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Observations on larval capelin (*Mallotus villosus*) in ICNAF Division 3L

by

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INTRODUCTION

In spite of the large commercial fishery for capelin in the Northwest Atlantic and the importance of capelin in the trophic structure of the North Atlantic ecosystem, little information is available on the early life history of capelin. Exceptions to this are found in Templeman (1948), Winters (1969), Hodder and Winters (1969), Bailey *et al.* (1976) and Jacquaz *et al.* (1976). In the period February 27 - March 9, 1977 we had the opportunity to obtain large numbers of capelin larvae in ICNAF Division 3L. This paper presents an analysis of distribution and some biological characteristics of these larvae.

MATERIALS AND METHODS

Larvae were caught with a Diamond 5 midwater trawl (MWT) with a codend liner of 0.5 in (13 mm) and a 10 ft Isaacs-Kidd midwater trawl (IKMT). The large midwater trawl was towed near bottom, usually for 30 min depending on ice conditions, at speeds of 3-4 knots. Estimates of MWT fishing depths were obtained in the following manner. Total water depth was read directly from the echo sounder recordings. Where a range of depths occurred, a mean depth was determined by averaging the greatest and shallowest depths. Net sounder recordings yielded both the distance between the bottom of the net and the sea bottom as well as the height of the net opening. Mean distance from the sea bottom to the bottom of the net was calculated by averaging the largest and smallest distance. Similarly the average net opening was calculated by averaging the largest and smallest net opening. Thus, mean water depth, mean distance of the bottom of the net from the sea bottom and mean net opening were calculated for each set. Approximate fishing depth was then calculated by the following formula:

$$\text{Approximate fishing depth} = \text{Mean water depth} - \left(\text{Distance between sea bottom and bottom of net} + \frac{\text{Height of net opening}}{2}\right)$$

The resulting depth is taken to represent the approximate depth at which the middle of the net opening was fishing in each set. The IKMT was towed nearer the surface at speeds of 4.5-5.0 knots. In most cases, tows were made using the following warp lengths: 175 fathoms, 125 fathoms, 75 fathoms and 25 fathoms for 10 min at each warp length. Assuming a ratio of 4:1 for warp length: depth fished, depths fished ranged from approximately 11 m to 79 m over a 40 min tow.

In many cases when using the MWT the bulk of the sample was entangled in the meshes of the net and relatively few capelin were taken from the codend.

All capelin analyzed for this paper exhibited most larval characteristics described by Bailey *et al.* (1976). All larvae were translucent, the gut when examined externally was straight and undifferentiated and the two rows of ventral melanophores were obvious. Fish were not examined for the presence of scales. Total lengths of fresh fish were measured to the nearest mm.

We also attempted to determine the effect of different methods of storage of these larvae on the total lengths. Two hundred larvae were chosen at random from one set and divided into 4 samples of 50 fish each. Total length was measured for each fish and fish were placed individually in vials and labelled. The four samples were then preserved in the following ways: sample 1 - 70% alcohol, sample 2 - 5% formalin, sample 3 - frozen dry and sample 4 - frozen wet. After approximately two weeks storage, total length of each fish was again measured by the same person. Because of the small length ranges, regressions were not calculated. However, mean lengths were calculated for each sample and the numbers of fish that shrank, the numbers of fish that had gotten larger and the numbers of fish that remained the same length during storage were tabulated.

RESULTS

Storage experiments

In all cases, there was a decrease in mean length of capelin larvae after storage (Table 1) although the difference was large only when capelin were frozen dry. In all cases, at least some fish shrank when stored dry. However, when frozen dry no fish became larger although using other methods of preservation, up to 10% of the fish increased in size during storage.

Distribution and biological characteristics

Because of heavy slob ice in most areas of operation the northern Grand Banks area could not be completely surveyed. The IKMT could not be used in many areas because of ice conditions and eventually had to be abandoned entirely because of ice damage.

A record of set details, depth of water and fishing depths are given in Table 2 and locations of sets and catches are illustrated in Fig. 1. Numbers of capelin larvae in the catches were highly variable and although accurate counts of larval capelin were not made for each set it was obvious that the large trawl caught more. For instance, the largest catch in the IKMT was 2 capelin larvae whereas in one set of the MWT, it was estimated that approximately 100 kg of larval capelin were taken. Most of the capelin measured from the MWT catches represented subsamples. Capelin larvae were taken in 3 of 8 IKMT sets and in 15 of 19 MWT sets.

The maximum depth fished by the IKMT was approximately 79 m and in all sets except one, it was fished to within 11 m of the surface. In the case of the MWT, its fishing depth ranged from 40 to 167 m in sets in which no larval capelin were taken and from 87 to 186 m in sets in which capelin larvae were caught.

Bottom temperatures in the areas where sets were made ranged from 0.7°C to -1.5°C. Typical temperature profiles and range of fishing depths are shown in Fig. 2. Water temperatures were relatively constant from surface to bottom and in most cases were below 0°C.

Mean total lengths, standard deviation and ranges of lengths of larval capelin by set are given in Table 1. Length frequencies by 3 mm groups are given in Table 3 and illustrated in Fig. 3. Fish taken in the IKMT were too few in number to compare mean lengths taken in the two gears. However, in October 1974 Jacquaz et al. (1976) found that mean lengths of Gulf of St. Lawrence capelin larvae captured in the IKMT and MWT were not significantly different. Although lengths of capelin larvae ranged from 37 to 72 mm, mean lengths per set were fairly constant, ranging from 50.5 to 60.9 mm. The overall mean of 700 fish measured was 53.4 mm.

DISCUSSION

Results from the preservation experiments would suggest that with the exception of larvae frozen dry, preservation in 70% alcohol, in 5% formalin or by freezing in water will yield unbiased mean lengths when the sample size is large. In such cases, no conversion of preserved lengths to true fresh length is necessary. In the case of larvae frozen dry, considerable shrinkage did occur (6% of fresh length) and thus conversion would be necessary to determine true lengths. Although larvae frozen dry exhibited considerable shrinkage, none became larger during preservation. The observation of an increase in length during preservation was somewhat unexpected. This phenomenon may be due in part to measurement error since fresh lengths were measured onboard the research vessel at sea where the ship's movement made the transparent caudal fin difficult to see. However, this source of error is not believed significant since the percentage of fish that became larger in the different methods of preservation varied with preservation methods and ranged from 0 to 10%. It would appear that this phenomenon is real in all methods of preservation except dry frozen storage.

Results of this experiment disagree with other studies. Winters (1969) reported that larval capelin from 20 to 40 mm shrank 2 mm when stored in 95% alcohol. Fish in the present experiment were larger and stored in 70% alcohol and these factors may contribute to the different results between the two studies. Because of these unresolved differences the use of alcohol as a preservative of capelin larvae should be avoided if length measurements are desired after preservation. Winters (1974) showed that for adult capelin, freezing results in shrinkage of approximately 3% and storage in 95% alcohol results in increases in length of about 5%. Bailey et al. (1976) said that frozen adult capelin shrank by 4% during frozen storage.

From the results of this experiment, we would conclude that storage of capelin larvae in 5% formalin or frozen in water would be acceptable and if sample sizes were large, mean lengths calculated from measurements of preserved specimens would be unbiased. Of the two acceptable methods of storage, freezing in water would be more preferable because 66% of these fish were the same length after storage. This experiment should be expanded to incorporate greater length ranges and some provision should be made to test measurement error under laboratory and shipboard conditions especially in view of the unexpected occurrence of larger length measurements after storage.

The presence of larval capelin during March is significant. In an examination of adult Gulf of St. Lawrence capelin otoliths Bailey et al. (1976) reported the presence of a check. After back-calculation it was found that this check occurred at an average length of 63 mm. This check did not correspond to lengths at age 1 or age 2 and the authors concluded that this check in the otolith was laid down at metamorphosis from the larval to the adult form. Observations of capelin before, during and after metamorphosis confirmed that metamorphosis did occur at the length suggested from the back-calculations. They also found that the "metamorphic check ring" was usually laid down after the first winter. In otoliths where this check was not visible, they suggested that its deposition occurred at the same time as the deposition of the first or second annulus.

Our samples, taken in March 1977, are assumed to represent the 1976 year-class (see discussion below). Thus, the presence of larval capelin at this time of year shows that the "metamorphic check ring" in Newfoundland capelin would also be expected to occur after the first winter. Bailey et al. (op. cit.) reported that 92.3% of Newfoundland otoliths from 2-year-old fish contained metamorphic checks. We did not take any capelin that had recently undergone metamorphosis. Differences in schooling and distribution after metamorphosis may have prevented us from capturing recently metamorphosed fish. Thus, we cannot say that metamorphosis does not occur before the first winter; we can confirm that metamorphosis can occur after the first winter.

A comparison of mean lengths of capelin taken for this study and capelin from the Gulf of St. Lawrence confirms that our samples were from the 1976 year-class. In November 1974 larval capelin collected in the northwestern Gulf ranged in length from 43 to 56 mm SL (mean 48.4 mm SL, 53 mm TL) (Jacquaz et al., 1976). Back-calculations of Gulf of St. Lawrence capelin revealed that maximum total length would be 60 mm at age 1 (Bailey et al., 1976). Mean length from our March samples was 53 mm TL which is very close to the lengths for young-of-the-year capelin found in the Gulf studies.

Hodder and Winters (1972) collected capelin larvae from the southern Gulf of St. Lawrence and southwestern Newfoundland in November 1969 and 1970. The mean length of capelin calculated from the combined samples was 33.0 mm with mean lengths from different areas, different years and different gears ranging from 30.0 mm to 36.8 mm. Thus, the mean lengths of capelin larvae from the southern Gulf of St. Lawrence and southwestern Newfoundland were considerably smaller than samples from the northwestern Gulf of St. Lawrence. Although sampling periods are not comparable, mean lengths of capelin given by Hodder and Winters (1972) would probably have been smaller than Grand Banks capelin sampled in November.

Winters (1969) found capelin larvae in Trinity Bay in October and December. The length distribution of October larvae was 20 mm - 45 mm and of December larvae was 40 - 62 mm. Thus, our samples taken in March agree with Winters' (1969) October and December observations. Winters (1974) also provided back-calculated lengths for 1-year-old capelin. Measurements were made to the outside of the winter zone, that is, to the end of the winter period. For Trinity Bay capelin, computed l_1's ranged from 66 to 81 mm and therefore on the average were larger than lengths we recorded. Similarly from the growth curves fitted by von Bertalanffy growth equation, l_1's were larger than lengths reported in the present study.

Templeman (1948) also provides lengths of capelin larvae caught in the Newfoundland area. Quoting Jeffers, Templeman reports that transparent larval capelin are frequently abundant in early spring in northern Newfoundland adding further support to the formation of a metamorphic check after the first winter. Six specimens taken in June 1929 varied in length from 50 to 64 mm and averaged 53 mm and 39 specimens taken in June 1930 varied in length from 42 to 66 mm and averaged 54 mm. These capelin were about the same size as capelin from the present study but were about 4 months older. Small capelin were also taken from the stomachs of herring which were caught in Fortune Bay between February 23 - March 10, 1944. Templeman concluded that all capelin up to 70 mm were 7 or 8 months old, the range of lengths being from 30 mm to 70 mm. These lengths are similar to the lengths reported in the present study.

The results of these studies suggest that growth rates of capelin in the first year are not only variable but that different growth rates may occur in different localities. Data from Templeman (1948) and Hodder and Winters (1972) suggest that larvae from northern Newfoundland and the southern Gulf of St. Lawrence are slower growing than capelin larvae from Trinity Bay (Winters, 1969), northwestern Gulf of St. Lawrence (Jacquaz et al., 1976) and the Grand Banks (this study). However, Templeman's (1948) Fortune Bay data would suggest that capelin in this area grew faster than the data presented by Hodder and Winters (1972) would suggest. Factors such as spawning times, hydrographic conditions and gear selectivity could affect the results of these studies; further work on larval capelin is necessary to evaluate these influences.

Although the quantities of capelin caught in the two gears in this study are not comparable, the fact that larvae were taken in both types fishing at different depths suggests that larval capelin were distributed throughout the water column during daylight hours. We made only one tow with the midwater trawl at night and no larvae were taken. Water temperatures were generally below 0°C from surface to bottom and the temperature range was not greater than 2°C. Thus, water temperatures would favour the vertical distribution of larval capelin reported in this paper. In the estuary of the Gulf of St. Lawrence during June-August 1974-1975 over 95% of capelin larvae were collected in the upper 50 m.

During this period water temperatures to this depth ranged from 2.4°C to 14.4°C. However, in September 1974 17% and in September 1975 28% of larvae were taken at depths greater than 50 m. The temperature range during the September 1975 collections was 0.2 - 14.4°C. Hodder and Winters (1972) towed the IKMT with a maximum warp length of 100 fathoms; thus, the maximum depth fished was approximately 45 m.

Capelin larvae were taken in most of the sets and at variable total water depths. In the case of the MWT sets, the water depths at which larvae did or did not occur overlapped to a great extent making it impossible to detect any relationship between total depth of water and the presence of capelin larvae. Because the hydrographic conditions at that time show little variation with depth, depth may not be an important factor in determining larval distribution. More samples over a wider area preferably with only one type of gear are necessary to provide detailed information on distribution of capelin larvae in relation to total water depth. Although the present study was hampered by heavy ice conditions, results from it and the literature (Templeman 1948, Winters 1969, Hodder and Winters 1972, Jacquaz et al. 1976) suggest that capelin larvae are widely distributed inshore as well as offshore on the northern Grand Bank.

ACKNOWLEDGEMENTS

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Table 1. Mean lengths and standard deviations of larval capelin, measured fresh and after preservation, and number of larval capelin that became larger, number that became smaller and number that remained the same length after preservation.

Preservation	Mean length (mm)	Standard deviation	Number larger	Number smaller	Number same size
Fresh	50.5	2.6			
70% Alcohol	50.4	2.6	5	27	18
Fresh	49.7	2.5			
5% Formalin	49.4	2.3	5	19	26
Fresh	51.6	2.7			
Frozen Dry	48.6	2.4	0	48	2
Fresh	50.3	3.0			
Frozen Wet	50.1	3.1	2	15	33

Table 2. Set details, water depth (m), approximate fishing depth (m) of midwater trawl and IKMT during larval capelin survey, February-March 1977. See text for determination of fishing depth.

Date	Time at end of set (NST)	Duration (min)	Location (end of set)	Gear	Larvae present	Water depth (m)	Approx. fishing depth (m)	Bottom temp °C	Mean length (SD) (mm)	Range of lengths (mm)	Number measured
Feb 27	1005	30	46° 18' N 53° 07' 45" W	MWT	No	150	130	-1.0			
Feb 27	1242	30	46° 19' N 53° 07' 15" W	IKMT	No	150	34-79	-1.0			
Mar 1	1445	30	47° 23' N 52° 10' W	MWT	Yes	150	125	-0.5	54.7 (5.1)	47-64	10
Mar 1	1620	40	47° 20' 15" N 52° 10' 00" W	IKMT	Yes	150	11-79	-0.5		48, 55	2
Mar 2	0910	20	47° 48' N 51° 13' 30" W	MWT	Yes	144	-	-0.0	57.2 (5.4)	46-64	10
Mar 2	1045	30	47° 51' N 51° 16' W	MWT	Yes	183	161	-0.1	55.5 (3.3)	52-64	15
Mar 2	1240	40	47° 52' 30" N 51° 10' 05" W	IKMT	Yes	166	11-79	-0.1		43	1
Mar 3	1152	22	48° 11' N 50° 58' 15" W	MWT	Yes	172	153	0.2		66	1
Mar 3	1418	40	48° 09' 55" N 50° 57' W	IKMT	No	202	11-79	0.2			
Mar 4	1045	30	47° 45' 45" N 50° 45' W	MWT	Yes	134	122	-0.7		62	1
Mar 4	1155	30	47° 42' 30" N 50° 48' 00" W	IKMT	No	112	11-79	-0.7			
Mar 4	1620	30	47° 31' 30" N 51° 04' 45" W	MWT	Yes	130	116	-1.0	50.5 (2.8)	44-60	200
Mar 4	1745	40	47° 28' N 51° 10' W	IKMT	No	135	11-79	-1.0			
Mar 5	1610	30	47° 36' 30" N 51° 54' 30" W	MWT	No	184	167	-0.1			
Mar 5	1720	40	47° 40' 15" N 51° 56' 30" W	IKMT	No	184	11-79	-0.1			
Mar 6	0934	34	48° 08' 45" N 52° 25' 30" W	MWT	Yes	203	186	0.0	60.9 (6.0)	50-67	9

.... Cont'd.

Table 2. Cont'd.

Date	Time at end of set (NST)	Duration (min)	Location (end of set)	Gear	Larvae present	Water depth (m)	Approx. fishing depth (m)	Bottom temp °C	Mean length (SD) (mm)	Range of lengths (mm)	Number measured
Mar 6	1320	30	48° 16' 15" N 52° 21' 30" W	MWT	Yes	105	87	-0.1	58.5 (5.5)	39-66	23
Mar 6	1545	40	48° 16' 00" N 52° 20' 30" W	IKMT	Yes	190	11-79	-0.1		37	1
Mar 7	1058	58	47° 01' 15" N 52° 08' 15" W	MWT	Yes	152	136	-0.8	55.4 (3.0)	49-62	100
Mar 7	1640	30	46° 53' 00" N 51° 34' 15" W	MWT	No	55	40	-1.1			
Mar 7	2252	27	46° 39' 45" N 51° 48' 30" W	MWT	No	112	101	-0.6			
Mar 8	0850	30	46° 36' 15" N 52° 22' 00" W	MWT	Yes	145	133	-0.7	52.2 (4.7)	42-63	100
Mar 8	1142	30	46° 23' 15" N 52° 40' 15" W	MWT	Yes	192	179	-0.8		51, 60	2
Mar 8	1425	30	46° 11' 15" N 52° 58' W	MWT	Yes	155	139	-0.9	57.3 (3.7)	54-62	6
Mar 9	0900	30	46° 06' N 53° 27' 30" W	MWT	Yes	153	138	-1.0	52.0 (4.3)	39-63	100
Mar 9	1135	30	46° 06' N 53° 46' 30" W	MWT	Yes	152	136	-1.0	55.9 (4.8)	47-71	100
Mar 9	1505	30	46° 23' 45" N 53° 17' 30" W	MWT	Yes	99	90	-1.5	56.8 (6.0)	50-72	19

Table 3. Length distribution of larval capelin in MWT and IKMT catches from ICNAF Div. 3L, February-March 1977.

Length-group (3 mm)	Number of larvae
36-38	1
39-41	2
42-44	8
45-47	51
48-50	146
51-53	159
54-56	181
57-59	74
60-62	52
63-65	17
66-68	6
69-71	2
72-74	1
Total number	700
Average length	53.4
Standard deviation	4.8

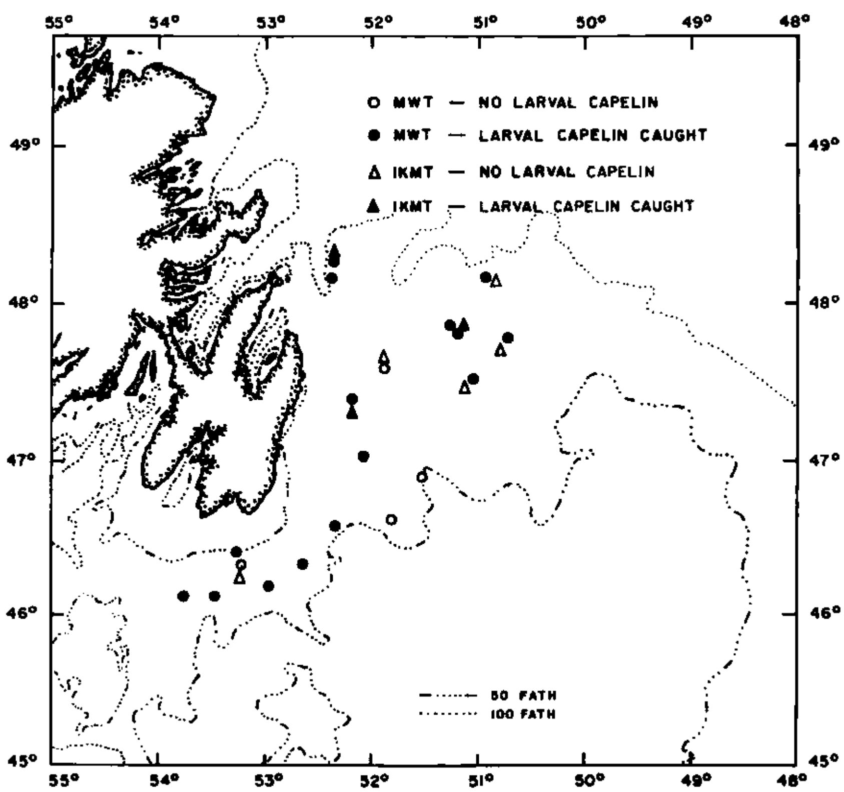

Fig. 1. Locations of sets and catches of larval capelin in ICNAF Div. 3L, February 27- March 9, 1977.

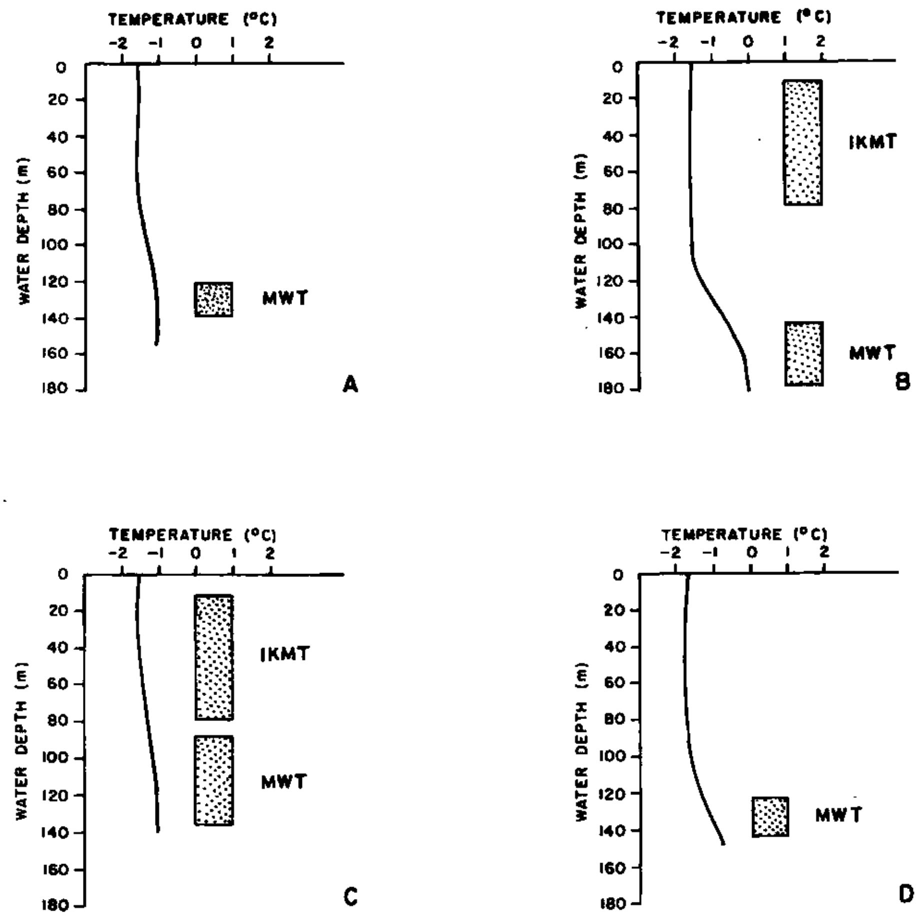

Fig. 2. Typical temperature profiles showing approximate depths fished. Arrows indicate the fishing depths given in Table 2. A - 27 February 1977, no larvae caught; B - 2 March 1977, larvae caught in both MWT and IKMT; C - 4 March 1977, no larvae in IKMT, larvae caught in MWT; D - 7 March 1977, larvae caught.

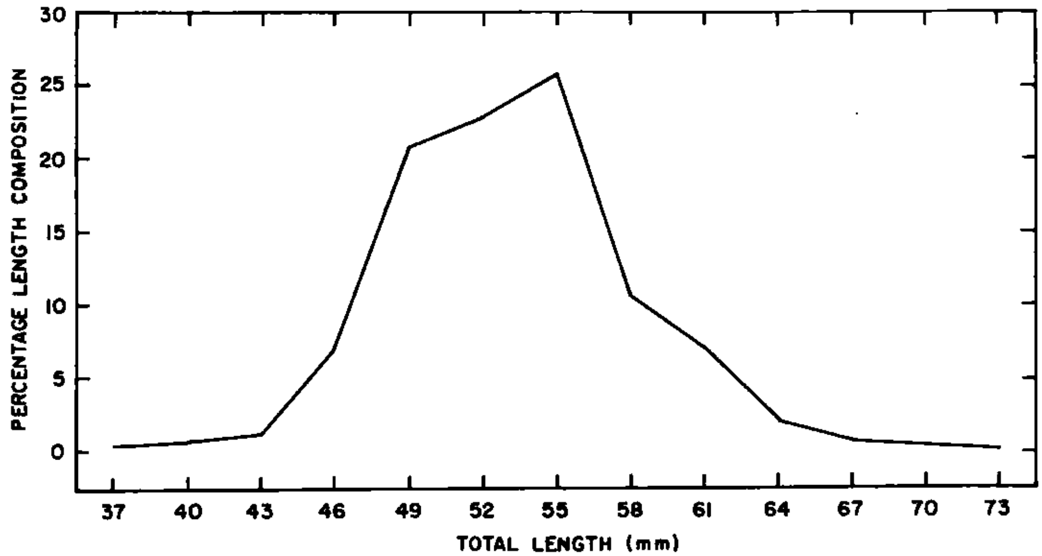

Fig. 3. Length frequencies of larval capelin from ICNAF Div. 3L, 27 February-9 March 1977.