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Variation in Length-Weight Relationships, Condition, and Feeding Spectrum of Short-finned Squid (*Illex illecebrosus*) at Holyrood, Newfoundland

by

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SPECIAL SESSION ON SQUIDS

INTRODUCTION

The short-finned squid (Illex illecebrosus) is a seasonal migrant to Newfoundland inshore waters, where it is fished commercially using jigging devices between July and November. Longevity for this species is believed to be approximately one year and the fishery is entirely dependent on a single year-class. The yearly Newfoundland inshore squid resource level fluctuates greatly. Since 1975 when a major market developed for short-finned squid, inshore catch levels have varied between 83,000 t in 1979 and 5 t in 1983 (Drew et al. MS 1984). Environmental relationships with Newfoundland inshore squid resource level have been described (Dawe and Hurley MS 1981) but little is known of biotic factors which may be related to yearly variations in squid abundance.

Coelho and Rosenberg (1984) described some causal relationships within years among squid abundance and several biotic and abiotic variables. They found that feeding intensity and abundance were strongly related on the Scotian Shelf in that gut fullness declines with abundance throughout the season. Short-finned squid are voracious predators, feeding almost exclusively on crustaceans, fish and squid (Squires 1957, Ennis and Collins 1979, Amaratunga MS 1980). Cannibalism is sometimes quite intense and it has been suggested that high incidence of cannibalism may reflect limited availability of other suitable prey types (Dawe et al. MS 1983).

In this paper an attempt is made to describe the effect of changes in feeding intensity and diet on condition or 'well being' of the squid population at Newfoundland. It was decided that variation in size would not necessarily reflect the 'well being' of the squid population since length and weight may be affected by time of spawning, presence of mixed age groups within a year-class, and size-dependent schooling. The approach taken therefore was to describe length-weight relationships and use those as a basis for examining variation in condition of squid. Variation in condition could then be examined by directly comparing predicted weights calculated from regression equations, at a standard length.

Seasonal and yearly effects on condition are related to changes in feeding intensity and diet. Annual variation in condition and feeding spectrum are also compared to levels of inshore squid abundance. The hypothesis is that if prey availability is a factor in regulating inshore resource level then squid condition would be poor and prey availability low during years of low squid abundance. If high squid biomass imposes stress on prey populations then poor condition and low availability of prey would be evident in years of high squid abundance, particularly late in the season after the period of intense feeding and rapid growth.

MATERIALS AND METHODS

The Data

Monthly squid samples were collected at Holyrood, Newfoundland (Fig. 1) using mechanical jigging devices during various years throughout the period 1964-82. Sampling inadequacies were generally due to unavailability of squid during some months or years. Samples were examined in either fresh condition or having been frozen and subsequently thawed.

Samples were measured in dorsal mantle length from the apex of the tail fin to the anterodorsal protuberance. Length determination may have been to the nearest centimeter or one-half centimeter but, in the latter case, lengths were later converted to centimeters. Total weight was determined to the nearest gram. Sex was determined and maturity stages assigned to males according to Mercer (MS 1973a). Stomachs were examined and fullness assessed as empty, small amount (not recently fed), half full, or full (recently fed). The occurrence of various food items in stomachs was recorded, where they could be identified. Parasite burdens were asssessed visually and, in females, nidamental glands were measured in length to the nearest millimeter. For 1966 and 1971 samples weights were also determined to the nearest gram for the mantle (head and all internal organs removed), digestive gland and gonad. Since total weights were not always determined, more data were available for analysis of feeding spectrum than for description of length-weight relationships.

Analysis and Treatment of Data

Linear regressions of weight (g) and length (cm) were calculated after logarithmic (base 10) transformation of the two variables, involving the data for total weight and, for 1966 and 1971, mantle weight. Relationships involving total weight were described by sex, month and year. Sample sizes are shown in Tables 1 and 2.

One-way analysis of covariance was used to determine significance of seasonal and yearly differences among slopes and y-intercepts. Where slopes were found to differ significantly at the 0.05 probability level pairwise comparisons were carried out to determine where differences occurred. Analysis of covariance was then employed to determine the significance of differences in y-intercepts for those relationships which did not differ significantly in slope.

As an index of condition for comparisons by season and year, a predicted total weight was calculated based on each relationship relative to the mean mantle length for the entire data set across which comparisons were made. Predicted weights were calculated only for those relationships which did not differ significantly in slopes. In relating squid condition to variations in inshore resource level predicted total weights were compared with a scale of inshore squid abundance, as originally developed by Squires (1957). That scale ranges from 1 (very low abundance) to 5 (very high abundance).

To determine if trends in condition were related to level of feeding or variation in the diet data from stomach analyses were summarized. The proportion of stomachs which were at least half full (recently fed) was used as an index of feeding intensity. Relative changes in diet were described using only those stomachs in which food could be identified as belonging to one of the three major prey categories - crustacean, fish, or squid. The relative proportion of these three prey categories were then summarized. Stomachs containing only small amounts of food were included for analysis of diet.

RESULTS

Length-weight Relationships and Conditions

The effect of sex on length-weight relationships was examined using both total weight and mantle weight for 1966 and 1971 (Fig. 2). All regressions were highly significant ($P < 0.001$) with coefficients of determination (r^2) ranging 0.92-0.98. Overall, the model appears to describe the empirical data adequately with mean square error terms ranging 0.0007-0.0025 for all relationships.

For the length-total weight relationships analysis of covariance indicated that for both years sexes differed significantly in slopes ($P < 0.001$). Slopes for males (3.60 and 3.73) were greater than those for females (3.23 and 3.39) indicating that increase in weight with length was greater for males than females. From inspection of the relationships it is clear that at lengths greater than 19 cm males were in better condition than females, being heavier at a given length. Because of these differenes sexes were not pooled for subsequent analyses.

Slopes for the length-mantle weight relationships were smaller than those for relationships involving length and total weight. For 1966 the slope for males (3.32) was significantly greater than that for females (3.06). For 1971 slopes for males (3.20) and females (3.12) were not significantly different and analysis of covariance showed that the y-intercept was significantly greater for females than males ($P < 0.001$). However for both years and at greater lengths males were in better condition than females, although the difference was not as pronounced as for the relationships involving total weight (Fig. 2).

The effect of season on condition of squid was examined for both sexes in 1971 and 1979 and for 1978 females. All regressions were highly significant ($P < 0.001$) with coefficients of determination ranging 0.55-0.94 (Table 1). Examination of residuals for representative montly regressions from a variety of years indicated that there was no systematic departure of empirical data from the fitted curves. Slopes varied considerably among months, showing no seasonal trend and fluctuating above and below 3.0 within all years for both sexes. For all but 1971 males monthly slopes differed significantly ($P < 0.05$). Pairwise comparisons showed where differences among slopes were significant and anomalous monthly slopes were identified for each year and sex. With months of anomalous slopes rejected, analysis of covariance showed that with the exception of 1979 females seasonal differences in y-intercepts were highly significant ($P < 0.001$, Table 1). For those years and sexes where y-intercepts differed significantly predicted monthly weights, calculated at the overall yearly length increased regularly throughout the season. Male predicted weights increased from 179.92 g and 168.68 g in July of 1971 and 1979, respectively, to 226.47 g and 216.39 g in November. Seasonal improvement of squid condition was also evident for females, increasing in predicted weight from 228.32 g and 217.34 g in July of 1971 and 1978, respectively, to 265.66 g and 249.01 g in November. Only for 1979 females was there no seasonal improvement in condition. Predicted weights at mean length were 265.38 g in August and 260.69 g in November.

Yearly length-weight relationships for each month by sex are presented in Table 2. All regressions were highly significant ($P < 0.001$). Coefficients of determination ranged 0.31-0.97 but were usually greater than 0.60. Slopes of fitted equations differed between sexes but not in any consistent manner. For all months and both sexes, slopes varied considerably among years. Analysis of covariance showed that yearly differences in slopes were significant ($P < 0.05$) for all months and sexes except July females ($P = 0.54$), September males ($P = 0.06$) and November females ($P = 0.06$). Pairwise comparisons among yearly slopes by month and sex showed where differences were significant and anomalous slopes were identified. Such comparisons were carried out for all but July females (i.e. in those cases where slopes differed at the 0.10 probability level).

With years of anomalous slopes rejected, analysis of covariance showed that differences in y-intercepts were significant ($P < 0.05$) in all cases and highly significant ($P < 0.001$) for all but August females. Predicted yearly weights at the mean monthly length across all years were calculated for each month and sex (Table 2). Predicted yearly weights differed considerably with differences between extreme years varying between 8 g for August females to 37 g for July females.

The relationship between predicted weight and yearly level of inshore squid abundance for each month is shown in Figure 3 for males and Figure 4 for females. For males (Fig. 3) low predicted weights and hence poor condition were related to years of very low to moderate abundance for all months except November. Only three years are compared for November, but in that month the predicted weight for 1971 (307.73 g) was higher than that for 1964 (284.54 g) and 1979 (306.36 g), two years of record high squid abundance. The same trends were seen for females (Fig. 4). For July, August and October squid were clearly in relatively poor condition during years of very low to moderate abundance and in much better condition during years of high abundance. This was most evident for July where predicted weights ranged 125.72-130.16 g for three years of low to moderate abundance (1966, 1971, 1981) and 136.59-162.45 g during the years of high abundance. Such a relationship was not evident for August and, as in the case of males, predicted weight during November was higher in 1971 than it was during two years of high abundance.

Feeding Intensity and Diet

Feeding intensity was generally quite low throughout the season with the proportion of stomachs which were at least half full (recently fed) seldom exceeding 40% (Fig. 5). Overall, feeding intensity was highest during July with proportion recently fed ranging 5-39% for males and 2-50% for females. It remained relatively high throughout the season during 1964 and 1965 but for all other years the proportion recently fed ranged 0-22% and 0-18% throughout August-November for males and females, respectively. There was no clear relationship between feeding intensity and level of inshore squid abundance.

Of the three major prey categories comprising the squid's diet, fish was the most common during July (Fig. 5). However, diet varied considerably among years in relation to level of squid abundance. In years of low to moderate squid abundance crustaceans represented a consistent component of the diet, being present in all cases except during September for both 1981 males and 1971 females. In such years and where crustaceans were present they ranged 1-58% in relative frequency of occurrence.

During years of high squid abundance crustacean was a component of the diet in only 37% of cases and was always insignificant except during August and September of 1980, when crustaceans occurred in 43-56% of stomachs. With that exception the proportion of stomachs containing crustaceans ranged 3-13% for those cases in years of high abundance when crustaceans were represented in the diet.

Seasonal trends in the diet during years of low to moderate abundance were not apparent. Crustacean remained a significant component but fish was overall more important, occurring in 10-86% of stomachs containing identifiable food, with the exception of September females in 1971 where only two stomachs contained food. Squid was consistently represented in the diet but never at very high levels, occurring in 11-54% of stomachs containing food, with the exception of September 1971 females.

Seasonal trends were quite pronounced however during years of high squid abundance (Fig. 5). Crustacean generally remained at insignificant levels throughout the season while occurrence of fish decreased and importance of squid increased. During July fish occurrence exceeded 80% in 75% of cases while squid occurrence exceeded 50% in only 17% of cases. During August-November fish occurrence was at much lower level, exceeding 80% occurrence in only 5% of cases (2 instances) and frequently not being represented in the diet at all, especially during 1977 and 1979. However, squid occurrence was at a much higher level during August-November than during July, exceeding 50% occurrence in 71% of cases. In some cases, especially during 1977 for both sexes and 1979 for males, the diet was comprised exclusively of squid during August-November.

Feeding characteristics during 1964 and 1965 are worthy of note as those years differed from other years of high abundance (Fig. 5). Feeding intensity remained relatively high for all months in those years and crustacean was completely absent from the diet. Most unusually, however, there was no seasonal trend for a shift from a predominantly fish diet toward cannibalism. During October 1965 occurrence of fish was still at a relatively high level (49% and 68% for males and females, respectively). Also unusual was the high occurrence of fish in diets during November 1978 (84% for males and 89% for females).

DISCUSSION

Overall yearly length-weight relationships described here for 1966 and 1971 (involving both total and mantle weights) were similar to generalized relationships described by Mercer (MS 1973b) with slopes greater than 3.0. Amaratunga (MS 1981) found that on the Scotian Shelf during 1977-80 slopes usually exceeded 3.0, whereas Lange and Johnson (1981) found that during 1975-77 slopes of relationships for short-finned squid on the Continental Shelf of the northern United States and on the Scotian Shelf were almost invariably less than 3.0. The considerable differences in regression equations for the Scotian Shelf in 1977 between Amaratunga (MS 1981) and Lange and Johnson (1981) may be due to the use of mean values for length and weight in regressions by the former author. Slopes of relationships presented here for 1966 and 1971 were greater for males than females, as also found by Mercer (MS 1973b) and Amaratunga (MS 1981). Males were in better condition than females for most sizes generally encountered in the commercial fishery.

While weight at length for large squid is overall greater for males than females considerable seasonal variation exists. For all years and both sexes slopes of length-total weight relationships differed significantly among months, fluctuating above and below 3.0 within most years. Slopes of monthly equations differed considerably between sexes but not in any consistent manner. Lange and Johnson (1981) found using 1975-77 data that slopes were significantly greater for males than females only during summer on the northern United States and Nova Scotian Continental Shelf.

Generalized length-weight relationships are not appropriate for different years. For all months and both sexes the form of the length-weight relationship differed significantly among years with predicted weight at a standard length varying by as much as 37 g. Lange and Johnson (1981) also found signficant yearly differences in length-weight relationships.

Squid condition generally improved throughout the season, although 1979 females represented an exception. This phenomenon was not related to trends in feeding intensity or diet since no such seasonal trends were apparent in years of low to moderate squid abundance. More likely, seasonal increase in weight at length is related to physiological changes associated with temperature or sexual maturation.

Condition was consistently lower in years of low to moderate squid abundance than in years of high abundance for all months except November. This was not related to variation in feeding intensity but rather to suitability of prey types available. Crustaceans, prominent in the diet during years of low to moderate abundance, represent a more unsuitable prey item than fish and squid which almost exclusively comprised the diet in years of high abundance. Crustacean are less suitable than other prey types due to the higher energy expenditure involved in securing a meal of such small prey. It is well known that early in the season squid feed almost exclusively on crustaceans on the Continental Shelf and then undergo a size-related shift in prey preference to larger prey types (Squires 1957, Amaratunga MS 1980, Ennis and Collins 1979). At Newfoundland squid may prey upon fish (mostly gadoids) as large as one-half the predator's own mantle length (Dawe et al. MS 1983) and may not feed on the day following consumption of a large meal (O'Dor et al. 1980). Thus relatively little energy is expended in preying upon large fish. Apparent deterioration of condition with length, as indicated by slopes of less than 3.0, for short-finned squid on the United States and Nova Scotian Continental Shelf (Lange and Johnson 1981) may be related to suitability of prey types in those areas. Vinogradov and Noskov (1979) found that in those areas during 1974 and 1975 crustaceans represented the most prominent prey type comprising 50.6% by weight of food items in stomachs of short-finned squid.

Yearly variation in squid condition at Holyrood may also be related to yearly differences in size of available gadoid prey. Dawe et al. (MS 1983) found that gadoid prey were much smaller during 1981, a year of moderate squid abundance than they were in 1980, a year of relatively high abundance. Gadoids consumed at several inshore localities were generally 7-10 cm in total length during 1980, but only 3.5-5.5 cm in 1981.

During years of high squid abundance suitable fish prey is generally abundant early in the season at Newfoundland. The striking shift from a predominantly fish diet to one of squid after July suggests that large squid populations quickly consume much of the fish prey available and resort to cannibalism thereafter. Cannibalism may also be promoted in such years by high squid density and the development of intra-school size disparity which results from hierarchial feeding and variable growth within schools (O'Dor et al. 1980, Dawe et al. MS 1983). It is apparent however that the shift to cannibalism does not merely reflect opportunity but is related to depletion of other suitable prey types. During 1964 and 1965 (two years of high squid abundance) feeding intensity remained higher throughout the year than for all other years, indicating an unusually high level of prey abundance. There was no prominent seasonal trend toward cannibalism in those years. Further, O'Dor et al. (1980) found that in captivity cannibalism only occurred when other food was unavailable. The absence of a pronounced seasonal shift toward cannibalism in years of low to moderate squid abundance suggests that fish and crustacean prey are not severely depleted by small squid populations. Also, during such years, there would be less opportunity for cannibalism due to lower squid density and frequency of encounters.

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Table 1. Monthly re-transformed equations by year and sex for length-total weight relationships of short-finned squid at Holyrood, Newfoundland, with results of covariance analysis and predicted weights at mean length (both sexes for 1971 and 1979 and 1978 females). Asterisks indicate months of anomalous slopes which were rejected for analysis of y-intercepts and for which predicted weights at $\bar{L}$ were not calculated.

Year	Sex $\bar{L}$ (cm)	Analysis of slopes F (p)	Month	Equation	r^2	N	Analysis of intercepts F (p)	Predicted wt at $\bar{L}$ (g)
1971	Male 21.74	0.52 (0.6752)					68.27 (0.0001)	
			July	$W = 0.0141L^{3.07}$	0.88	54		179.72
			Aug.	$W = 0.0219L^{2.94}$	0.82	142		187.06
			Sept.	$W = 0.0046L^{3.46}$	0.79	17		194.84
			Nov.	$W = 0.0162L^{3.10}$	0.71	79		226.47
			TOTAL			**292**		
	Female 23.72	2.67 (0.0470)					23.73 (0.0001)	
			July	$W = 0.0117L^{3.12}$	0.86	33		228.32
			Aug.	$W = 0.0135L^{3.09}$	0.87	152		239.57
			*Sept.	$W = 0.0012L^{3.86}$	0.94	16		-
			Nov.	$W = 0.0282L^{2.89}$	0.88	127		265.66
			TOTAL			**328**		
1978	Female 23.10	4.88 (0.0007)					11.25 (0.0001)	
			July	$W = 0.0257L^{2.88}$	0.80	46		217.34
			*Aug.	$W = 0.0039L^{3.49}$	0.82	44		-
			*Sept.	$W = 0.0032L^{3.55}$	0.87	109		-
			Oct.	$W = 0.0288L^{2.87}$	0.72	164		236.03
			Nov.	$W = 0.0457L^{2.74}$	0.68	109		249.01
			TOTAL			**472**		
1979	Male 21.10	3.26 (0.0127)					8.08 (0.0001)	
			July	$W = 0.0776L^{2.52}$	0.73	63		168.68
			*Aug.	$W = 0.0038L^{3.55}$	0.86	62		-
			Sept.	$W = 0.0166L^{3.07}$	0.55	34		193.04
			Oct.	$W = 0.0234L^{2.97}$	0.68	53		200.60
			Nov.	$W = 0.0575L^{2.70}$	0.66	24		216.39
			TOTAL			**236**		
	Female 23.96	2.74 (0.0298)					0.14 (0.9327)	
			*July	$W = 0.0646L^{2.60}$	0.76	37		-
			Aug.	$W = 0.0042L^{3.48}$	0.89	38		265.38
			Sept.	$W = 0.0056L^{3.38}$	0.80	66		257.55
			Oct.	$W = 0.0052L^{3.40}$	0.80	47		254.83
			Nov.	$W = 0.0032L^{3.56}$	0.83	26		260.69
			TOTAL			**214**		

Table 2. Yearly re-transformed equations by month and sex for length-total weight relationships of short-finned squid at Holyrood, Newfoundland, with results of covariance analysis and predicted weights at mean length (various years). Asterisks indicate months of anomalous slopes which were rejected for analysis of y-intercepts and for which predicted weights at $\bar{L}$ were not calculated.

Month	Sex $\bar{L}$ (cm)	Analysis of slopes F (p)	Year	Equation	r^2	N	Analysis of intercepts F (p)	Predicted wt at $\bar{L}$ (g)
July	Male	3.40					39.92	
	18.90	(0.0015)					(0.0001)	
			1964	$W = 0.0275L^{2.87}$	0.86	10		126.70
			1966	$W = 0.0054L^{3.38}$	0.93	31		111.39
			1967	$W = 0.0039L^{3.51}$	0.88	28		117.88
			1971	$W = 0.0141L^{3.07}$	0.88	54		116.94
			1978	$W = 0.0145L^{3.08}$	0.76	56		123.84
			*1979	$W = 0.0776L^{2.52}$	0.73	63		-
			1980	$W = 0.0204L^{3.02}$	0.80	36		146.06
			*1981	$W = 0.0589L^{2.57}$	0.70	335		-
			TOTAL			**613**		
July	Female	0.86					28.43	
	19.81	(0.5355)					(0.0001)	
			1964	$W = 0.0034L^{3.55}$	0.90	15		136.59
			1966	$W = 0.0089L^{3.20}$	0.96	21		125.72
			1967	$W = 0.0324L^{2.81}$	0.89	26		142.82
			1971	$W = 0.0117L^{3.12}$	0.86	33		130.16
			1978	$W = 0.0257L^{2.88}$	0.80	46		139.62
			1979	$W = 0.0646L^{2.60}$	0.76	37		152.10
			1980	$W = 0.0468L^{2.73}$	0.74	14		162.45
			1981	$W = 0.0219L^{2.90}$	0.81	417		126.30
			TOTAL			**609**		
Aug.	Male	4.94					79.30	
	20.31	(0.0001)					(0.0001)	
			1964	$W = 0.0170L^{3.04}$	0.80	72		160.65
			*1966	$W = 0.0052L^{3.40}$	0.96	60		-
			1971	$W = 0.0219L^{2.94}$	0.82	142		153.15
			1978	$W = 0.0427L^{2.71}$	0.64	56		149.39
			1979	$W = 0.0038L^{3.55}$	0.86	62		-
			1980	$W = 0.0174L^{3.03}$	0.78	93		159.56
			1981	$W = 0.0389L^{2.71}$	0.59	650		136.09
			TOTAL			**1135**		
Aug.	Female	6.34					3.97	
	21.02	(0.0001)					(0.0086)	
			*1964	$W = 0.0363L^{2.80}$	0.76	53		-
			1966	$W = 0.0148L^{3.05}$	0.97	62		160.06
			1971	$W = 0.0135L^{3.09}$	0.87	152		164.92
			1978	$W = 0.0039L^{3.49}$	0.82	44		161.08
			1979	$W = 0.0042L^{3.48}$	0.89	38		168.27
			*1980	$W = 0.0019L^{3.74}$	0.91	56		-
			*1981	$W = 0.0037L^{3.48}$	0.82	588		-
			TOTAL			**993**		
Sept.	Male	2.01					17.62	
	22.00	(0.0643)					(0.0001)	
			*1964	$W = 0.0871L^{2.52}$	0.70	23		-
			1966	$W = 0.0083L^{3.25}$	0.89	44		191.40
			1971	$W = 0.0046L^{3.46}$	0.79	17		203.02
			1978	$W = 0.0056L^{3.40}$	0.77	91		205.32
			1979	$W = 0.0166L^{3.07}$	0.56	34		219.46
			1980	$W = 0.0115L^{3.19}$	0.81	91		220.30
			*1981	$W = 0.0003L^{4.36}$	0.83	21		-
			TOTAL			**321**		

Table 2. Continued.

Month	Sex $\bar{L}$ (cm)	Analysis of slopes F (p)	Year	Equation	r^2	N	Analysis of intercepts F (p)	Predicted wt at $\bar{L}$ (g)
Sept.	Female 23.61	2.91 (0.0087)					13.13 (0.0001)	
			*1964	$W = 0.0309L^{2.85}$	0.87	25		-
			1966	$W = 0.0074L^{3.27}$	0.96	26		228.69
			1971	$W = 0.0012L^{3.86}$	0.94	16		239.51
			1978	$W = 0.0032L^{3.55}$	0.87	109		239.68
			1979	$W = 0.0056L^{3.38}$	0.80	66		245.05
			1980	$W = 0.0081L^{3.28}$	0.91	159		258.37
			*1981	$W = 0.0513L^{2.65}$	0.65	29		-
			TOTAL			**430**		
Oct.	Male 22.78	8.26 (0.0001)					9.94 (0.0001)	
			1964	$W = 0.0056L^{3.42}$	0.85	61		246.05
			1966	$W = 0.0062L^{3.37}$	0.78	65		232.99
			*1978	$W = 0.5754L^{1.94}$	0.31	127		-
			1979	$W = 0.0234L^{2.97}$	0.68	53		251.85
			*1980	$W = 0.0007L^{4.05}$	0.78	25		-
			TOTAL			**331**		
Oct.	Female 24.61	3.64 (0.0063)					7.62 (0.0001)	
			1964	$W = 0.0085L^{3.26}$	0.90	56		291.37
			1966	$W = 0.0115L^{3.14}$	0.92	66		268.40
			*1978	$W = 0.0288L^{2.87}$	0.72	164		-
			1979	$W = 0.0052L^{3.40}$	0.80	47		279.11
			1980	$W = 0.0037L^{3.50}$	0.94	75		273.59
			TOTAL			**408**		
Nov.	Male 24.00	3.68 (0.0130)					15.93 (0.0001)	
			1964	$W = 0.0037L^{3.54}$	0.62	33		284.54
			1971	$W = 0.0162L^{3.10}$	0.71	79		307.73
			*1978	$W = 0.3802L^{2.08}$	0.39	91		-
			1979	$W = 0.0575L^{2.70}$	0.66	24		306.36
			TOTAL			**227**		
Nov.	Female 25.29	2.48 (0.0597)					17.64 (0.0001)	
			1964	$W = 0.0282L^{2.87}$	0.83	71		299.72
			1971	$W = 0.0282L^{2.89}$	0.88	127		319.72
			1978	$W = 0.0457L^{2.74}$	0.68	109		319.15
			*1979	$W = 0.0032L^{3.56}$	0.83	26		-
			TOTAL			**333**		

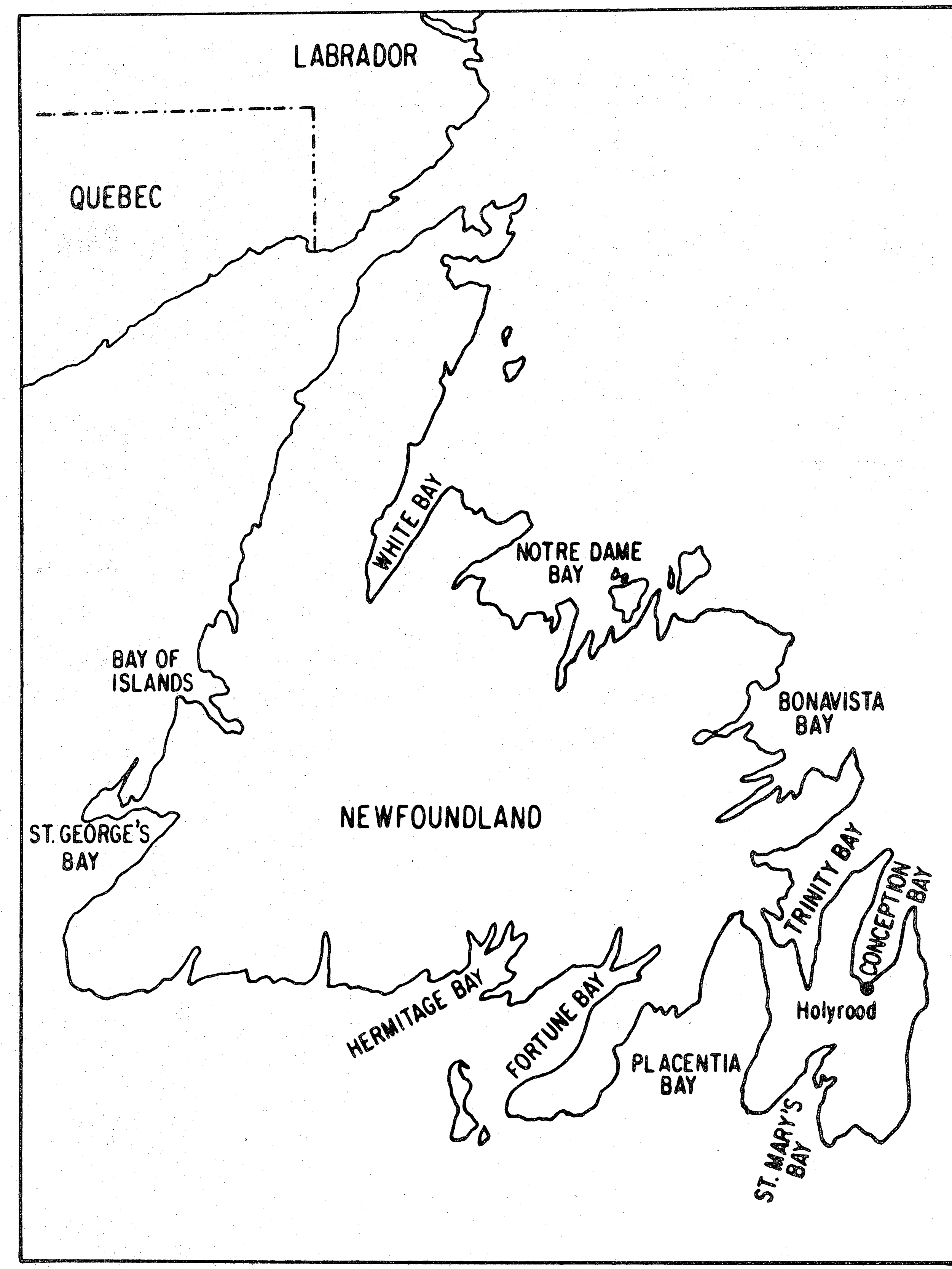

Fig. 1. Map of insular Newfoundland showing the location of sampling at Holyrood.

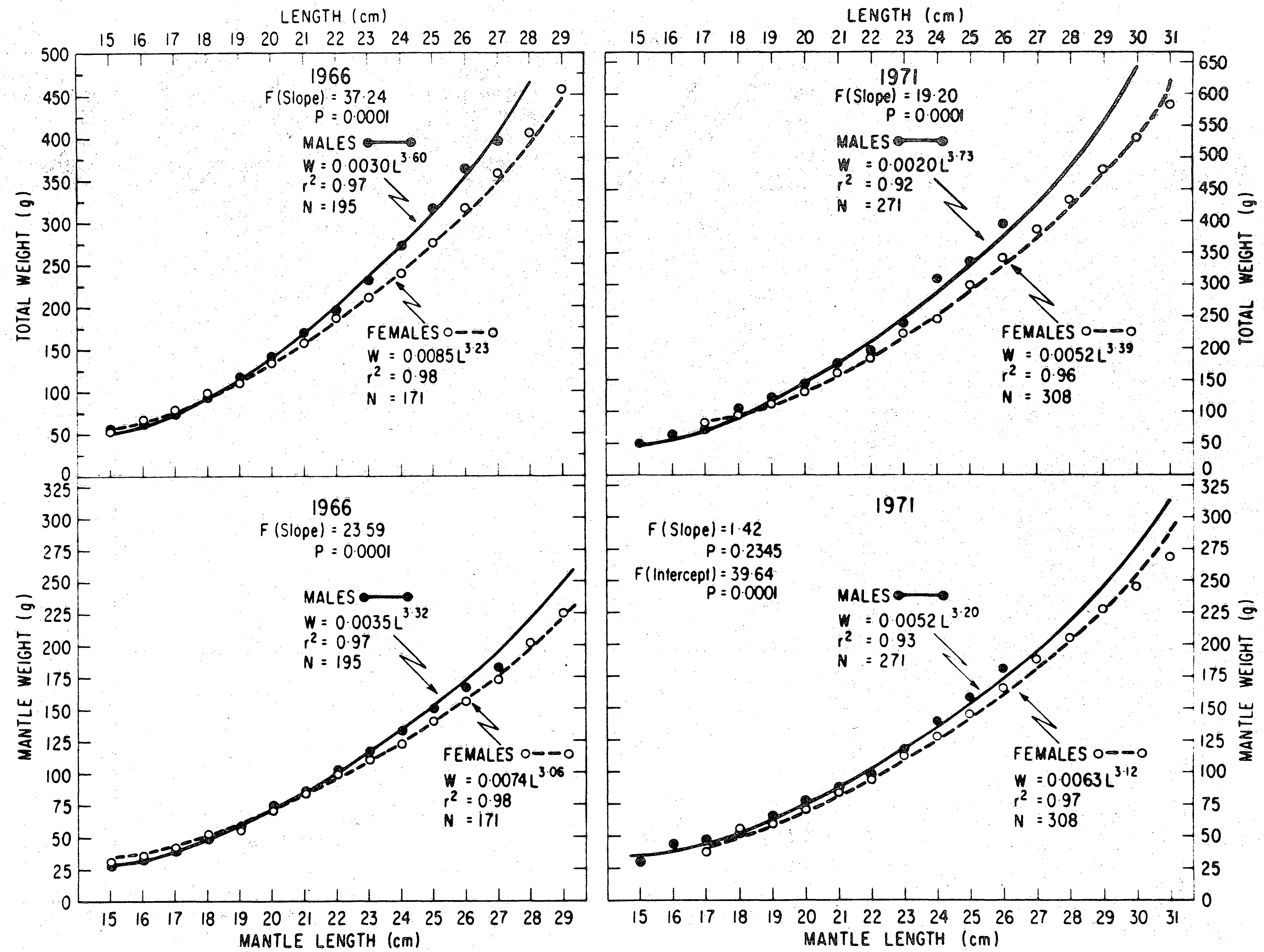

Fig. 2. Length-weight relationships (sexes separate) for short-finned squid at Holyrood, Newfoundland, 1966 and 1971, with results of covariance analysis between sexes. Relationships were described using data for total weight (top) and mantle weight (bottom). (Plotted points are mean weight at length values.)

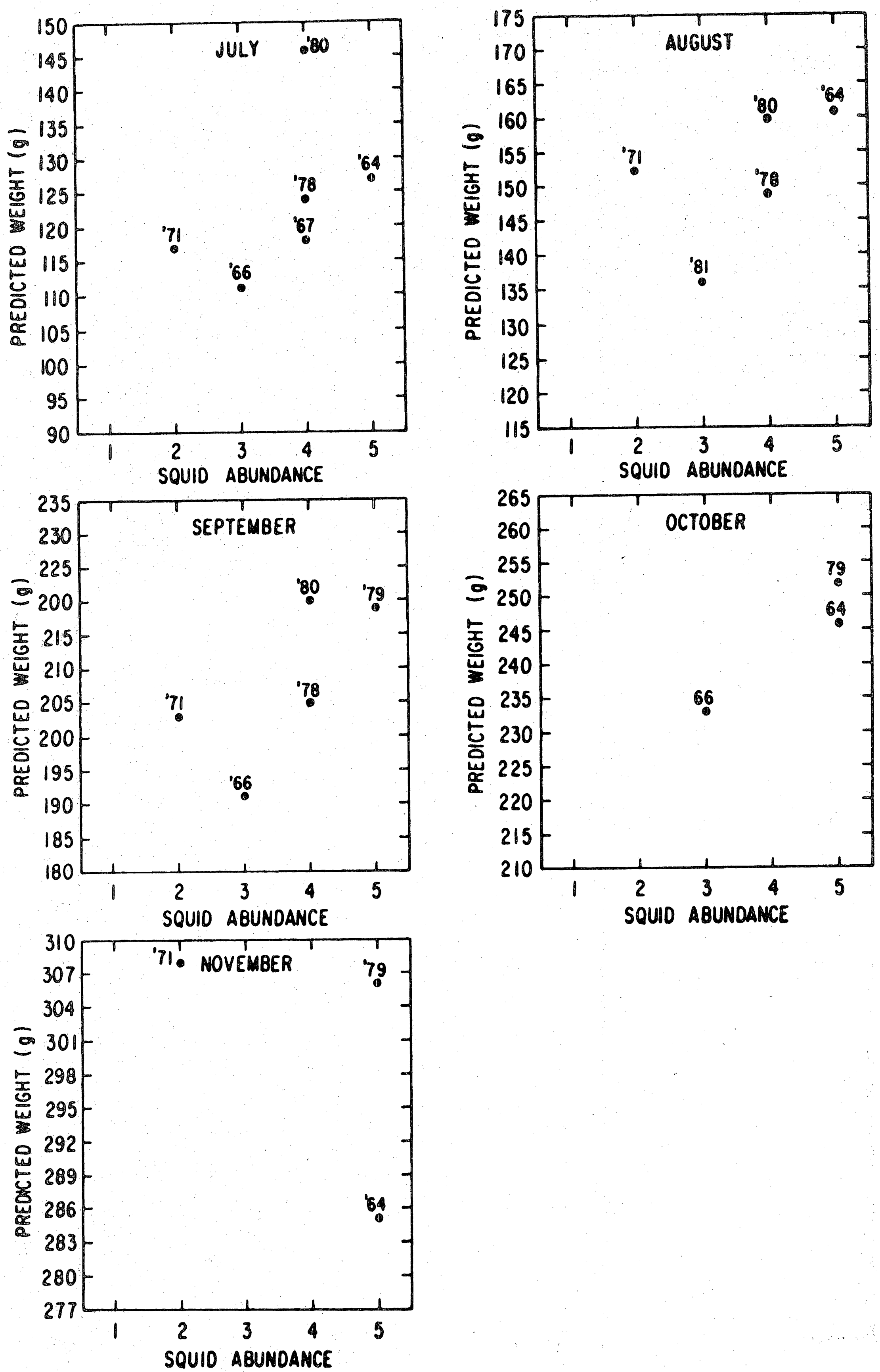

Fig. 3. Relationship, for male short-finned squid at Holyrood, between predicted weight (from monthly equations) at overall mean length for all years and yearly level of inshore squid abundance.

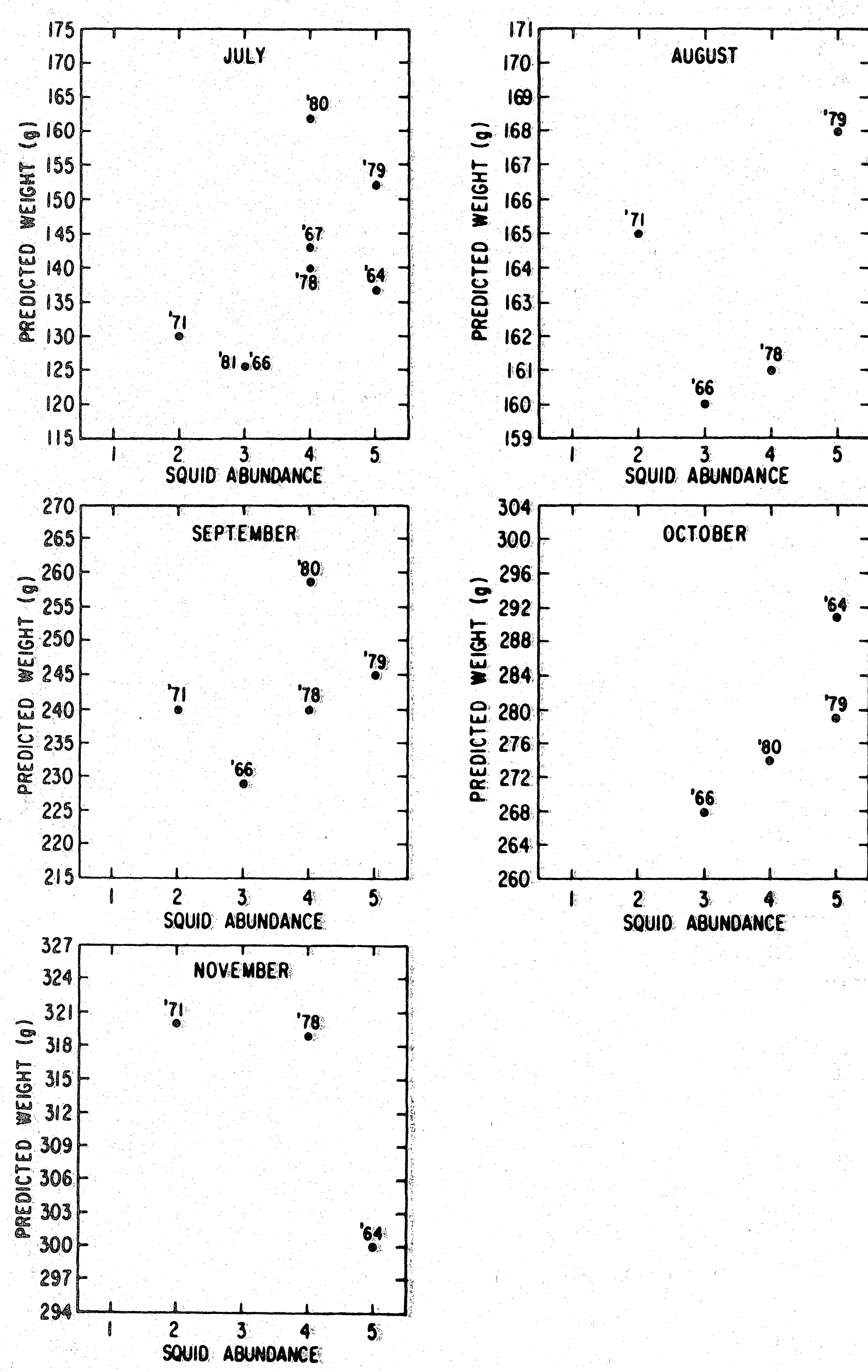

Fig. 4. Relationship, for female short-finned squid at Holyrood, between predicted weight (from monthly equations) at overall mean length for all years and yearly level of inshore squid abundance.

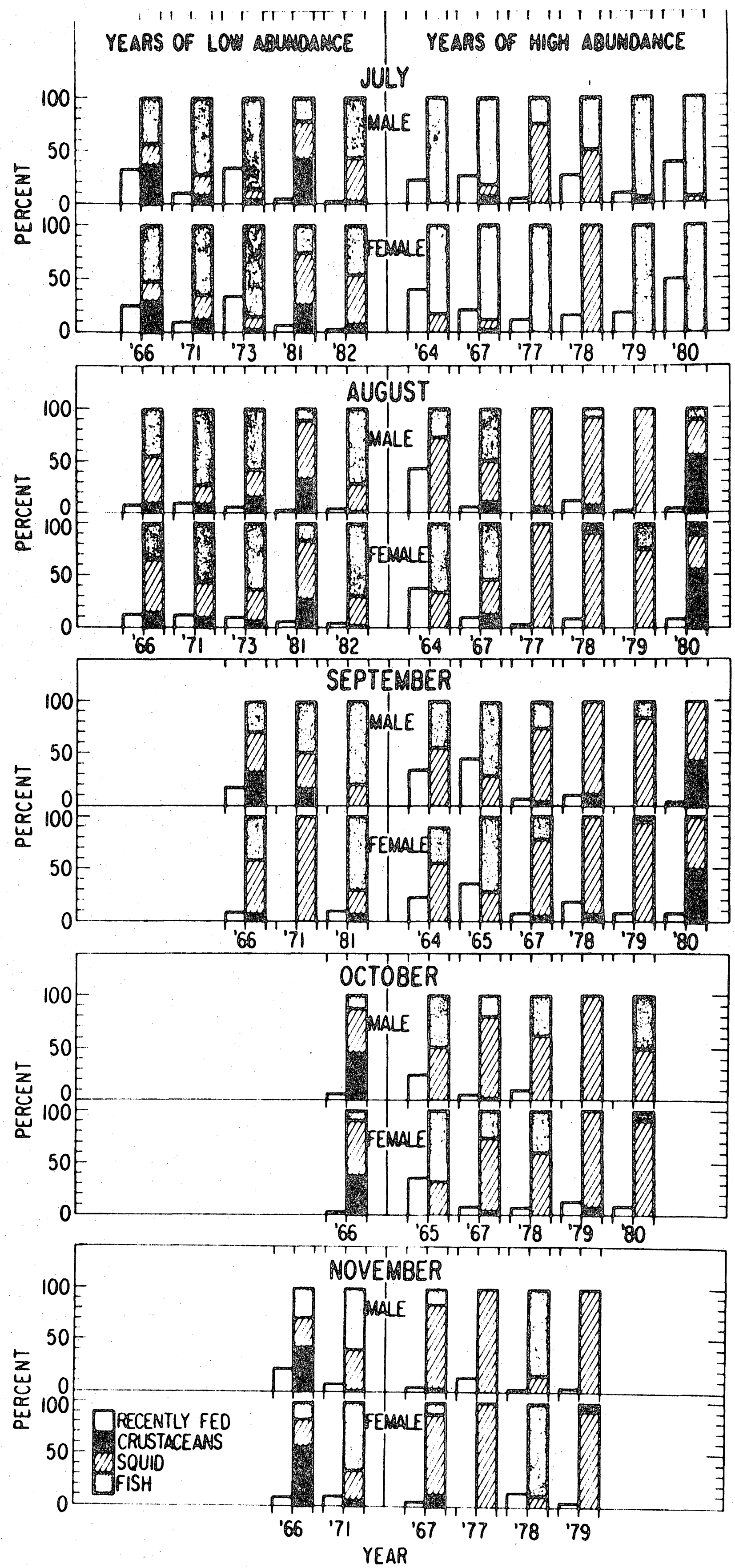

Fig. 5. Breakdown by month, sex, and year of proportion of squid stomachs collected at Holyrood which were at least half full (recently fed) and relative frequency of occurrence of the three major prey types for those stomachs which were not empty. Years are grouped into two general levels of inshore squid abundance.