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Some biological characteristics of capelin, Mallotus villosus, in the Newfoundland area

by

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Introduction

Traditionally, the capelin fishery in the Newfoundland area has been mainly associated with the exploitation of coastal stocks of capelin during the beach-spawning period, when they are easily available to such primitive gear as beach seines and cast nets. Landings have generally amounted to less than 10,000 tons and most of the catches have been used for bait or as raw fertilizer. The recent decline in the herring fishery of the Northwest Atlantic together with the increased world demand for fish have focused attention on the capelin resources of the Newfoundland-Labrador area. As a result, landings of capelin increased from about 6000 tons in 1971 to an estimated 70,000 tons in 1972 of which a substantial proportion was taken by the Soviet fleet in offshore waters. A further increase in landings is expected in 1973 as other member countries become involved in the fishery.

The anticipated rapid expansion of an offshore fishery for capelin has led to concern that over-exploitation of the capelin resource may have a detrimental effect on other fish species which support important fisheries both offshore and inshore in the Newfoundland area. Coastal fishermen may be particularly affected as capelin are known to attract cod, salmon and other species to coastal waters where they can be caught by a variety of fixed gears.

This paper examines the available information on the biology of capelin stocks in the hope that management measures may be implemented at an early stage while additional biological data are collected.

Distribution

Capelin have a boreo-Arctic distribution and so are found in the northern regions of the Atlantic and Pacific oceans. In the eastern Atlantic, the species is abundant from the Trondheim Fjord of Norway north to the vicinities of Jan Mayen, Spitzbergen and western Novaya Zemlya at the eastern extremity of the Barents Sea. Capelin not only occur around the shores of Iceland and the Faeroes but also off Greenland where they are found as far north as Thule (76°N) on the west and Scoresby Sound (70°N) on the east. Capelin have been reported from the Coronation Gulf, Bathurst Inlet and Great Fish River of the Canadian Arctic as well as from the southern half of Hudson Bay including James Bay and from Ungava Bay. From Saglek south along the Labrador coast, capelin occur in large quantities wherever suitable spawning beaches are found and their distribution extends over the banks of the Labrador Shelf, the Grand Bank and St. Pierre Bank. They are especially abundant off the southern, eastern and northeastern shores of Newfoundland. In the western Gulf of St. Lawrence capelin are common on the northern shore, although in colder years they also occur extensively around Gaspé, Anticosti Island and Bay Chaleur. South of the Cabot Strait, they occur sporadically and in cold periods have been reported from southeastern Cape Breton and occasionally from the Bay of Fundy and the Gulf of Maine. In the Pacific, capelin are distributed from Cape Barrow, Alaska around the Bering Sea south along the Pacific coast of Canada to the State of Washington and on the Asiatic coast from the Sea of Chukotsk south to Hokkaido Island, Japan and the Tumen River, Korea (McAllister, 1963; Templeman, 1968; Winters, MS, 1966).

Reproduction

Two types of spawning occur in the Northwest Atlantic area, demersal offshore spawning and inshore beach-spawning. Offshore spawning aggregations of capelin were first discovered in 1950 on the Southeast Shoal of the Grand Bank (Pitt, 1958). These offshore capelin were found to spawn under highly specific conditions requiring a narrow temperature range (2.5-4.5°C) and a well defined substrate (fine gravel between 0.5 and 2.2 mm in diameter). In the Southeast Shoal area spawning normally begins during the third week of June and is generally completed by mid-July. In cold years, however, spawning may extend into early August (Pitt, 1958). Although demersal spawnings have not been reported from other offshore areas, it is possible that capelin also spawn on the shallow parts of St. Pierre Bank and perhaps also Whale and Green banks off the south coast of Newfoundland. It is unlikely that offshore spawning occurs on Hamilton Inlet Bank as temperature, depth and substrate conditions conducive to bottom spawning do not appear to be available in that area.

Beach-spawning of capelin begins progressively later from south to north in the Canadian Atlantic area. In the southern Gulf of St. Lawrence, spawning begins in early May, which is several weeks earlier than the spawning period on the south coast of Newfoundland where mass beach-spawning usually begins the first week in June (Templeman, 1948). Along the east coast of Newfoundland, beach-spawning does not begin until the third or fourth week in June and in northern Labrador it is uaually mid-August before mass beach-spawning occurs. The most favourable temperatures for beach-spawning ranges from 6.0 to 8.5°C and the best spawning beaches are made up of gravel 5 to 15 mm in diameter.

Capelin may reach sexual maturity as early as age-group 2, but mass maturation normally occurs at age-groups 3 and 4 (Fig. 1). The larger and older fish spawn first and, in the case of males, remain on the spawning grounds longer than the younger fish. Fecundity ranges from 16,550 eggs to 61,500 eggs with a mean of 33,850 eggs (Winters, 1971).

Following the spawning season, masses of dead capelin have been found on the surface indicating a high mortality at this time. Preliminary results show that repeat spawning does occur in capelin and on a percentage basis, repeat spawning is more common in females (30%) than among males (10%). Thus the size of the spawning stock of capelin is not entirely determined by recruitment alone but also in part by the survival of fish from previous spawnings (Winters, MS, 1970a).

Seasonal Distribution and Movement of Stocks

At least some of the capelin stocks along the east coast of Newfoundland remain near the coast during the winter and spring months. During the overwintering period (January-March), Winters (1970b) found coastal capelin concentrated in large inactive schools in Trinity Bay, Newfoundland at a depth range of 140-200 m. These aggregations were composed of both sexes, quite high in fat content but were not feeding. In early April, echo-sounder surveys verified by mid-water trawl hauls, indicated that the overwintering capelin moved up into the warming surface waters and dispersed to feed. At this time the maturing fish became segregated from the immatures which tended to form relatively larger schools than the maturing fish. Feeding continued into early June when the ripening fish were approaching the beaches for spawning.

That capelin are present in coastal waters all along the coast of Newfoundland and Labrador during the overwintering and pre-spawning period has been substantiated by the following observations:

(1) Many reports of mass mortalities of capelin in winter and spring in inshore bays due to the effect of cold water (Templeman 1948).

(2) Sporadic occurrences of capelin in shallow water close inshore in late winter-early spring; these so-called "whitefish" are often taken by the local residents for food.

(3) Presence of capelin in the stomachs of cod, salmon, Greenland halibut, seals and sea-birds in coastal waters during the winter and spring.

(4) Frequent catches of capelin by commercial trawlers and purse seiners in various Newfoundland bays during winter and spring.

Capelin are also abundant on the Grand Bank in winter and spring (Templeman, MS, 1967). On the northern section of the Grand Bank in late March 1961, large quantities of cod were present feeding on concentrations of capelin (Templeman, 1965). In February 1972, Soviet vessels located schools of capelin in deep water (150-250 m) on the northern slope of the Grand Bank and on the northern and northwestern

parts of the Bank in March (Kovalyov and Kudrin, MS, 1973). During this period concentrations of capelin were also present in the Avalon Channel area. During May and June the same vessels reported an intensive southerly migration towards the southern part of the Bank where fishable concentrations of capelin were present in early June (Hinds, MS, 1973).

During late May and early June 1972, Norwegian survey vessels showed capelin to be widely distributed throughout the Grand Bank area from the ice border to the tail of the Bank (Dragesund and Monstad, MS, 1972). The largest concentrations at this time were in the northern area of the Grand Bank and consisted mainly of immature capelin. This observation agrees with those of Templeman (MS, 1967) and Kovalyov and Kudrin (MS, 1973) suggesting that the northern part of the Grand Bank is a major nursery area for immature and pre-recruiting capelin. Kovalyov (MS, 1972) also reports that the survivors of the South-east Shoal spawning migrate to the northern part of the bank after spawning. This is supported by the capture of spent capelin by the R.V. A. T. Cameron in the northern and central area of the Bank in June 1969.

There is some evidence to suggest that a portion of the Grand Bank capelin, particularly those on the western and northwest slopes migrate inshore to spawn on the beaches of eastern Newfoundland. Templeman and Fleming (1962) report that cod tagged on the northwest part of the Grand Bank in early June were feeding heavily on capelin. These cod approached the Avalon Peninsula very rapidly and tagged fish were recaptured on the western side of the Avalon Peninsula in late June during the capelin spawning period in that area. Since capelin form almost the sole food of the cod at this time it seems likely that the cod followed the capelin from the Grand Bank to shore.

The post-spawning movements of the survivors of inshore spawning are not known but presumably they move offshore to feed, perhaps joining the pre-recruits of the subsequent spawning season. Substantial concentrations of adult and immature capelin have been found in the Hamilton Inlet Bank in late August-September of 1970 and 1971 by Norwegian survey vessels (Devold, 1970; Devold and Westergaard, 1972). Soviet surveys of the area from September to December in 1972 (Kovalyov and Kudrin, MS, 1973) indicate that these capelin gradually migrate southwards in the autumn and by early December are mainly located off Notre Dame Bay, Newfoundland between 50°00'-51°00'N and 52°30'-54°00'W (Fig. 2). It is possible that these capelin subsequently migrate inshore to overwinter under the ice in Notre Dame Bay.

Feeding Intensity and Fat Content

Mature capelin do not appear to feed from late January to March but by early April feeding resumes and becomes very intense in mid-May (Winters, 1970b). Feeding intensity greatly decreased by early June. Immature capelin follow the same pattern when feeding except that there is no decrease in June. By the start of the spawning season in mid-June, capelin cease feeding, except for capelin eggs swallowed incidental to their respiratory activities. The survivors of spawning resume feeding again several weeks after the end of the spawning period and feeding proceeds at a high intensity until late fall when feeding ceases.

There is a gradual decline in the fat content of mature capelin from the overwintering to the spawning period. Fat content of ripe capelin captured at the beginning of the spawning season ranges from 3 to 8% and may decline to between 1-2% during the spawning period. During the post-spawning season the survivors of spawning appear to regain their fat content rapidly and by late autumn possess a fat content as high as 20%. Capelin caught off the coast of Labrador in the vicinity of Hamilton Inlet in 1972 had a fat content of from 13 to 20%.

Landings of Capelin

Concentrations of capelin which can be commercially exploited occur during the spawning period and the overwintering or feeding period. The location, distribution and movement of these aggregations indicate that both an inshore and offshore fishery can exist.

During the early 1900's capelin were used extensively for raw fertilizer, dog food and bait. Landings were as high as 25,000 tons (Templeman, MS, 1967) for the Newfoundland area. In 1950 about 20,000 tons were reduced into meal and oil on an experimental basis and since then landings have declined continuously to around 5000 tons between 1960 and 1970 (Table 1). This decline has been mainly due to a change in fishing methods for cod (gillnets instead of baited hook and line) and a decrease in the domestic use of capelin as fertilizer and dog food. Canadian offshore landings of capelin were reported for the first time in 1972 as a result of exploratory fishing surveys conducted by vessels under charter to the Fisheries and Marine Service of Environment Canada (Hinds, MS, 1973).

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Capelin Predators

Capelin are the main prey organism for a great variety of fish, marine mammals and sea-birds in the Newfoundland-Labrador area and as such play a vital role in the trophic ecology. Off the east coast of Newfoundland, cod migrate from the northwestern edge of the Grand Bank to the Avalon Peninsula in pursuit of capelin during the months of June and July (Templeman, MS, 1967). These cod have mostly spawned and by feeding almost entirely on capelin regain condition and put on a large proportion of their annual growth (Templeman, 1965). Consequently the inshore codtrap fishery in most areas of Newfoundland is at least to some extent dependent on the movement, availability and abundance of capelin. Later in the summer cod in deeper water are found to feed almost exclusively on small 1-year-old capelin (Templeman, 1948). Salmon which approach the coast in May and June feed mainly on capelin while haddock, American plaice and halibut also prey on capelin or capelin eggs at certain times in the year.

Discussion and Conclusions

The development of an intensive fishery for capelin in the Newfoundland area will undoubtedly reduce the biomass of capelin available to its major predators. In terms of the predator-prey relationship, this reduction can have two effects. Firstly, if food is a limiting factor to the survival of the species and no suitable alternative prey organism is available in similar quantities, a reduction in the biomass of capelin would result in a reduction in the abundance of the predator. This may have a selective effect, having its greatest influence at those times of the year when the predator is either dependent on capelin to regain body condition after the overwintering and spawning period (i.e. cod) or when the predator requires capelin to nourish its young (i.e. sea-birds). Secondly, assuming that suitable alternative prey organisms are available, a reduction in capelin abundance may greatly affect the predator's distribution and migratory pattern. This could have a great effect on the fishery prospects of inshore fishermen who depend on the spawning migration of capelin to attract various fish species towards shore where they become available to fixed gear. Cod and salmon are of particular importance in this instance even though natural migration instincts may also play a role.

A crude estimate of the biomass of capelin in the Newfoundland-Labrador area may be obtained from estimates of the biomass of the major predators and their consumption rates of capelin. Population numbers for the period 1966-69 of the 2J-3KL and 3NO stocks of cod are available from Pinhorn and Wells (MS, 1972; MS, 1973). Application of mean weights to these numbers gives an average stock size of approximately 2,500,000 tons for the 2J-3KL stock and 300,000 tons for the 3NO stock for the 1966-69 period. The 2GH cod stock complex averaged about 150,000 tons over the same period (Wells, pers. comm.). This provides a total stock biomass of cod along the eastern coast of 2,950,000 tons.

Preliminary data from feeding studies on cod in Subarea 3L indicate that on the average cod consume from 0.5 to 1 times their own weight in capelin annually. Assuming that this consumption rate applies all along the coast of Newfoundland and Labrador, then a crude estimate ranging from 1,475,000 to 2,950,000 tons of capelin would be consumed by cod annually.

Sergeant (1973) has estimated that the harp seal population along the Canadian east coast consume about 400,000 tons of capelin annually. Other species of seal (grey, harbour, hood) may consume upwards to 50,000 tons of capelin annually. Muir (MS, 1973) provides estimates of 150,000 tons of small fish consumed by sea-birds, most of which are located along the coast of Newfoundland and Labrador and feed principally on capelin. Fin whales off Newfoundland and Nova Scotia consume approximately 120,000 tons of fish annually (Muir, MS, 1973) some of which are capelin. The dominant food item of Minke whales off Newfoundland is capelin (Sergeant, 1963). These consume 15-30 tons of fish per whale during their stay in the North Atlantic area but no estimate is available of the stock size. Besides the above species, predating on capelin at some time in their life history are salmon, dogfish, yellowtail flounder, turbot and tuna. Thus, a rough estimate of the annual consumption of capelin along the east coast of Newfoundland and Labrador ranges from 2,200,000 to 3,700,000 tons. This amount is essentially then an estimate of the surplus production of capelin for this area.

The 2J-3KL cod stock prior to the development of an offshore fishery in the mid-1950's was probably substantially larger than current levels of stock abundance and comprised a greater proportion of large adult fish (Pinhorn, Pers. comm.). Also, the larger adult portion of the stock in cod from 3NO in recent years is less than in the early 1960's. Furthermore, the harp seal population as recently as 1950 was most likely twice the current size. Haddock which feed on capelin eggs on the Grand Bank have been reduced to a small fraction of their former population size; however, the yellowtail population on the Grand Bank has increased substantially (Pitt, 1970). Since yellowtail also feed on capelin eggs (Pitt, pers. comm.), some of the capelin production released by the decline of the haddock stock has possibly been taken up by the yellowtail. Nevertheless, there would appear to be a substantial amount of

of surplus production of capelin released by the decline in stock abundance of its major predators. This surplus production may be partially taken up by other species which compete with the major predators for the capelin resource.

In conclusion, there is probably a significant surplus production of capelin available on the east coast of Newfoundland and Labrador which could be commercially exploited without undue detriment to the viability of its major predators. However, any attempts to exploit vast quantities of capelin must first be reviewed in the light of the resultant effect such a depletion would have on the important commercial species for which capelin form an important source of food.

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Table 1. Landings of capelin (metric tons) for the period 1960-72 (data from the Annual Statistical Review of Canada's Fisheries, Environment Canada).

Year	Newfoundland		Quebec	Total
	Inshore	Offshore	Inshore	
1960	7,014	-	-	7,014
1961	5,106	-	-	5,106
1962	4,449	-	-	4,449
1963	5,374	-	-	5,374
1964	4,877	-	-	4,877
1965	4,784	-	-	4,784
1966	4,848	-	-	4,848
1967	3,456	-	188	3,644
1968	3,314	-	62	3,376
1969	3,446	-	157	3,603
1970	3,340	-	119	3,459
1971	2,517	-	49	2,566
1972	881	3,487	165	4,533
Total	53,406	3,487	740	57,633

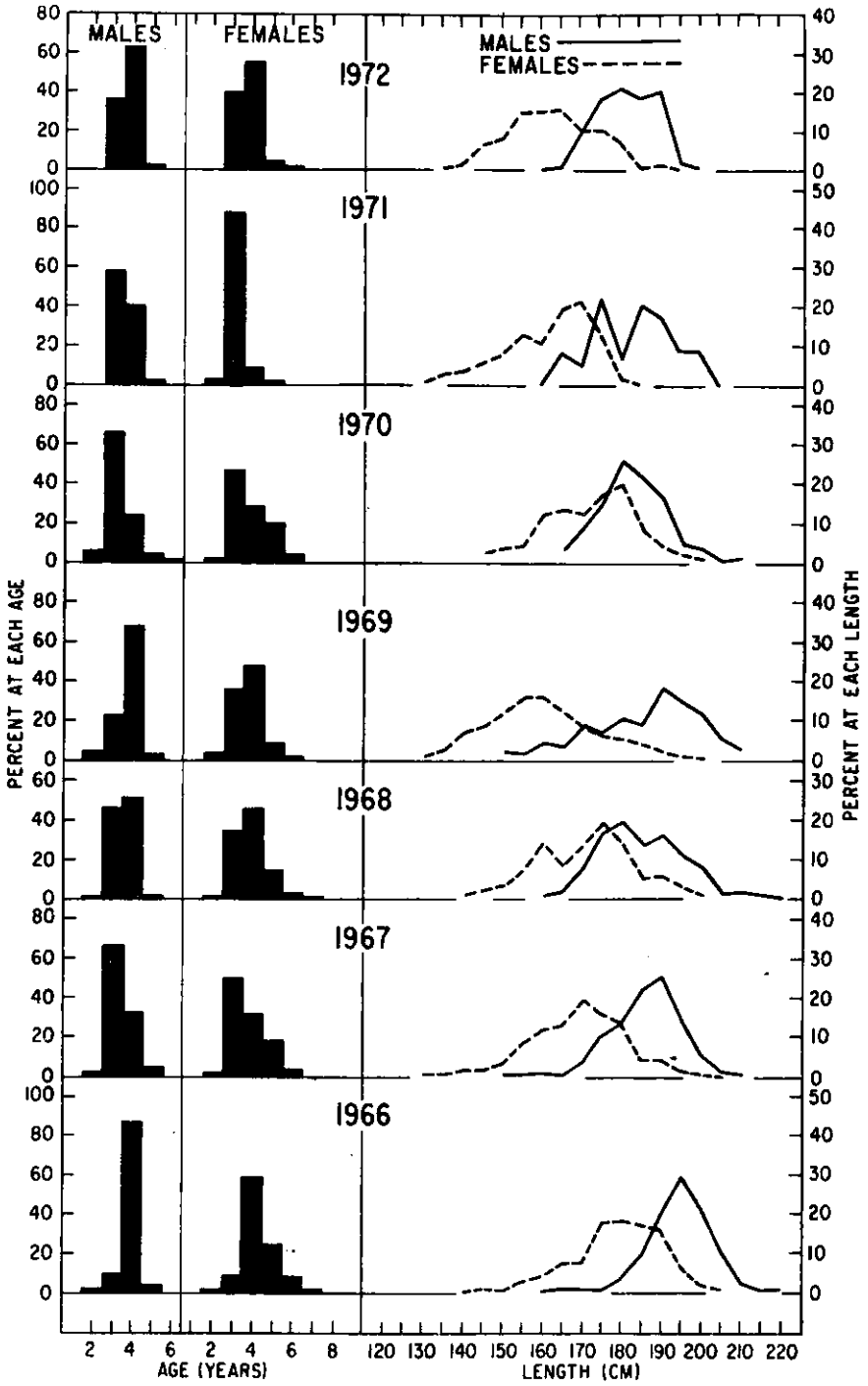

Fig. 1. Age and length frequency by percent of pre-spawning capelin from the Grand Bank, June 1966-72.

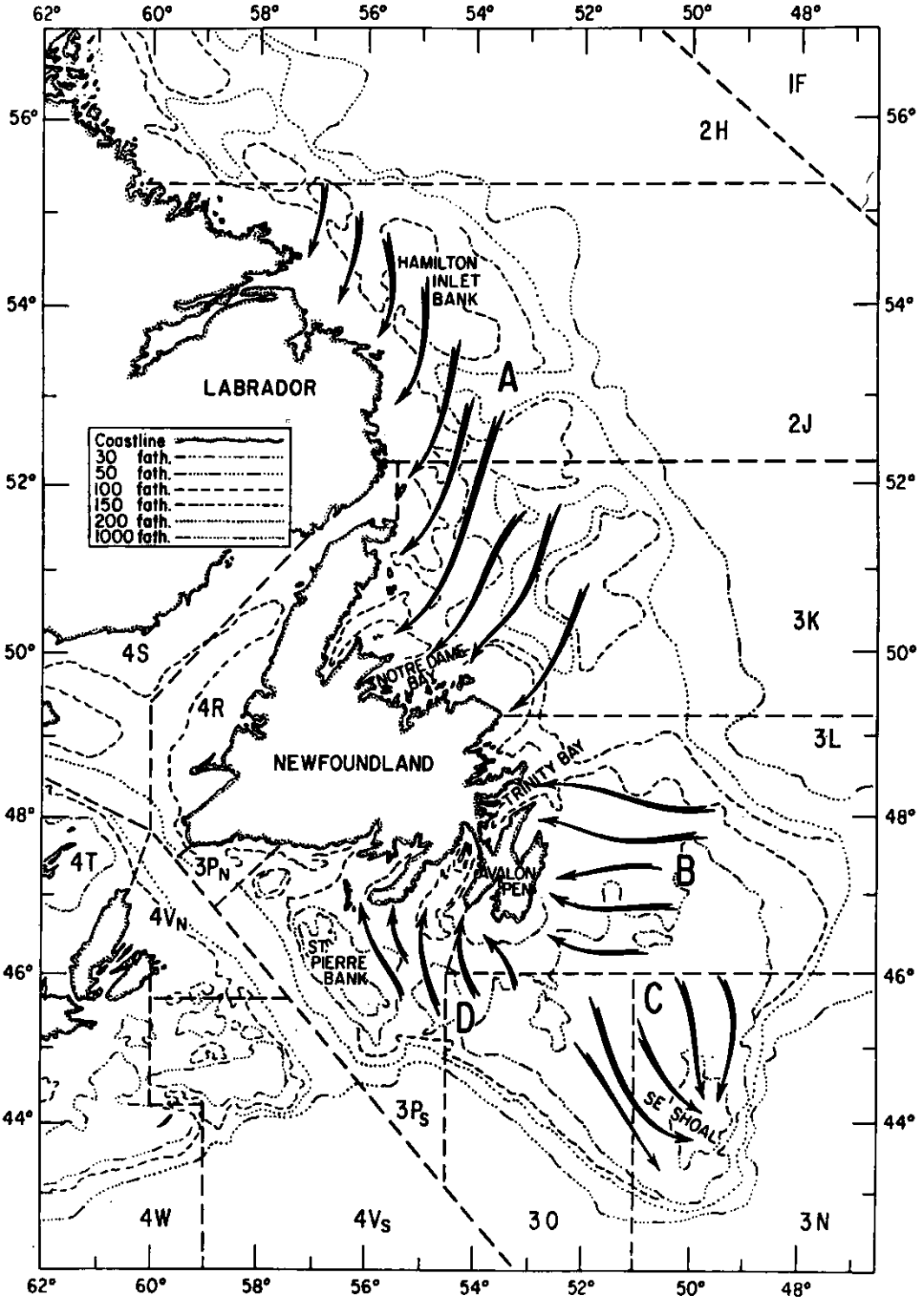

Fig. 2. Possible migration pattern of mature capelin off Newfoundland and Labrador.

A. Labrador-Northeast Newfoundland stock
B. Northern Grand Bank-Avalon stock
C. South Grand Bank stock
D. St. Pierre-Green Bank stock

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Addendum

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Some biological characteristics of capelin, Malotus villosus, in the Newfoundland area

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Contribution of capelin to the total food consumed by cod as a percentage by volume by month. Divisions 2J-3KLNO, all gears combined[a].

Month	% capelin of total food
January	-
February	0.9
March	0.9
April	0.9
May	14.4
June	97.6
July	88.4
August	26.7
September	12.7
October	9.7
November	1.5
December	-

Mean % February-November = 25.4 (unweighted)

[a] Data obtained from Templeman (1965), ICNAF Spec.Pub.No.6: 449-461, and Templeman (personal communication)

Additional Analyses

Mean % June-November	=	39.0
Mean % April-October	=	48.0
Mean % January-October	=	18.9
Mean % of all data	=	31.9