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Status of capelin

(Mallotus villosus)

stocks in the Gulf of St. Lawrence

by
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Introduction

Prior to 1972, the yearly capelin catch represented only a small proportion of total fish landings in eastern Canada. In Quebec, catches never exceeded 200 metric tons annually (J. Bergeron, per. comm.), while catches in Newfoundland rarely exceeded 5000 tons a year (Parent and Brunel 1976). However, recent declines in cod and herring stocks have forced the fishing industry to look to alternate resources, such as the capelin, to maintain its market. Consequently, large-scale capelin fishing operations were initiated in the N.W. Atlantic during 1974-75, using ICNAF set TAC's of 110,000 and 150,000 metric tons for the Labrador and Newfoundland east coast areas respectively (Hinds 1975; Winters 1975). Recent large capelin spawns observed in the southern Gulf of St. Lawrence (D. Ware, per. comm.)have enhanced interest in this area as another possible fishing resource.

This report summarizes data available on capelin stocks in the Gulf of St. Lawrence and presents estimates of the size of the population and of its possible exploitation.

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Spawning sites and activity

The most comprehensive work to date on the distribution of spawning sites and activity in the Gulf of St. Lawrence is that of Parent and Brunel (1976). They undertook a survey of possible beach spawning sites on the whole north and south shores, around the Gaspé peninsula to the Miramichi River, and on Anticosti Island. They observed, as did Bailey et al. (1977) and Templemam (1948), that maximum spawning activity occurs between 6.4-8.4°C. Peak spawning activity follows the progression of this isotherm up the St. Lawrence River into the Gulf. Thus, in the estuary, spawning occurs from mid-April to mid-May. Along the north shore, the spawning period starts in mid-May at Ile aux Coudres and in mid-July at Bradore. Along the south shore spawning commences at Petite-Matane in early June and at Cloridorme about 3 weeks later. In the Gulf, spawning generally occurs from mid-May to mid-June. These areas and times are summarized in Figure 1.

Spawning intensity is fairly high along the north shore and only occasional along the south shore. The most extensive spawning in the southern Gulf occurs around the Gaspé peninsula and Chaleur Bay area, down to the Miramichi River. It has been previously stated (McKenzie, 1959) that

the Miramichi River represents the southern-most extent of capelin in the Gulf. However, spawning in St. Georges Bay was observed for the first time in June, 1974 and has increased in intensity since that time (D. Ware, per. comm.). Examination of temperature data available for this area (Lauzier, 1957; Lauzier and Bailey, 1957; Lauzier et. al., 1957) indicates that beach spawning occurs at 7-9°C, temperatures not inconsistent with Templeman's (1948) earlier observations.

As shown in figure 1, beach spawning has also been observed at Cheticamp, N.S. in June (Cox, 1921) and on the west end of Anticosti Island and west coast of Newfoundland from mid-June to mid-July (Parent and Brunel, 1976).

Evidence to suggest the presence of offshore spawning in the Gulf, as occurs on the Grand Banks (Pitt, 1958), is also available. It has been observed in June on the Natashquan Cod Banks in 40 m of water (Bailey et al, 1977). As well, the presence of yolk sac larvae in the estuary during 30 July - 9 August and on 14 and 20 September, 1975 (Jacquaz et al., 1977) further suggests that offshore spawning has occurred in the estuary.

Pitt (1958) showed that although offshore spawning generally occurs in cold water (as low as 2.8°C), the spawning act itself may take place at the same time as inshore spawning in the same area. What is most often affected is the time to

emergence of the larvae, which at 2.8°C may take 40-45 days, in contrast to 15 days at 10°C (Jeffers, 1931). Hodder and Winters (1972) present length frequency data for larvae caught off Chaleur Bay in November of 1969 and 1970. According to Jacques et al. (1977), larvae spawned in mid-June should be approximately 42 mm in total length by November, which is some 8-9 mm longer than the mean lengths of Hodder and Winters' sample. This is another indication that demersal spawning has occurred in the Gulf. Unfortunately, little can be said about the possibility of offshore spawning in the southern Gulf at this time.

Fall feeding areas

Following spawning, the surviving spent adults and juveniles migrate to feeding areas where they build up energy reserves before becoming non-trophic during the winter. When hatched, the new larvae also migrate to these areas for the same reasons (Jacquaz et al., 1977). The area just west of Anticosti Island exhibits the highest primary production in the Gulf (Steven, 1971) and here Jacquaz et al. (1977) found large numbers of juvenile and adult capelin concentrated in the fall, suggesting that this may be a feeding area. They further suggest that these individuals have actually been flushed out of the estuary and become trapped in the area by a large counter-clockwise gyre observed in the region's current.

A similar gyre exists to the east of Anticosti Island (Trites, 1970) and may be the site of another such feeding ground (Figure 1.).

Two sources of information have been used to ascertain where the larval concentrations in the southern Gulf are situated. The first is data from plankton cruises made out of St. Andrews, N.B. from 1965 to the present date. At the moment, data later than 1973 is going through the initial processing stages while the rest is in the middle of being transferred from St. Andrews to BIO for further statistical analysis. However, the results of some initial data reduction of the 1965-1973 cruise data is summarized in Figure 2. In May, catches of 500-1000 larvae per tow were caught off Chaleur Bay and north of Cape Breton. Being so early in the year, it seems unlikely that they were just spawned, and were probably age group I individuals. However, the Chaleur Bay concentration could have resulted from mid-April estuary spawn being flushed into this area of the Gulf. Without further analysis of the length frequency distributions of these samples, it is impossible to go any further on this speculation. In August, high larval concentrations were again encountered off Chaleur Bay as well as just southwest of the Magdalen Islands and off the west coast of Newfoundland.

The second source of information is a study carried out by Hodder and Winters in November 1969 and 1970.

They observed larval concentrations in the southern Gulf to be highest off Chaleur Bay and on Bird's Rock, northeast of the Magdalen Islands.

Taking these two sources of data together, it seems probable that a fall feeding area exists off Chaleur Bay. Another such area may exist southwest of Newfoundland in the Laurentian Channel (Figure 1).

Stock identification and changes in abundance

An important preliminary to defining the biological characteristics of capelin in the Gulf, i.e. to first determine how many stocks are actually present. Sharp et al. (1977) compared morphometric characteristics of spawning capelin from Ile aux Coudres, Sept-Iles, Natashquan and Grande Rivière and, through the use of discriminant function analysis, determined that four separate stocks could be identified. The recent intensive spawning in St. Georges Bay may represent the activity of another stock. This would mean the presence of at least four stocks in the Gulf.

As no catch statistics exist for the Gulf capelin stocks, no VPAs can be carried out to determine population size and fluctuations in abundance over time. Some idea of the latter may be obtained by examining changes in the average larval catches per tow obtained from the St. Andrews cruise data (Table I). Some explanation of the biology behind this data is first needed.

It has been previously noted (Jacquaz et al., 1977; Jangaard, 1974) that larvae, when first hatched, assume a pelagic mode of life in the top 20 m of the water comumn and remain there until the winter cooling sets in, at which time they move closer to the bottom where the older capelin reside. In table I, the surface catches represent those from the first 0-1 m of the water column. Catches here were lower than those from the mid-water depths (15-80 m). Unfortunately, neither catch would include animals from the 1-15 m zone. This may explain why catches in June were generally the lowest of the year, and progressively increased during August-October. Essentially, as the spawned larvae grow, they move down in the water column and hence become available to the mid-water gears. The high levels in May may just represent age group I larvae which have overwintered at the mid-water depths. Figure 3 illustrates the relationship between May catches and August catches of the previous year. Although not strong, this relationship is the basis for futher investigation.

The 1968 year-class appears to have been particularly strong. High larval catches were also caught in May of the following year, as indicated on figure 3. Interestingly enough, high numbers of larvae were also caught in the fall of 1971. This may be the spawn of the three year old's of the 1968 year-class. Other than this trend, the data is too sketchy

to observe any overall yearly pattern.

Stock size estimation

An estimate of the size of the Chaleur Bay stock was obtained by examining stomach content data of cod sampled in the Chaleur Bay-Gaspé region. It might be pointed out that cod in the Gulf tend to concentrate in two areas - off Chaleur Bay and St. Georges Bay, areas where capelin spawning is also evident. This may indicate that capelin are now a prime food source of cod in the Gulf, in contrast to the situation in the 1950's, when herring were the main source of food energy (Powles, 1958). Unfortunately, data on the gut contents of cod in the St. Georges Bay region is not available.

Using data from stratified random research cruises in the Gulf, it was determined that 36% of the total southern Gulf cod stock resides in the Chaleur Bay region. For this stock component, the mean number of capelin in the stomach of an individual cod was related exponentially to its length (Figure 4). No capelin were found in the stomachs of cod under 35 cm. This relationship was applied to the different mean lengths of cod for different age groups in the population (Table II).

The average water temperature during May-October, when cod are in the Chaleur Bay area consuming capelin is

approximately 5°C. On the average at this temperature, cod would fill their stomachs with capelin and other food material once every 1.5 days (Daan, 1973), which means that, in effect, there are 120 feeding days during May-October. It was calculated that the cod population would eat 1.6×10^9 capelin during this time. Winters and Campbell (1974) assumed that the natural mortality of capelin was 0.2. If we assume that 50% of this is due to cod predation (since mackerel are also known to consume capelin while resident in the Gulf), then the Chaleur Bay capelin population size could be expected to be about 1.6×10^{10} individuals. At an average weight of approximately 10 g, this would translate into a standing stock biomass of 160,000 metric tons.

An estimate of the TAC can be made based on catch per unit effort (CUE) data from different parts of eastern Canada. Exploratory fishing operations off the Gaspé peninsula, northeast and west coasts of Newfoundland, Labrador and the Grand Banks (Hinds, 1975) have provided average CUE values during 1972-1974 of 15, 20, 15, 25 and 65 metric tons of capelin caught per fishing hour respectively. The CUE for the Grand Banks is high since an aggregated spawning stock is being fished. The Labrador and Newfoundland northeast coast estimates are lower since a relatively dispersed fall feeding stock is being fished. If one were to consider the Chaleur Bay fishery as a "spawning fishery", then availability is more comparable to the Grand Banks situation. The TAC of the latter stock is

150,000 mt (ICNAF meeting, January 1974). Knowing that the Grand Banks are 4-5 times the size of the Chaleur Bay area, one could predict a TAC for the latter of 7,000-9,000 mt. If the same were true of the St. Georges Bay stock, then the combined estimated TAC for the southern Gulf of St. Lawrence would be 14,000-18,000 mt. Similarly, an estimated TAC for the northern Gulf, if based on a fall feeding fishery, would be approximately 22,000 mt. Therefore, for the entire Gulf, a capelin TAC of 36,000-40,000 mt could be predicted.

As the biomass calculation is very crude and the TAC is based on TAC's that themselves may be incorrect, these calculations can only be taken as indicative of the order of magnitude of stock biomass and TAC in the Gulf area. In this, they represent, at the very least, starting values for discussion.

Summary

Inshore capelin spawning occurs in most parts of the northern Gulf of St. Lawrence and has recently been observed in the St. Georges Bay area of the southern Gulf. Heaviest spawning activity in the south has been observed in the Chaleur Bay area. Offshore spawning has been observed in the north but not in the south.

Fall feeding areas have been located in the northwest Gulf and may also exist in the northeast Gulf, off Chaleur Bay, and southwest of Newfoundland, in the Laurentian Channel.

Four capelin stocks are estimated to be in the Gulf, two in the north at Sept-Iles and Natashquan, and two in the south at Chaleur and St. Georges Bay. Crude calculations indicated that the Chaleur Bay stock could have a standing stock biomass in the order of 160,000 mt. The TAC for the whole Gulf could be in the order of 36,000-40,000 mt. These values are only preliminary estimates and in no way constitute recommended quotas. They serve primarily as starting points for further discussion.

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TABLE I. Catch (N) per 100,000 M^3 water strained of larval capelin *(Mallosus villosus)* from the Gulf of St. Lawrence between 1965-1973. Values represent weighted (on tows of 100,000 M^3) geometric means of cruise data summarized over year and month.

(A) SURFACE CATCHES

YEAR	MAY	JUNE-JULY	AUGUST	SEPT.-OCT.
1965	0	0	-	1.09
1966	0	0	0	0
1967	0.67	0.52	0	0
1968	2.62	1.20	1.70	-
1969	2.58	1.41	0.87	1.97
1970	1.56	-	0	-
1971	1.63	-	0	0
1972	1.97	-	-	-
1973	1.63	1.88	-	-
Mean	1.41	0.84	0.43	0.61

(B) MID-WATER CATCHES

YEAR	MAY	JUNE-JULY	AUGUST	SEPT.-OCT.
1965	-	-	-	0
1966	0	0	0	-
1967	3.50	1.44	0	0.61
1968	1.38	1.32	18.14	-
1969	19.49	3.38	5.40	7.46
1970	1.11	-	1.88	-
1971	2.42	-	6.65	37.99
1972	4.25	-	5.22	-
1973	-	1.88	-	-
Mean	4.59	2.01	5.33	11.52

Table II. Calculations used in estimating number of capelin eaten by cod population in the Chaleur Bay area. Cod population numbers in the area were obtained by applying the factor 0.36 to the Gulf population estimates after the winter fishery.

Cod Age	Average Length (cm)	Predicted N capelin/stomach	Cod Population numbers x 10^{-3}	Ration of capelin per 1.5 days at 5.0°C x 10^{-3}
5	46.7	0.67	2711	1817
6	53.9	1.35	954	1287
7	59.7	2.30	1261	2900
8	63.2	3.40	515	1751
9	66.1	4.40	398	1751
10	67.1	4.60	308	1417
11	65.7	4.10	191	783
12	76.7	14.00	54	756
13	82.5	25.00	19	475
14	82.5	25.00	13	325
15	82.5	25.00	1	25

TOTAL = 13,287 x 10^{3}/1.5 days

OR

1.6 x 10^{9}/ 120 days

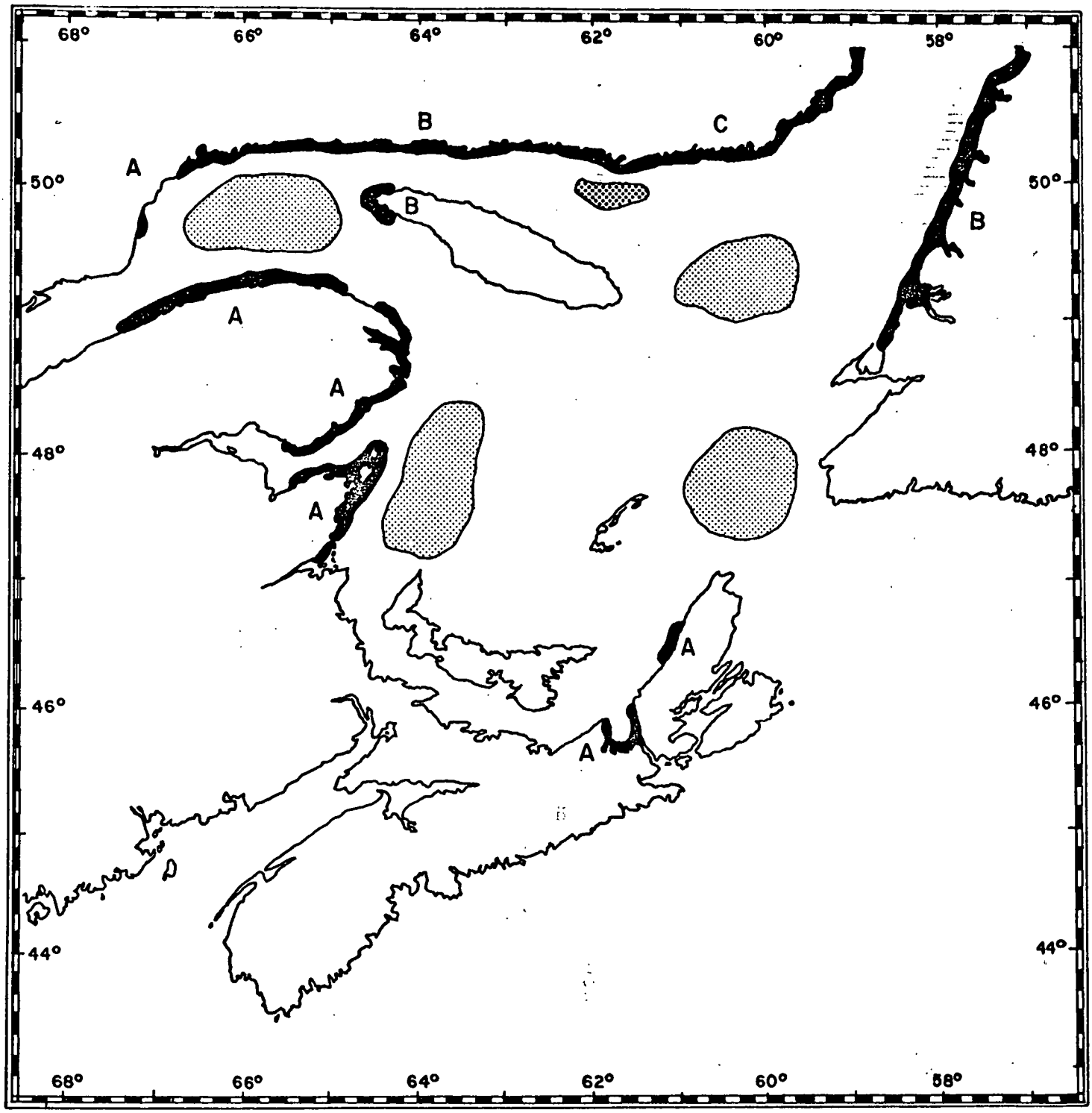

Figure 1. Spawning and feeding sites of capelin (Mallotus villosus) in the Gulf of St. Lawrence. Dark solid areas represent inshore spawning sites while the dark stippled area represents a site of deepwater spawning. The light stippled areas represent possible sites of fall-winter feeding. The letters indicate approximate times of spawning. A - mid-May to mid-June ; B - mid-June to mid-July & C - July.

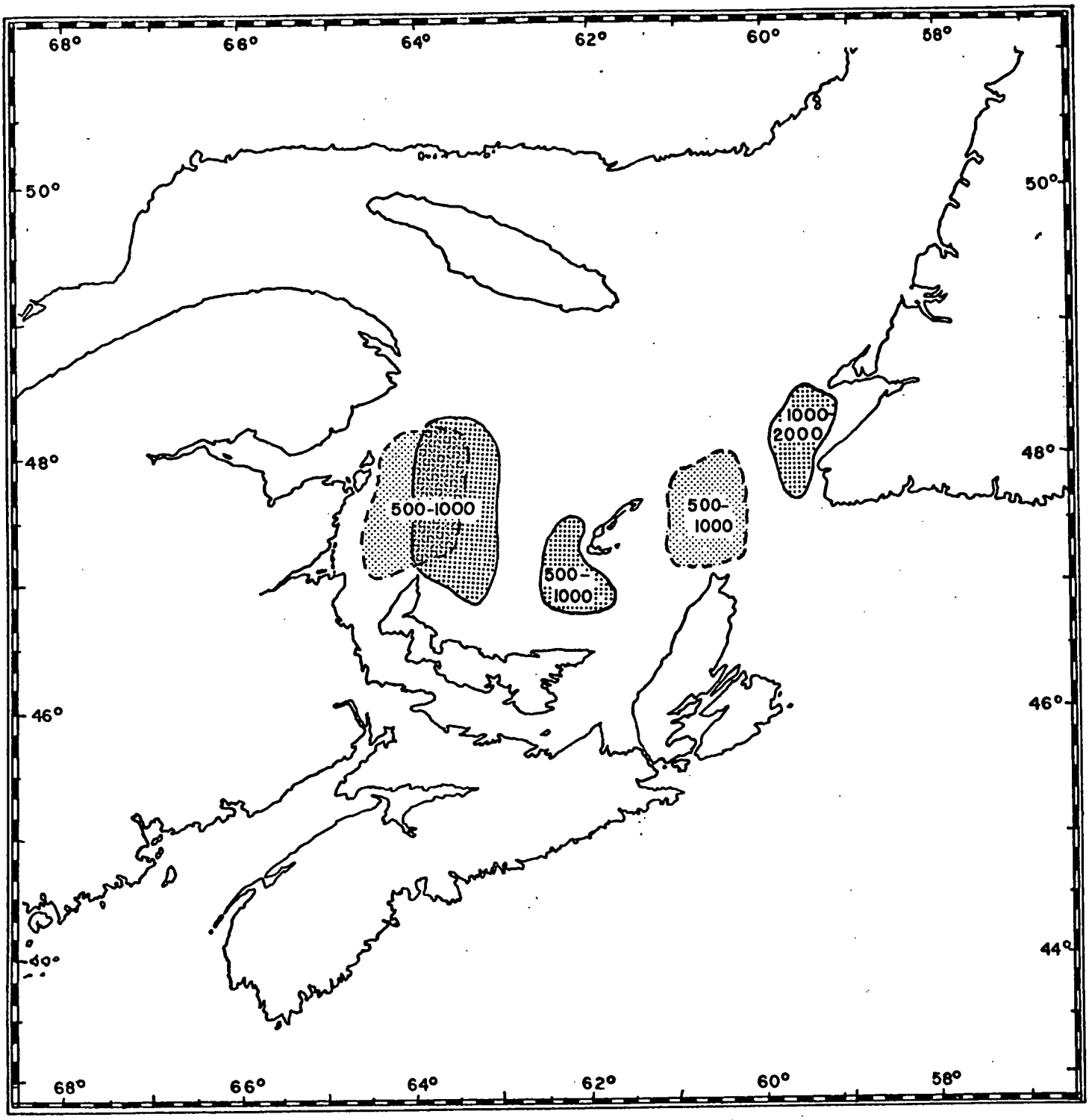

Figure 2. Distribution of tow catches in May (light stippled area) and August (heavy stippled area) for 1965-1973. Enclosed values represent range of mean catches per successful tow of 100000 M^3 water strained. Areas not enclosed generally exhibited catches of 100-300 larvae per successful tow. A successful tow was considered as one in which at least one larva was caught.

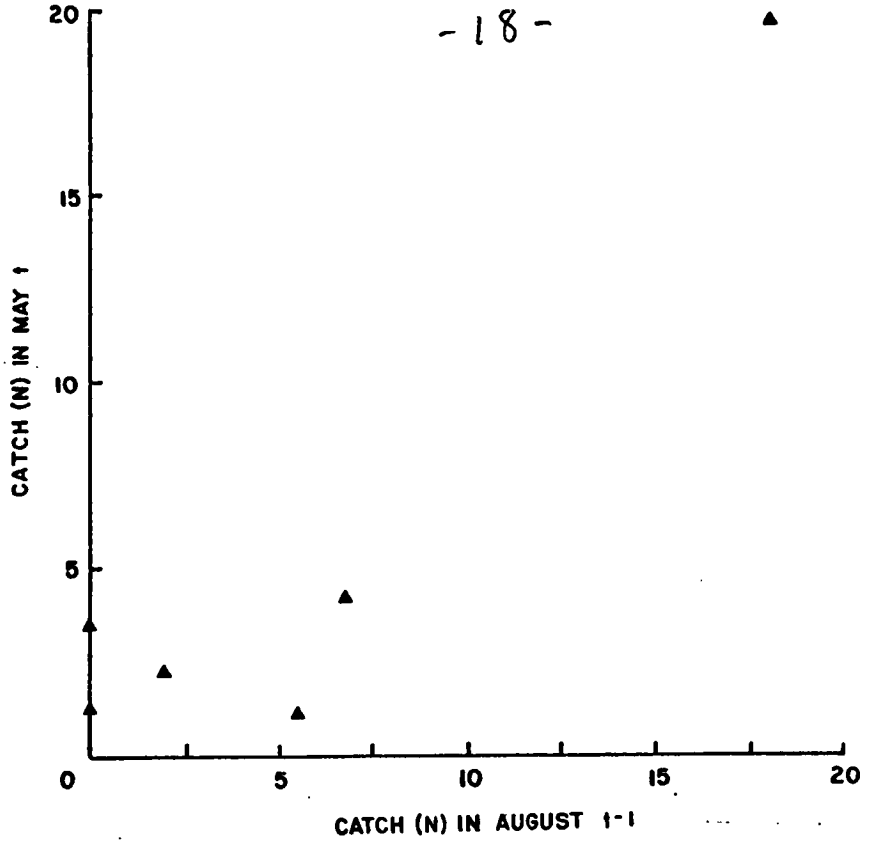

Figure 3. Relationship between catch (N) in May and catch in August (N) of the previous year.

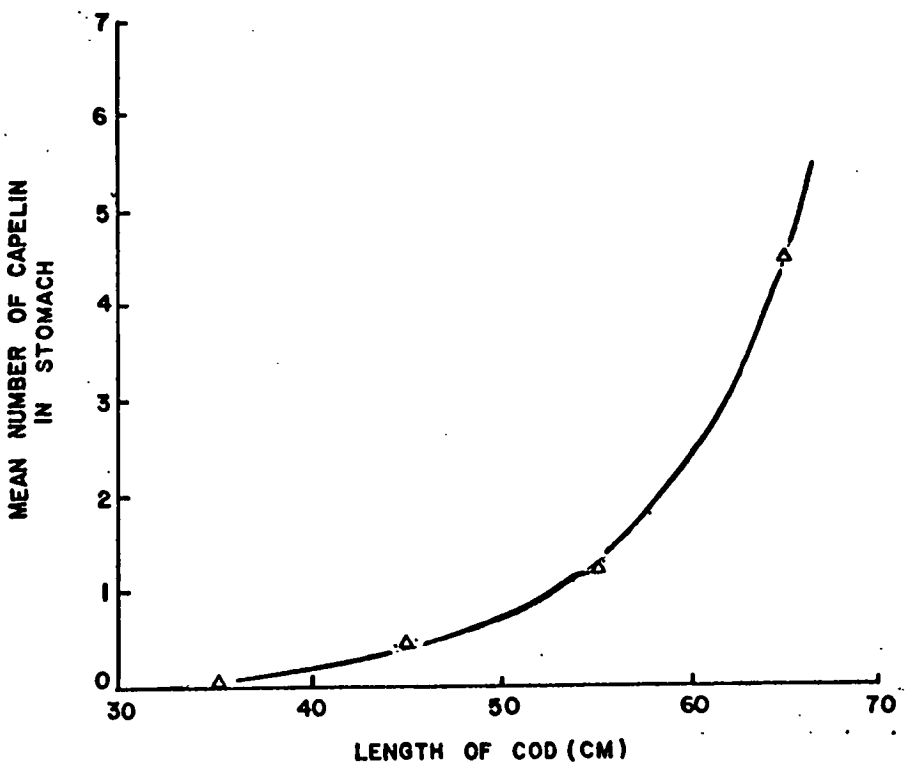

Figure 4. Relationship between length (cm) of cod and mean number of capelin in stomach for the Chaleur Bay - Gaspe area.