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Capelin (*Mallotus villosus*) in the Gulf of St. Lawrence

by

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INTRODUCTION

During the early 1970's, a foreign fishery for capelin developed in the Northwest Atlantic. From 1973 to 1975 Industrial Development Branch conducted exploratory fishing to aid the Canadian fishing industry in catching capelin (Hinds 1975). However, it is only in the most recent years that Canadian fishermen have shown an interest in taking capelin to supply the Japanese market for roe capelin. This interest has been evident in the Gulf of St. Lawrence notably the west coast of Newfoundland (landings 1977: 1514 m tons; 1978: 8341 m tons) and in New Brunswick.

This paper reviews selected aspects of capelin biology and presents new data pertinent to the management of capelin in the Gulf of St. Lawrence.

DISTRIBUTION

Distribution of adult capelin in the Gulf of St. Lawrence has been reported by Templeman (1948), Hinds (1975), Parent and Brunel (1977), O'Boyle and Lett (1977) and Bailey *et al* (1978). (Fig. 1 shows locations mentioned in text). During the late spring and early summer, capelin spawn inshore on suitable beaches. Along the St. Lawrence River and Quebec coast, spawning begins earliest (mid-April) upriver and is progressively later downstream (mid-July) (Parent and Brunel 1977, Bailey *et al* 1978). Templeman (1948) reported that spawning is earlier (late May) on the southern part of the west coast of Newfoundland but later (as late as mid-July) on the northern part of this coast. Capelin spawning also occurs on the Gaspé Peninsula, Anticosti Island, Bay of Chaleur area and parts of Cape Breton Island (Parent and Brunel 1977, O'Boyle and Lett 1977).

During exploratory fishing in the Gulf of St. Lawrence capelin were reported near the coasts during May and June (spawning periods), along the west coast of Newfoundland, Straits of Belle Isle and north shore in August and throughout the northern Gulf during September (Hinds 1975).

Capelin were detected along the north shore of the St. Lawrence from 57° W to 67° W longitude and along the Newfoundland coast during a September-November 1976 survey using chartered commercial vessels. Personnel from St. Andrews reported that small catches of capelin were made from Bonaventure Island into the St. Lawrence River as far as Trois Pistoles (St. Andrews Trip Report, Gulf Gunn #1). During a later trip (Hillsborough #7) from Bonaventure Island to Matane, capelin were taken in most catches especially near Cap-de-Madelaine (St. Andrews Trip Report, Hillsborough Cruise #7).

In a detailed study of capelin larvae in the St. Lawrence estuary and Northwestern Gulf of St. Lawrence, Jacquaz et al (1977) reported a decline in abundance in the upper estuary between June and September. This decline was attributed to downstream transport of larvae by water currents. During October and November large concentrations of larval capelin were detected in the Northwestern Gulf between Anticosti Island and Pointe des Monts. The authors suggested that this is an important feeding area for capelin.

O'Boyle and Lett (1977) summarized distribution of larval capelin in the southern Gulf based on plankton cruises conducted from St. Andrews and information from Hodder and Winters (1972). From this information it would appear that the entire Southern Gulf is a nursery area for capelin with highest concentrations in the area off St. George's Bay, Newfoundland.

During a research vessel cruise (E.E. Prince #169) from July 29-August 6, 1976, large concentrations of young capelin were reported in the Bay of Islands area (J. Moores, pers. comm.). These fish consisted of a mixture of young fish (1975 year-class) and post-spawning females (Fig. 2).

Stock Discrimination

In an analysis of meristic and morphometric characters of capelin collected from the Gulf of St. Lawrence and the Northwest Atlantic, Sharp et al (1978) reported that morphometrics were potentially more useful in defining capelin stocks than meristics. Furthermore, they found that there were statistical differences between morphometric characters of capelin from the four sampling areas in the Gulf (Ile aux Coudres, Grande Riviere, Sept Iles, Natashquan) and the two sampling areas in the Atlantic (Herring Neck and Southeast Shoal). Although these results were considered preliminary, they suggested that there are at least four capelin stocks in the Gulf of St. Lawrence.

Carscadden and Misra (1979) compared meristic characters of capelin spawning inshore in Newfoundland and offshore on the Southeast Shoal. Capelin spawning on beaches on the west coast of Newfoundland (ICNAF Div. 4R) were distinct from capelin spawning offshore on the Southeast Shoal (ICNAF Div.3N). In addition, these two stocks were distinct from capelin collected from other spawning areas inshore in Newfoundland (ICNAF Div. 3KLPs). These stock separations agree reasonably well with those reported by Sharp et al (1978).

O'Boyle and Lett (1977) noted that in recent years capelin spawning has occurred in St. George's Bay and suggested that this may be a separate stock.

The available evidence suggests that there may be at least 6 capelin stocks in the Gulf of St. Lawrence: 1) St. Lawrence Estuary, 2) Northwestern Gulf-Quebec (Sept Iles), 3) Northeastern Gulf-Quebec (Natashquan), 4) Chaleur Bay, 5) Western Newfoundland and 6) St. George's Bay (N.S.). Many of these stocks probably mix either as larvae (Jacquaz et al 1977) or during feeding. Such mixing may be very common between estuary, Northern Gulf and Western Newfoundland stocks.

Biomass Estimates

Two minimum biomass estimates of capelin in the Gulf of St. Lawrence are available, both based on feeding dynamics of cod. Minet and Perodou (1978) reported that for cod in Div. 3Pn, 4R and 4S there was little seasonal variation in the diet of cod ; capelin constituted 78% of the diet in summer and 59% in winter. However, size of cod had an effect with predation on capelin declining with the size of the predator. The authors estimated that cod consume 0.8 to 1.3 times their body weight of capelin per year which is in good agreement with the estimate of 1.0 provided by Winters and Carscadden (1978). Using biomass estimates of cod, the annual consumption of capelin by cod in Div. 3Pn, 4R and 4S during 1965-69 was 240,000 to 400,000 tons (Minet and Perodou 1978). These consumption estimates are obviously minimum total biomass estimates of capelin because:

1. cod predation represents only a portion of natural mortality of capelin, and
2. the estimates encompass only a portion of the geographical distribution of capelin.

Based on these observations, it is probable that the entire Gulf of St. Lawrence capelin population is, on the average, in excess of 1 million metric tons.

O'Boyle and Lett (1977) produced an estimate of capelin biomass for the Chaleur Bay area. Although their estimate was also calculated on the basis of cod feeding rates, some of their data on feeding and digestion rates differed from that of Minet and Perodou (1978) and some of their assumptions regarding natural mortality and mean weights are open to question. For instance, O'Boyle and Lett (1977) reported that cod under 35 cm were not feeding on capelin but that numbers of capelin per stomach increased with the size of cod. Minet and Perodou (1970) found that capelin comprised 89% of the diet of cod from 26-55 cm, but this proportion declined to 13% in cod greater than 75 cm. However, Minet and Perodou (op cit) noted that the actual quantities of capelin consumed by cod of different size groups may have been fairly stable as the quantities of capelin eaten increased with the size of the predator.

O'Boyle and Lett (1977) used 5° C as the average water temperature for the Chaleur Bay area between May and October and from this determined that a cod would require 1.5 days to digest a meal. On the other hand, Minet and Perodou (1978) estimated that it would take 3 days for a cod to digest a meal.

The estimate of 0.2 for natural mortality of capelin used by O'Boyle and Lett (1977) may be too low for a short-lived species such as capelin. Carscadden et al (1978), Carscadden and Miller (1979) and Miller and Carscadden (1979) assumed a value for M = 0.30 for Northwest Atlantic capelin during periods other than spawning. Spawning mortality increased with age and was greater than 1.0 (Winters and Campbell 1974; Carscadden and Miller 1979).

The derivation of the mean weight of 10 g for capelin is not given by O'Boyle and Lett (1977). However, mean lengths of capelin from the Gulf of St. Lawrence (Bailey et al 1978) applied to length-weight regressions for capelin (Winters and Campbell 1975) and our own data (Table 1) for Gulf of St. Lawrence capelin suggest that this estimate is too low. Cod feed heavily on mature capelin during June and July but later in the summer they feed almost exclusively on 1-year-old capelin (Templeman 1948). Thus, during the time period of May to October considered by O'Boyle and Lett (1977), the mean weight of individual capelin being consumed by cod is likely to be greater than 10 grams.

O'Boyle and Lett (1977) calculated a biomass of 160,000 metric tons of capelin in the Bay of Chaleur and extrapolated this to other areas of the Gulf. In view of the questions regarding the accuracy of some of their assumptions, the acknowledgement by the authors that their biomass estimates were very crude should be taken seriously.

Age Composition

During 1974 and 1975, Bailey et al (1978) reported that 90% of the mature males and 80% of the females were 3-year-olds in capelin populations spawning in the St. Lawrence Estuary and Western Gulf of St. Lawrence. The remainder of the males were 4-year-olds while the female portion of the population contained 2, 4, and 5-year-olds.

Capelin samples have been collected for a number of years on an ad hoc basis by personnel from the St. John's Laboratory during research vessel and field trips. However, these samples provide very little information on a time-series basis because of the lack of consistency in their collection. Since 1976, samples of capelin spawning inshore in Newfoundland (Div. 4R) have been collected to provide estimates of relative year-class strength. Analysis of these samples reveals that the 1973 year-class was strong and predominated in 1976 and 1977 and was strong even in 1978 (Fig. 3).

In an analysis of capelin in ICNAF Div. 3LNO, Carscadden and Miller (1979) found that there was a positive correlation between estimates of year-class strength as 2-year-olds in the northern (Div. 2J3K) and southern (Div. 3LNO) capelin stocks. From sequential capelin abundance models (Carscadden and Miller 1979, Miller and Carscadden 1979) and sampling (Carscadden and Miller 1979, Bakanev and Seliverstov 1978), the 1973 year-class was found to be relatively strong over the entire area investigated. The fact that in all areas of the Northwest Atlantic including the Gulf of St. Lawrence the 1973 year-class was strong suggests that large-scale effects are affecting capelin recruitment. Careful monitoring of year-class strength in all areas for a number of years will be necessary to test this hypothesis.

Ichthyoplankton Surveys

Plankton cruises were conducted from St. Andrews, New Brunswick from 1965-1977 and from preliminary analysis of the data, the 1968 year-class was strong and high numbers of larvae were taken in 1971 (O'Boyle and Lett 1977). Kohler, Faber and McFarlane (1974, 1975, 1976, 1977) have provided data reports of these cruises. Different gears have different efficiencies depending on the size of the larvae (Jacquaz et al 1976). Consequently the data for capelin catches in the Isaacs-Kidd Midwater Trawl (IKMT) were chosen for examination since this gear was used from 1968-1974. To further diminish gear bias, only the August cruise each year was selected. These data were expressed as percent occurrence of capelin larvae and geometric mean of the number of larvae per successful tow (Table 2). In 1968 and 1974, capelin larvae occurred in porportionately more tows than in other years and mean numbers per tow were also high.

The relative strength of the 1968 year-class in relation to other year-classes up to 1972 agrees with the observations of O'Boyle and Lett (1977). However, the relative strength of the 1974 year-class does not agree with our observations of year-class strength based on analysis of age-composition of mature capelin spawning in 4R. Any conclusions drawn from the analyses of the ichthyoplankton surveys in this paper and in O'Boyle and Lett (1977) should be treated with caution. In the O'Boyle and Lett paper, the authors did not indicate which gears were being used in their analysis in spite of different sampling efficiencies of the gear. In addition, Kohler et al (1974, 1975, 1976, and 1977) provide only the notation "no observation" for the amount of water strained for many of the tows in earlier years. Thus, it is impossible to evaluate how O'Boyle and Lett (1977) converted the numbers of capelin caught to their standard of numbers of larvae per 100,000 m^3. In this paper, the observations cannot be considered quantitative since no observations for the amount of water strained are available presumably because such observations are not possible with the IKMT. With proper analysis by someone who has complete access to and understanding of the ichthyoplankton collection, these data should provide valuable information on relative year-class strength of capelin in the Gulf of St. Lawrence.

DISCUSSION

It is obvious from this brief review that there are insufficient data available to provide precise biological information suitable for management of capelin stocks in the Gulf of St. Lawrence. The lack of historical data is further complicated by the fact that the annual biomass of capelin is heavily dependent on recruitment of the maturing year-class.

The only biomass estimates available are at best crude and represent only minimum estimates. Estimates based on trophic dynamics are subject to considerable error depending on such assumptions as feeding rates of predators and on population estimates of predators which themselves may be in error. No adjustments are made for annual changes in feeding patterns due to availability of both prey and predators, changes in digestion rates, annual changes in capelin abundance due to variation in recruitment, etc. The annual variation in some of these factors could be large. For instance, the lowest estimate of abundance of Barents Sea capelin has been observed to be about 20% of the

average (Gjosaeter 1972). As a result, estimates of capelin abundance based on feeding by predators should be considered only as very crude estimates and any TAC's recommended for the Gulf of St. Lawrence capelin should be precautionary TAC's. It should again be noted that year-class strength of capelin in the Gulf and the Atlantic appears to be related. Capelin year-classes in the Northwest Atlantic have been relatively weak since 1973 with the possible exception of the 1977 year-class.

The evidence available concerning capelin stocks suggests that there may be at least 6 distinct stocks of capelin in the Gulf of St. Lawrence. If the present fishing pattern does not change on a temporal basis, then it might be advisable to partition any future TAC's so that excess fishing mortality is not exerted on one stock. Because of the current fishing interest in the New Brunswick and Newfoundland areas, the Chaleur Bay and Western Newfoundland stocks should receive the most attention from fisheries managers and scientists.

From the scientific standpoint, acoustic and pre-recruit surveys offer the most promise of yielding information useful for providing management advice. The acoustic method, although still in its development in Canada, does provide comparable annual estimates of capelin biomass. The pre-recruit surveys designed for capelin should provide estimates of incoming year-class strength. In this respect, a rigorous analysis of the back-data from past ichthyoplankton cruises in the Gulf would provide guidance in designing future capelin cruises. The sequential capelin abundance models (Carscadden et al 1978, Carscadden and Miller 1979, Miller and Carscadden 1979) will not be useful until a suitable backlog of commercial fishing data is available. However, complete sampling and fishing effort data should be collected to make such models useful in future years.

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Table 1. Mean weights-at-age (g) by sex of capelin from the Gulf of St. Lawrence.

ICNAF Div. 4R - June - 1976

	Age						
	1	2	3	4	5	6	Mean
Males							
1976			37.5	39.7	42.0	50.0	38.0
1977			35.9	42.3	37.8		41.5
Females							
1976		14.0	22.8	25.0	30.0		23.2
1977			21.6	25.9	31.7	26.0	25.3

ICNAF Div. 4T - Aug. - 1976

	Age					
	1	2	3	4	5	Mean
Males	4.8	11.7	18.7	15.0		14.7
Females	4.8	11.3	15.0	19.5		13.0

ICNAF Div. 4T - Oct. - 1976

	Age					
	1	2	3	4	5	Mean
Males	8.0	20.8	22.9			21.9
Females		15.7	20.7	18.0		18.3

Table 2. Percent of tows (IKMT 6) with capelin larvae and geometric mean of number of larvae per successful tow.

Year	Percent occurrence	Mean no./tow
1968	81	5.99
1969	40	3.26
1970	21	2.55
1971	44	4.18
1972	34	3.42
1973	35	3.75
1974	88	13.52
1975	IKMT 6 Not Used	

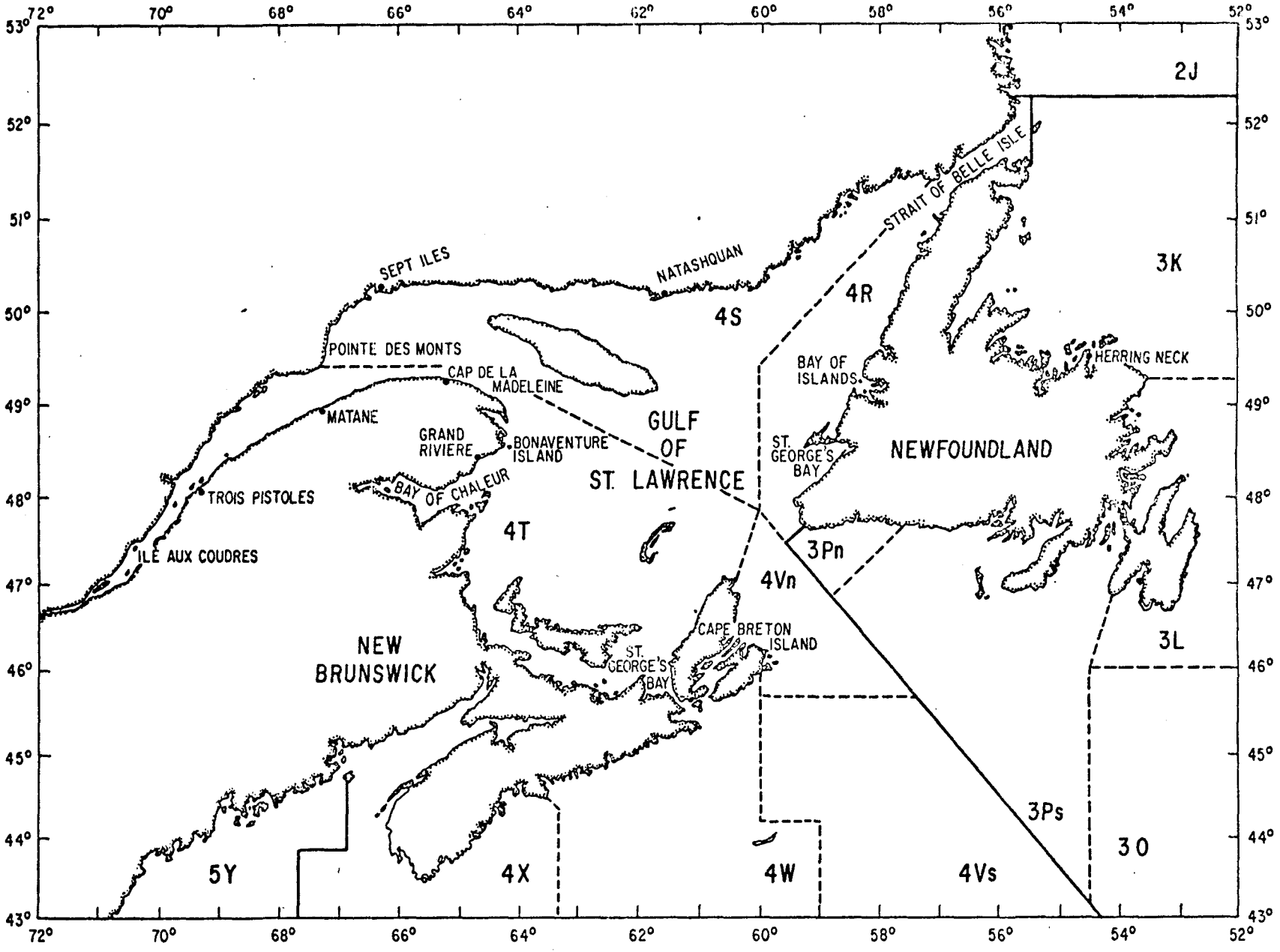

Fig. 1 Locations mentioned in text.

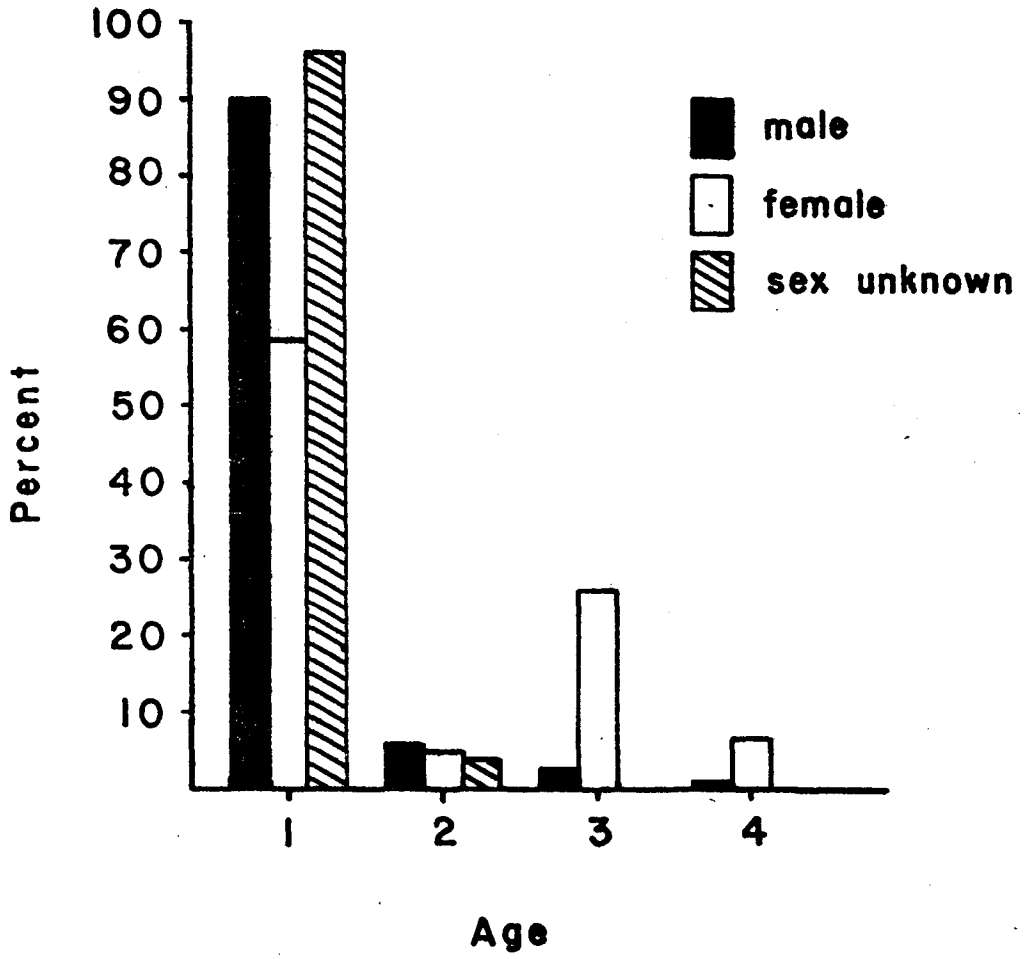

Fig. 2. Age composition, by sex, of capelin from Bay of Islands area, July and August, 1976.

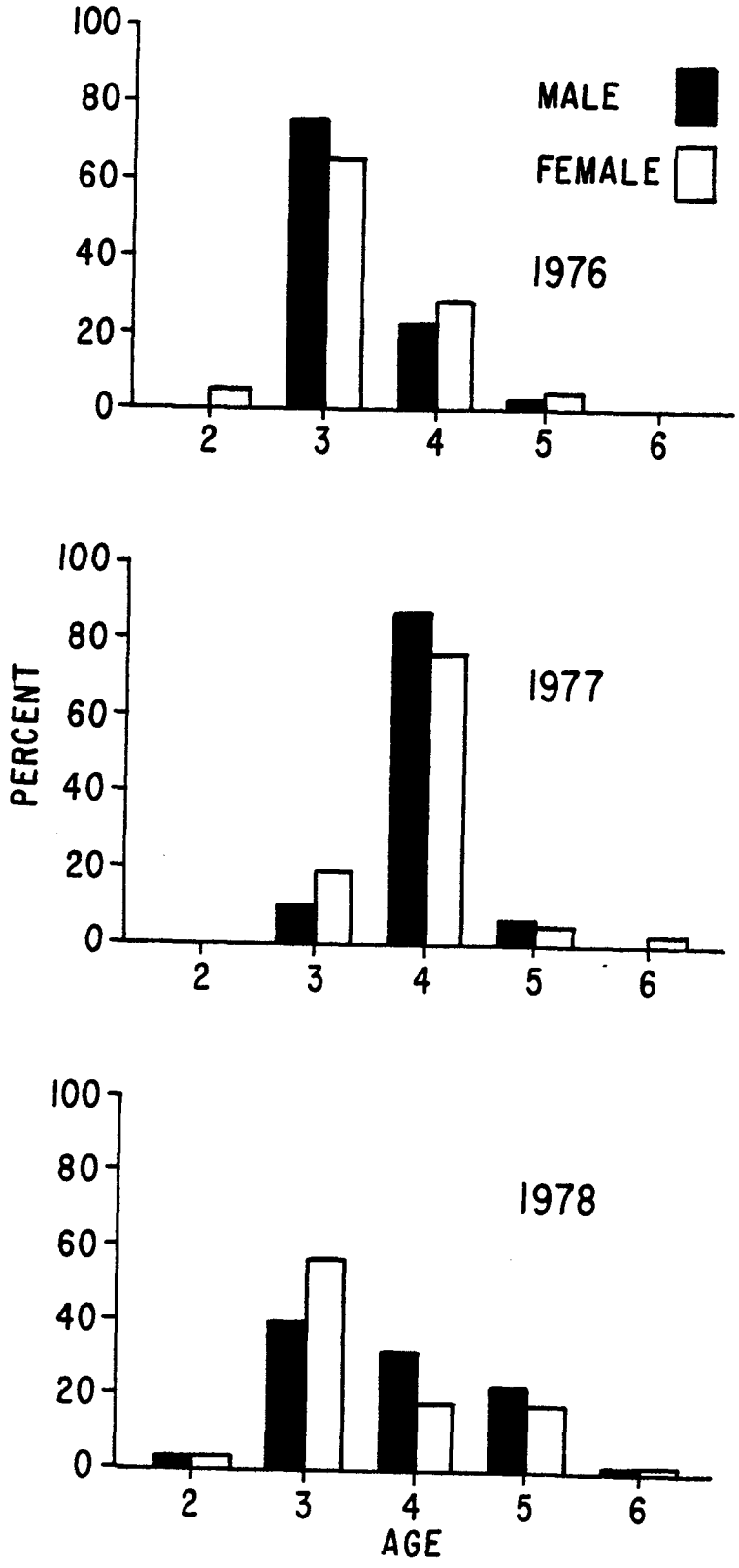

Fig. 3. Age composition, by sex, of capelin, ICNAF Div. 4R, June 1976, 1977, and 1978.