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Predation by Atlantic Cod (*Gadus morhua*) on Short-finned Squid (*Illex illecebrosus*) off eastern Newfoundland and in the northeastern Gulf of St. Lawrence

by

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Abstract

In years of high abundance, the short-finned squid (Illex illecebrosus) was a common prey of Atlantic cod (Gadus morhua) in summer and autumn in both inshore and offshore waters of eastern Newfoundland and in the eastern and northern Gulf of St. Lawrence. The frequency of occurrence of squid in cod stomachs and the number of squid per stomach increased with cod length. The intensity of predation by cod on squid was low compared with peak predation on capelin (Mallotus villosus) and sand lance (Ammodytes sp.). Nevertheless, the annual immigration of squid in years of high abundance provided an increase in total food availability, especially for large cod.

Introduction

A dominant feature of the marine environment of eastern Newfoundland is the spring migration of many aquatic animals into the warming, near-surface waters, particularly near the coast. Capelin (Mallotus villosus) migrate from the offshore banks to spawn in coastal waters in late June and July (Templeman 1948), and are preyed upon intensively by Atlantic cod (Gadus morhua) which have migrated to shallow inshore areas from warm, deep water offshore (Templeman 1965, 1966). Short-finned squid (Illex illecebrosus) arrive in coastal waters in July from warm water south of the Grand Banks (Squires 1957). In contrast to capelin, squid are reported (Thompson 1943; Templeman and Fleming, 1956) to be preyed upon only occasionally by cod, even though squid is an excellent bait for cod. Templeman and Fleming (1956) note that squid are typically in the shallower layers of water whereas cod move progressively deeper in late summer and autumn to avoid the warm temperature in shallow water.

This paper will present more recent observations illustrating that cod frequently prey upon squid in the summer and autumn in eastern Newfoundland and the Gulf of St. Lawrence. The intensity of predation by cod on squid will be compared with the intensity of their predation on other prey, particularly capelin. In addition, to determine whether the annual immigration of squid represents a significant but variable pulse of prey for cod, the intensity of total food consumption by cod during the autumn in a year of high squid abundance will be compared with that in years of low squid abundance.

Materials and Methods

Stomachs were collected from cod caught by poundnet, gillnet, and baited hook (handline) in the commercial fishery near Trouty, Trinity Bay (Fig. 1), in June-August 1980 (Table 1). Stomachs were examined without fixation on the day of capture. Prey were separated into taxonomic categories and the volume of individuals in each taxon was measured to the nearest cc in a graduated cylinder.

Stomachs were collected from cod caught in research gillnets set in 40-102 m, but primarily in 70-90 m, off the Horse Chops, Trinity Bay (Fig. 1) in October 1967 and November 1968 (Table 1). Most stomachs were examined fresh at sea. The two major food types in terms of mass were recorded for each stomach. In addition, one sample each year was preserved in 10% formalin for detailed examination in the laboratory. Examination included separation of food items into taxonomic categories. Items in each taxon were placed briefly on absorbent paper to remove excess liquid and then weighed to the nearest 0.1 g.

Cod and squid were caught during a line-transect bottom-trawl survey by the research side trawler A. T. Cameron (Trip 295) in October 1979 off southeastern Newfoundland in a triangular area from off Cape Bonavista to Cape Race to the Virgin Rocks. Stomachs were collected from a stratified-random sample of up to 5 cod per 10 cm length-group from the catch of each of the 46 sets. Stomachs were preserved in formalin and examined in detail in the laboratory, as described above. The number of embedded pairs of squid beaks in each stomach was recorded. The hood lengths of upper beaks were measured to the nearest 0.01 mm using vernier calipers under a dissecting microscope. The dorsal mantle lengths of the squid were estimated from the following relationship, which was derived from paired measurements of dorsal mantle length (DML, cm) and hood length of upper beak (UHL, mm) of the specimens described by Mercer et al. (1980):

$$DML = 300.70 \log_{10} UHL - 123.92 \quad (n = 115;\ r^2 = 0.93).$$

Additional samples of cod stomachs were collected off southeast Newfoundland during stratified-random bottom-trawl surveys of Div. 3L (Doubleday, 1981) in October-December 1982 by the A. T. Cameron (Trips 333, 334) and the stern-trawler Wilfred Templeman (Trip 1) and in October-November 1983 by the Wilfred Templeman (Trips 7, 8, 9). Stomachs were excised from a stratified-random sample of 3 cod per 9 cm length-group per set, preserved in 10% formalin, and examined in the laboratory.

Cod and squid were caught during stratified-random bottom-trawl surveys in the eastern and northern Gulf of St. Lawrence (Doubleday 1981) by the A. T. Cameron in October 1978 (Trip 283) and September-October 1979 (Trip 294). In 1978 stomachs were collected opportunistically from cod from some of the sets and examined in detail. Some additional stomachs were examined at sea. In 1979 a portion of the catch of some sets was examined at sea.

The relative quantity of food in the stomachs and the relative importance of individual prey types was assessed using three indices:

1) Percent occurrence (number of stomachs with specific prey as percentage of total number of stomachs).

2) Percent weight (total weight of specific prey in all stomachs as percentage of total weight of all prey) (gravimetric method).

3) Stomach fullness index:

Mean total fullness index (TFI) =

$$\frac{1}{n} \sum_{f=1}^{n} \frac{\text{mass of stomach contents of fish}_f}{(\text{length of fish}_f)^3} \times 10^4$$

where n is the number of stomachs examined and mass is volume or weight of prey.

Mean partial fullness of prey_p (PFI_p) =

$$\frac{1}{n} \sum_{f=1}^{n} \frac{\text{mass of prey}_p \text{ in fish}_f}{(\text{length of fish}_f)^3} \times 10^4.$$

Results

Eastern Newfoundland inshore

The dominant prey of cod caught in the shallow-water commercial fishery at Trouty, Trinity Bay, in summer 1980 was capelin (Table 1, Fig. 2). Squid first occurred on July 17 and were recorded frequently after that date, attaining PFI values greater than 1.0 on several days in early August. Squid was a more important prey than capelin on several days in late August, but at no time did the PFI values for squid reach the high values recorded for capelin during the capelin spawning season (approximately late June to end of July).

Squid were found in stomachs of cod caught with gillnets off the Horse Chops in Trinity Bay in 1967 (Table 1). The PFI value for squid in the sample examined in detail was low (0.37), and the frequency of occurrence in stomachs examined at sea was also low (19%). Squid were not found in cod stomachs in 1968. Squid abundance was rated high in 1967 and very low in 1968 (abundance index of 4 and 1 respectively on scale of 1-5; Dawe, et al., MS 1983).

Eastern Newfoundland offshore

Squid was the major prey of cod caught by bottom-trawling off eastern Newfoundland in October 1979. Squid were found in only 26% of the stomachs examined but comprised 53% of the diet by weight (Table 2). Other major prey were capelin (Mallotus villosus), sand lance (Ammodytes sp.), and a shrimp (Pandalus montagui). The mean PFI value for squid was 0.6, and the TFI was only 1.7 (Table 2), indicating that feeding conditions were relatively poor.

Intensity of predation on squid varied with cod size. The smallest cod digesting a squid was 39 cm in length (Fig. 3a). Most cod containing squid had only one partly digested squid, but six were found in a 104 cm cod. Beaks not embedded in tissue were frequently found. Most stomachs with free beaks had only one or two free uppers, but a maximum of 8 free uppers was found in a 66 cm cod. The frequency of occurrence of squid increased from 8% in 30-49 cm cod to 91% in 80-89 cm cod (Fig. 3b). The PFI value for squid rose from 0.03 in 30-39 cm cod to 2.36 in 80-89 cm cod (Fig. 3c) and the contribution of squid to the total fullness index (TFI) increased from 2% to 92% over the same length range.

During the survey squid were caught in only 46% of the sets and catches were generally small (<10 kg) (Fig. 4a). Largest catches were taken in the outer part of Trinity Bay and in the southern Avalon Channel. Predation on squid was widespread, with PFI values highest in some northern and central sets and lowest in the south, particularly in the southeast on the plateau of Grand Bank (Fig. 4b). Squid were found in cod stomachs from many sets in which squid were not caught. This is related in part to the relationship between squid catch and time of day. Most large (>2 kg) catches were taken during daylight hours, whereas small to nil catches were taken during hours of darkness (Fig. 5).

The sizes of squid consumed by cod were estimated from the hood lengths of upper beaks. Dorsal mantle lengths estimated from embedded beaks had a mean of 22.9 cm (range 20.9-25.4 cm), whereas lengths estimated from free beaks had a mean of 22.3 cm (range 19.7-24.0 cm) (Fig. 6). Visual inspection of the length-frequencies indicated possible bimodality. This bimodality could be due to a difference between sexes frequently noted in the autumn (Squires, 1957; Beck et al., MS 1982). Resolution of the length-frequency for embedded beaks into two distributions was not possible because the larger distribution appears to be skewed to the right.

To determine whether annual variation in squid abundance might result in variation in total food consumption by cod, the TFI of cod in 1979 when squid abundance was high (index = 5) was compared with the TFI in 1982 and 1983 when squid abundance was low (index of 2 and 1 respectively; E. G. Dawe, Department of Fisheries and Oceans, St. John's, pers. comm.). The comparison was restricted to a relatively small area (47°00' - 48°50'N; 51°30' - 52°40'W) because the surveys in 1982 and 1983 did not approach as closely to the coast as did the 1979 survey, and because an increase in predation on sand lance increased the TFI in the southern Avalon Channel in 1982 (unpub. data). In 1979 the TFI increased from 1.7 in 30-39 cm cod to 3.3 in 60-79 cm cod, but the PFI values of all prey other than squid decreased from 1.6 to 0.6 (Fig. 7). In 1982-83 no squid were found in cod stomachs, and the TFI values were similar to the 1979 values with squid removed (Fig. 7). That is, in the area defined above there was no compensatory feeding on other prey in years of low squid abundance.

Gulf of St. Lawrence

Squid were caught throughout most of the survey area in the eastern and northern Gulf of St. Lawrence (Fig. 8a, b). Most of the large catches occurred off the southwest corner of Newfoundland. No squid were caught west of Anticosti Island in 1978, but they were caught in three sets just off the western tip of the island in 1979. Cod stomachs were examined from only a portion of the catches in both years. Cod predation on squid occurred throughout the area (Fig. 8c, d), including several sites at which squid were not caught in the net.

Discussion

Although earlier reports (Thompson 1943; Templeman and Fleming, 1956) stated that cod seldom prey on squid, the selected observations presented in this study illustrate that such predation is common off eastern Newfoundland in years of high squid abundance. Templeman and

Fleming (1956) noted that squid prefer warm water and implied that this would keep them horizontally segregated from cod which in late summer and autumn move into deeper, cooler water. Many of the squid caught by bottom-trawling in October 1979 (Fig. 4a) were obtained at sites where the bottom temperature was very cold (<0°C), and many of the cod which had eaten squid were captured in cold water. It is not clear if the squid were captured near the bottom or if, as Squires (1957) speculated, they were taken at warmer temperatures higher in the water column as the net was retrieved. The diel periodicity in squid catch rates (Hurley 1980; present study) supports the thesis that squid migrate downward during daylight hours. It may be this migration which makes them accessible to cod, but it is also possible that cod move upward to prey on the squid.

There are, to the authors' knowledge, no other reports of cod predation on squid offshore in eastern and southern Newfoundland, even though squid occur from the Grand Banks and Flemish Cap to Hamilton Bank off southern Labrador (Squires 1957). For example, Popova (1962) made extensive observations of cod stomachs during the summers of 1959 and 1960, when the inshore squid abundance index was moderate (3) and high (4) respectively, but did not report Illex illecebrosus as a prey. Similarly, Turuk (1968) observed thousands of cod stomachs at all seasons in 1964-66, when the abundance index decreased from very high (5) in 1964 to moderate (3) in 1966, but reported no I. illecebrosus.

The presence of squid in the eastern and northern Gulf of St. Lawrence was previously reported by Squires (1957). In the southern Gulf of St. Lawrence squid catches during autumn bottom-trawl surveys were rare from 1971 to 1975, but there were significant catches from 1976 to 1979 (Brown and Halliday, 1983). Largest catches tended to be along the edge of the Laurentian Channel (Koeller and LeGresley, 1981), as also noted in the present study, but there were intrusions into shallower water in 1978 and 1979. Powles (1958) found squid to be an infrequent prey of cod in the southern Gulf of St. Lawrence. There appear to be no reports of widespread predation by cod on squid as noted in the present study.

The squid found in cod stomachs off eastern Newfoundland in October 1979 were of a narrow size range (19.7-25.4 cm DML). Totally digested squid, represented by free beaks, were smaller than partly digested squid, probably because of growth by the squid population in the intervening time since squid represented by free beaks were ingested.

The apparent bimodality of the length frequencies could not be resolved because of an apparent skewness in the distributions. Distributions skewed to the right have been found in commercial samples from eastern Newfoundland (Beck, et al., MS 1982). The modes in the length frequency for embedded beaks (21.5-22.0; 23.0-23.5) compare favorably with mean lengths obtained from commercial samples at St. John's (males 22.2; females 23.6) and Holyrood (males 22.5; females 23.5) during October, 1978 (Beck et al., 1982).

The size-relationships of predation by cod on squid in October 1979 (Fig. 3) were similar to those reported by Dupouy, et al. (MS 1982) for predation on squid by 4 species of groundfish, including cod, on the Scotian Shelf in August-September 1981. In the latter study no squid were ingested by predators smaller than 35 cm, most squid occurred in stomachs of predators greater than 50 cm, and both the frequency of occurrence of squid and the number of squid per stomach increased with predator length.

Although squid was the major prey of cod in many of the samples described in the present paper, the quantity of squid found in cod stomachs was small compared with the quantities of other prey reported at other times and places. Partial fullness indices for squid were seldom greater than 2 and usually less than 1, whereas values of 4-6 were reported for predation on capelin and sand lance in various offshore locations (Lilly and Fleming, 1981) and values greater than 10 have been found for predation on capelin inshore during the capelin spawning period (Lilly and Botta, MS 1984; present study). Nevertheless, the annual immigration of squid might provide a major pulse of prey for cod, particularly large cod. For example, at Trouty in 1980 squid was the major prey after mid-August and PFI values were 0.5-1.0, whereas at Bonavista in 1983 no squid were found in cod stomachs and total fullness indices in August and September were generally less than 0.5 (Lilly and Botta, MS 1984). Squid occurred in cod off the Horse Chops in 1967, a year of high abundance (index of 4), but not in 1968, a year of low abundance (index of 1), and contributed to a higher fullness index in 1967. Such comparisons must be made with caution, for within-year differences of similar magnitude could occur, but there is some evidence that after the capelin move offshore in late July-early August feeding conditions for cod are better in years of high squid abundance than in years of low squid abundance.

More convincing evidence of the importance of squid may be found in the results from bottom-trawl surveys (Fig. 7). The total fullness indices in 1982-83 were similar to partial fullness indices of all prey other than squid in 1979, when predation on squid considerably increased the total fullness indices. Thus, immigration of squid in years of high squid abundance provides an increase in total food availability, especially for large cod. Any investigation of factors affecting growth of cod, such as variability in the abundance of capelin (Akenhead, et al., 1982), should also take into account variability in the abundance of squid.

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References

Akenhead, S. A., J. Carscadden, H. Lear, G. R. Lilly, and R. Wells. 1982. Cod-capelin interactions off northeast Newfoundland and Labrador, p. 141-148. In M. C. Mercer (ed.). Multispecies approaches to fisheries management advice. Can. Spec. Publ. Fish. Aquat. Sci. 59.

Beck, P. C., E. G. Dawe, and J. Drew. MS 1982. Breakdown of short-finned squid catches in NAFO Subarea 3 and Division 4R for 1980 and biological characteristics for Newfoundland inshore commercial samples and early season offshore samples. NAFO SCR. Doc. 82/27, Serial No. N515, 16 p.

Brown, B. E., and R. G. Halliday. 1983. Fisheries resources of the Northwest Atlantic - some responses to extreme fishing perturbations, p. 96-109. CNC/SCOR. Proceedings of the Joint Oceanographic Assembly 1982 - General Symposia. Canadian National Committee/Scientific Committee on Oceanic Research, Ottawa, Ontario, 189 p.

Dawe, E. G., G. R. Lilly, and H. J. Drew. MS 1983. Predation by short-finned squid (Illex illecebrosus) in Newfoundland inshore waters. NAFO SCR Doc. 83/74, Serial No. N740, 16 p.

Doubleday, W. G. (ed.) 1981. Manual on groundfish surveys in the Northwest Atlantic. NAFO Sci. Coun. Studies 2: 7-55.

Dupouy, H., T. Amaratunga, and L. Coelho. MS 1982. Preliminary data on predation of fishes on squid (Illex illecebrosus) on the Scotian Shelf (NAFO Div. 4VWX). NAFO SCR Doc. 82/43, Serial No. N532, 8p.

Hurley, G. V. 1980. Recent developments in the squid, Illex illecebrosus, fishery of Newfoundland, Canada. Mar. Fish. Rev. 42(7-8): 15-22.

Koeller, P. A., and M. LeGresley. 1981. Abundance and distribution of finfish and squid from E. E. Prince trawl surveys in the southern Gulf of St. Lawrence, 1970-79. Can. Tech. Rep. Fish. Aquat. Sci. 1028.

Lilly, G. R., and J. R. Botta. MS 1984. Food of Atlantic cod (Gadus morhua L.) near Bonavista, Newfoundland in 1983. NAFO SCR Doc. 84/51, Serial No. N838, 8 p.

Lilly, G. R., and A. M. Fleming. 1981. Size relationships in predation by Atlantic cod, Gadus morhua, on capelin, Mallotus villosus, and sand lance, Ammodytes dubius, in the Newfoundland area. NAFO Sci. Coun. Studies 1: 41-45.

Mercer, M. C., R. K. Misra, and G. V. Hurley. 1980. Sex determination of the ommastrephid squid Illex illecebrosus using beak morphometrics. Can. J. Fish. Aquat. Sci. 37: 283-286.

Popova, O. A. 1962. Some data on the feeding of cod in the Newfoundland area of the Northwest Atlantic. In: Soviet Fisheries investigtions in the Northwest Atlantic, VNIRO-PINRO, Moskva. (Transl. for U.S. Dep. Int., Nat. Sci. Found., Washington, D.C., by Israel Prog. Sci. Transl., 1963. p. 228-248).

Powles, P. M. 1958. Studies of reproduction and feeding of Atlantic cod (Gadus callarias L.) in the southwestern Gulf of St. Lawrence. J. Fish. Res. Board Can. 15: 1383-1402.

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

Templeman, W. 1948. The life history of the capelin (Mallotus villosus O. F. Muller) in Newfoundland waters. Bull. Nfld. Gov. Lab. Vol. 17. 151.

1965. Some instances of cod and haddock behaviour and concentrations in the Newfoundland and Labrador areas in relation to food. ICNAF Spec. Publ., No. 6: 449-461.

1966. Marine resources of Newfoundland. Bull. Fish. Res. Board Can. 154: 170 p.

Templeman, W., and A. M Fleming. 1956. The Bonavista longlining experiment, 1950-53. Bull. Fish. Res. Bd. Canada, 109: 1-55.

Thompson, H. 1943. A biological and economic study of cod (Gadus callarias L.) in the Newfoundland area incuding Labrador. Nfld. Dept. Nat. Resour. Fish. Bull., 14: 1-160.

Turuk, T. N. 1968. Seasonal changes of cod feeding in the Labrador and Newfoundland areas in 1964-68. Trudy PINRO, 23: 370-382. (Fish. Res. Bd. Canada Transl. Ser., No. 1937).

Table 1. Summary results of analysis of stomachs of cod caught by various gears in the inshore area of eastern Newfoundland.

Location	Date	Gear[a]	No. of samples	No. of stomachs	Occurrence of squid (%)	PFI of squid	TFI
Trouty (Trinity Bay)	June 16-July 18, 1980	Poundnet (C)	20	355[d]	1.1	0.03	7.61
	July 21-Aug. 8, 1980	Gillnet (C)	13	222[d]	14.1	0.56	5.28
	Aug. 11-29, 1980	Handline (C)	14	247[d]	7.7	0.35	1.69
Horse Chops (Trinity Bay)	Oct. 21, 1967	Gillnet (R)	1	40[c]	7.5	0.37	2.15
	Oct. 22-27, 1967	Gillnet (R)	9	352[b]	18.5		
	Nov. 15, 1968	Gillnet (R)	1	43[c]	0	0	1.17
	Nov. 15-22, 1968	Gillnet (R)	7	89[b]	0		

[a]C = commercial; R = research.

[b]Stomachs examined at sea. Two major prey noted.

[c]Stomachs exmained in laboratory. Mass measured by weight to nearest 0.1 g.

[d]Stomachs exmained on shore. Mass measured volumetrically to nearest cc.

Table 2. The food of cod off southeastern Newfoundland, October 1979.

	Percent[a] frequency	Percent by weight	Mean PFI
Polychaeta	35.3	1.61	0.04
Mollusca			
Illex illecebrosus	26.0	53.4	0.62
Others and unidentified		0.9	0.02
Crustacea			
Amphipoda		1.5	0.05
Euphausiacea	16.6	0.9	0.03
Natantia			
Pandalus montagui	35.3	8.0	0.20
Others and Unidentified		4.9	0.16
Reptantia			
Hyas araneus	12.9	2.0	0.03
Others and Unidentified		2.2	0.04
Others and Unidentified		0.1	0.01
Echinodermata		1.9	0.02
Invertebrata (Others and Unidentified)		0.5	0.02
Pisces			
Mallotus villosus	9.7	11.0	0.27
Ammodytes sp.	2.8	5.0	0.09
Miscellaneous		5.0	0.07
Unidentified		0.9	0.02
Unidentified and Miscellaneous		0.2	+[b]
Total		100.0	1.68
No. of Stomachs: 668			
Percent empty: 2.0			

[a]Provided only for those taxa not initially identified at a lower taxonomic level.

[b]+ indicates PFI <0.005.

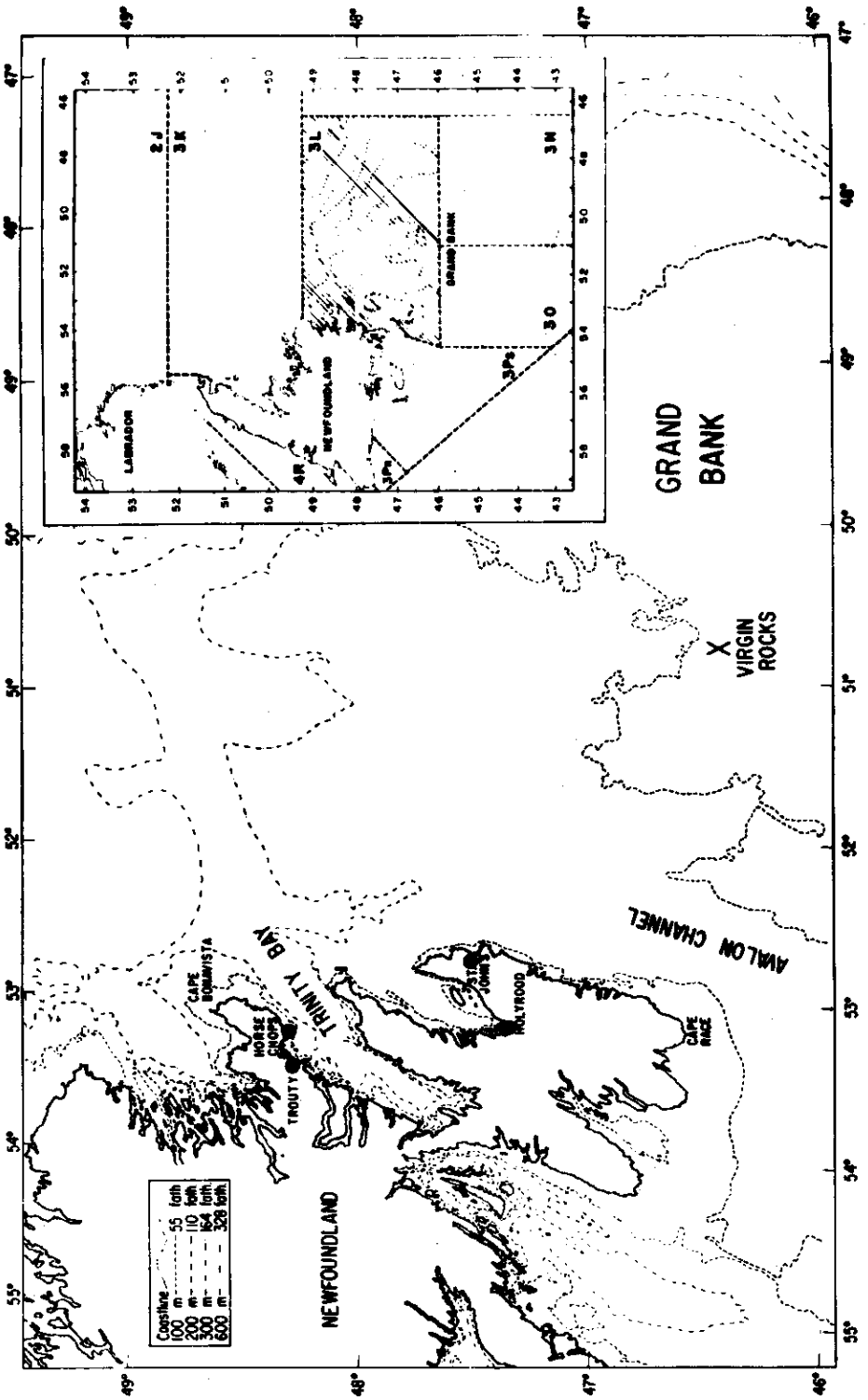


Fig. 1. NAFO Div. 3L, showing place names mentioned in the text.

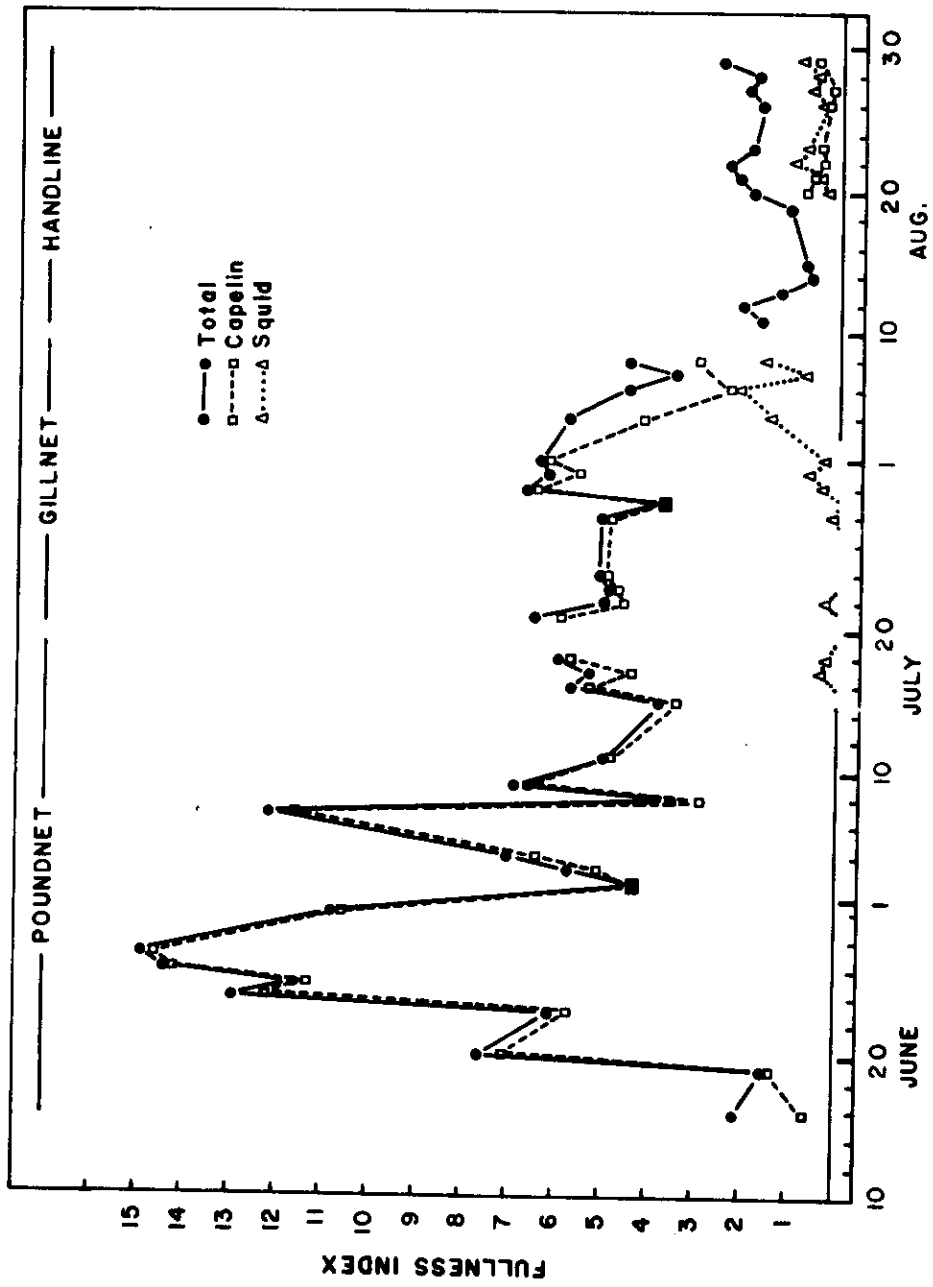


Fig. 2. Total fullness index and partial fullness indices for capelin and squid in samples of cod collected from the commercial inshore fishery at Trouty, Trinity Bay, during summer 1980.

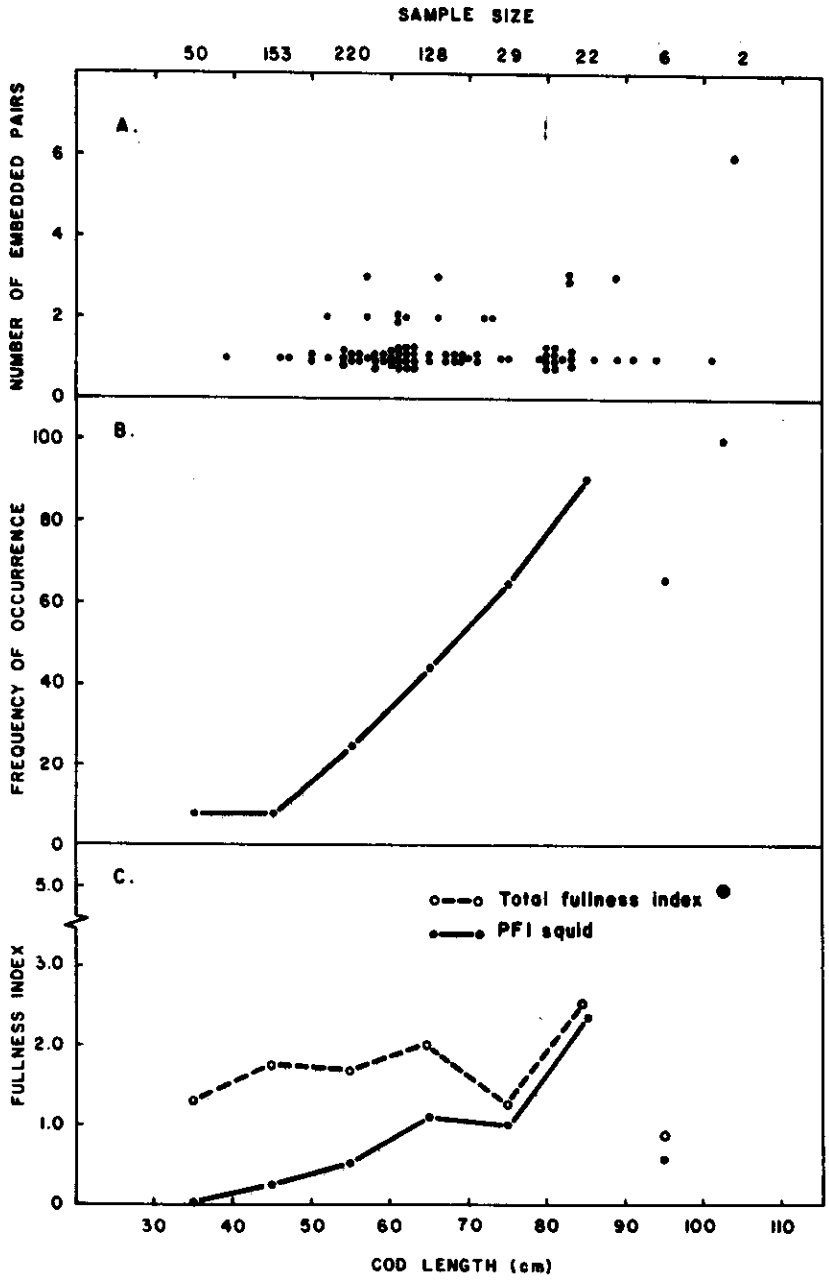


Fig. 3. Relationships between length of cod and (A) the number of embedded pairs of squid beaks found in each stomach; (B) the percentage frequency of occurrence of squid in cod stomachs; (C) total fullness index and partial fullness index for squid.

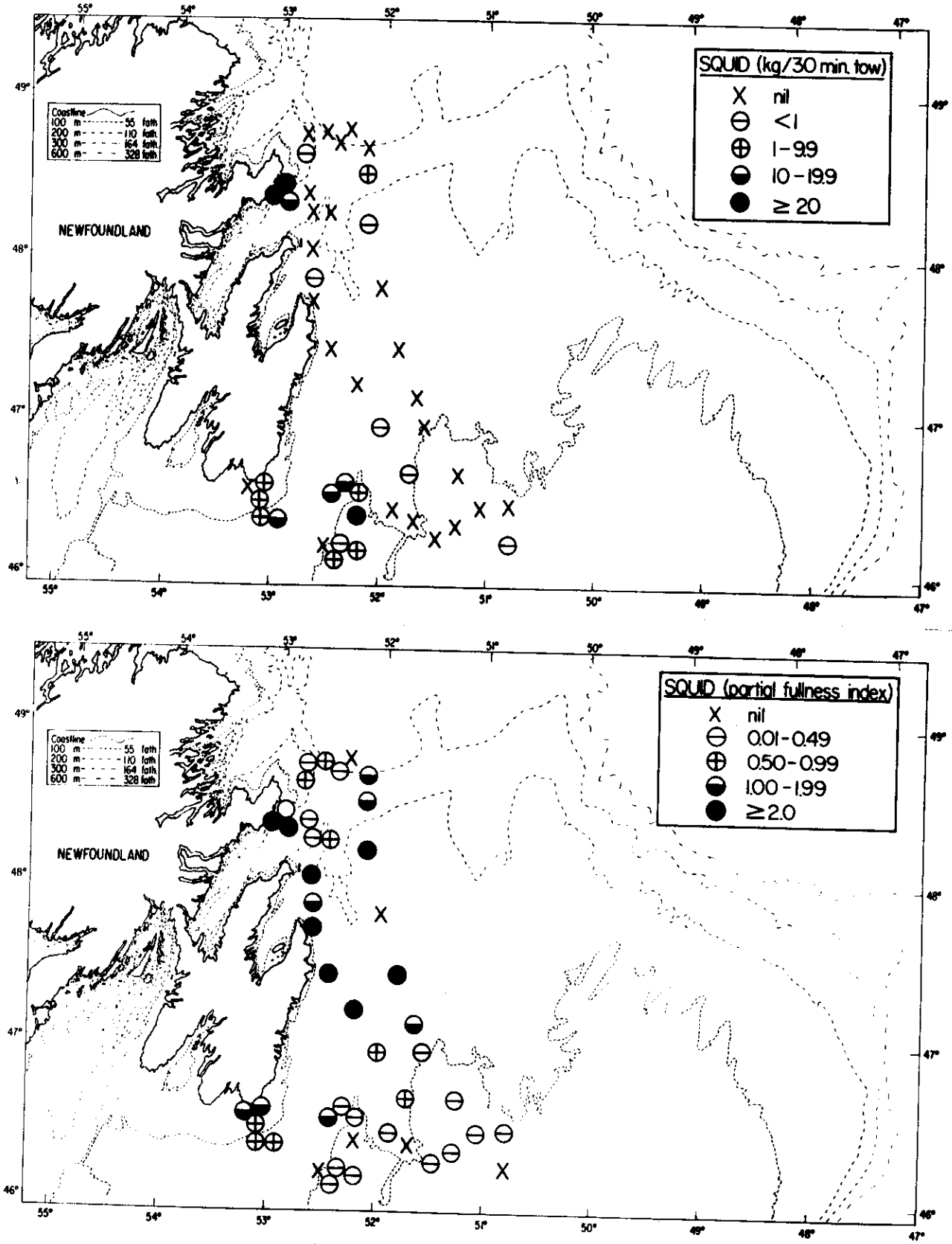


Fig. 4. Distribution of squid off southeastern Newfoundland, October 1979. (A) Squid catches; (B) partial fullness index of squid by set. Only cod ≥50 cm were used in calculating PFI.

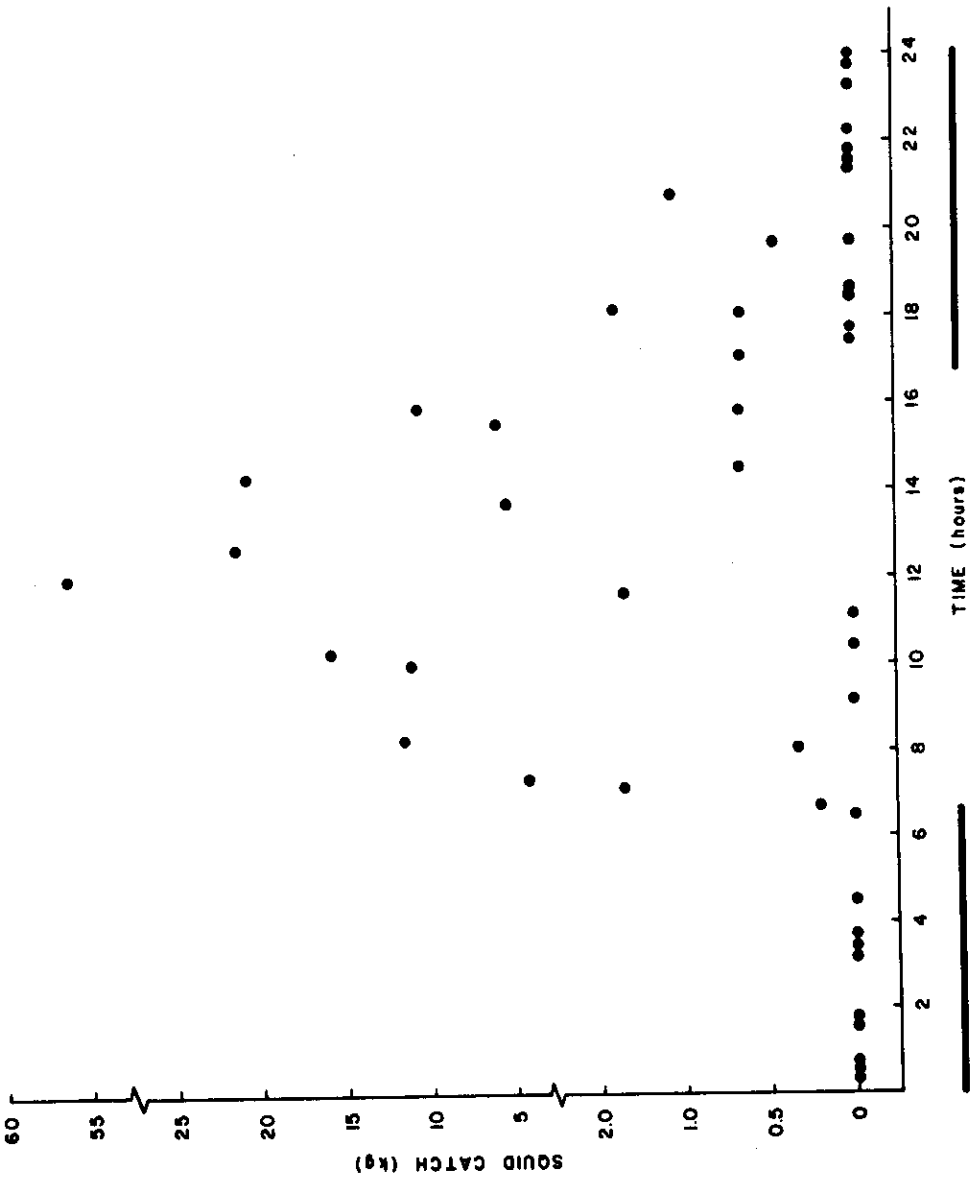


Fig. 5. Squid catches as a function of time of day. Black horizontal bars indicate darkness.

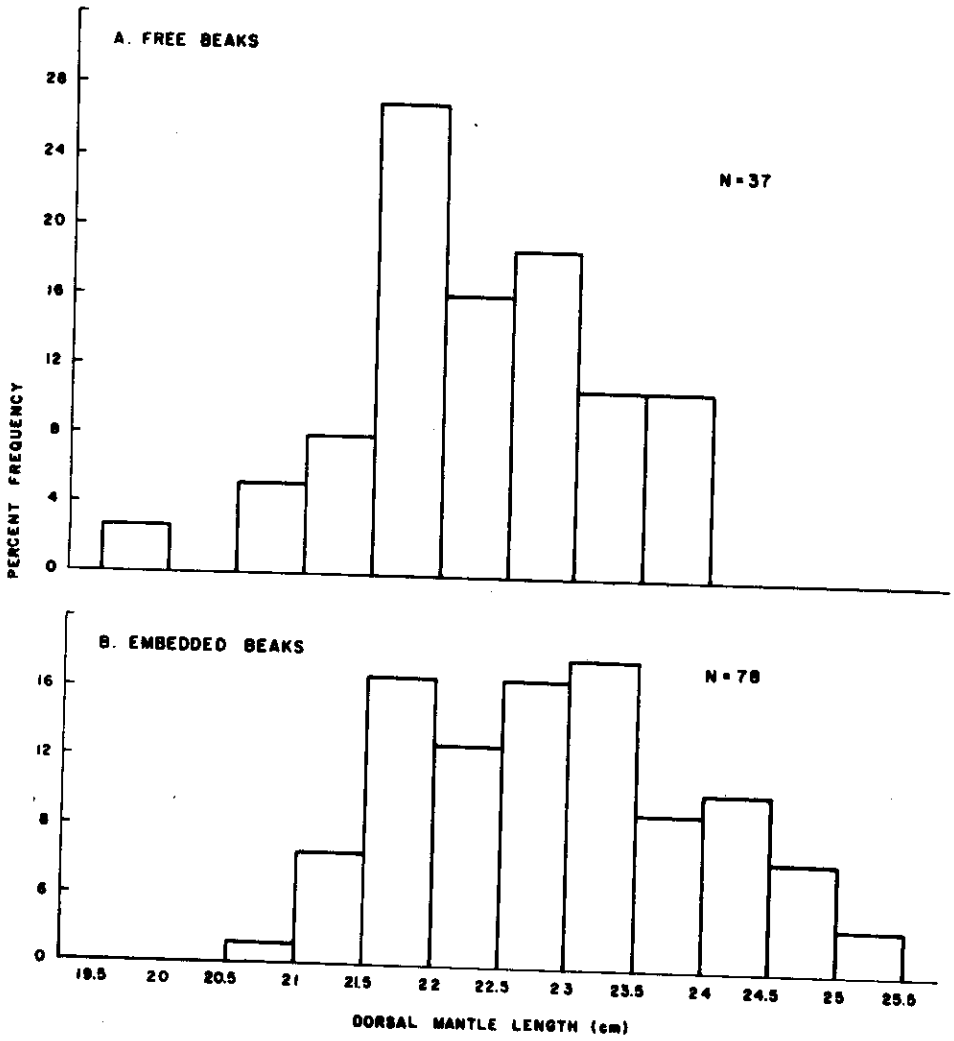


Fig. 6. Length frequencies of squid found in cod stomachs. Lengths estimated from (A) free beaks; (B) embedded beaks.

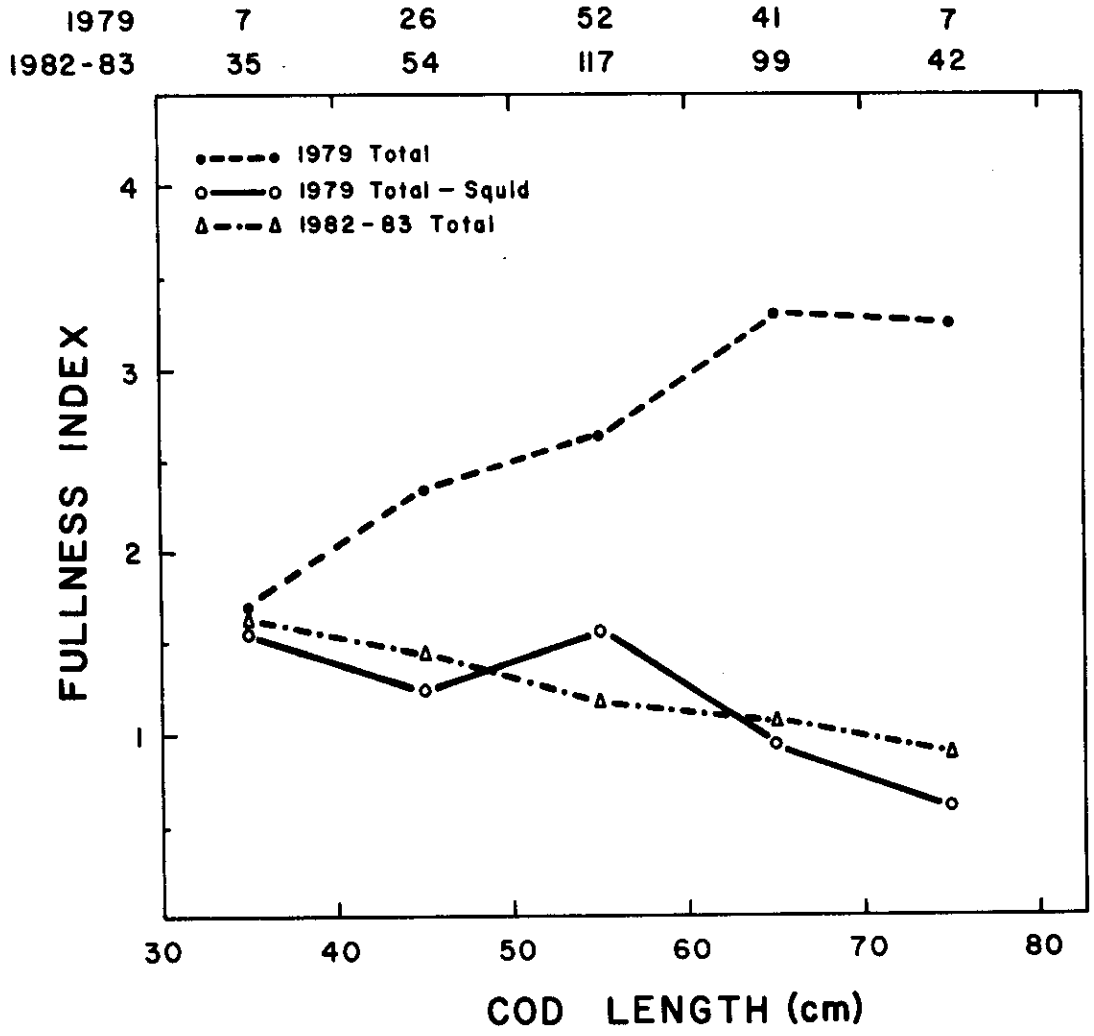


Fig. 7. Total fullness index in 1979 and 1982-83, and partial fullness index of all prey other than squid in 1979, in cod from eastern Newfoundland (47°00' - 48°50'N; 51°30' - 52°40'W). Sample sizes are shown at top.

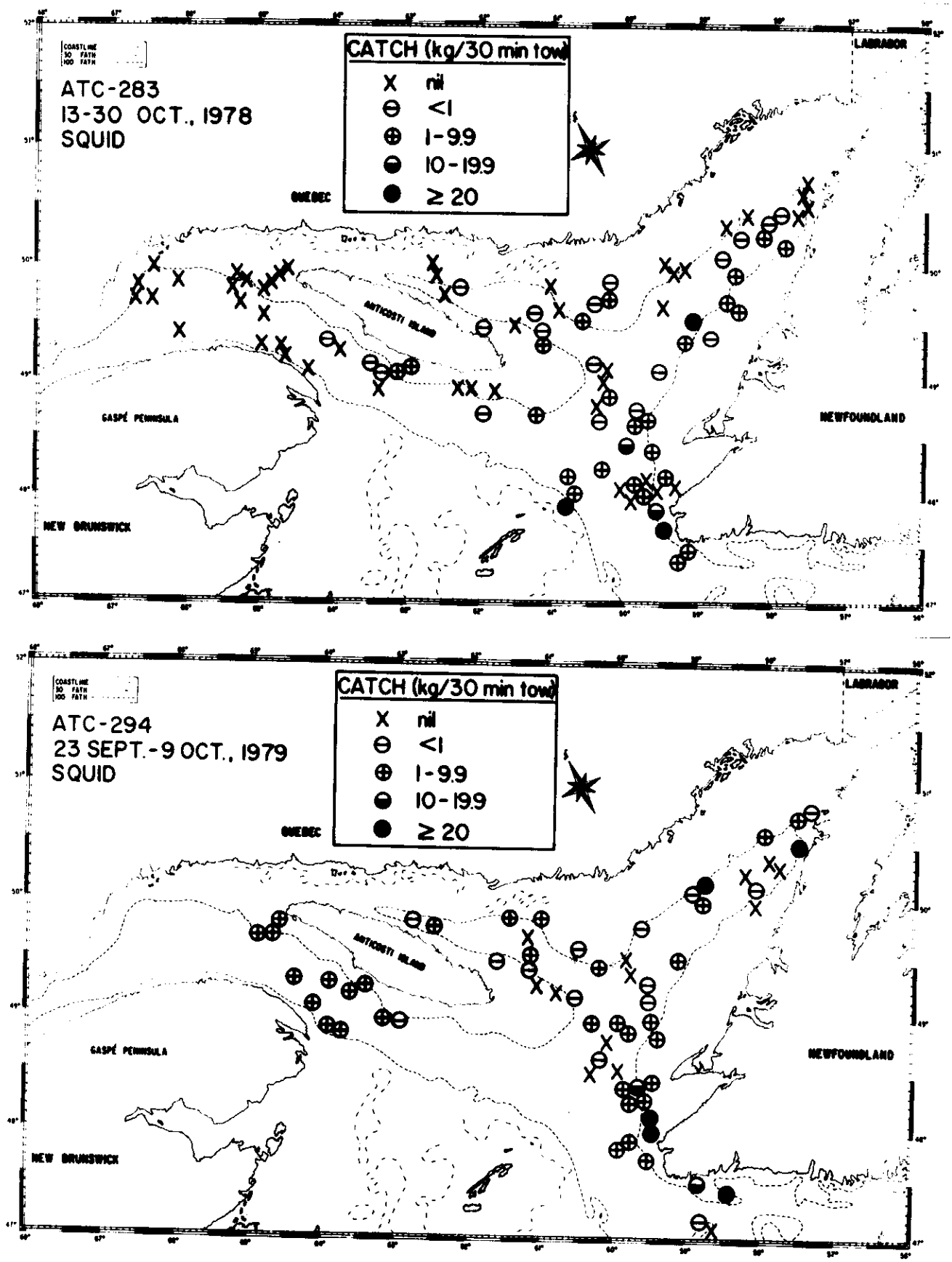
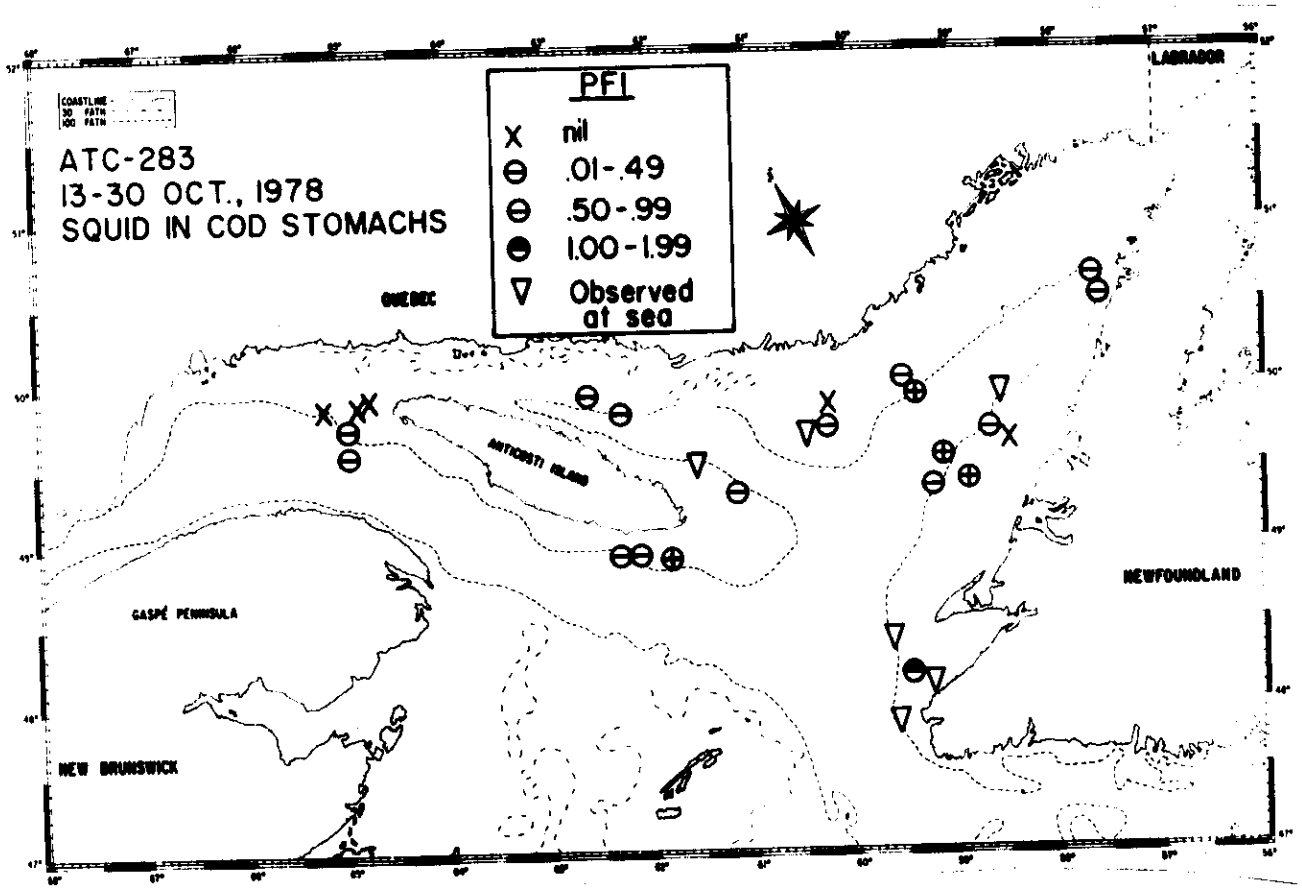


Fig. 8. Distribution of squid in the Gulf of St. Lawrence. (A) Catches in 1978; (B) catches in 1979; (C) occurrence in cod stomachs in 1978; (D) occurrence in cod stomachs in 1979.



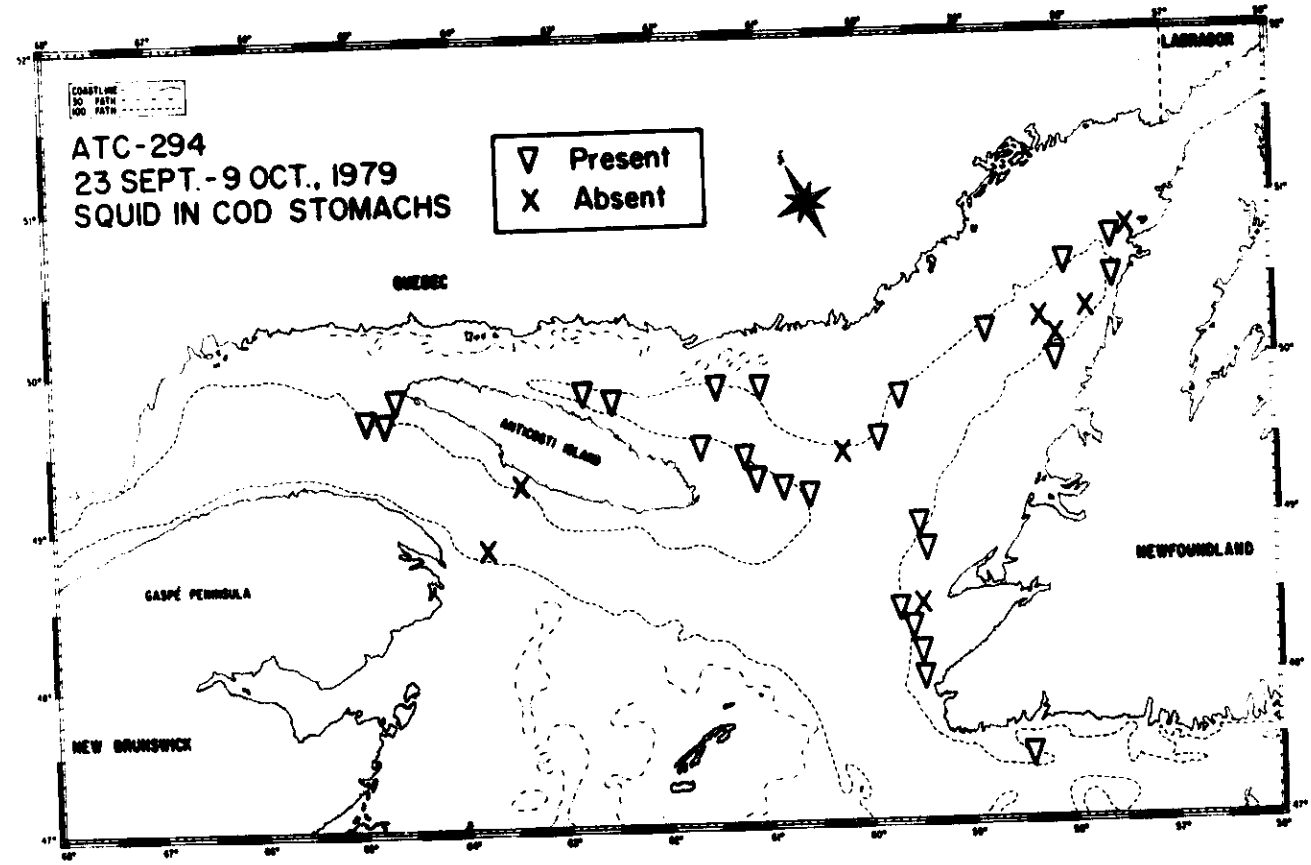


Figure 8 continued