

~~26~~
28

RIT FISKIDEILDAR

IV. BINDI — VOL. IV

Nr. 4

JUTTA MAGNÚSSON

ON CAPELIN LARVAE (*Mallotus villosus* O.F.Müller)
IN ICELANDIC WATERS

During the Years 1960 to 1964

With Some Notes on Other Fish Larvae

HAFRANNSÓKNASTOFNUNIN
MARINE RESEARCH INSTITUTE

REYKJAVÍK 1966

93
30

ON CAPELIN LARVAE

(*Mallotus villosus* O.F.Müller)

IN ICELANDIC WATERS

DURING THE YEARS 1960 TO 1964

With Some Notes on Other Fish Larvae

By

JUTTA MAGNÚSSON

CONTENTS

Preface	Page 3
I. Introduction	— 3
II. Material and Methods	— 4
III. Distribution and Abundance of Capelin Larvae	— 5
1. Yearly and Monthly Distribution and Abundance	— 5
2. Comparison of the Distribution of Capelin Larvae in the Different Months	— 17
IV. Length Composition	— 21
1. Yearly and Monthly Length Distribution	— 21
2. Length Composition According to Areas	— 26
V. Discussion	— 26
VI. Notes on Other Fish Larvae	— 29
Summary	— 34
Íslenzkt ágríp	— 35
References	— 36

PREFACE.

During the yearly herring search cruises off the west, north and east coasts of Iceland, a considerable number of plankton samples have been collected in recent years. This paper, which is mainly based on the above mentioned plankton collections, deals with the distribution and abundance of capelin larvae off the west, north and east coasts of Iceland in the years 1960 to 1964.

The author wishes to express her thanks to Mr. JAKOB JAKOBSSON and Dr. UNNSTEINN STEFÁNSSON for placing unpublished temperature data at her disposal, and to Miss SÍGRÚN STURLAUGSDÓTTIR and Mr. GEIR MAGNÚSSON for their assistance in working up the material.

I. INTRODUCTION.

Capelin larvae are the most frequent fish larvae in the waters around Iceland in the spring and summertime. However, there are not many publications on capelin larvae in these waters. The basic work in this respect was done by JESPERSEN (1920). His publication is based upon material which was collected by SCHMIDT on his cruises with the Danish research vessel "Thor" in the years 1903 to 1908. Capelin larvae at Iceland are also mentioned by SCHMIDT (1904, 1906), EHRENBAUM (1909), SÆMUNDSSON (1926, 1934), EINARSSON (1949, 1956) and MAGNÚSSON (1962, 1964, 1965).

Already in 1904, SCHMIDT pointed out that capelin is one of the species which spawn all around Iceland (SCHMIDT 1904). The spawning time extends over a rather long period but there are differences in time at the various coasts. Thus, the capelin begins to spawn at the south coast (from Eystrahorn in the east) and southwest coast in the beginning of March, some weeks later successively from the south at the west, northwest and north coasts and at last at the east coast in August—September (JESPERSEN 1920, SÆMUNDSSON 1926). According to JESPERSEN (1920) and SÆMUNDSSON (1926), the spawning time is highly dependant on the water temperatures and it is supposed that temperatures of about 6° C (surface) are most favourable

for spawning. Thus, the spawning begins at the different coasts when the surface water temperature has reached 6° C, i.e. at the northwest and north coasts in June—July and at the east coast in about August. JESPERSEN (1920) considers surface water temperatures of about 10° C as the upper limit for spawning so that the spawning time at the south coast will be over in June.

II. MATERIAL AND METHODS.

As mentioned before, this paper is mainly based on material collected on herring search cruises during the years 1960 to 1964. Also included is material from several research cruises during this period. Since the aim of the cruises was in all cases other than capelin larvae investigations, the station grid shows some gaps. Thus, in the coastal region, mainly off the north coast, denser observations would have given better information as to spawning. On the other hand, the repeated covering of the area in question, mainly in the more offshore direction during the summer time supplies fairly dense observations in each year and month from May to September.

In the following table an outline of the capelin larvae material used in this paper is given.

TABLE 1.
Number of capelin larvae given by year and month.

Year	May		June		July		August		September		Total	
	Number of <i>pos. larvae</i> <i>stat.</i>		Number of <i>pos. larvae</i> <i>stat.</i>		Number of <i>pos. larvae</i> <i>stat.</i>		Number of <i>pos. larvae</i> <i>stat.</i>		Number of <i>pos. larvae</i> <i>stat.</i>		Number of <i>pos. larvae</i> <i>stat.</i>	
1960	—	—	—	—	146	4905	—	—	—	—	146	4905
1961	31	28068	61	1744	142	2033	86	244	—	—	320	32089
1962	32	11119	58	6653	45	2725	71	619	16	49	222	21165
1963	23	10772	43	2437	19	239	26	194	7	41	118	13683
1964	—	—	68	8346	63	768	29	109	15	23	175	9246
Total . . .	86	49959	230	19180	415	10670	212	1166	38	113	981	81088

The larvae here treated were exclusively sampled with the Icelandic High Speed Samplers (I.H.S.S.) which were towed 1.5 n.m. at each station, the filtration being about 20 m³ for each sampler. In most cases two samplers were used simultaneously at each station, in some cases one or three. The towing depth was from about 3 m to 25 m. The plankton samples were fixed in 4% neutralized formaldehyde. The larvae were sorted out of the samples, species determined, counted and measured in the laboratory.

III. DISTRIBUTION AND ABUNDANCE OF CAPELIN LARVAE.

1. Yearly and Monthly Distribution and Abundance.

In this chapter the distribution and abundance of capelin larvae is described. For comparison of the distribution and abundance of larvae with the temperature conditions, the temperature in 20 m depth has been chosen according to the level in which the larvae were mainly caught.

1960: In this year material was only available from July, but in that month the area east of 22° W was very well covered. Capelin larvae were observed in the whole area surveyed, i.e. north to appr. 68° N and east to 10° W (see fig. 1). On the whole, the capelin larvae were apparently more abundant off the north coast than off the east coast. The greatest concentrations were found in an area near the coast between Grímsey and Melrakkaslétta, the maximum density being 19.2 larvae per m³. Though the larvae were densest near the coast mainly within the 200 m depth contour, they were also found in considerable numbers over greater depths as far from the coast as observations were made (over 1000 m).

Off the north coast the larvae were found mainly in water temperatures of 7° to 8° C (in 20 m depth). But off the east coast they were found in temperatures of 4° to 7° C.

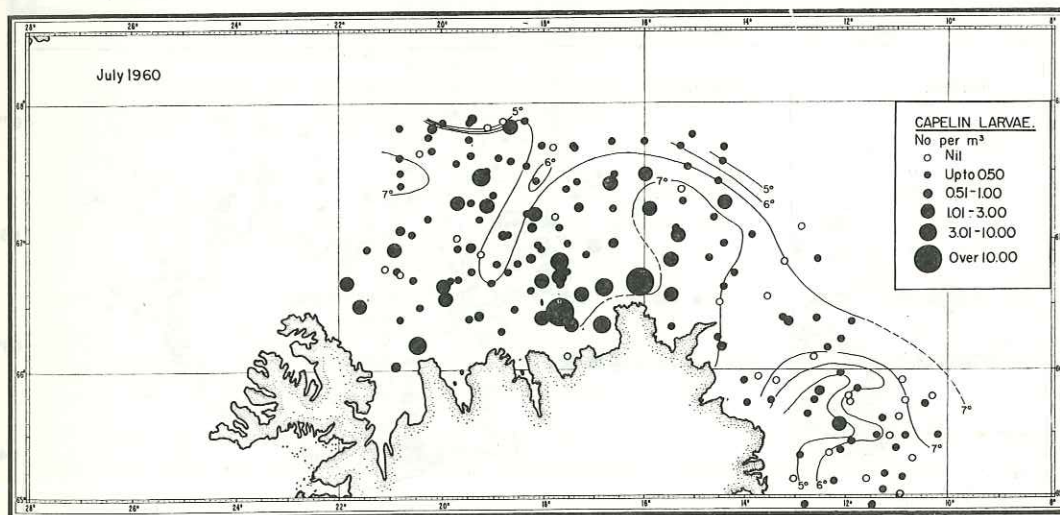


FIG. 1. Distribution and abundance of capelin larvae in July 1960. Also showing the isotherms for 5, 6 and 7° C in 20 m depth.

1961: In 1961 material was available for the period May to August. In *May* observations were made in the waters off West Iceland. Capelin larvae were found to be very abundant in the area from Reykjanes to Látrabjarg with the greatest concentrations in the Faxa Bay area. The maximum density was 240.8 larvae per m^3 . North of Látrabjarg the number decreased rapidly (see fig. 2). Almost all larvae were found within the 200 m depth contour. The water temperature in which the larvae were found ranged from about $8^\circ C$ (in south) to about $6^\circ C$ (in north).

In *June* observations were made off the west, north and east coasts of Iceland, from Snæfellsnes in the west to Gerpír in the east. Capelin larvae were observed off all coasts (see fig. 2). During the first half of June they were abundant west of Iceland though not in such densities as in May, the maximum being 9.6 larvae per m^3 . Off the north and east coasts they occurred only rather scarcely with the exception of the area of Melrakkaslétta, where considerable numbers of larvae were obtained, the maximum being 4.1 larvae per m^3 . In the latter half of June observations off the north, northeast and east coasts showed that the number of positive stations and the number of larvae had increased considerably, when compared with the first half of June. Though the larvae were mostly found within the 200 m depth contour, some findings were recorded both off the west and east coasts at over 1000 m depth, and off the north coast between 500 and 1000 m. A comparison of the distribution of the larvae in May in west showed that the larvae were spread out over greater depths in June than in May. The water temperatures at 20 m depth off the west and northwest coasts were

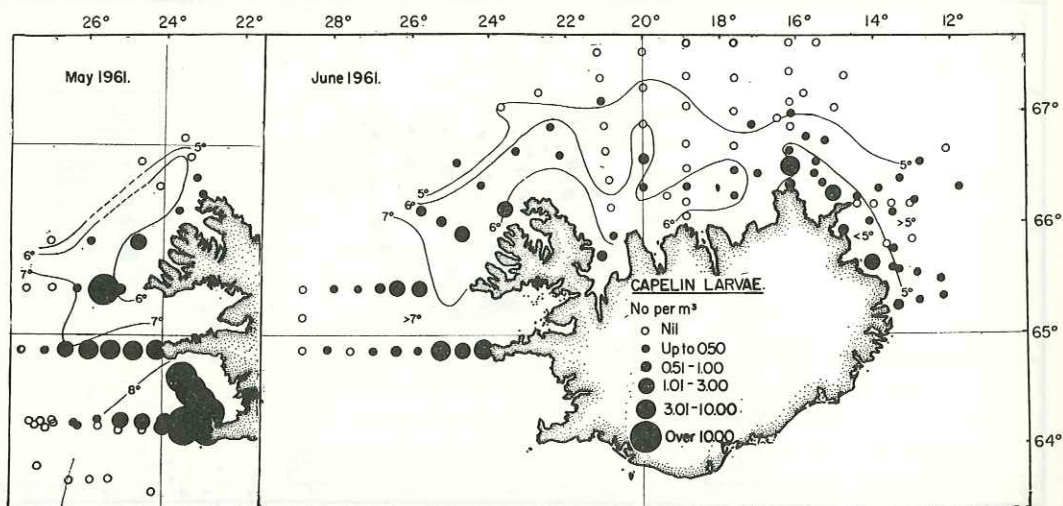


FIG. 2. Distribution and abundance of capelin larvae in May and June 1961. The isotherms for 5, 6, 7 and $8^\circ C$ in 20 m depth are indicated.

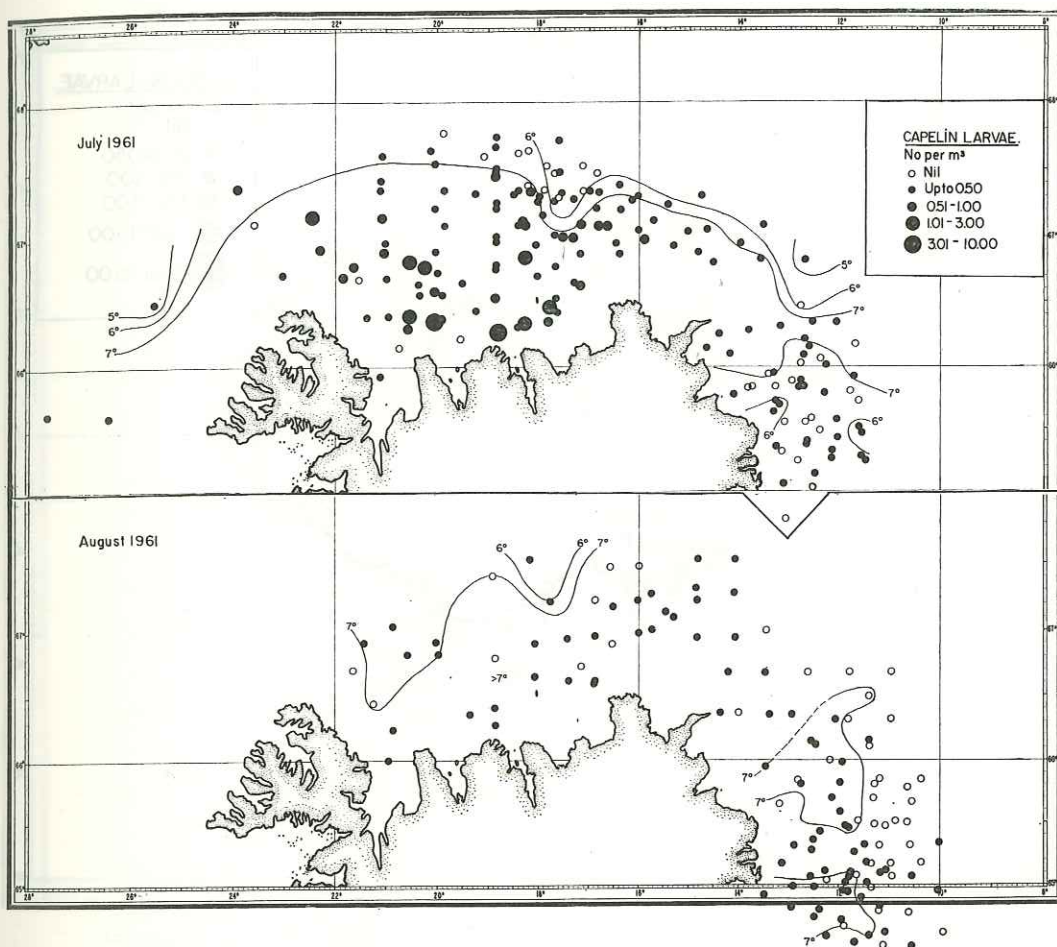


FIG. 3. Distribution and abundance of capelin larvae in July and August 1961. The isotherms for 5, 6, 7° C (July) and 6, 7° C (August) in 20 m depth are indicated.

from 6° to 8° C. Off the north coast (east to Melrakkaslétta) temperatures of 5° to 6° C were dominating, but east of this area they were about 5° C.

In July the area from northwest to east of Iceland was covered. There are very few observations off the northwest coast but the waters north and east of Iceland were fairly well observed. In the north the situation has considerably changed compared with the foregoing month, as capelin larvae were spread over the whole area with marked densities mainly along the coast within the 200 m depth line (see fig. 3), 4.4 larvae being the maximum per m³. Off the northeast and east coasts capelin larvae were distributed over the whole area, but no great concentrations could be observed. The temperatures in July in 20 m depth were mainly 7° to 8° C and were, on the whole, 1° to 2° C higher than in June in the area north of Iceland. As the isolines

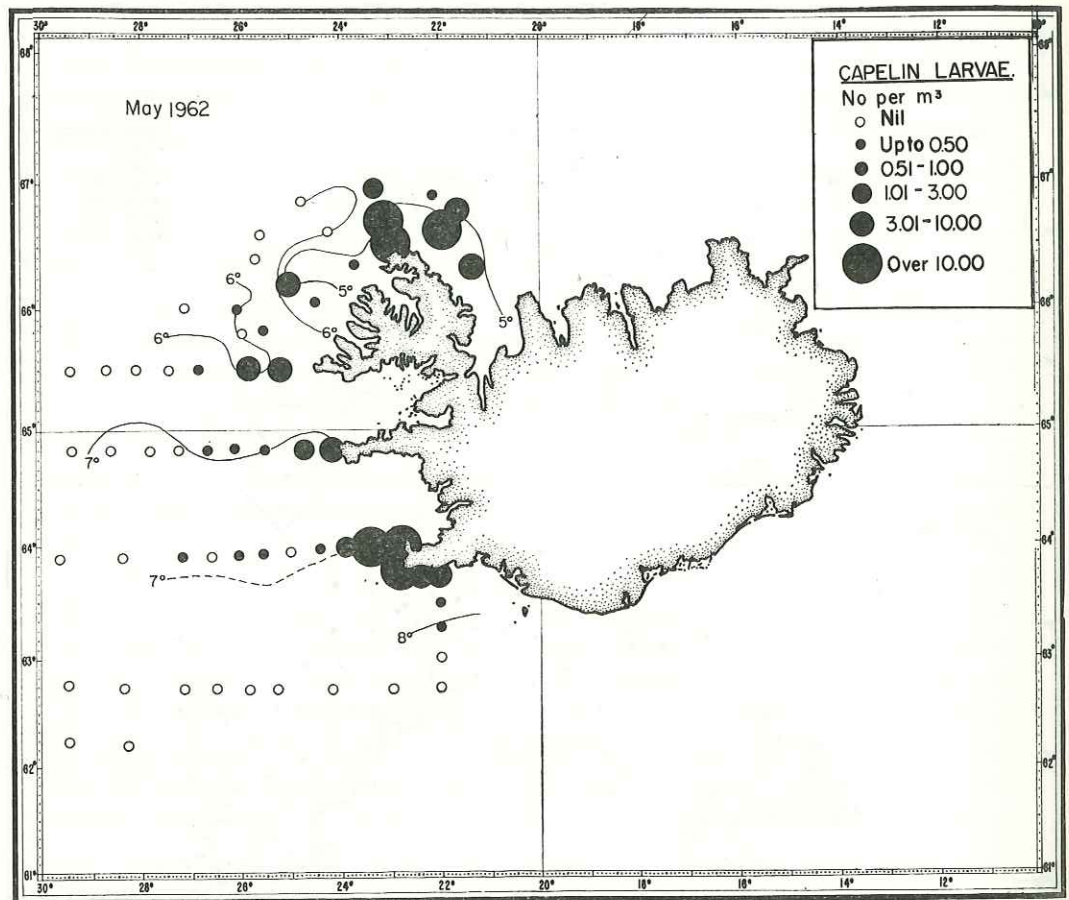


FIG. 4. Distribution and abundance of capelin larvae in May 1962 with isotherms for 5 to 8° C in 20 m depth.

in fig. 3 indicate, the temperature distribution was rather unique in the main area. East of Iceland temperatures of 6° to 7° C were dominating and had thus also increased about 1° to 2° C from June.

In *August* the area north and east of Iceland between 22° W and 10° W was observed. As can be seen from fig. 3, the distribution of capelin larvae was rather equal with no greater concentrations. There had been great changes in the abundance of capelin larvae off the north coast since July. In the east capelin larvae were only scarcely found farther out from the coast than some 60 n.m. Temperatures (in 20 m depth) of about 7° to 9° C were observed in almost the entire area surveyed, with the temperature of 8° and 9° C dominating.

1962: Observations were made from May to September. In *May* the area west and northwest of Iceland (to about 21° W) was covered (see fig. 4).

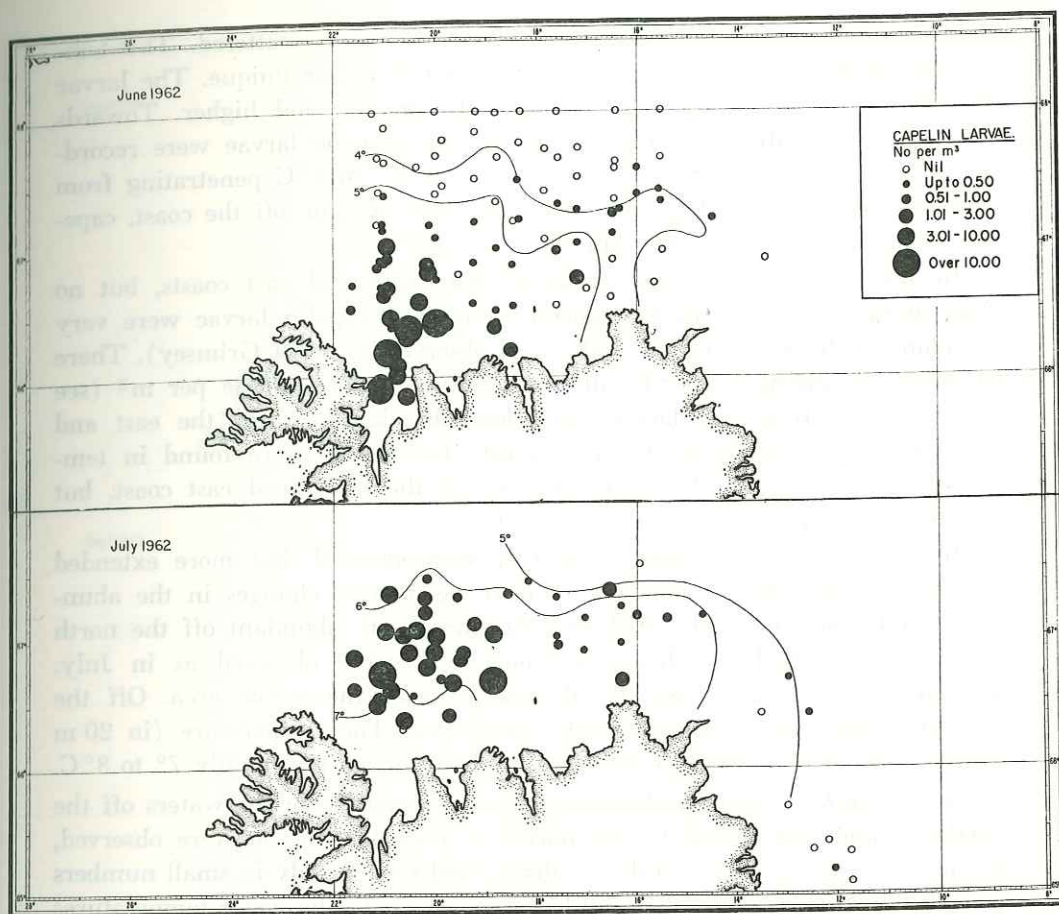


FIG. 5. Distribution and abundance of capelin larvae in June and July 1962. Also given the isotherms for 4 and 5° C (June) and for 5, 6, 7° C (July) in 20 m depth.

In the area along the coast capelin larvae were very abundant. Great densities around Reykjanes and Hornbjarg (Cape Horn) were observed with maxima of 15.1 larvae per m^3 (Reykjanes) and 62.0 larvae per m^3 (Cape Horn). The larvae were almost exclusively found within the 200 m depth contour. The temperature in 20 m depth was from about 5° C to about 7° C. The larvae concentration around Reykjanes was found in temperatures of about 7° C and slightly higher, but off Kögur and east of it in about 5° C and somewhat below.

In June observations off the north coast were available. Great concentrations of capelin larvae (max. 30.1 per m^3) were observed in Húnaflói and off Skagi (see fig. 5). The number of larvae decreased rapidly towards east and north. The larvae were mainly recorded within the 200 m depth con-

tour. Over greater depths they occurred more or less scattered. The temperature at 20 m depth in the area surveyed was rather unique. The larvae were found off the north coast almost only in 5°C and higher. Towards north the temperatures decreased rapidly, and here no larvae were recorded. In a tongue of water with temperatures of 4° to 5°C penetrating from north into colder water towards east, some 50 to 60 n.m. off the coast, capelin larvae were found, though in small numbers.

In *July* observations were made off the north and east coasts, but no observations were done in the coastal areas. The capelin larvae were very abundant in the western part of the area observed (west of Grímsey). There great concentrations occurred with a maximum of 15.9 larvae per m³ (see fig. 5). As in June, the larvae were less abundant towards the east and appeared only scarcely off the east coast. The larvae were found in temperatures (in 20 m depth) of 5° to 8°C off the north and east coast, but dominating temperatures were 6° to 7°C.

In *August* the same area as in July was observed, but more extended and with denser observations. There have been great changes in the abundance of larvae since July. Although the larvae are abundant off the north coast in this month, no heavy concentrations were observed as in July. The larvae were rather equally distributed over the whole area. Off the east coast they were rather scarcely distributed. The temperature (in 20 m depth) were of 6° to 8°C in the whole area surveyed, but mainly 7° to 8°C.

In *September* only few observations are available from the waters off the northeast and east coasts. In the northeast very few larvae were observed, but in the east they occurred denser distributed though only in small numbers (see fig. 6), the maximum being 0.15 larvae per m³. The water temperatures in which the larvae were found ranged from about 7° to 9°C, but were mainly of 7° to 8°C.

1963: Observations were available from May to September. In *May* the area from Reykjanes to Látrabjarg was investigated. Capelin larvae were very abundant in this area and were found in great densities with a maximum of 41.3 larvae per m³ (see fig. 7). However, the larvae were almost exclusively found within the 200 m depth contour and their number decreased rapidly with increasing distance from the coast. Dominating temperatures in this area were 5° to 7°C (in 20 m depth).

In *June* observations were made from Snæfellsnes in the west to Langanes in the east. The larvae were found from Snæfellsnes to Siglunes and were very abundant in the northwestern part of the area surveyed (see fig. 8), the maximum count being 15.3 larvae per m³. East of the area mentioned before, the larvae occurred equally distributed but only in very small numbers. East of Siglunes no larvae could be observed. In the zone with the larvae concentrations the temperatures were from 6° to 7°C, the 7° iso-

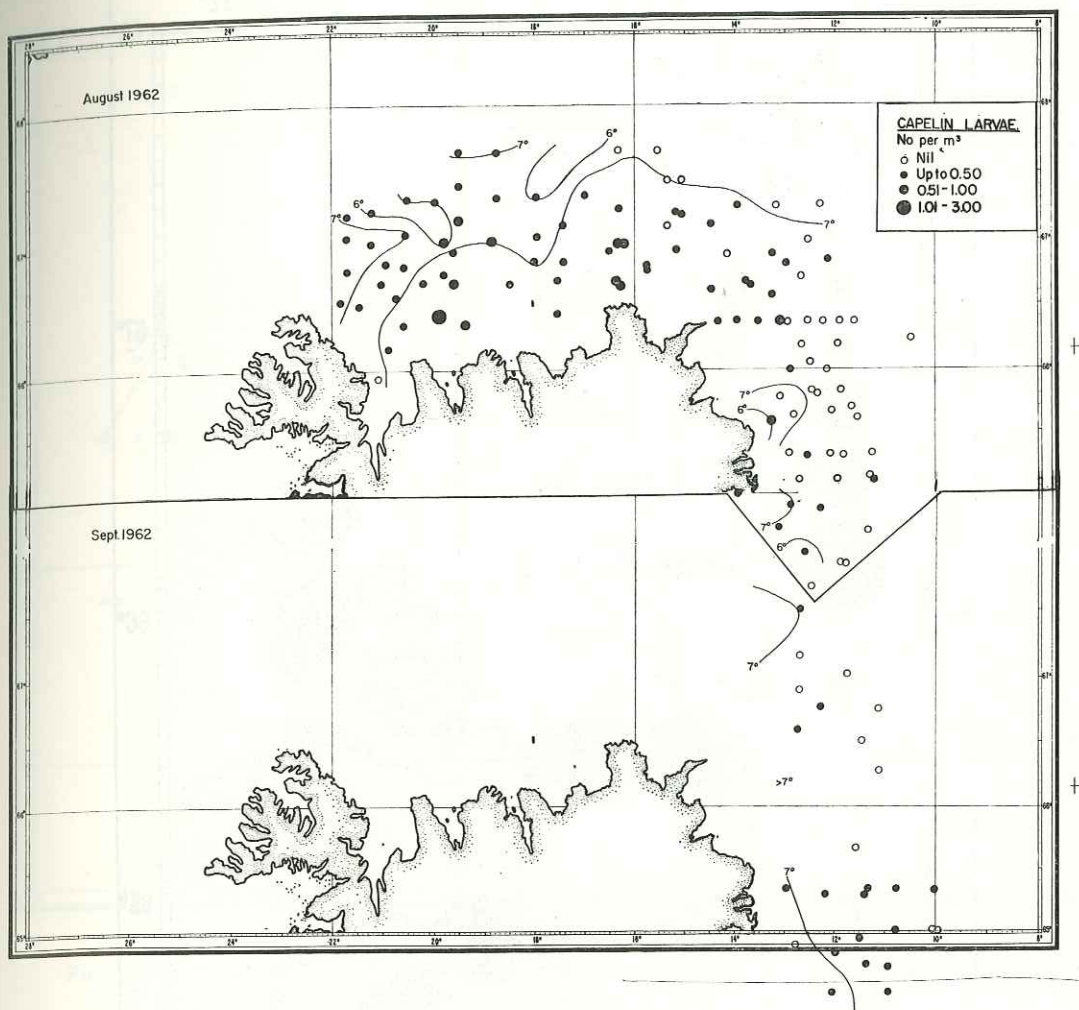
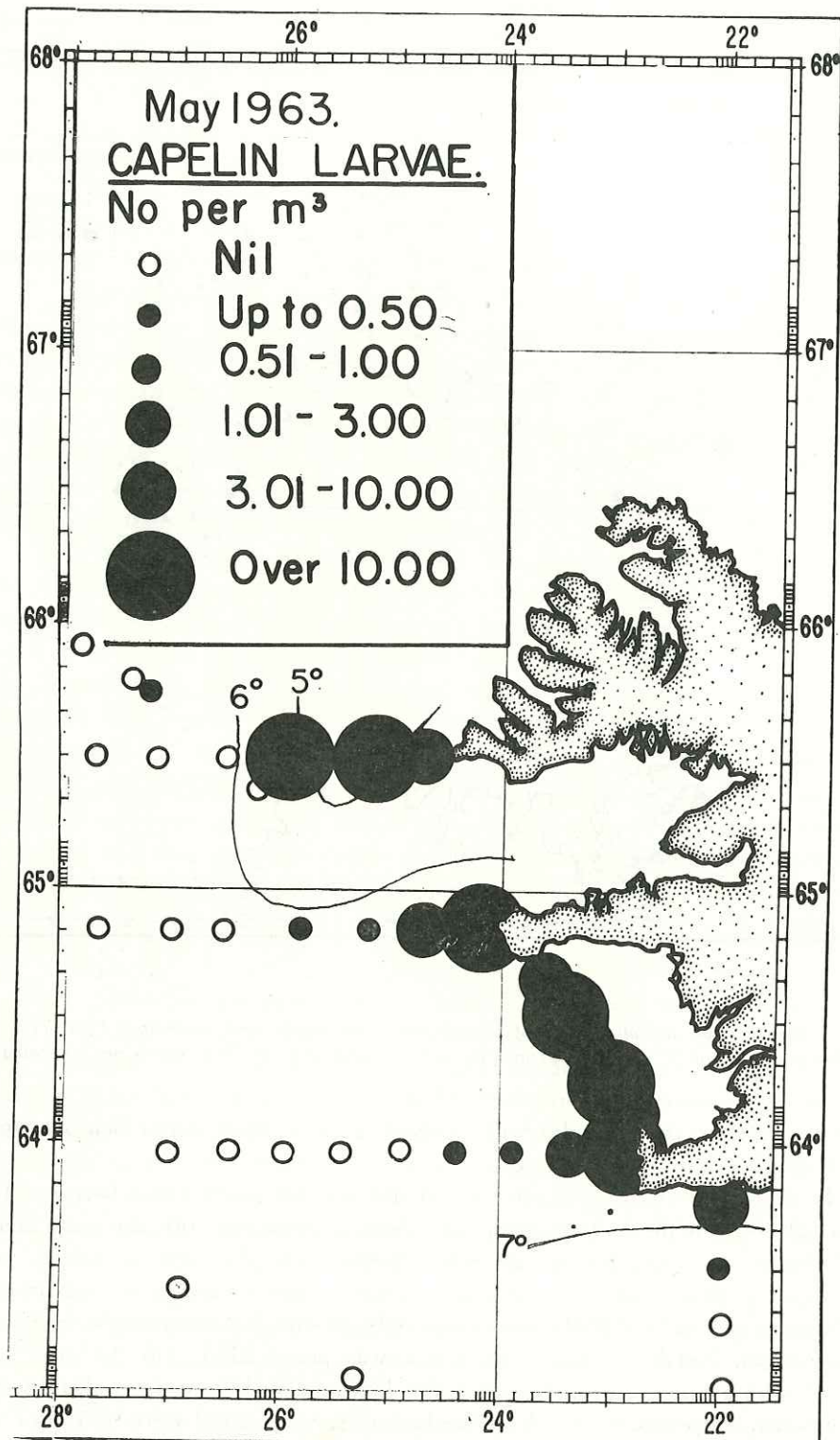


FIG. 6. Distribution and abundance of capelin larvae in August and September 1962. The isotherms for 6 and 7°C (August) and for 7°C (September) in 20 m depth are indicated.

therm forming the boundary of it. East of this zone water temperatures of 4° to 5°C were dominating.

In July investigations were carried out off the north coast between 16° and 22°W. Further, there are some few observations off the east coast. Off the north coast the larvae were spread over the area surveyed (see fig. 8), but there did not occur any great concentrations (the maximum: 2.0 larvae per m^3). Off the east coast only at one station a single specimen was caught. North of Skagi cold water was penetrating into the area surveyed which apparently influenced the larvae distribution (see also fig. 8). The water temperatures in which the larvae were observed were of 5° to 7°C.



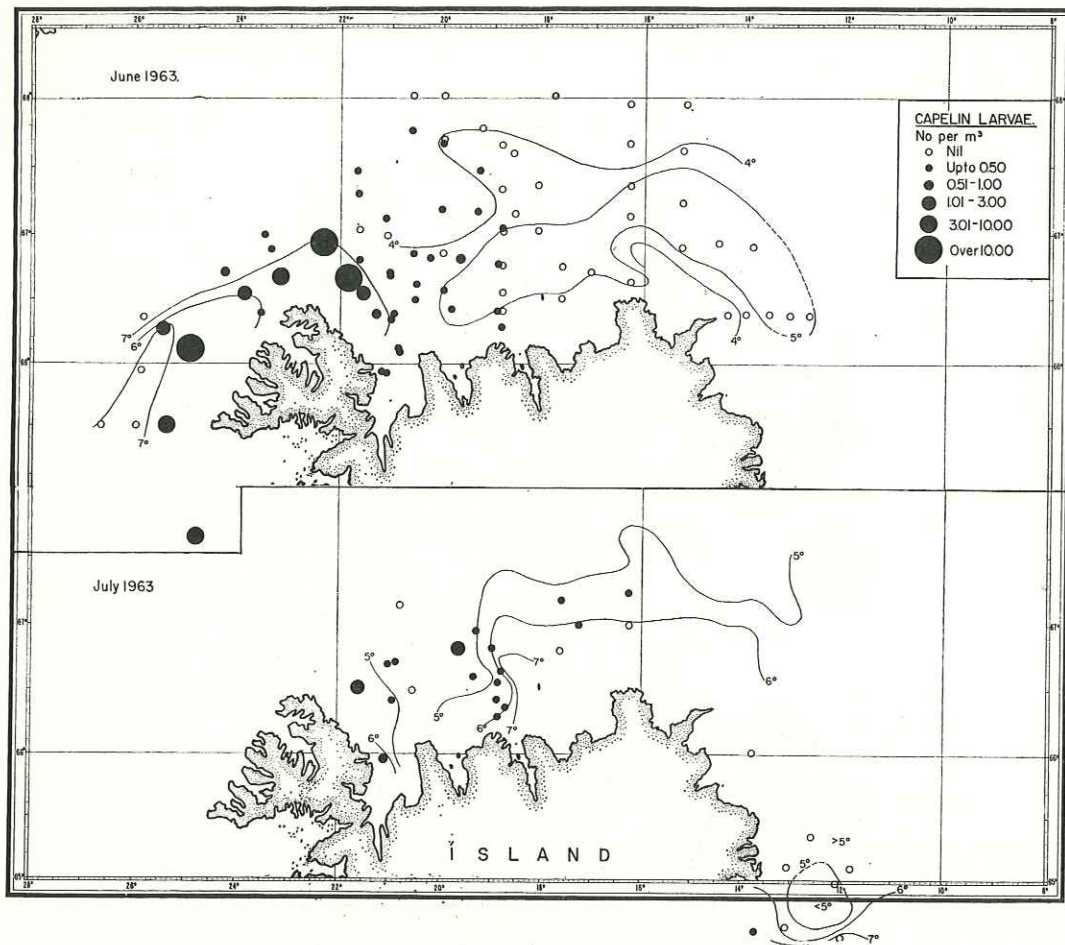


FIG. 8. Distribution and abundance of capelin larvae in June and July 1963. The isotherms for 4, 5, 6, 7° C (June) and 5, 6, 7° C (July) in 20 m depth are shown.

In August observations were made from Húnaflói in the west to Gerpír in the east. Larvae were found to be evenly spread over the western part of the area surveyed, but in the eastern part they occurred only scattered. As in July, they did not appear in concentrations, the maximum density being 0.9 larvae per m^3 (see fig. 9). The influx of cold water into the area surveyed had increased and most of the larvae were now observed in water temperatures below 5° C.

In September a similar area as in August was observed, but the station

FIG. 7. Distribution and abundance of capelin larvae in May 1963 with isotherms for 5, 6, 7° C in 20 m depth.

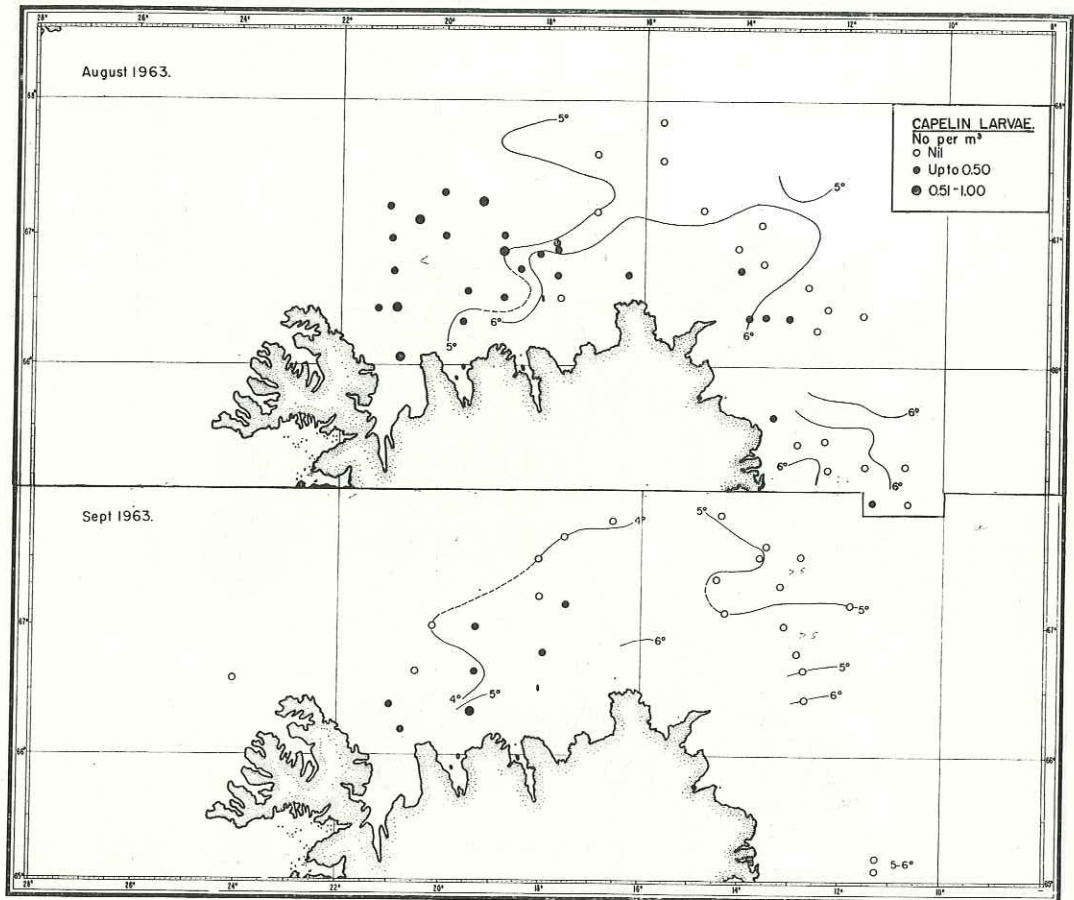


FIG. 9. Distribution and abundance of capelin larvae in August and September 1963. Shown are also the isotherms for 5 and 6° C (August) and 4, 5 and 6° C (September) in 20 m depth.

grid was not as dense. The few larvae findings in this month were off the north coast in temperatures mainly about 4° to 5° C (see also fig. 9).

1964: In this year observations were made in the months June to September. In *June* a survey was carried out off all coasts except the south coast. As can be seen from fig. 10, the capelin larvae were almost exclusively found in the western part of the survey area. Here they were very abundant with the greatest concentrations in the area from Látrabjarg to Húnaflói. The maximal density was 30.7 larvae per m³. Towards the northeast and east the capelin larvae decreased rapidly in number and off the east coast they were recorded only at the two southernmost stations. The greatest concentrations of larvae were found within the 200 m depth contour. Off the

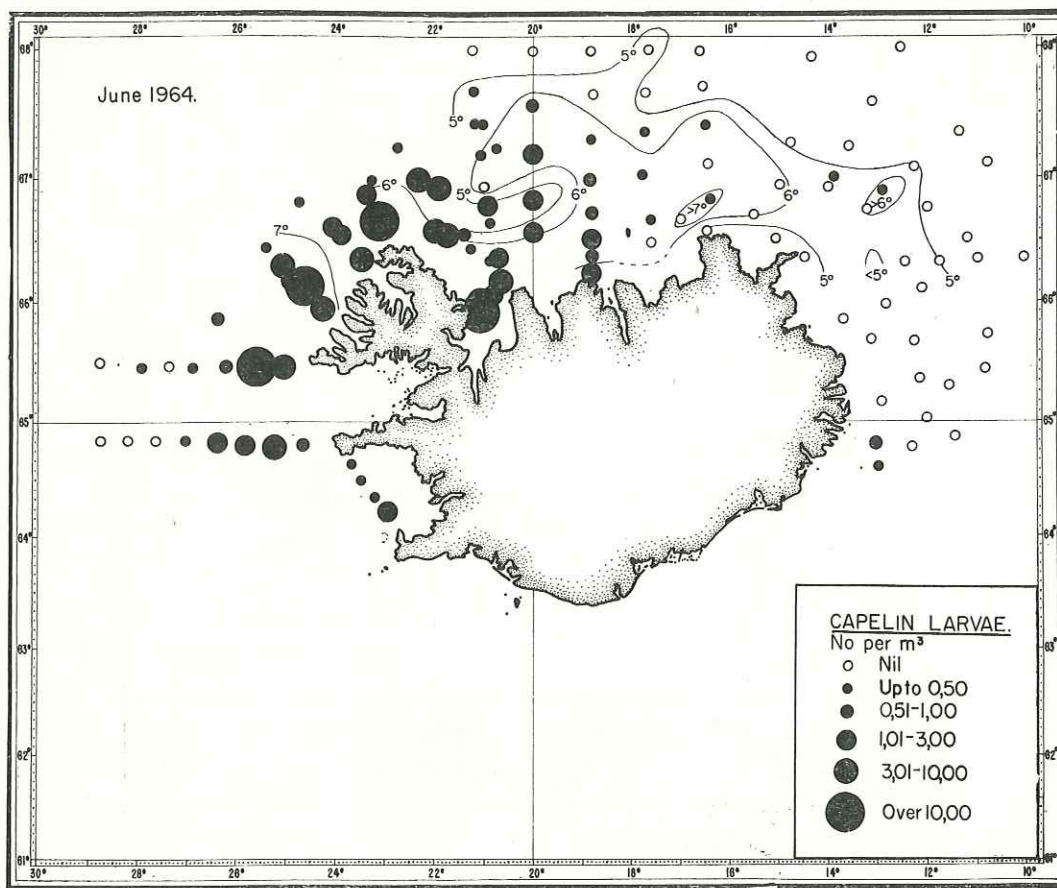


FIG. 10. Distribution and abundance of capelin larvae in June 1964. The isotherms for 5, 6 and 7° C in 20 m depth are indicated.

west coast the water temperatures in 20 m depth ranged from 6° to 8° C. Off the north coast the larvae were found in temperatures of 5° to 7° C, with 6° to 7° C dominating.

In July the area north and east of Iceland was investigated. Capelin larvae were found in two separated areas with no findings between (see fig. 11). Capelin larvae were only abundant off the north coast (maximum density 1.7 larvae per m³). Off the east coast they appeared only scattered and only in small number. Temperatures of 5° to 7° C in 20 m depth were dominating in the whole area. But the greatest numbers of larvae were taken in temperatures of about 7° C. There seemed to be an accumulation of larvae in a tongue of water with temperatures slightly above 7° C, penetrating northwards from the central north coast.

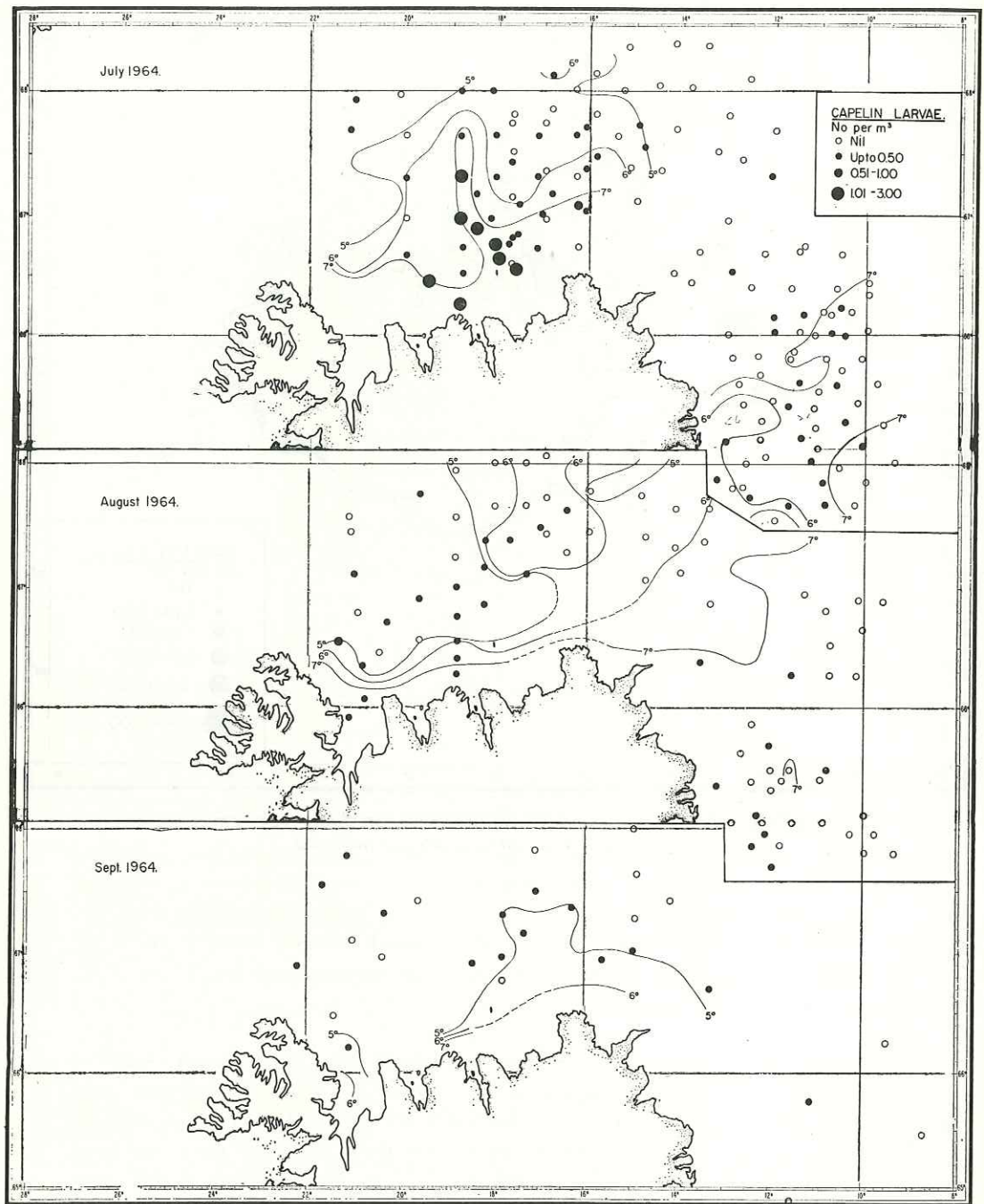


FIG. 11. Distribution and abundance of capelin larvae in July, August and September 1964. The isotherms for 5, 6, 7° C in 20 m depth are indicated.

In *August* a similar area was observed as in July. Now the before mentioned separation of distribution areas for capelin larvae observed in July was still more pronounced (see fig. 11). However, now the larvae occurred only in small numbers in both areas, the maximum density was 1.0 larvae per m^3 . As to the temperature in 20 m depth, it was very variable and the larvae were observed in temperatures of 1° to $8^\circ C$ in the survey area.

Also in *September* appr. the same area was covered as in the two previously mentioned months, but the observations were by far not as dense, mainly in the eastern area. Only few larvae were recorded in this month with a very scattered distribution. The larvae were found in water temperatures of $0.3^\circ C$ to $6^\circ C$.

2. Comparison of the Distribution of Capelin Larvae in the Different Months.

For a study of the monthly changes in the distribution and abundance of capelin larvae in the survey area, the observations have been summarized according to months.

May: Observations were only available off the west and northwest coast. The temperature range was from 5° to $8^\circ C$ in 20 m depth. But in this month capelin larvae were very abundant and showed the highest monthly densities in all years (1961—1963). This is also demonstrated in table 2 which gives the average number of capelin larvae per positive station by year and month.

TABLE 2.
Average number of capelin larvae per m^3 per positive station by year and month.

	<i>May</i>	<i>June</i>	<i>July</i>	<i>August</i>	<i>September</i>	<i>Average</i>
1960			0.85			0.85
1961	15.88	0.72	0.37	0.10		4.25
1962	7.97	2.89	3.66	0.27	0.85	3.22
1963	7.83	1.75	0.40	0.32	0.29	2.12
1964		2.75	0.30	0.10	0.04	0.80
Total Av.	10.56	2.03	1.12	0.20	0.39	

June: The abundance and distribution of capelin larvae in June showed considerable variation from one year to another. Thus, they were very abundant off the western part of the north coast in the years 1962 and 1964,

in both years showing a similar distribution. They were less abundant in 1963 with a more limited distribution towards east. In this month in 1961 the distribution was quite different from the other years. Here no concentrations were observed in the above mentioned area. On the other hand, off the northeast coast capelin larvae were abundant, but in this area they have not been observed in any notable concentrations in the other years. The bulk of the larvae in June 1961 to 1964 was found in water temperatures of 5° to 8° C.

July: The yearly distribution in July 1960 and 1961 was similar both in the area off the north and east coasts, but the larvae were more abundant in 1960. Great concentrations were observed in 1962, but here the distribution was more limited to the north coast. In the years 1963 and 1964 the larvae were not as abundant off the north coast as in the previous years and were only scarcely found off the east coast in the years 1962 to 1964. The larvae were mainly found in the above discussed years in temperatures of about 5° to 8° C in 20 m depth though the temperatures in 1963 were somewhat lower than in the other years.

August: The distribution of capelin larvae in this month did not show any remarkable concentrations, the larvae being distributed in small numbers though over a wide area. In 1961 the larvae were densest and widely distributed off the east coast and in 1962 off the north coast. In 1963 and 1964 the larvae were less abundant than in the previous two years. The temperature range in which the larvae were observed was rather wide, especially in the last two years when larvae were recorded in temperatures of 1° to 8° C, mainly below 5° C. But in the previous two years larvae were mainly found in temperatures of 6° to 9° C.

September: During this month capelin larvae were found to be scattered distributed and only in small quantities. In 1962 and 1963 observations are available from the northeast and east coast. In 1962 they were found to be fairly common off the east coast, while they were totally lacking in this area in 1963. Off the north coast observations are available from 1963 and 1964. In 1964 the capelin larvae showed a wider distribution over greater depths than in 1963, though the number of larvae was in all years very small. As to the temperature in which the larvae were recorded, they showed the greatest variation in this month (0.3° to 9° C). In 1962 e.g., the larvae were found mainly in water temperatures above 7° C, but in 1963 and 1964 in water temperatures below 6° C.

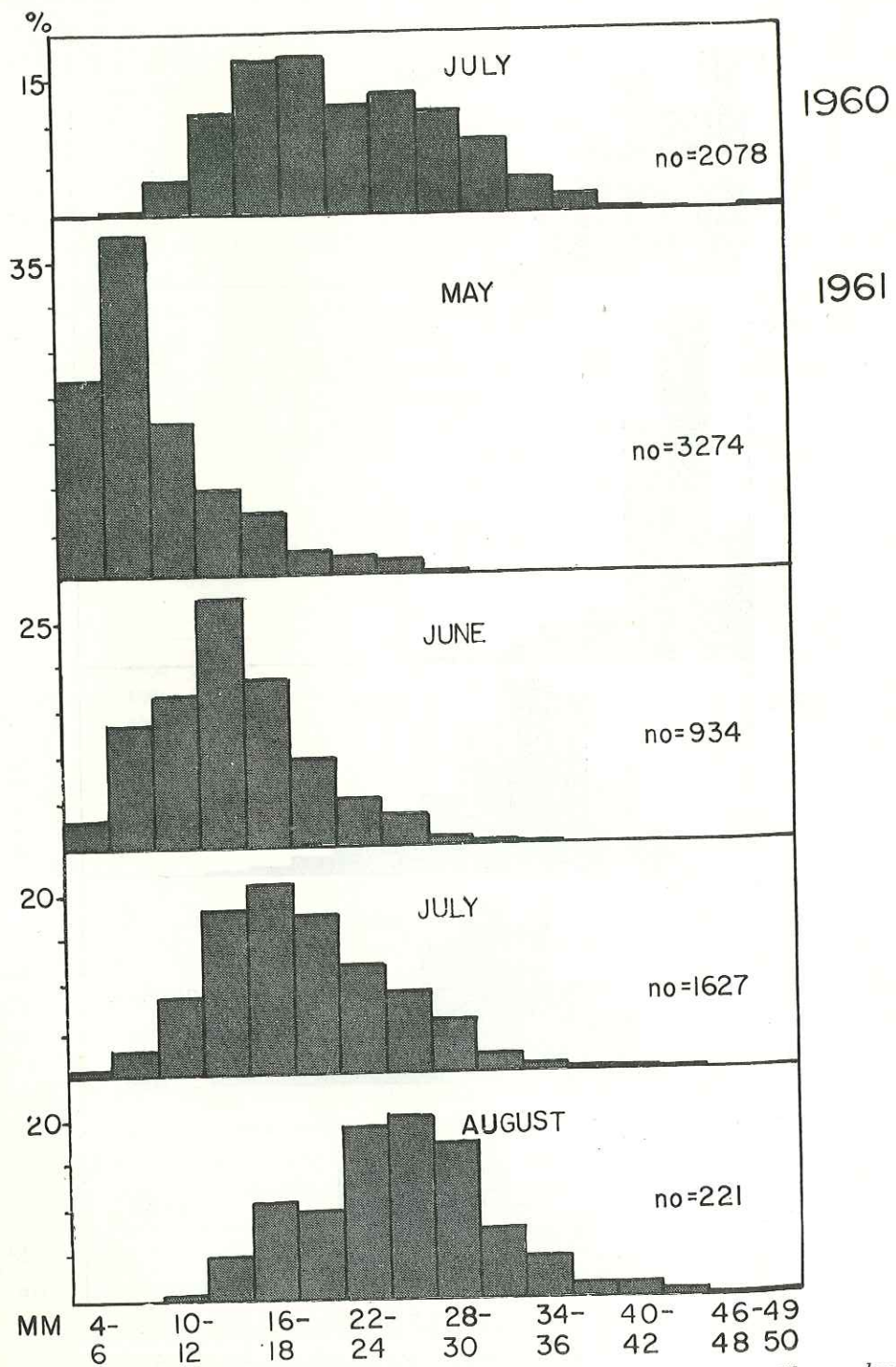


FIG. 12. The monthly length distribution of capelin larvae for the year 1960. The number of larvae measured in each month is also indicated.

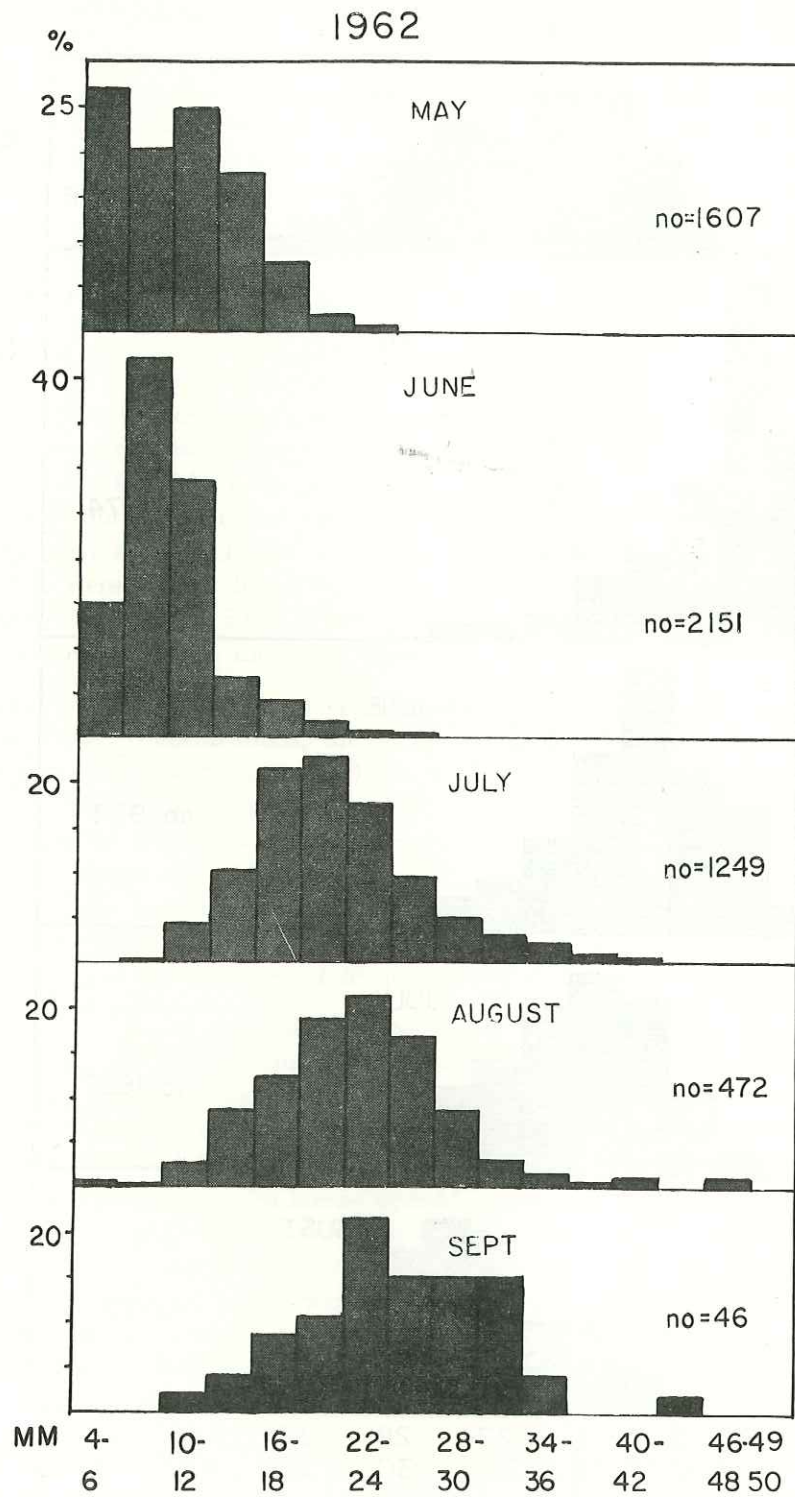


FIG. 13. The monthly length distribution of capelin larvae for the year 1962. The number of larvae measured in each month is also indicated.

IV. LENGTH COMPOSITION.

1. Yearly and Monthly Length Distribution.

The length distribution of capelin larvae in different months and years is demonstrated in figs. 12 to 15. As can be seen from the figures, all years of observation show similar features in the length distribution of the larvae. The highest percentage of newly hatched larvae is always to be found in May, but the size range becomes wider during the following months and the bigger size groups become more dominant. Table 3 shows the mean length of the larvae by month and year.

TABLE 3.
Mean length (in mm) of capelin larvae by year and month.

	<i>May</i>	<i>June</i>	<i>July</i>	<i>August</i>	<i>September</i>
1960	—	—	22.54	—	—
1961	10.04	14.68	19.06	25.18	—
1962	9.99	9.80	21.07	22.76	25.15
1963	10.57	17.32	22.67	31.00	38.28
1964	—	17.25	24.34	30.92	42.85
Mean ...	10.20	14.76	21.94	27.47	35.42

Each year shows a progressive increase in the mean length from May to September, but within a month there are considerable yearly differences.

May: Observations were made from SW to NW Iceland, i.e. off the west coast of Iceland. The length range was rather great, from 4 to 31 mm, but the average length per month for all 3 years of observations was rather similar with a range of 9.99 to 10.57 mm, the mean being 10.20 mm. About 50% of the larvae measured were below 10 mm in size, i.e. newly hatched (thus 1961: 59.7%, 1962: 47.1%, 1963: 46.8%). Thus, about half of the larvae caught originate most probably from an early spawning off the south coast in April, cf. JESPERSEN (1920). As observed earlier (JESPERSEN 1920, MAGNÚSSON 1962, 1965), these observations showed too that the size of the capelin larvae increased with increasing distance from the shore.

June: In June observations are available from the north coast and in some years also from the west and east coasts. The length range was from 4 to 47 mm, but the average length range was 9.80 mm to 17.32 mm, the

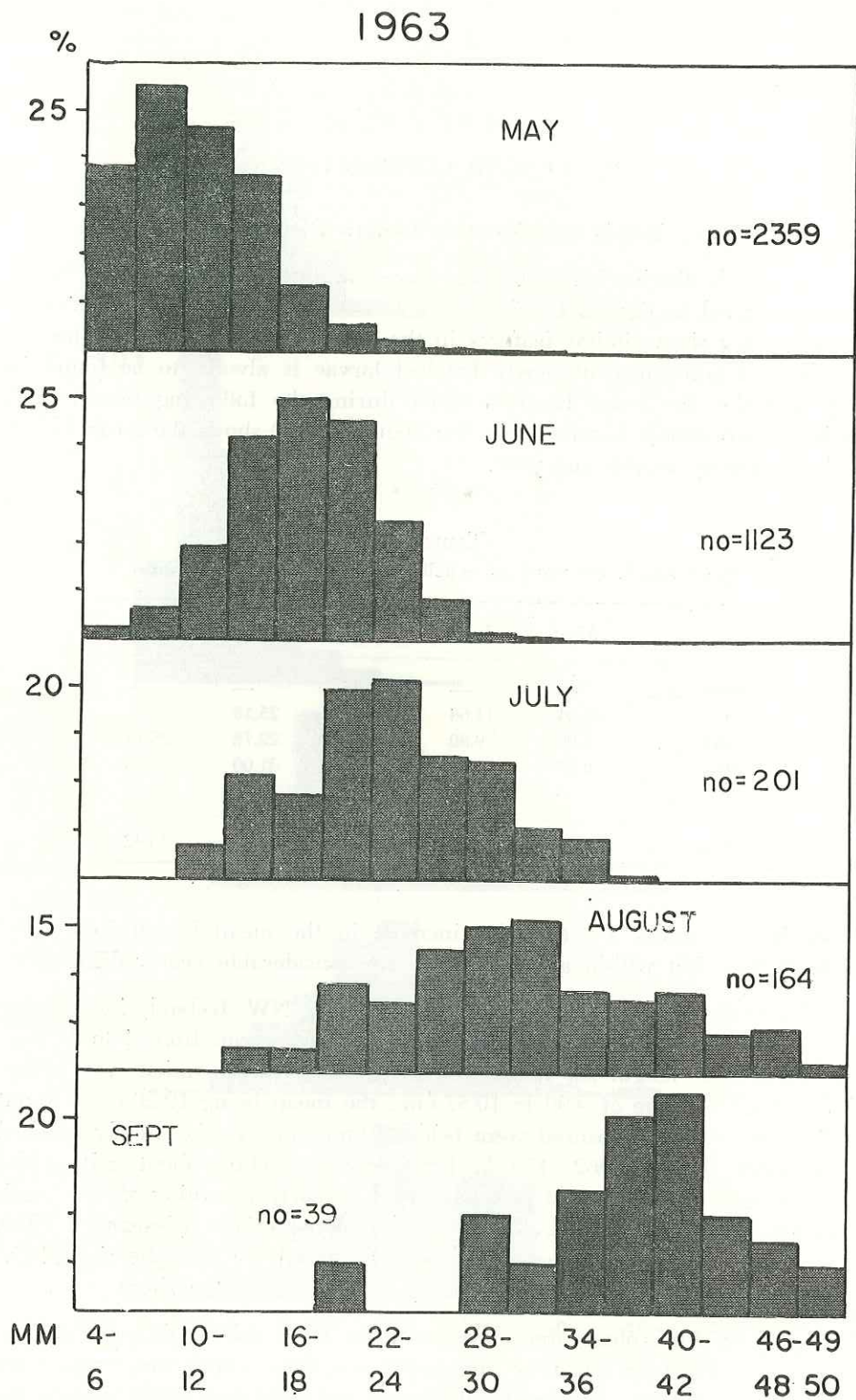


FIG. 14. The monthly length distribution of capelin larvae for the year 1963. The number of larvae measured in each month is also indicated.

1964

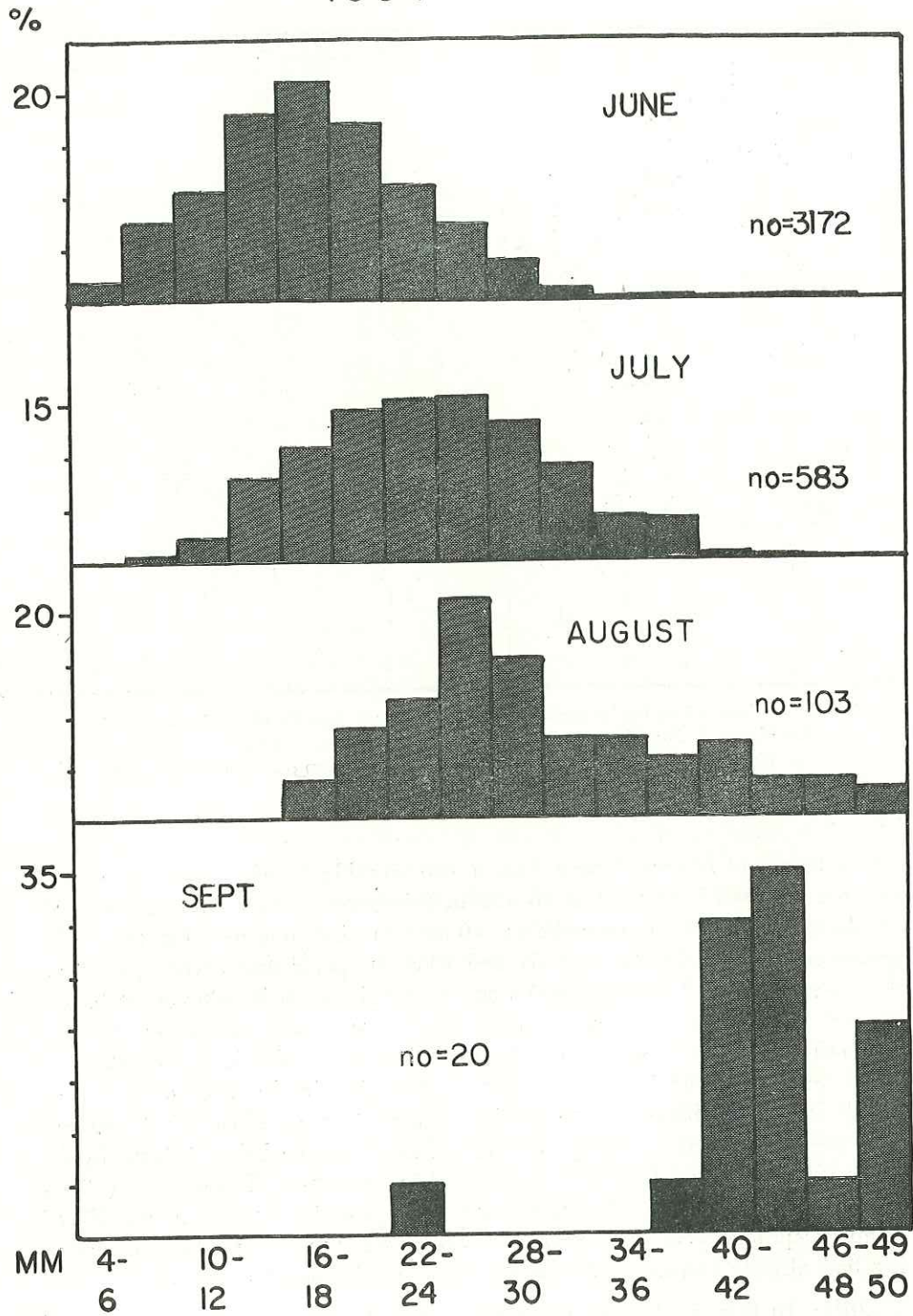


FIG. 15. The monthly length distribution of capelin larvae for the year 1964. The number of larvae measured in each month is also indicated.

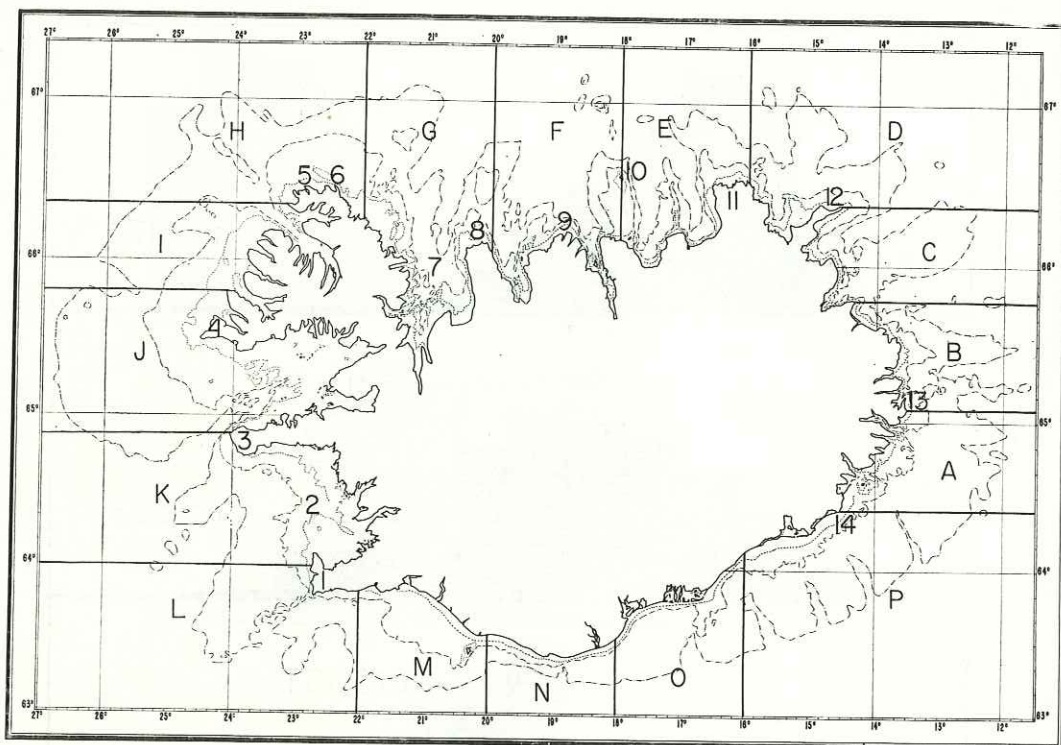


FIG. 16. Division of Icelandic coastal waters into areas (A—P) after EINARSSON 1956.
 1. Reykjanes, 2. Faxa Bay, 3. Snæfellsnes, 4. Látrabjarg, 5. Kögur, 6. Hornbjarg
 (Cape Horn), 7. Húnaflói, 8. Skagi, 9. Siglunes, 10. Grimsey, 11. Melrakkaslétta,
 12. Langanes, 13. Gerpir, 14. Eystra Horn.

mean being 14.76 mm. There was a considerable yearly variation in the number of small larvae below 10 mm in this month. Thus, in 1962, 56.89% of all larvae measured were below 10 mm in size, but in 1963 these size groups made only 4.27%. In 1961 and 1964 the percentages were 16.81 and 9.37, respectively. The high percentage of small larvae in 1962 must be explained by an intensive spawning in the western part of the north coast (Húnaflói area, see also fig. 5). On the other hand, the low percentage of small larvae in 1963 indicates a lack of spawning in this area during June which is most probably due to the low temperature (see also fig. 8), as has been mentioned before. The percentage of small larvae below 10 mm in the years 1961, 1963 and 1964 correspond well to the results of JESPERSEN (1920) as to the spawning of capelin in June. The year 1962 must be considered as an exceptional year in this respect since in this month an intensive spawning had already started in the western part of the north coast.

July: In this month the area north and east of Iceland was well covered during all the years of observations, though best in 1962 and 1961. The length

range was from 5 to 50 mm, the average length range being 19.06 to 24.34 mm, with a mean of 21.94 mm. Only very small numbers of larvae below 10 mm in size were found in July; in the years 1960, 1962, 1964 only 0.40 to 0.51%, in 1961 3.41% and none in 1963. These small larvae were mainly found off the north coast and only very few off the east coast, although the latter named area was fairly well surveyed. These findings are opposed to the results of JESPERSEN as he found an intensive spawning at the east coast during this month. Thus, there seemed to have been major changes in the spawning of the capelin off the east coast during the last half century.

August: In August observations are available from the same area as in July. The length range was then 6 to 50 mm, the average length being from 22.76 to 31.00 mm with a mean of 27.47 mm. Small larvae of below 10 mm in size were only found in 1962 (1.06% of the larvae measured). None were recorded in the other three years, but the very few small larvae found in 1962 were observed off the east coast which is in correspondance with JESPERSEN's results as he also found small larvae only off the east coast during this month.

September: Observations are by far not as dense as in the previous months and they are scattered over a wide area (see also figs. 6, 8 and 11). The length range was from 11 to 50 mm, mainly from 20 to 50 mm, with an average length range of 25.15 to 42.85 mm, the mean being 35.43 mm. Thus, newly hatched larvae were not observed during this month.

Summarizing the results of the length measurements we find:

- 1) During May intensive spawning was observed which extended into June, mainly in the areas from SW Iceland to the western part of North Iceland.
- 2) During middle and late summer (July to September) no notable spawning could be observed in the area surveyed, i.e. off the north and east coasts; a fact which seems therefore to disagree with earlier observations of a successive spawning along the north coast in clockwise direction to the east during the summer months.

It is a well known fact that the capelin spawns along the south coast in the late winter and spring time although yearly fluctuations may occur (SÆMUNDSSON 1934). This fact and the results of these investigations show that the main spawning area of capelin at Iceland is from the south coast to the western part of the north coast in the period March to June. On the other hand, off the eastern part of the north coast and off the east coast no notable spawning could be observed during the time of observations.

2. Length Composition According to Areas.

For a more detailed study of the successive spawning of the capelin from south to north and eastwards, the area observed was divided into sections according to EINARSSON (1956) and the length composition was studied within each section separately for each month and year (see fig. 16).

In general, the tendency of successive spawning from south northwards to section G could be observed during May and June. East of section G the findings of small larvae did not indicate a successive spawning from June and onwards, since the small larvae in this area were only found in very small numbers more or less scattered through the months and sections. However, the percentage of bigger larvae increased towards the east. Fig. 17 demonstrates the above mentioned detailed study of length distribution within different sections for the year 1961, since the area during this year was best covered.

V. DISCUSSION.

A comparison of the distribution of capelin larvae in the different years and months (figs. 1 to 11) shows that there are considerable yearly and monthly variations in the abundance. This is also demonstrated in Table 2 (see page 17) which gives the mean number of capelin larvae per positive station by year and month.

In general, capelin larvae were very abundant in May during the years of observations. The same can be established for June though here are some differences in the yearly distribution. In July the larvae are on the whole abundant, but they are variably distributed from one year to another and decreasing in number in the last two years. In August the number of capelin larvae has decreased considerably and they occur only sporadically in the plankton catches in September.

When comparing the different years, we see that 1963 was the poorest year as to the abundance of capelin larvae. 1964 was a relatively poor year, too. These yearly variations in the abundance and distribution seem to be

FIG. 17. *Monthly length distribution of capelin larvae in different sections (as indicated in fig. 16) for the year 1961.*

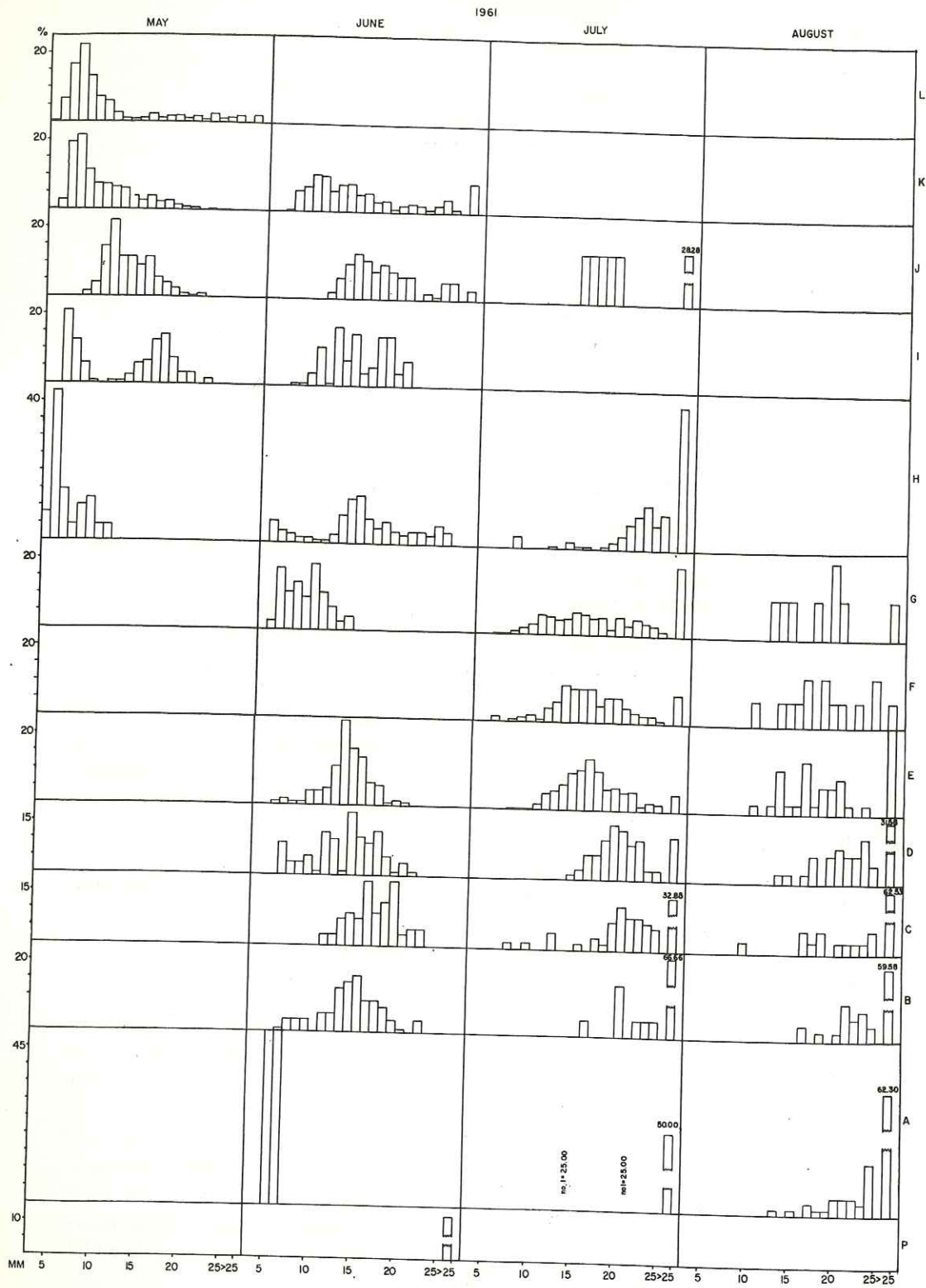


TABLE 4.
Species composition of fish larvae in July 1960.
All gear.

Species	Number of		%
	pos. stat.	larvae	
<i>Mallotus villosus</i>	146	4905	96.56
<i>Gadus morhua</i>	24	47	0.93
<i>Melanogrammus aeglefinus</i>	5	5	0.10
<i>Micromesistius poutassou</i>	1	1	0.02
<i>Hippoglossoides limandoides</i>	21	39	0.77
<i>Platessa platessa</i>	1	1	0.02
<i>Limanda limanda</i>	5	7	0.14
<i>Glyptocephalus cynoglossus</i>	5	6	0.12
<i>Ammodytes</i> spp.	14	31	0.61
<i>Clupea harengus</i>	2	2	0.04
<i>Onos mustela</i>	13	22	0.43
<i>Onos cimbrius</i>	7	7	0.14
<i>Sebastes marinus</i>	3	3	0.06
<i>Cottus</i> spp.	1	1	0.02
<i>Lumpenus</i> spp.	1	1	0.02
<i>Chirolophis galerita</i>	1	1	0.02
<i>Pholis gunnellus</i>	1	1	0.02
Total		5080	100.02

directly linked with the water temperature predominating in the surveyed area. Thus, in the years 1960 and 1961 the water temperatures are relatively high in the area surveyed and the larvae are very abundant and show a wide distribution. In 1962 larvae are also abundant, but in limited areas determined by decreasing temperatures. In 1963 and 1964, the years with the smallest numbers of capelin larvae, relatively low temperatures are predominating mainly in the late summer.

The year 1964 demonstrates clearly the influence of temperature on the distribution and abundance of capelin larvae. Thus, in June the larvae are very abundant and "normally" distributed. In July the influx of colder water from northwest causes a sudden decrease in number and limitation in the distribution of the larvae, and in August, when those cold waters are still more extended in the survey area, the number of larvae is also very small.

A comparison of the years 1960 and 1961, on one hand, and 1963 and 1964, on the other hand, demonstrates clearly how essential the water temperatures are for the distribution and abundance of capelin larvae in these areas. But the fluctuations in the abundance of capelin larvae will be better understood in correlation with the mean temperatures in 20 m depth which

have been calculated for the survey area during May to September for the period 1950 to 1960 (STEFÁNSSON 1960, 1962). During *May* in the years of observations the deviation from the mean temperature west of Iceland did apparently not have any great influence on the abundance of capelin larvae in this area. Capelin larvae were very abundant in May during all 3 years of observation although there were some deviations from the mean water temperatures, as in 1961 the temperature was above average, but in 1963 below average. In *June* there seemed to be a correlation between the deviation of the average temperature and the abundance of capelin larvae off the north coast. Thus, when the temperature was above average the capelin larvae were abundant (e.g. 1963, 1964 west of Húnaflói), but when the temperature ranged below average the abundance of larvae was more or less scarce (1963, east of Húnaflói). The only exception of this rule was in 1961, when in this region the number of larvae was rather small although the temperature was well above average.

The same can be said for *July* and *August* off the north coast: when the temperature was above average, as in 1960, 1961, also the larvae were very abundant. On the other hand, by water temperatures below average (1963, 1964) the larvae were less abundant.

The temperature in the year 1962 corresponded fairly well with the above mentioned average temperature and this year seemed therefore to show a "normal" picture of temperature distribution and consequently also a "normal" capelin larvae distribution.

It is known that in some years the capelin larvae occur in such quantities in certain areas that this has unfavourable influence on the herring fishery since herring, feeding on capelin larvae, are not found to be in suitable shoals for purse-seining.

VI. NOTES ON OTHER FISH LARVAE.

In Tables 4 to 8 the occurrence of all fish larvae obtained during these investigations is given by year and month.

Further, a comparison of these tables shows that both the variety of species and the number of larvae are greatest in May. The observations made in that month are all off the west coast. Also in June in some years (1961, 1964), the number of larvae and variety in species is relatively high when including observations off the west coast. But in June of the other years both the occurrence and number of larvae has decreased considerably and it is striking that in all the other months which include observations from the north and east coasts the number, as well as the variety of species, is

TABLE 5.
Species composition of fish larvae in 1961. All gear.

Species	May		June		July		August		Total	
	Number of pos. larvae stat.	%	Number of pos. larvae stat.	%	Number of pos. larvae stat.	%	Number of pos. larvae stat.	%	Number of pos. larvae stat.	%
Mallotus villosus	34	35453	67	1868	146	2127	88	248	335	39696
Gadus morhua	34	5873	20	396	23	45	2	3	79	6317
Melanogrammus aeglefinus	21	1135	9	24	5	6	3	4	38	1169
Pollachius virens	22	210	11	13	11	13	0.27	1.50	33	223
Trisopterus esmarkii	18	2924	5	15	1	1	0.04		24	2940
Gadus merlangus	11	126	1	1	1	1	0.04		12	127
Hippoglossoides limandoides	24	741	17	129	46	476	4	6	72	922
Platessa platessa	14	1206	3	5	5	5	2.05	2.25	27	922
Limanda limanda	9	38	3	8	2	2	0.22		27	1250
Glyptocephalus cynoglossus	23	176	13	28	3	3	0.18		14	50
Ammodytes spp.	10	81	2	4	3	3	0.13		39	207
Clupea harengus	12	86	4	11	2	2	0.38		13	86
Onos cimbrius	12	240	4	8	2	2	0.16		16	97
Onos mustela	12	240	4	8	2	2	0.18		19	251
Onos spp.	2	3	3	11	3	3	0.47		3	11
Brosmus brosme	2	3	1	1	1	1	0.02		3	4
Molva molva			2	2	2	2	0.01		2	2
Sebastes marinus			10	130	3	3	0.07		13	133
Sebastes viviparus			3	3	3	3	0.13		4	4
Myctophum glaciale	13	43	1	1	1	1	0.38		15	45
Scopelidae spp.	7	29	1	1	1	1	0.38		7	29
Cottus scorpius			2	2	2	2	0.05		2	2
Cottus spp.	7	15	2	3	2	2	0.07		9	18
Liparis spp.	4	6	2	3	1	1	0.03		7	10
Triglops pingeli	8	11	2	2	1	1	0.02		10	13
Agonus cataphractus	1	1	2	2	2	2	0.02		1	1
Gobius spp.	4	9	4	5	1	1	0.02		9	15
Lumpenus lampretiformes	4	10	1	3	1	1	0.02		5	13
Lumpenus spp.	1	1	1	1	1	1	0.04		1	1
Chirolophis galerita	2	5	2	2	2	2	0.01		2	2
Pholis gunnellus	7	9	1	1	1	1	0.02		9	11
Indeterminate			1	1	1	1	0.02		9	11
Total	48431	100.00	2712	99.98	2244	99.99	266	100.01	53653	99.99

TABLE 6.
Species composition of fish larvae in 1962. All gear.

Species	May		June		July		August		September		Total	
	Number of pos. larvae stat.	%	Number of pos. larvae stat.	%	Number of pos. larvae stat.	%	Number of pos. larvae stat.	%	Number of pos. larvae stat.	%	Number of pos. larvae stat.	%
<i>Mallotus villosus</i>	33	11301	67	6967	47	2728	75	629	16	49	238	21674
<i>Gadus morhua</i>	16	538	5	10	7	17	5	5			33	570
<i>Melanogrammus aeglefinus</i> ..	9	124			1	2					10	126
<i>Pollachius virens</i>	13	41	2	4	3	3					18	48
<i>Trisopterus esmarkii</i>	9	169									9	169
<i>Gadus merlangus</i>	4	14									4	14
<i>Hippoglossoides limandoides</i> ..	13	97	11	23	14	29					4	14
<i>Limanda limanda</i>	9	298	2	4							38	149
<i>Glyptocephalus cynoglossus</i> ..	3	7	1	3							11	302
<i>Amnodytes</i> spp.	23	139	9	43	2	2	2	2			4	10
<i>Clupea harengus</i>	2	2									36	186
<i>Onos mustela</i>	3	8									2	2
<i>Onos</i> spp.	2	7									3	8
<i>Molva molva</i>	1	1			1	1					3	8
<i>Sebastes marinus</i>											1	1
<i>Sebastes viviparus</i>	4	5			1	1					1	1
<i>Scopelidae</i> spp.											1	1
<i>Cottus scorpius</i>	1	2					3	15	2	3	5	18
<i>Cottus bubalis</i>	1	1			1	1					6	8
<i>Cottus</i> spp.	3	7									1	1
<i>Liparis</i> spp.	4	24									3	7
<i>Agonus</i> spp.											4	24
<i>Cyclopterus lumpus</i>	1	1	1	1							1	1
<i>Lumpenus lampretiformes</i> ...	5	14	3	3							1	1
<i>Chirolophus galerita</i>	2	3									8	17
<i>Pholis gunnellus</i>	1	1									2	3
<i>Indeterminate</i>	8	16									1	1
Total	12820	100.00	7063	100.00	2784	100.00	651	100.00	52	100.00	23370	99.96

TABLE 7.
Species composition of fish larvae in 1963. All gear.

Species	May		June		July		August		September		Total	
	Number of pos. stat.	%	Number of pos. stat.	%	Number of pos. stat.	%	Number of pos. stat.	%	Number of pos. stat.	%	Number of pos. stat.	%
<i>Mallotus villosus</i>	29	11046	46	2484	19	240	27	198	7	41	128	14009
<i>Gadus morhua</i>	17	6469	7	52	8	29	1	1	1	1	34	6552
<i>Melanogrammus aeglefinus</i> ..	12	759	2	4	1	2					15	765
<i>Pollachius virens</i>	11	127			1	2					12	132
<i>Trisopterus esmarkii</i>	14	1019			1	5					14	1019
<i>Gadus merlangus</i>	9	90									9	90
<i>Gadus saida</i>	1	1	1	1							2	2
<i>Hippoglossoides limandoides</i> ..	16	246	12	39	3	11	3	3			34	299
<i>Limanda limanda</i>	12	598	2	2	1	1					15	601
<i>Platessa platessa</i>	4	10									4	10
<i>Microstomus kitt</i>	6	27									7	28
<i>Glyptocephalus cynoglossus</i> ..	5	26					1	1			5	26
<i>Scophthalmus norvegicus</i>	1	1									1	1
<i>Ammodytes</i> spp.	29	663	9	57	1	1					39	721
<i>Clupea harengus</i>	6	13									6	13
<i>Onos</i> spp.	12	64			1	1					13	65
<i>Brosimius brosme</i>	7	9									7	9
<i>Sebastes marinus</i>			1	1							1	1
<i>Sebastes viviparus</i>	12	40			1	1					13	41
<i>Myctophum</i> spp.	2	15									2	15
<i>Trigla</i> spp.	1	1									1	1
<i>Cottus bubalis</i>					1	2					1	1
<i>Cottus</i> spp.	8	13									8	13
<i>Liparis montagui</i>	1	1									1	1
<i>Liparis</i> spp.											1	1
<i>Agonus decagonus</i>			1	1	1	1					2	3
<i>Gobius</i> spp.	2	2			1	2					3	5
<i>Lumpenus lampretiformes</i>	2	2									2	2
<i>Chirolophis galerita</i>	1	2									3	5
<i>Pholis gunnellus</i>	3	8			1	1					4	9
Indeterminate			1	1							1	1
Total	21251	100.03	2647	100.00	300	100.00	203	100.00	42	100.00	24433	100.03

TABLE 8.
Species composition of fish larvae in 1964. All gear.

Species	June		July		August		September		Total	
	Number of pos. larvae stat.	%	Number of pos. larvae stat.	%	Number of pos. larvae stat.	%	Number of pos. larvae stat.	%	Number of pos. larvae stat.	%
<i>Mallotus villosus</i>	70	84.34	63	768	29	109	15	23	177	93.34
<i>Gadus morhua</i>	31	341	2	2	5	6			38	349
<i>Melanogrammus aeglefinus</i> ..	15	70		0.75					15	70
<i>Pollachius virens</i>	3	4		0.04					3	4
<i>Trisopterus esmarkii</i>	8	18		0.19					8	18
<i>Gadus merlangus</i>	6	16		0.17					6	16
<i>Hippoglossoides limandoides</i> ..	22	63	3	3	1	1	0.85		26	67
<i>Platessa platessa</i>	3	8		0.09					3	8
<i>Limanda limanda</i>	13	135	2	2	1	1	0.85		16	138
<i>Glyptocephalus cynoglossus</i> ..	7	33		0.35					7	33
<i>Scophthalmus norvegicus</i>	3	4		0.04					3	4
<i>Ammodytes</i> spp.	25	100	3	7			0.91	1	29	112
<i>Onos</i> spp.	10	36		0.39				5	10	36
<i>Brosmius brosme</i>	1	1		0.01					1	1
<i>Sebastes marinus</i>	10	38		0.41					10	38
<i>Sebastes viviparus</i>	12	31		0.33					12	31
<i>Cottus scorpius</i>	1	1		0.01					1	1
<i>Cottus bubalis</i>	1	1		0.01					1	1
<i>Cottus</i> spp.	1	1		0.01					1	1
<i>Liparis</i> spp.	4	6		0.06					4	6
<i>Agonus decagonus</i>	2	2		0.02					2	2
<i>Anarhichas lupus</i>	1	1		0.01					1	1
<i>Lebetus orca</i>	1	2		0.02					1	2
<i>Pholis gunnellus</i>	2	2	1	1		0.13			3	3
Indeterminate	3	10		0.11					3	10
Total	9358	99.99	783	100.00	117	99.99	28	100.00	10286	100.00

so low in these areas compared with the abundance of larvae off the west coast.

Next to capelin the most common larvae off the west coast are of the gadoid group, with *Gadus morhua* dominating. The pleuronectid group was also fairly well represented. As to the larvae surveys in May 1961, 1962 and 1963, the list of species is not complete since those larvae have been omitted which were caught on special redfish larvae cruises almost exclusively in oceanic areas outside the proper region discussed in this paper, e.g. *Sebastes marinus*, *Micromesistius poutassou*.

All tables show very clearly the dominance of capelin larvae in the ichthyoplankton of the west, north and east coasts of Iceland during the late spring and summer months. Thus, the percentage frequency of capelin larvae in the catches never descended 50%, but was mostly above 90%.

SUMMARY.

This paper is based upon capelin (*Mallotus villosus* O.F.Müller) larvae material from the west, north and east coasts of Iceland collected during the summer months in the period 1960 to 1964. The distribution and abundance of capelin larvae for each year and month is described as well as the water temperature conditions in 20 m depth and the monthly distribution of capelin larvae is discussed. Further, the length composition of the capelin larvae is described and given for different months and years. The general tendency of successive spawning from south northwards is outlined.

The correlation between abundance of capelin larvae and the prevailing water temperature as well as the mean temperatures in 20 m depth is discussed. Finally, a review of the fish larvae in the material discussed is given.

Íslenskt ágríp.

Þessi ritgerð fjallar um loðnuseiði, sem safnað hefir verið í leiðöngrum „Ægis“ á vorin og sumrin úti fyrir Vestur-, Norður- og Austurlandi árin 1960—1964.

Mjög mikið var af seiðum í maí öll árin úti fyrir Vesturlandi. Úti fyrir Norður- og Austurlandi var mjög breytilegt magn yfir sumarmánuðina á hinum einstöku árum. Samanburður við hitastig sjávar sýndi, að náíð samband er milli magns og útbreiðslu loðnuseiða á svæðinu og sjávarhitans í 20 m dýpi.

Lengdarmælingar á loðnuseiðunum sýndu, að veruleg hrygning hefir ekki átt sér stað þessi ár fyrir austan Húnaflóa.

Í lokin er gefið yfirlit yfir öll fiskseiði, sem fengust ásamt loðnuseiðunum, og er langmest um loðnuseiði á öllum tímum og svæðum, sem athuganirnar ná yfir.

REFERENCES.

- EIHRENBaum, E., 1909: Eier und Larven von Fischen des Nordischen Planktons. Nordisches Plankton, Zool. Teil, Bd. I, Kiel.
- EINARSSON, H., 1949: Eggs and Larvae at Iceland. Ann. Biol. Vol. IV.
- 1956: Frequency and Distribution of Post-Larval Stages of Herring (*Clupea harengus* L.) in Icelandic Waters. Rit Fiskideildar, Vol. II, nr. 4.
- JESPERSEN, P., 1920: On the Occurrence of the Postlarval Stages of the Herring and the "Lodde" (*Clupea harengus* L. and *Mallotus villosus* O.F.M.) at Iceland and the Faeroes. Medd. fra Komm. f. Hav.søg., Ser. Fiskeri, Bd. 6, Nr. 1.
- JÓNSDÓTTIR, S., 1962: Hydrographic Conditions in Icelandic Waters in May/June 1962. Annal. Biol. Vol. XIX.
- 1963: Hydrographic Conditions in North Icelandic Waters in June 1963. Annal. Biol. Vol. XX.
- MAGNÚSSON, J., 1962: Distribution and Abundance of Fish Larvae West of Iceland in May 1961. ICES, C.M. 1962, No. 91.
- 1964: IV. Cod Eggs and Larvae with Notes on Some Other Species, in: ICNAF, Northwestlant 2, National Report, Doc. 24.
- 1965: Report on Capelin Larvae (*Mallotus villosus* O.F.Müller). ICNAF, Northwestlant 1—3, 1963, Final Report.
- MAGNÚSSON, J.; MAGNÚSSON, J., and HALLGRÍMSSON, I., 1965: The "Ægir" Redfish Larvae Expedition to the Irminger Sea in May 1961. Rit Fiskideildar, Vol. IV, Nr. 2.
- SCHMIDT, J., 1904: Fiskeriundersøgelser ved Island og Færøerne i Sommeren 1903. Skrifter Komm. f. Hav.søgelse No. 1.
- 1906: On the Larval and Post-Larval Development of the Argentines (*Argentina silus* (Ascan.) and *Argentina sphyraena* Linné) With Some Notes on *Mallotus villosus* (O.F. Müller). Medd. Komm. f. Havunders. Ser. Fiskeri, Bd. II Nr. 4.
- STEFÁNSSON, U., 1960: Temperature at 20 Meters in Icelandic Waters in May—June 1950—1959. Rit Fiskideildar, Vol. II, Nr. 8.
- 1962: North Icelandic Waters. Rit Fiskideildar, Vol. III.
- STEFÁNSSON, U. and DIETRICH, G., 1961: Hydrographic Conditions in North Icelandic Waters in June 1961. Annal. Biol., Vol. XVIII.
- SÆMUNDSSON, B.J., 1926: Íslenzk dýr I. Fiskarnir. Reykjavík.
- 1934: Probable Influence of Changes in Temperature on the Marine Fauna of Iceland. Rapp. et Procès-Verbaux, Vol. LXXXVI.