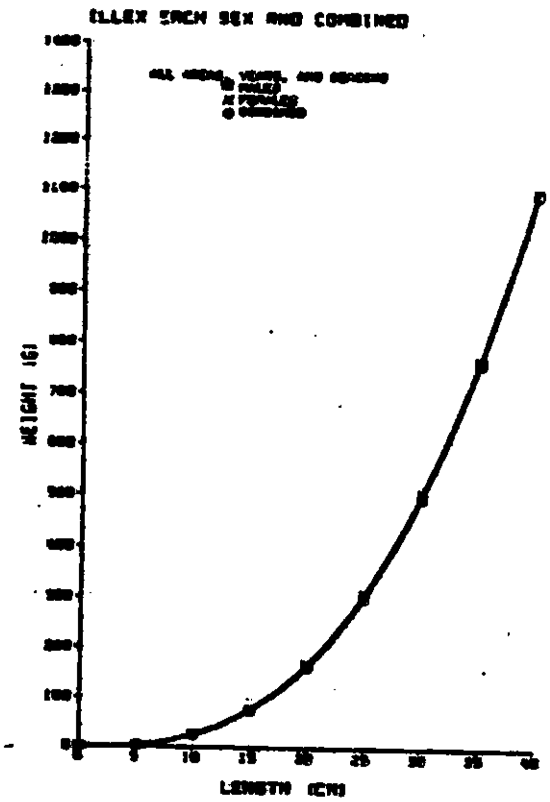



Figure 5a. Illex length-weight relationships by sex: all areas, years and seasons.

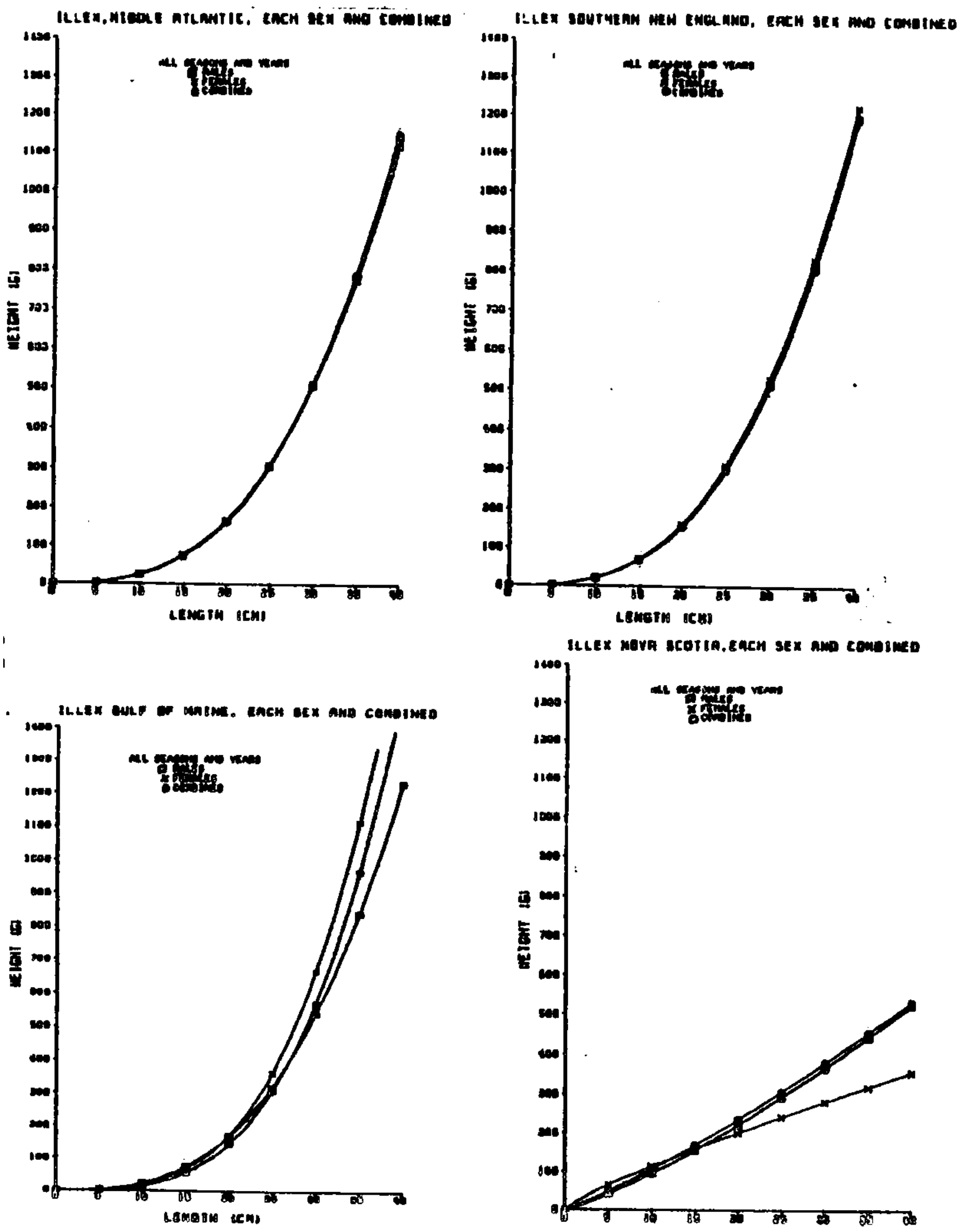
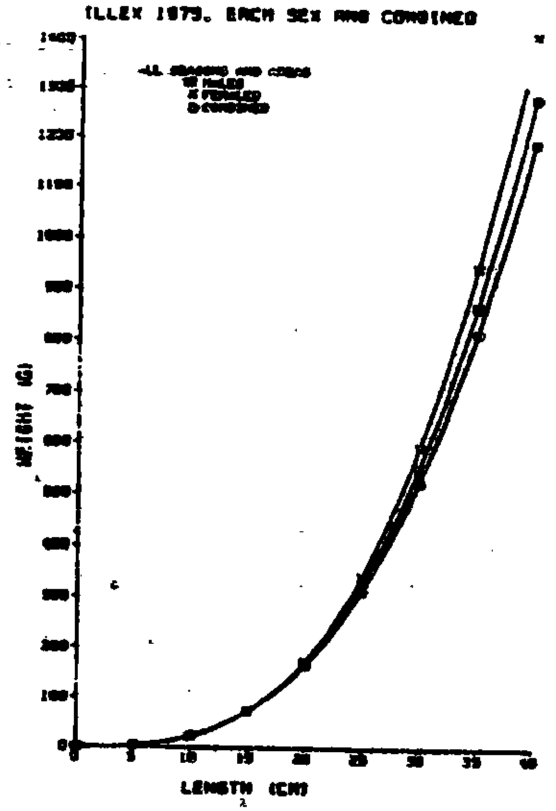
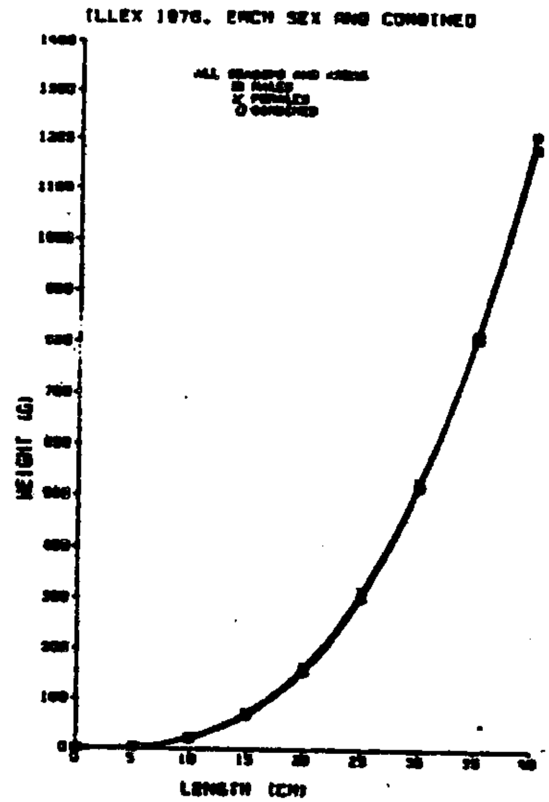



Figure 5b. *Illex* length-weight relationships by sex; each area: all seasons and years.



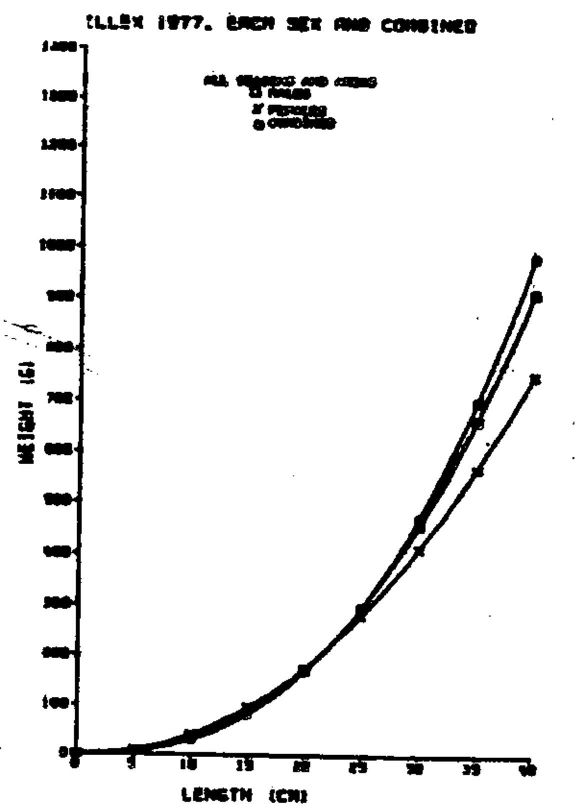
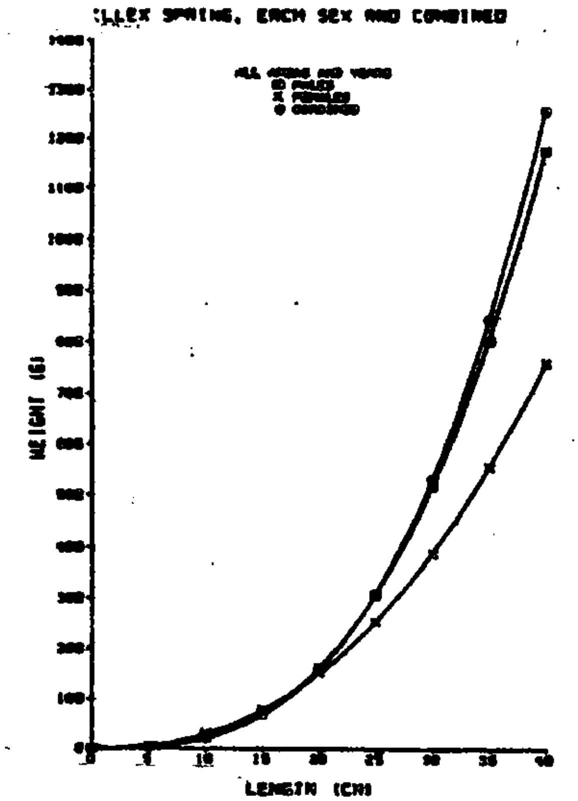
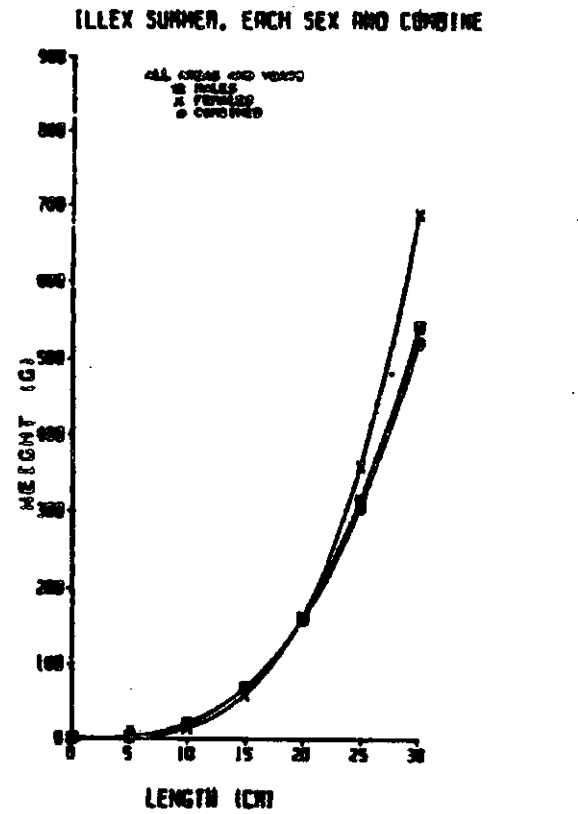




Figure 5c. *Illex* length-weight relationships by sex, each year: all areas and seasons.



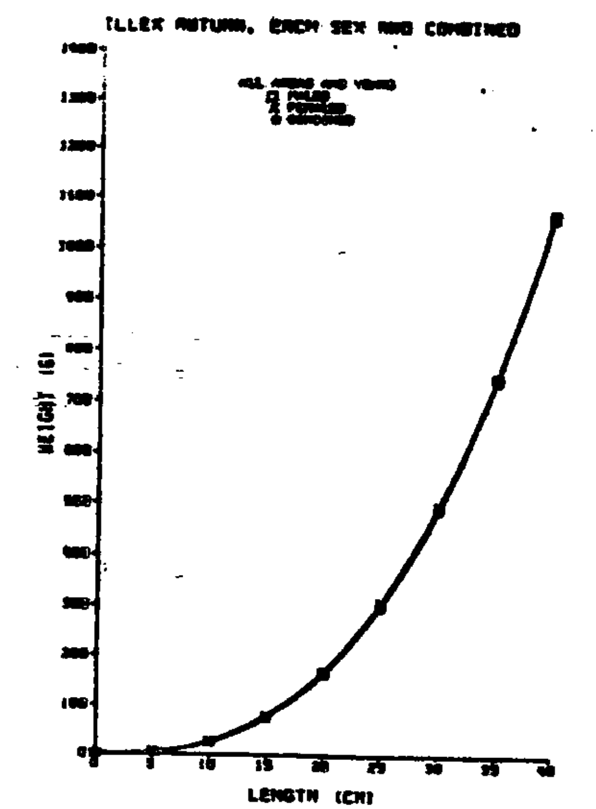




Figure 5d. <u>Illex</u> length-weight relationships by sex, each season: all areas and years.

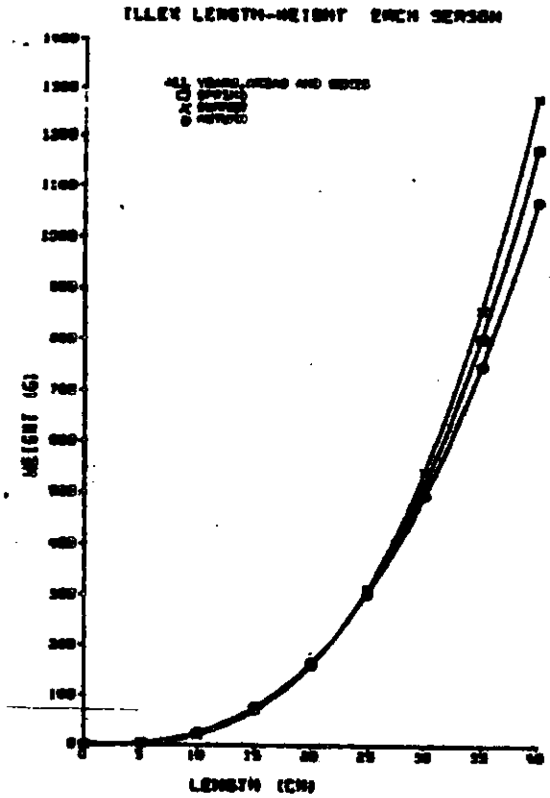
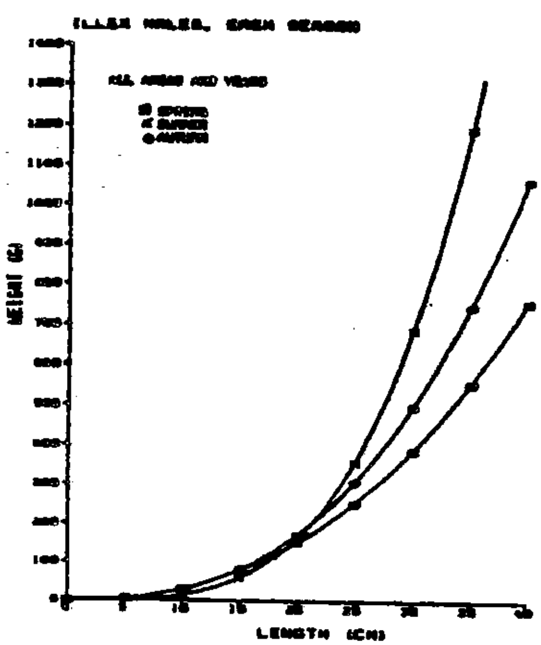
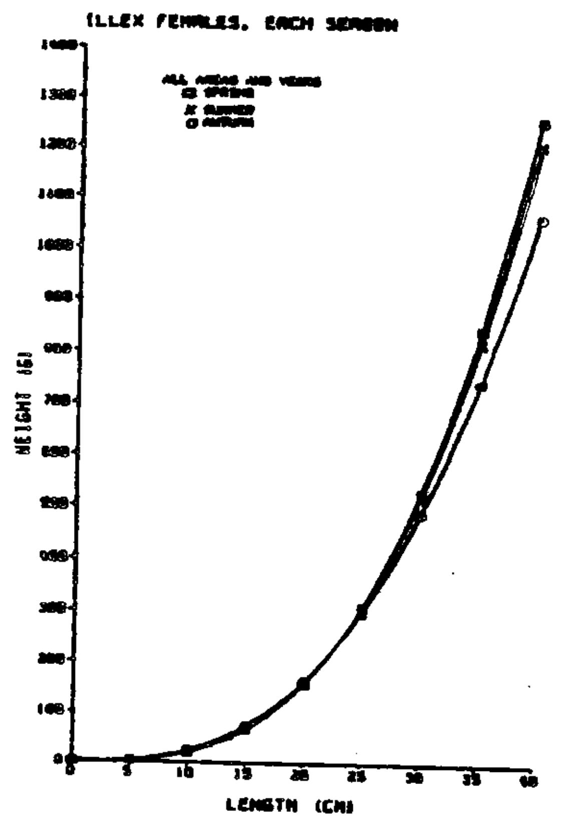



Figure 5e. *Illex* length-weight relationships by season; each sex; all areas and years.



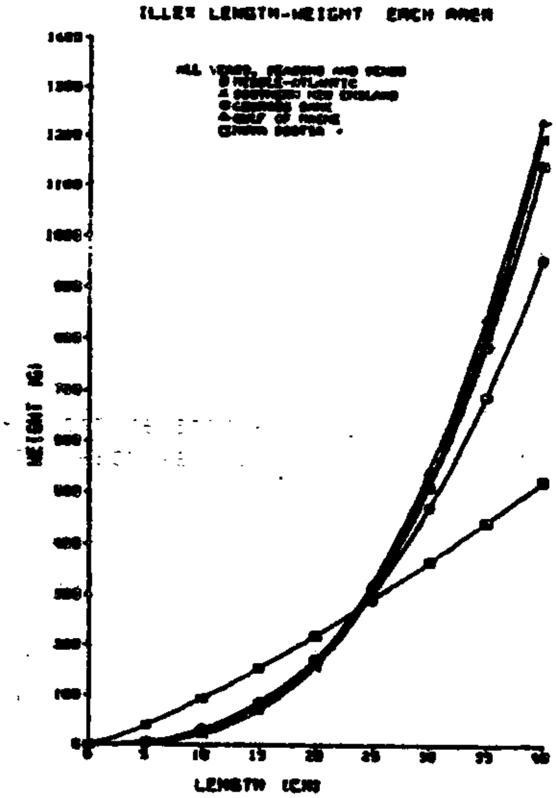
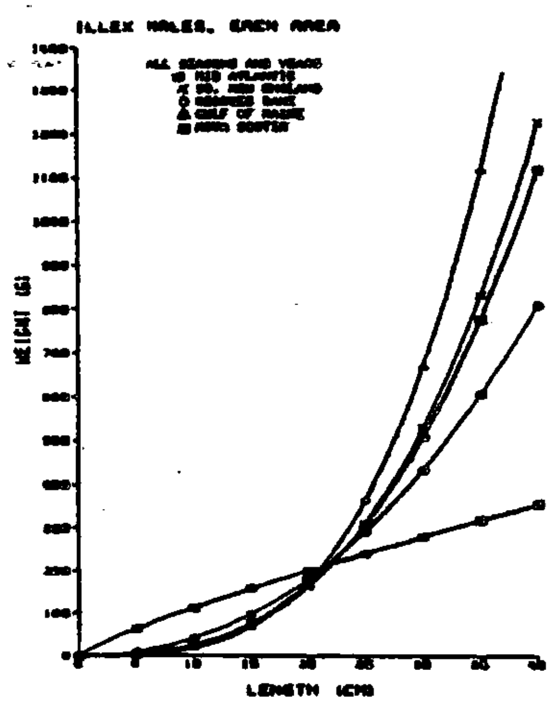
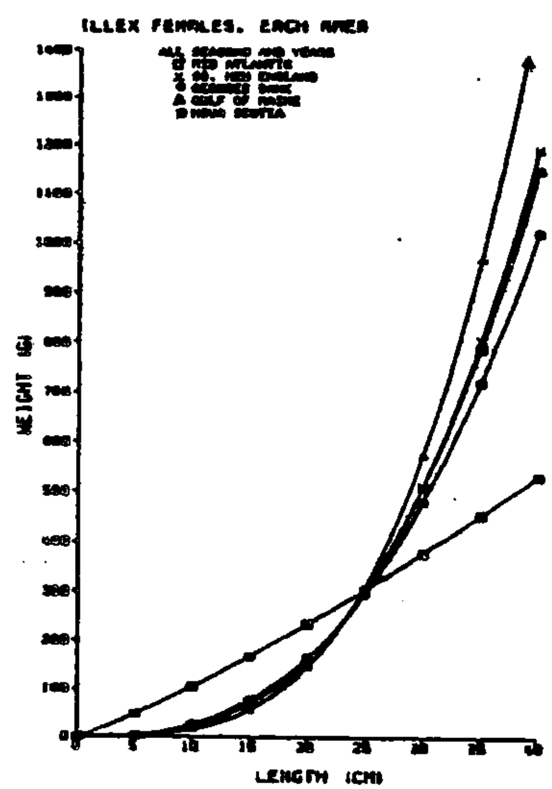



Figure 5f. Illex length-weight relationships by area, each sex; all seasons and years.



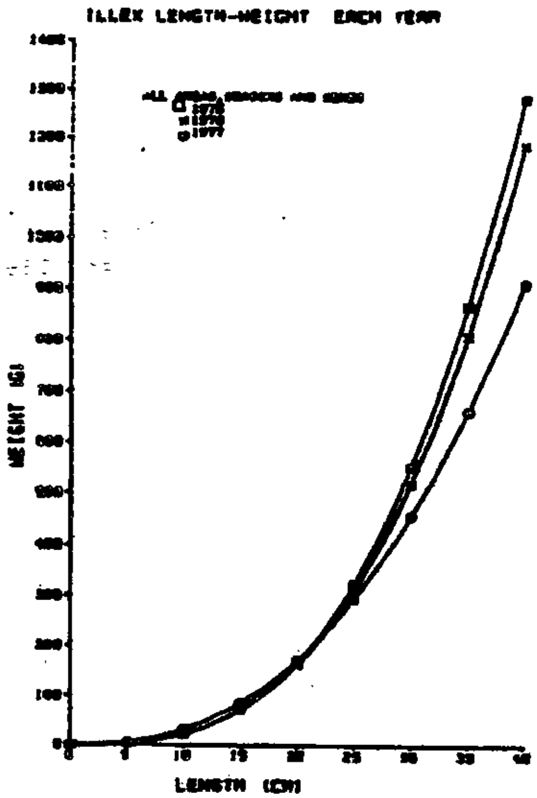



Figure 5g. *Illex* length-weight relationships by year, each sex; all areas and seasons.