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The Fry of Sebastes in Icelandic Waters and Adjacent Seas*

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CONTENTS

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Doc. E. 3. „Distribution, Abundance and Size of Young Stages of *Sebastes* in Icelandic waters and Adjacent Seas“, and
Doc. E. 13. „On the Environment of the *Sebastes* Larvae in the Irminger Sea“.

I. INTRODUCTION

Large numbers of stramin-net samples have been taken in Icelandic waters and adjacent seas. It is to be regretted that this comprehensive material has only been partly evaluated and with the adoption of new collecting methods it seems important to summarize some of the main findings these surveys have yielded.

The present contribution is intended to cover a wider field, the tables and charts being planned for comparison with data on other species of young fish, collected with the same gear in the same localities.

I am greately indebted to the late Dr. Å. Vedel Tåning and to Dr. Erik Bertelsen, his successor as director of the Marine Biological Laboratory in Copenhagen, for permission to use the Danish collections.

I should also like to express my thanks to Miss Sigrún Sturlaugsdóttir and Mr. Sverrir Gudmundsson for their help during the preparation of this paper, and to Dr. James H. Fraser, Aberdeen, for correcting my English.

The work was aided by a grant from the Icelandic Science Fund (Vísindasjóður).

II. METHODS AND MATERIAL

Figure 1 shows the division into areas of the region investigated.

The stramin-net material was collected by Danish and Icelandic research ships; the Danish data were collected during the years 1903—1939 and the Icelandic during 1948—52. Two types of gear, which are considered comparable, have been used; the Petersen young-fish trawl in the period 1903—1908 and 2 m stramin-net in the period 1924—1952.

The upper water layers have been most extensively sampled. During 1903—1937, two 10 or 15 minute hauls were made at most stations: a surface haul and a deeper haul with 65 or 100 m of wire out. During 1938—1952 only one haul was made of 30 minutes' duration, taken in three steps. The lengths of wire used were most frequently: 300—200—100, 200—150—50, or 150—100—50 m.

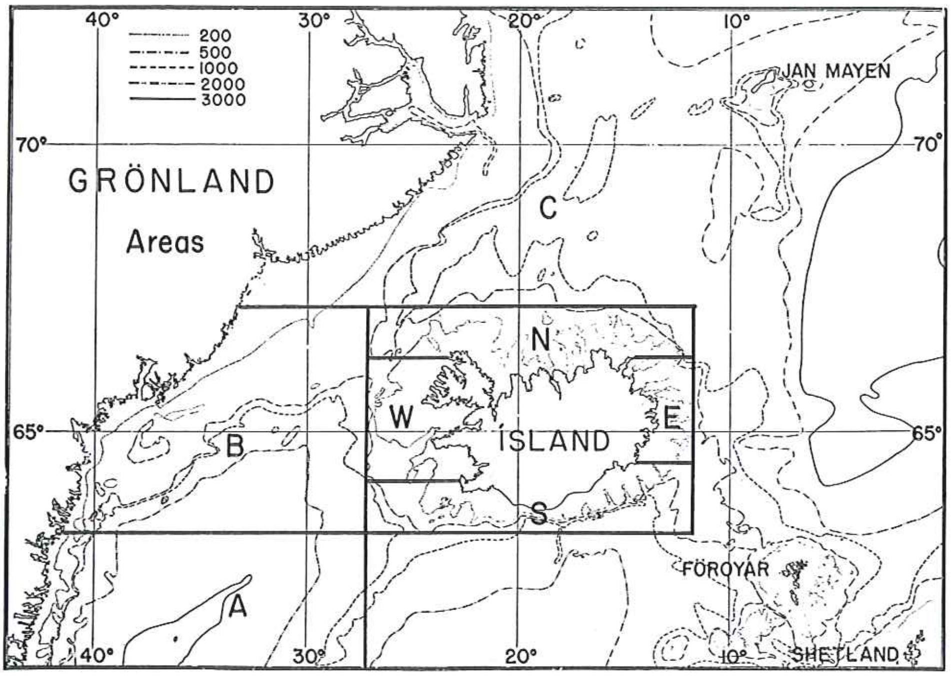

Fig. 1. *The division of the region investigated into areas.*

For comparison the numbers have been calculated per 30 minutes' haul.

The present survey is based on 1787 stations, taken mainly in Icelandic coastal waters, and to supplement this the Danish collections from the oceanic area between Iceland and Greenland were also considered.

Numerous Hensen-net hauls from the years 1954 to 1958 were examined, but with disappointing results. This net samples *Sebastes* larvae very ineffectively.

PLATE I.

1. A young stage of *Sebastes marinus*, size 7 mm. Note the absence of a tail melanophore. (Stat. A59/15).
2. A young stage of *Sebastes marinus*, size 10 mm. Note the absence of a tail melanophore. (Stat. A59/13).
3. Preextrusion larvae from a female *Sebastes viviparus*, caught off the Faroes 11. 5. 1938. Size 5 mm. Note the tail melanophore.
4. The earliest planktonic stage of *Sebastes viviparus*, size 5 mm. Note the tail melanophore. (Stat. 624, 1948).
5. A young stage of *Sebastes viviparus*, size 6.5 mm. Note the tail melanophore. (Stat. 624, 1948).

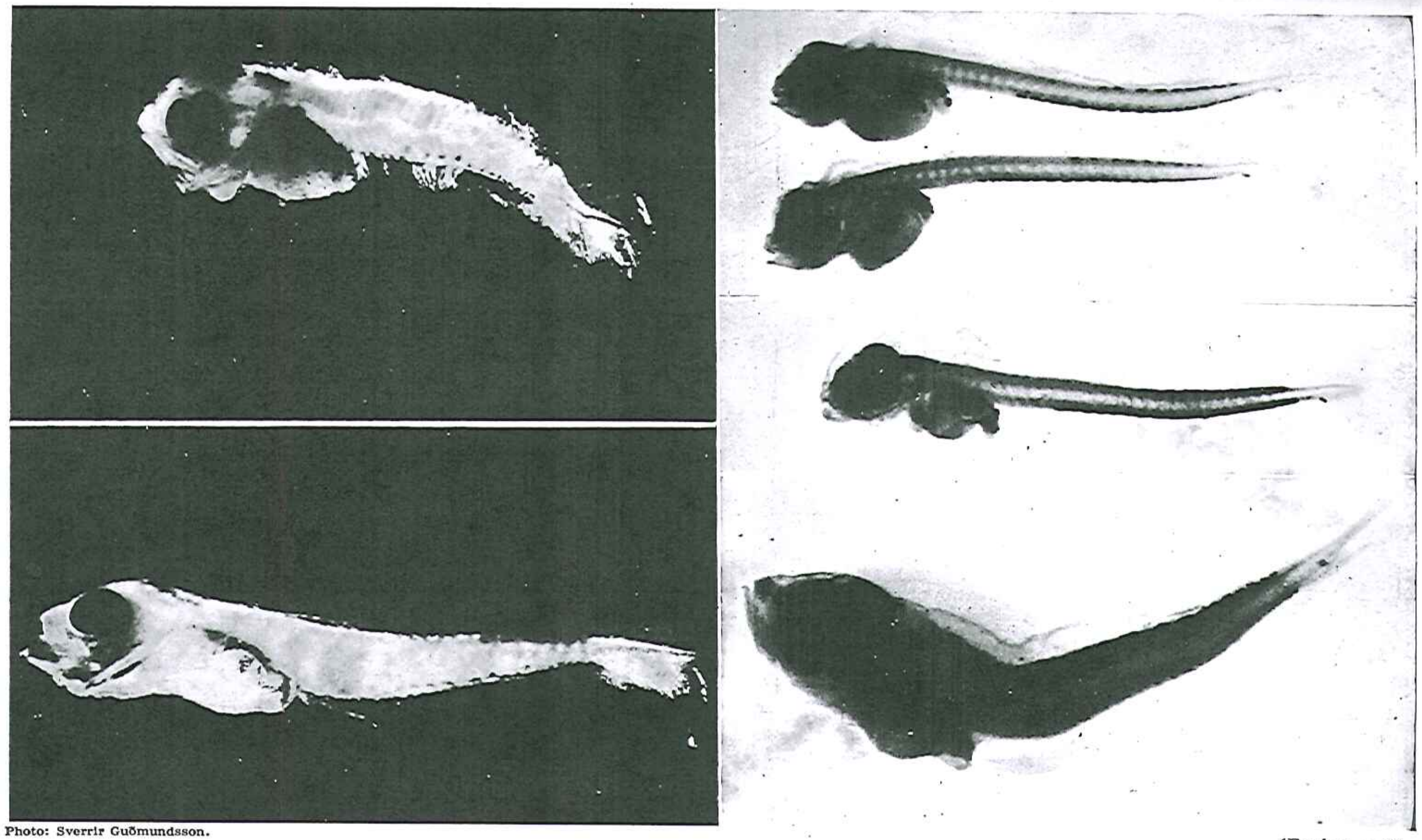

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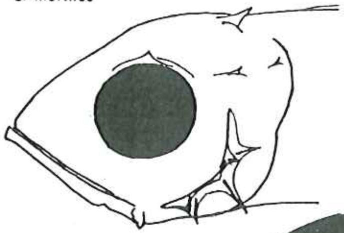
Photo: Sverrir Guðmundsson.

(Facing p. 4).

S. marinus



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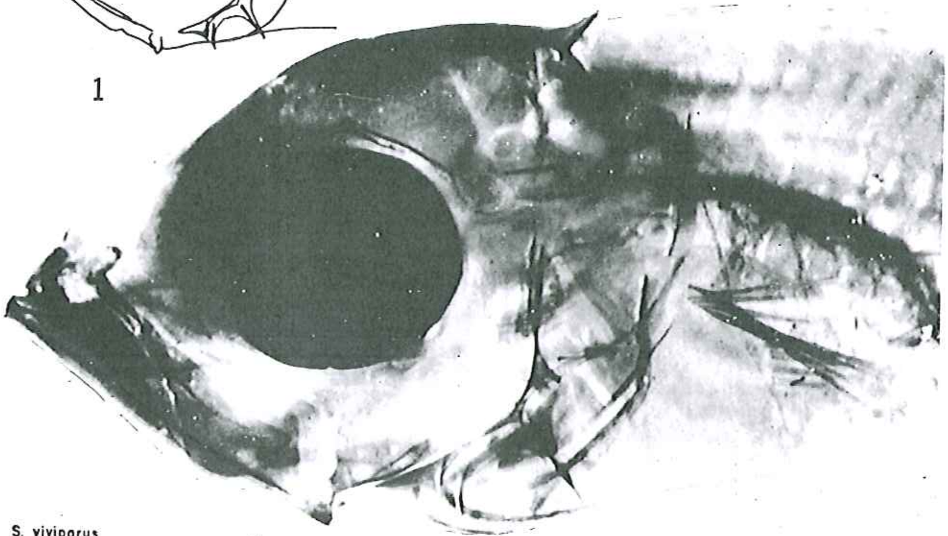
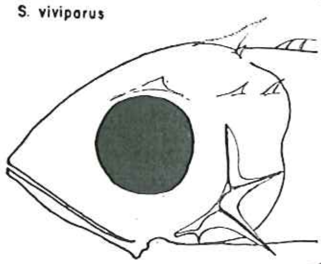


S. viviparus



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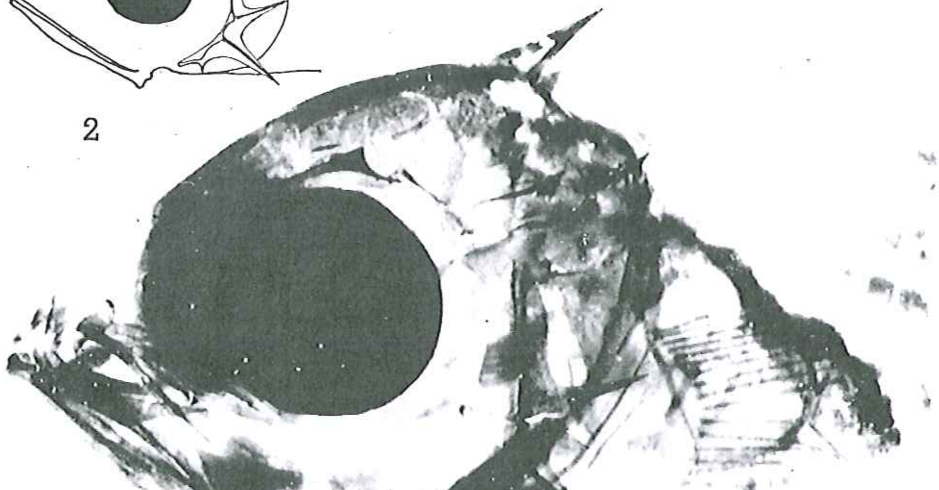


Photo: Sverrir Guðmundsson.

Hauls with Plankton Indicators (Hardy) and with a High Speed Sampler of our own design, were also made. The Plankton Indicators were not found suitable, because of the very low numbers caught, while the High Speed Sampler has proved of great value as a collecting instrument.

As will be discussed below, it is believed that echotraces in oceanic waters may yield valuable information on the distribution and abundance of the young stages of *Sebastes marinus* and data from the years 1954—58 are presented in this paper.

III. IDENTIFICATION

Many years ago the late Dr. Vedel Tåning pointed out to me the distinguishing characteristics of the young stages of *marinus* and *viviparus*, but his description has not yet been published. In the earlier stages *viviparus* can be distinguished from *marinus* by melanophores lying below the posterior end of the notochord. In later stages the more prominent opercular spines characterize the young stages of *viviparus*. These characteristics have been used in the identification of the present material (see plates I and II).

I have not yet seen any young specimens which could be referred to other species of *Sebastes*.

IV. SEBASTES MARINUS (L.)

(1) Distribution.

(A) *Stramin-net hauls.*

The charts of distribution (Figs. 2—9) are self-explanatory, and it is only necessary to draw attention to some main features.

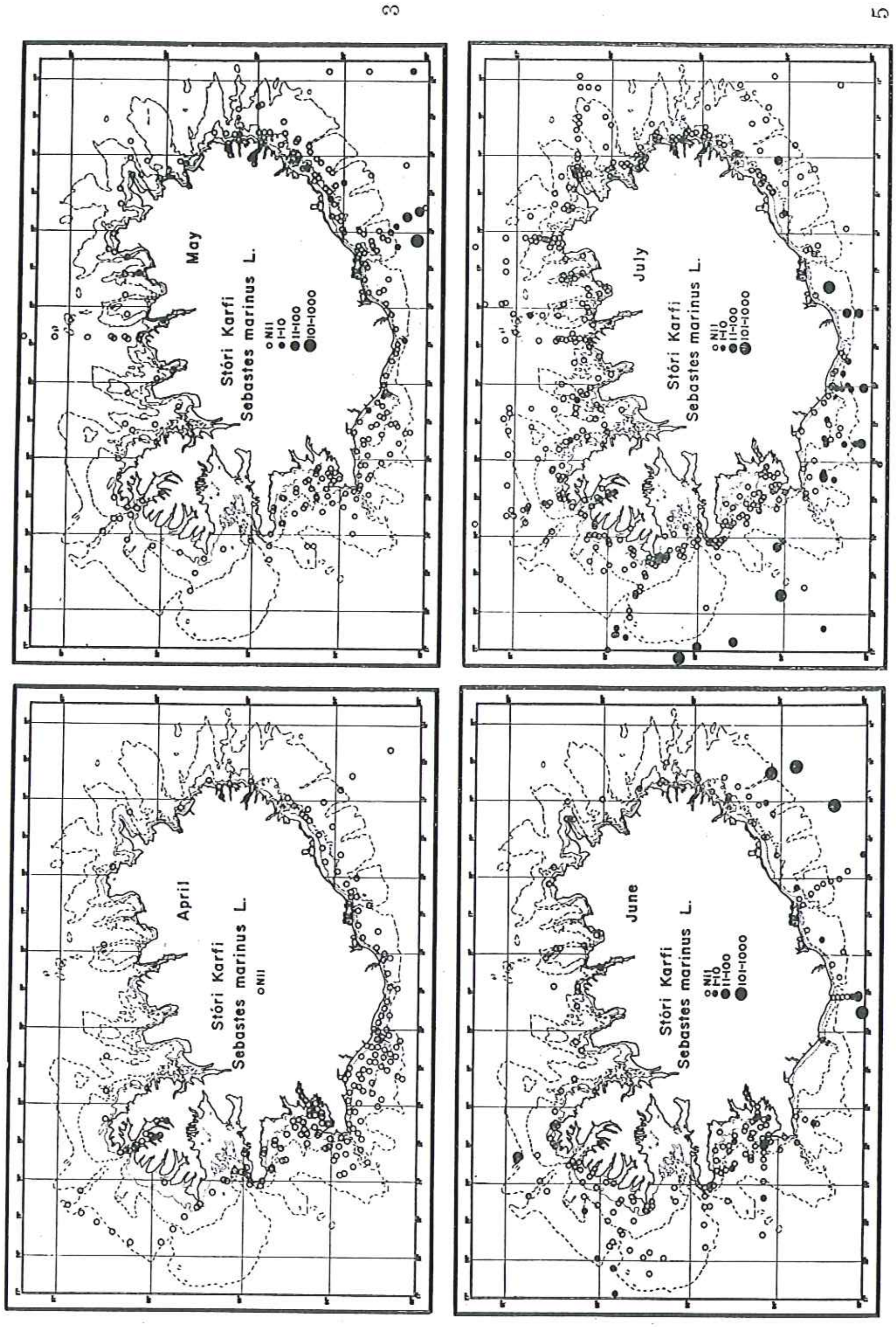
In April the *marinus* fry were not found in the stramin-net hauls. It is probable that the newly emitted fry are present in the latter half of April, but not caught by this coarse-meshed gear.

In May the fry were caught off the south coast as described by Schmidt (1904), but were only taken in quantities above great depths.

PLATE II.

1. Alizarine-stained head of *Sebastes marinus*, size 13 mm. (Stat. A55/16).
2. Alizarine-stained head of *Sebastes viviparus*, size 12 mm. (Stat. 1147, 1949).

Schematic drawings of headspines of *S. viviparus* and *S. marines*. Note the stronger development of spines in *S. viviparus* and the presence of an anterior row of praeopercular spines in *S. marinus*. At the same size the ossification is further advanced in *S. viviparus* than *S. marinus*.



Figures 2—5. *The frequency and distribution of young stages of* Sebastes marinus *around Iceland, April—July.*

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Figures 2—5. *The frequency and distribution of young stages of* Sebastes marinus *around Iceland, April—July.*

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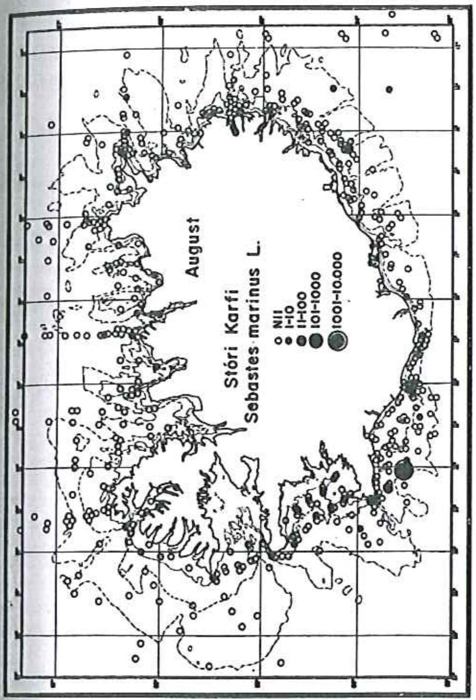

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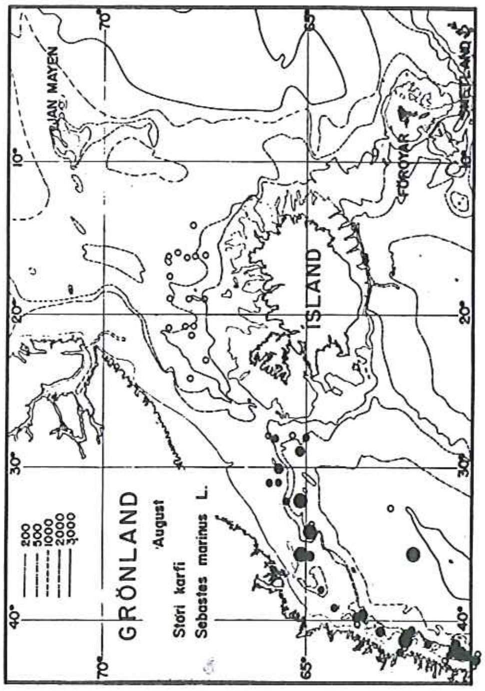

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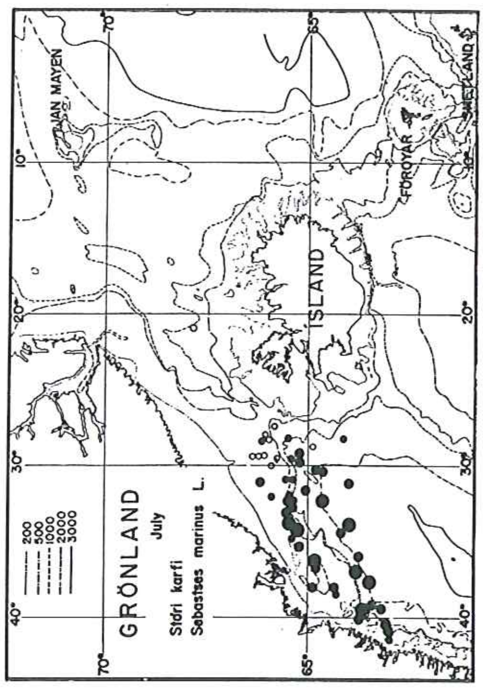

Figures 6—9. *The frequency and distribution of young stages of* Sebastes marinus *around Iceland, August—September, and in the Irminger Sea, July—August.*

This was also true for June, but stray individuals were then more frequent in the coastal waters, especially off the west coast, and the distribution was extended further northward.

In July a drift into coastal waters was noticeable, but the quantities found were always low — single or a few individuals per haul. On the whole the fry were remarkably restricted to oceanic waters, and in August and September there were only few records from the costal waters.

„Spawning" obviously does not occur off the north and east coast of Iceland.

The main concentration of *marinus* fry was observed in oceanic waters south and west of Iceland as described by Tåning (1949). The occurrences are shown in figures 8 and 9, for the months July and August. Unfortunately no systematic investigations by means of stramin-nets have been made during May and June in the area west of Iceland, and the central part of the Irminger Sea, where the main concentrations are undoubtedly located, is still largely unexplored.

The distributional charts given here do not depict the spawning area proper as they show the location of the fry after considerable drifting, and for other purposes the stations lay mainly in the border areas between cold and warm water. On the other hand, this provides the valuable information that *marinus* fry are brought into the East Greenland shelf waters in considerable quantities and it is not improbable that an appreciable part of the larval stock spends the first winter of its life in these border areas.

(B) *Echo-traces in oceanic waters.*

In the latter half of May and the beginning of June 1955, I made an echo-survey in the waters between West Iceland and East Greenland along the route shown in App. A, fig. 2a.

We started our off-shore lines near Reykjanes. At this time of the year we invariably record continuous echo-traces in the upper water layers of the coastal water. These traces are thought to be caused by the presence of great quantities of fish larvae, but they will not be further discussed in this paper. Some distance from the coast these traces disappeared, and over the outer part of the banks very faint traces were only observed in the uppermost layers.

Then, just after leaving Station 11, which lies near the 1000 m contour, the continuous traces reappeared, as shown in App. A, fig. 2b. Soon they increased in intensity, as shown by the sample between Stations 12 and 13. The depth of the traces was generally between 5 and 20 m. The traces were either continuous throughout long stretches or discontinuous, as shown by the sample between Station 14 and 15, and sometimes they were more concentrated in a certain layer, as in the neighbourhood of Station 22.

Just before we reached Station 26 the echo-traces petered out as shown in the two lowermost samples in App. A, fig. 2b.

Very faint traces of this kind were observed between Stations 37 to 38 and 40 to 41. But when we again entered the warm Atlantic water at Station 45 they reappeared in full strength. They were then observed all along the return route towards Iceland, but between Stations 54 and 55 they petered out. The echo-traces of this type were particularly strong on the Icelandic side of the Irminger Sea basin above depths of 1000—2000 metres.

In my cruise report (Einarsson, 1956), I concluded that these traces most probably were caused by the presence of the fry of *Sebastes marinus*.[1]) This conclusion was based on the results of various experiments made with the aim of ascertaining which organisms could possibly cause the traces.

At each station we used Plankton Indicators in three different depths: — at 2 m, 15 m, and 30 m. The only fish larvae caught in oceanic waters were *Sebastes marinus* (see App. A, fig. 2a), but otherwise the plankton consisted mainly of *Calanus* and phytoplankton. Long experience has shown that *Calanus* concentrations do not give any echo-traces with the sensitivity used.

Stramin-net hauls were made at Stations 16 and 21, where the traces were conspicuous, and great numbers of *Sebastes marinus* fry were caught on both occasions. In the colder water of the East Greenland continental shelf we caught no *marinus* larvae, but in the warm water pockets, where faint traces were observed, *marinus* larvae were caught.

Drift-nets of various mesh sizes were shot at Station 54 where the traces appeared very dense, but no fish were caught.

From the beginning of our echo-surveys in 1954 we have recorded these kinds of traces as „continuous traces", and graded them according to their strength into five categories. The oceanic traces belong invariably to one of the three first categories of this scale, stronger traces being observed only in coastal waters.

During the preparation of this report it was thought desirable to examine

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1) Fraser (1957) also made observations during 1955, in the area west and north-west of the British Isles. He states (l. c., p. 44):

„Investigations with an Icelandic pelagic trawl fitted with a small mesh cod-end, in areas over the banks and deep water west and north-west of the British Isles showed that sonic scattering in the subsurface layers was due to small fish. Behaviour differences could be used to distinguish between the traces caused by *Gadus poutassou*, 8—14 mm., and those caused by *Myctophum* spp., *Stomias*, etc. It was found that the distribution of *G. poutassou* followed closely that of salps. Experiments with nets at different depths clearly showed that salps, even in immense quantity, caused no visible scattering on the machines in use on the „Scotia". Similar experiments showed that dense quantities of *Calanus* were equally ineffective as sonic reflectors."

Hansen and Andersen (1959) also found good agreement between the occurrence of echo-traces in 5—30 m depth and the presence of *Sebastes* fry in the upper layers as judged by the results of stramin-net hauls.

the available records in order to see whether they showed a consistent picture, and the results are shown in a series of figures showing the routes and selected samples of the echo-traces recorded (see Appendix A). Lines across the route give an approximate estimate of the strength of the traces observed. In 1956 our previous conclusions received considerable support from the results of the High Speed Sampler.

All the recordings were made on board „Ægir“, with the same echo-sounder (Simrad) and with the same sensitivity (7).

The main features can be sumarized as follows: —

1954 (App. A, fig. 1a-c). From this year we have only records from the west side of Iceland. In June the strongest traces were observed in the neighbourhood of the 1000 m contour (shown on the charts), but in a rather restricted area (see sample Æ 20—21). In July more traces were found along our route. A sample is shown before they appeared (A 10—11), when they appeared (A 13—14), were in full strength (A 14—15 and A 27—28), and when they had disappeared (A 31—32).

1955 (App. A, fig. 2a-b). These echo-traces were discussed above.

1956 (App. A, fig. 3a-b). From this year records are available both from the southern and western area, divided by the Reykjanes Ridge. This year strong traces were found in the southern area and samples of the traces are shown when they appeared (Stations 15—16) and when they disappeared (Stations 20—21). Off the west coast the traces were considerably fainter and often discontinuous (e. g. to Station 38). This patchiness was also borne out by the results of the High Speed Sampler data.

1957 (App. A, fig. 4a-b). The traces recorded in the southern area were very faint (e. g. to Stations 12 and 14—15). Off the west coast they were stronger and were only observed beyond the 1000 m contour. Typical examples are illustrated.

1958 (App. A, fig. 5). No echo-traces were observed on the same route as investigated in 1957. This feature was noticed at once and subsequent experience showed that this could not be due to any fault in the recording apparatus.

The results of these surveys seem to show a very consistent picture. Firstly, the traces are confined mostly to oceanic waters where the depth exceeds 1000 m. Secondly, there are annual variations in the strength of the echo-traces, which could be due to different strengths of the larval stock. Thirdly, the areas south and west of Iceland, i. e., east and west of the Reykjanes Ridge, show independent variation in the strength of the echo-traces. The last point is of special significance, as Tåning has previously shown that such variations have been established.

In general it can be said that the echo-traces conform with the pattern of the extensive collections of *Sebastes* larvae made off Iceland.

TEXT TABLE 1.

Number of young stages of *Sebastes marinus* and *Sebastes viviparus* in horizontal stramin-net hauls of 30 min. duration, according to month and area.

			SEBASTES MARINUS				*SEBASTES VIVIPARUS*			
Month	*Area*	*No. of Stat.*	*No. of pos. Stat.*	*Total no. captured*	*Av. no. per Stat.*	*Av. no. per pos. Stat.*	*No. of pos. Stat.*	*Total no. captured*	*Av. no. per Stat.*	*Av. no. per pos. Stat.*
April	S	105	0	0	0	0	0	0	0	0
—	W	72	0	0	0	0	0	0	0	0
—	N	10	0	0	0	0	0	0	0	0
—	E	9	0	0	0	0	0	0	0	0
April	Total	196	0	0	0	0	0	0	0	0
May	A	2	2	1995	998	998	0	0	0	0
—	B	2	2	200	100	100	0	0	0	0
—	S	125	11	427	3	39	6	15	1	3
—	W	52	0	0	0	0	1	1	1	1
—	N	32	0	0	0	0	0	0	0	0
—	E	45	0	0	0	0	0	0	0	0
May	Total	258	15	2622	10	175	7	16	1	2
June	S	47	12	1187	25	99	15	100	2	7
—	W	100	9	123	1	14	29	531	5	18
—	N	36	1	12	1	12	0	0	0	0
—	E	17	0	0	0	0	0	0	0	0
June	Total	200	22	1322	7	60	44	631	3	14
July	A	4	4	148	37	37	0	0	0	0
—	B	47	38	3806	81	100	0	0	0	0
—	C	1	0	0	0	0	0	0	0	0
—	S	79	21	420	5	20	35	900	11	26
—	W	151	7	551	4	79	45	919	6	20
—	N	170	6	7	1	1	12	16	1	1
—	E	71	0	0	0	0	1	2	1	2
July	Total	523	76	4932	9	65	93	1837	4	20
August	A	18	13	1172	65	90	0	0	0	0
—	B	19	15	1164	61	78	0	0	0	0
—	C	16	0	0	0	0	0	0	0	0
—	S	164	10	1560	10	156	12	22	1	2
—	W	97	4	6	1	2	10	23	1	2
—	N	146	0	0	0	0	4	4	1	1
—	E	87	2	2	1	1	2	5	1	3
August	Total	547	44	3904	7	89	28	54	<1	2
Sept.	S	17	0	0	0	0	0	0	0	0
—	W	19	1	1	1	1	1	1	1	1
—	N	11	0	0	0	0	0	0	0	0
—	E	16	0	0	0	0	0	0	0	0
Sept.	Total	63	1	1	1	1	1	1	<1	1

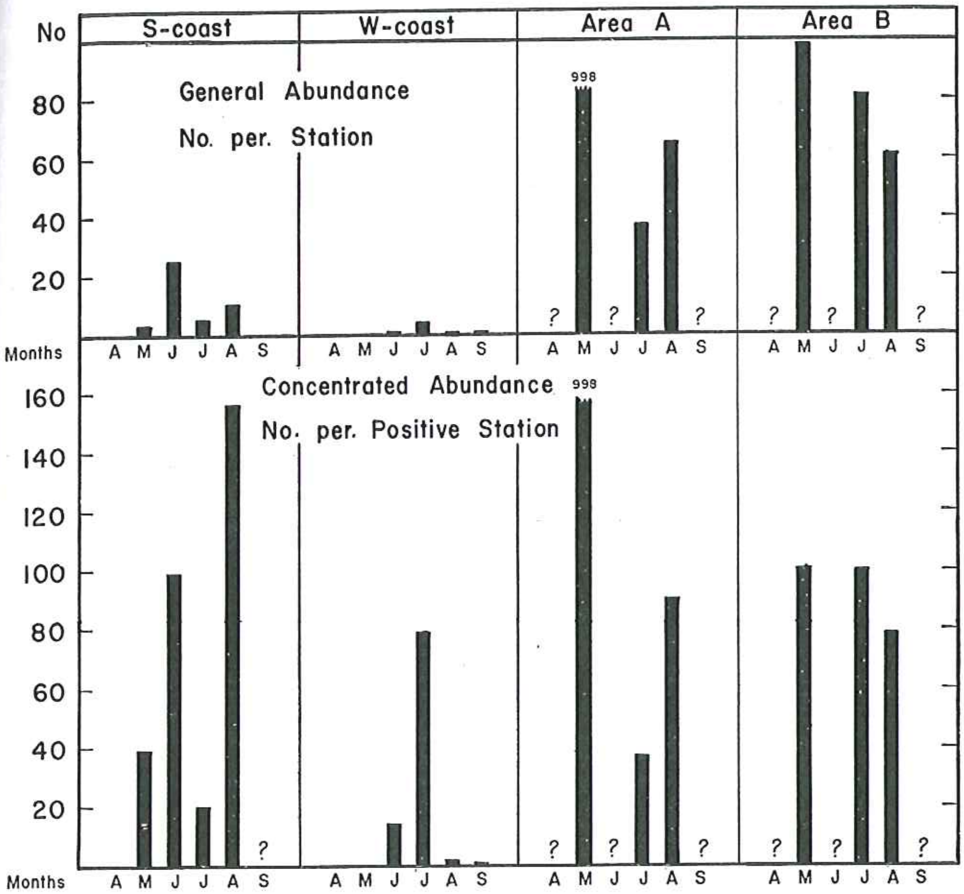


Fig. 10. *General and concentrated abundance of young stages of* Sebastes marinus, *according to area and month, based on the number caught in 30 min. stramin-net hauls.*

(3) **Size.**

(A) ***Size distribution in different months.***

Measurements of *marinus* larvae from the stramin-net hauls are listed in Appendix B, according to month and area. The difference between the size distribution in May—June on the one hand, and July—August on the other, is so pronounced that it requires an explanation.

It will be seen that the average size for May was found to be 9.29 mm, for June 7.63 mm, for July 20.20 mm, and for August 24.95 mm. During May and June the length lies within the narrow range of 5 to 15 mm. By July the range increased very rapidly upwards to 38 mm. It is not difficult to explain the lower average in June than in May: it may be simply due to slow growth and continued expulsion of young which lowers the average. It is more difficult to explain the rather explosive growth in July, after such a very slow start. We must bear in mind that the growth figures are minimal values, because the larvae tend with increasing size to evade the net.

It seems natural to ask the question whether it is possible that the collections from July and August comprise older year-classes, which would tally with the opinion that *Sebastes marinus* is a very slow growing fish, but this explanation leaves discrepancies. Why do we not find a single specimen belonging to higher size categories during May and June? And why are there no definite modal lengths to be observed in July and August?

It is true that the size distribution for area S in July shows slight indication of modality, the first mode being at 12 mm, the second at 20 mm, and the third at 32 mm, which could be explained by assuming that three year-classes were present, but in the much larger material from area B these modes are not discernible.

It seems also exceedingly improbable that the main bulk of the young fish caught could belong to the I-group, and not the O-group which would be expected if more than one year-class were present.

It is therefore thought that all the young stages of *Sebastes* caught by the stramin-net during one summer belong to the same year-class, with the possible exception of a few specimens lying outside the continuous size range.

What then is the explanation of the sudden increase in growth? The most probable suggestion that I can offer is that food conditions are primarily responsible.

The Plankton Indicator samples taken during the May—June cruise in 1955 showed that phytoplankton was generally very abundant and clogged the discs. *Calanus* on the other hand, were mostly in rather poor condition, being whitish, i. e. without oil drops. The sequence has not been worked out yet, but it is highly probable according to our experience, that zooplankton production increases enormously in late June, following a great upwelling of nutrient-rich water in late spring and great production of phytoplankton in May—June. It was shown that the *Calanus* production was most vigorous above the slope in late June 1951 (Einarsson, 1951). Concurrently, the *Sebastes* larvae present on the fringes of the „spawning" area are the first to gain in size, and throughout the summer we found the slope water especially productive, which would account for the greater size of the young stages caught near the edges of the continental slope.

Another important feature is the long duration of the „spawning" season. Young stages down to 7 mm in length were observed in areas B, S, and W in July. It would be interesting to know whether the „spawning" activity is continuous or if there are distinct phases.

Our measurements of the young stages of *Sebastes marinus* have been graphically summarized in fig. 11, which shows the percentage values

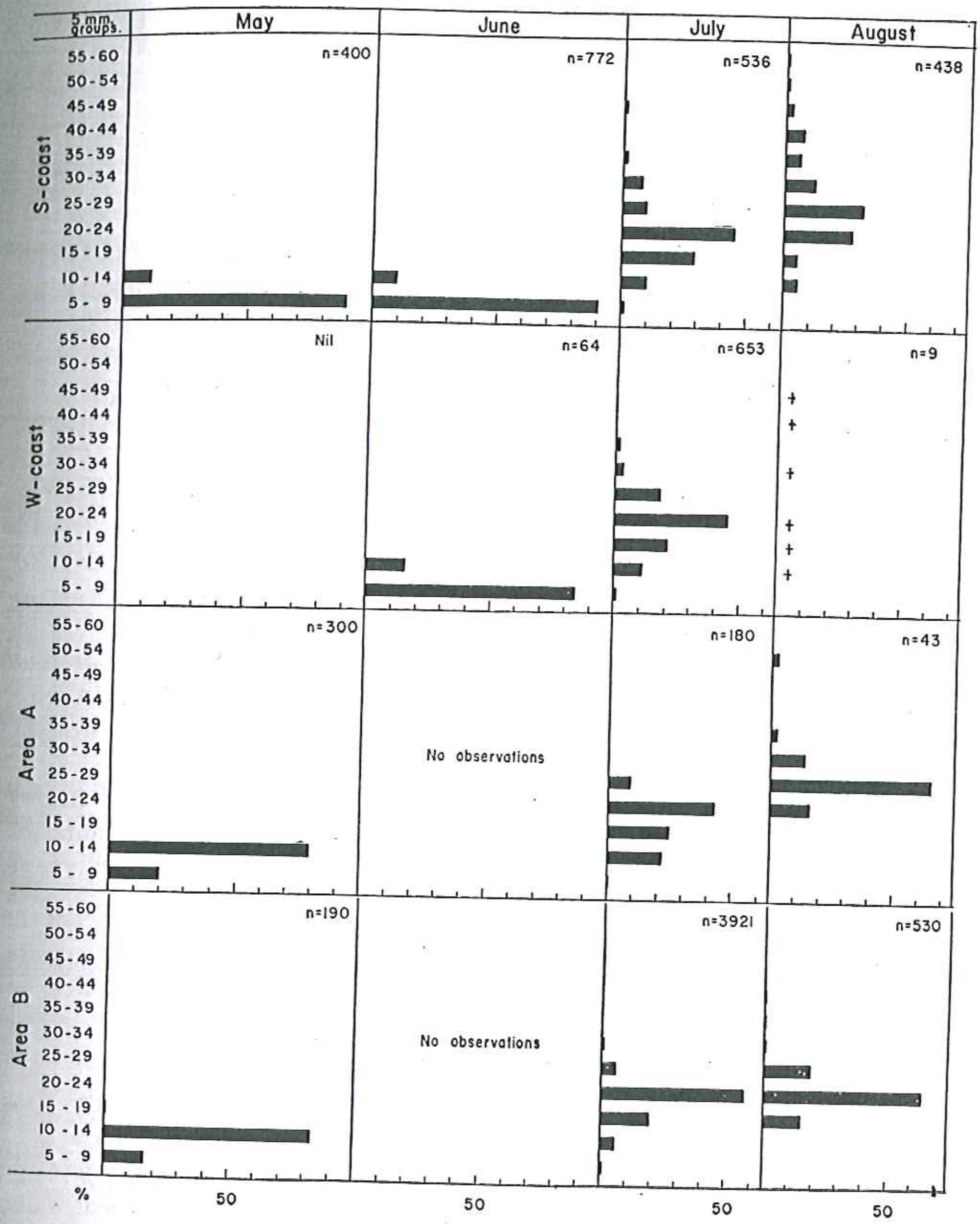


Fig. 11. *Size distribution of young stages of* Sebastes marinus, *5 mm groups, according to month and area.*

in 5 mm groups, according to area and month. This figure shows that development proceeds similarly in all areas investigated. Apparently the „spawning" begins earlier in oceanic waters (areas A and B) than in slope waters off south and west Iceland (areas S and W) as seen by the relative importance of the 5—9 mm and 10—14 mm length groups. On the other hand, the „spawning" seems to last longer, and the growth is more rapid, in the slope waters.

(B) ***Size distribution in different years.***

Considerable annual variations in the size distribution have been observed. As other scientists may wish to use our data to substantiate interpretations differing from those offered in the present report, Table 2 in App. B was computed. In this table the material is arranged according to month, area, and year of capture. Years when fewer than 30 specimens were caught have been omitted.

When this table is examined, it must be borne in mind that, with the exception of areas A and B, the collections are mainly from the fringes of the distribution area, where variations in size may be more pronounced. It will be seen that the *marinus* fry measured were unusually small in 1936 and 1938. It is known that the growth of larval fish was very slow at least in 1938 according to investigations made on board „Dana" in Icelandic waters during the summer of that year. (TÅNING, 1943). Otherwise the most conspicuous difference is found between the 1949 and 1950 collections in August in area S. As far as I know, data are not available which could explain this difference.

However, the variations indicate a strong effect of environmental factors on the rate of growth in different years. This would appear to give additional support to the opinion that only one year-class is present in each year's catches.

(4) Ecological remarks.

(A) ***Temperature.***

TÅNING (1949) provided a hypothesis to link the occurrrence of fry with temperature conditions. He wrote: „From these facts we were obliged to conclude that the boundary of the spawning area of the Large Red Fish towards the warm Atlantic water was to be found where the boreal mixed water of 8°—9° C. did not lie essentially below a depth of 200 metres, but in the main higher up, and further that the cold water of less than ca. 3°—4° C. near the paths of the Arctic currents should not occupy the area in depths of about 200 to 500 metres." (l. c., p. 89).

TÅNING continues: „During the 1947 cruise it was actually proved that *when* these requirements were fulfilled, the fry of the large Red Fish were to be found *everywhere*, even so far south as about 50° N."

As far as I know no contradictory evidence has been put forward against TÅNING's general conclusion that „On the whole the Large Red Fish quite clearly requires temperatures between 3°—4° and 8°—8.5° C. in its spawning area....“ (l. c., p. 91). However, its general application, as indicated by TÅNING's remarks on the results of the 1947 cruise, seems open to doubt.

Firstly the evidence brought forward in the present paper indicates that the expulsion of the young occurs outside the 1000 m contour, although the temperature requirements are fulfilled in 200—500 m depth nearer the coast.

Secondly, although the temperature requirements are fulfilled fry may be absent or very scarce, e. g. in 1958.

Through the courtesy of MR. UNNSTEINN STEFÁNSSON pertinent temperature sections were made available for the present study. Two sections will be specially considered here, the section going westwards from Reykjanes and the section going southwards across the Selvogsbanki (figs. 12 and 13).

A comparison between the conditions in 1956 and 1957 on the one hand, and 1958 on the other, shows that in 1958 the temperatures were decidedly lower than usual. Note, for instance, that the upper layer, warmer than 8° C., was less extensive in 1958, and it penetrated to about 100 m. depth as compared with about 200 m. depth in 1956 and 1957.

TÅNING concluded that a deeper penetration and volume of warm water, more than 8° C., prevented the spawning of *Sebastes* in the area south of Iceland during later years, as compared with the conditions in the beginning of the century, when SCHMIDT (1904) found large numbers of *Sebastes* fry in this area, and the volume of warm water was less extensive. But this hypothesis does not seem to explain the paucity of *Sebastes* fry in the region south of Reykjanes in 1958.

It will be seen that in all the three years mentioned the conditions meet TÅNING's demands as regards suitable temperatures for the spawning of *Sebastes,* i. e. 3°—8.5° C. in 200—500 m. depth. In spite of this we have observed great variations, both annual and regional, in the abundance of the *Sebastes* fry south and west of Iceland.

It was concluded that *Sebastes* fry were abundant in 1956, especially south of Iceland. In 1957 small quantities were found south of Reykjanes but moderate numbers to the west. In 1958 the larval stock was extremely poor in both areas.

This does not invalidate TÅNING's general conclusion, but it strongly suggests that other external factors may influence the intensity of „spawning“ or the survival of the young. „Spawning“ may even be successful although the resulting larval stock is poor. It seems difficult to envisage a total failure of spawning in a stock of such longevity as assumed for redfish. Such a stock must always be composed of many year classes, which would ensure a similar spawning intensity during long periods.

There is another aspect of this temperature problem to which attention

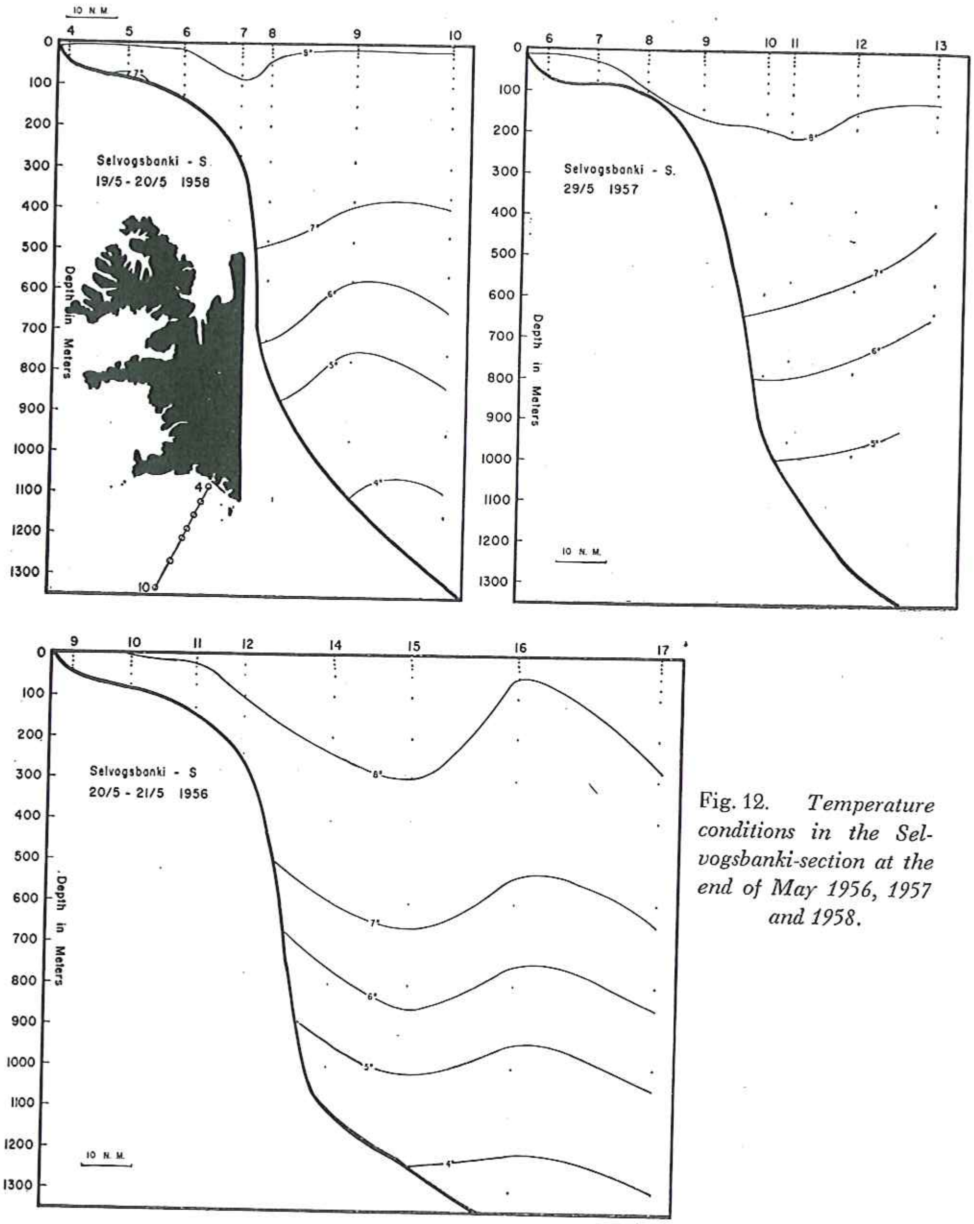


Fig. 12. *Temperature conditions in the Selvogsbanki-section at the end of May 1956, 1957 and 1958.*

must be drawn. We must remember that the depth level, 200—500 m., at which expulsion of young is supposed to occur, is still hypothetical. Deplorably enough no observations are available on this important issue. Does the fact that the *Sebastes* fry are mainly caught outside the 1000 m. contour mean that the redfish descend below 500 m. for „spawning"?

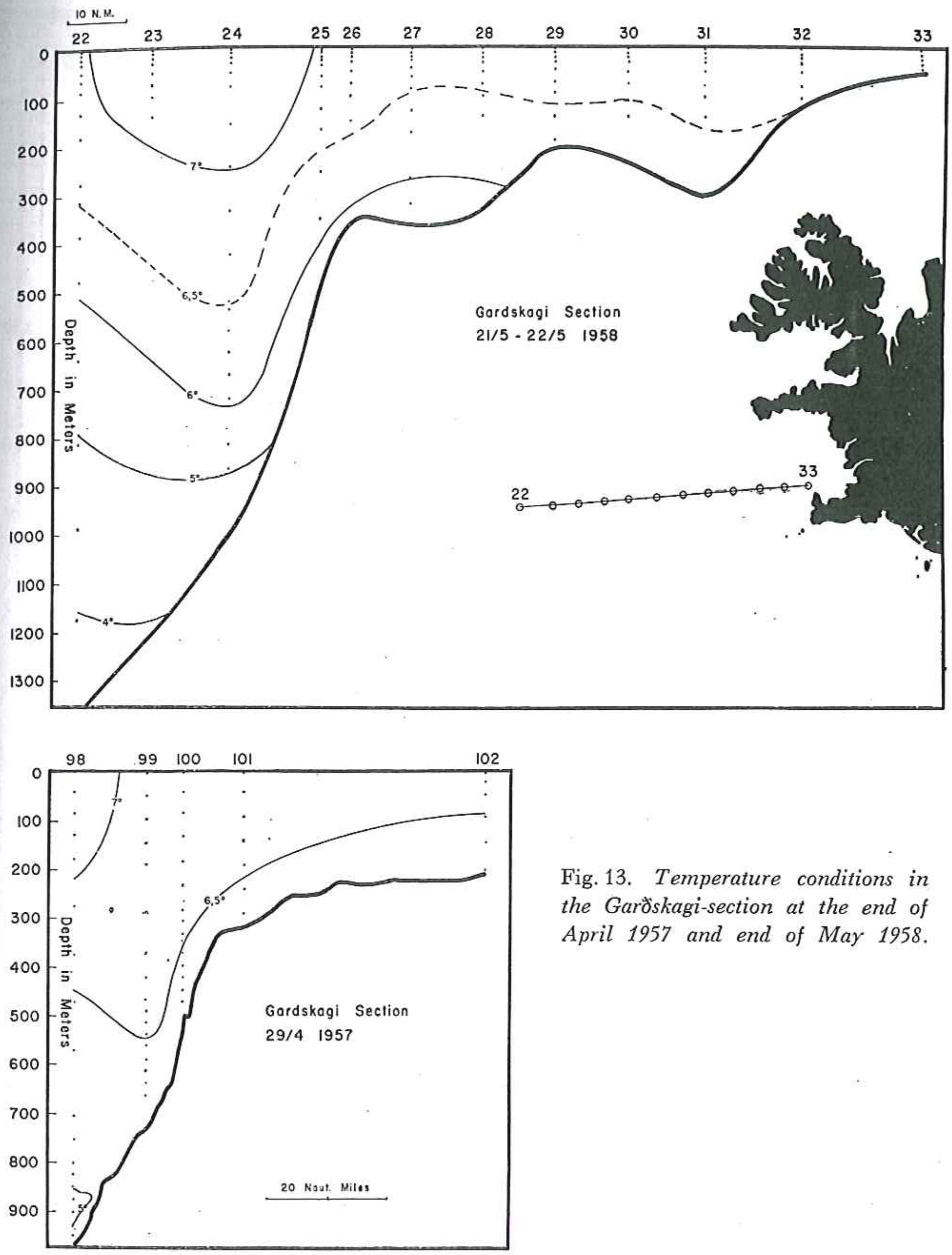


Fig. 13. *Temperature conditions in the Garðskagi-section at the end of April 1957 and end of May 1958.*

It may even prove useful to formulate an alternative hypothesis, based on the assumption that the spawning occurrs in 500—800 m. depth, although it may be modified or rejected when more observations are available.

Let us assume that *Sebastes* being a bathypelagic „spawner“ has a narrower temperature range for spawning than Tåning concluded e. g. 4°—6° C.,

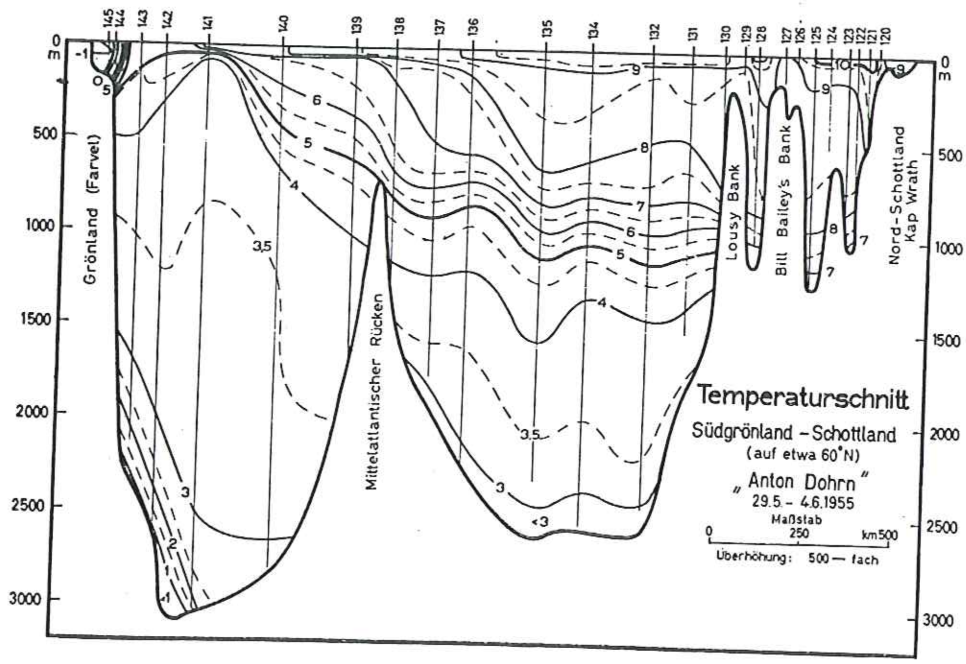


Fig. 14. *A hydrographic section between Scotland and S-Greenland in May 1955. (From* Dietrich *1957, fig. 25, p. 295).*

and emits the young in depths between 500 and 800 m. We can test such a hypothesis by considering the distribution and abundance in one particular year and comparing it with the hydrographic situation, and then seek confirmatory evidence in observations from other years.

If we examine the 1955 conditions and study the section between Scotland and South Greenland discussed by Dietrich (1957), the hydrographic situation would indicate the following larval distribution pattern (see fig. 14): In the area east of stat. 135 there would be no larvae of *Sebastes*, because the 4°—6° layer lies entirely below 800 m. depth. Conditions would become favourable midway between stations 135 and 136 and remain favourable westwards to stations 140—141, where the temperature drops below 4° C. in 500 m. depth.

This hypothesis would account for paucity of *Sebastes* fry in two areas, i. e. in the eastern part of the North Atlantic and near the coast of South Greenland, while an area of high productivity would be expected in between. This distribution pattern seems indicated by Henderson's (1959) results and our survey across the Irminger Sea in 1955 (see App. A, fig. 2a).

Because of the difficulty of catching „spawning" *Sebastes* bathypelagically such hypotheses may at present be tested only by larval sampling, but it must be emphasized that a prerequisite for such testing is the right timing,

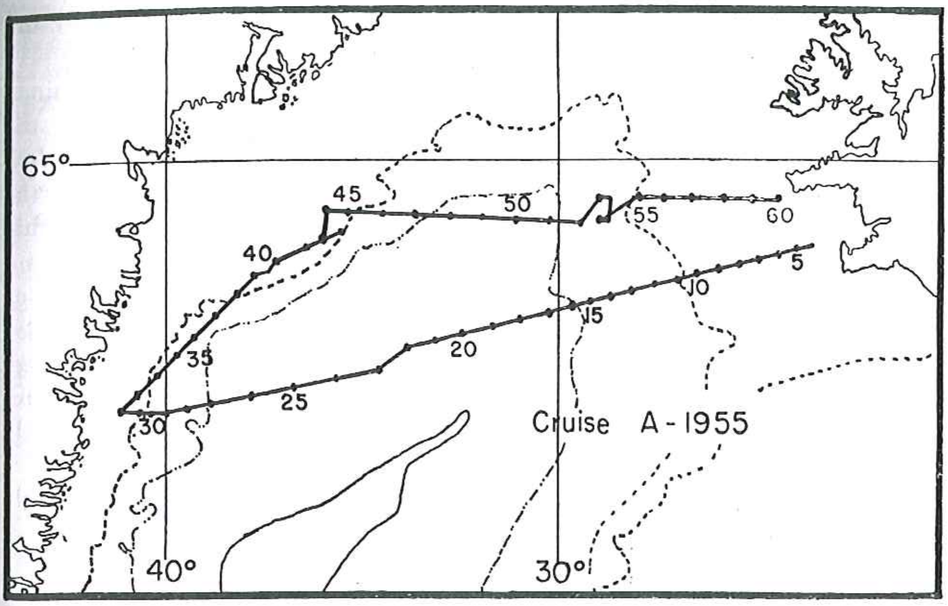


Fig. 15. *Plankton Indicator stations during the zooplankton survey in the Irminger Sea 27. 5.—3. 6. 1955.*

because larval drift may alter the distribution pattern markedly and invalidate the comparison with temperature conditions at expulsion.

(B) *Plankton.*

In the preceding chapter it was concluded that temperature conditions did not explain the great annual and regional variations in the abundance and distribution of the *Sebastes* fry. Therefore we must turn our attention to other external factors that may be responsible for this. A study of the general composition of the zooplankton seems of great interest in this connection.

As far as I know, no attempt has previously been made to systematize our knowledge regarding the quantitative composition of the zooplankton of the Irminger Sea, but FRASER (1958, 1959) has given interesting qualitative information on annual characteristics.

On the other hand, the microplankton has been studied in considerable detail (BRAARUD 1935, GILLBRICHT 1959). The distribution of suspended matter in the sea was thouroughly discussed by JOSEPH (1959) and THÓRDARDÓTTIR (1960) has published her productivity measurements in this area during 1958.

(a) *Identification of zooplankton communities.*

The following remarks are based upon a study of samples taken by means of Plankton Indicators at the end of May and the beginning of June 1955 in the Irminger Sea (see fig. 15). The analyses were made on board the ship in the time interval between stations.

In connection with studies on the young stages of *Sebastes* I re-examined the Plankton Indicator countings and I noticed a certain regularity in the occurrence of the zooplankton components. Some of these characteristics had been observed previously, during a survey made in late June 1951 in the Icelandic west coast waters (EINARSSON, 1951). This survey revealed that the macroplankton off the southwest coast of Iceland contained three main components: Coastal plankton, Mixed plankton and *Calanus* plankton (l. c., p. 163—164, fig. 11).

It is thought that the Plankton Indicator material is comprehensive enough for the identification and characterization of the main zooplankton communities in the Irminger Sea, and the ecological relations of the *Sebastes* fry would seem to be better defined with this background described in some detail.

The Indicators, provided by the Oceanographical Laboratory in Edinburgh, were towed for 10 minutes at a speed of 8 knots, in two or three different depths, at 2 m, 15 m, and 30 m. (For description of apparatus see JAKOBSSON, 1958, pp. 4—5).

The tables show the results of the counts. The overwhelming majority of the copepods were *Calanus finmarchicus*. The dominant copepodite stages are noted under „Remarks": „Juv." are mainly copepodite stages I—III, „ads." mainly copepodite stages IV and V.

The communities will be identified and characterized in the order they were encountered along the route (fig. 15).

The isotherms (figs. 16—19) are based on bathythermograph records.

Stations 3—4. The Mixed *Calanus* Community. App. C, I.

This was an intermediate community, between the coastal communities (not treated in this paper) and the Pure Calanus Community, but is was well defined. *Calanus* was dominant, but *Temora* could also be very abundant. The following species and groups were also abundant: Larvae of euphausids (*Thysanoessa inermis* and *Meganyctiphanes norvegica*), cirripede larvae, *Evadne* and decapod larvae. In the upper layers the temperature was uniform, 7°—7.5° C. The largest numbers of copepods were found in the 30 m. hauls.

Note: (a). Considerable numbers of *Calanus* mixed with *Temora*. (b). Presence of neretic components. (c). Net phytoplankton scarce.

Stations 5—10. The Pure *Calanus* Community. Fig. 16 (see also App. C, I).

This community was confined to the slope of the continental shelf. The composition was remarkably uniform, *Calanus finmarchicus* being the only component of any importance. Temperature was uniform 6.5°—7.5 C. The greatest numbers were found in the hauls from 30 m.

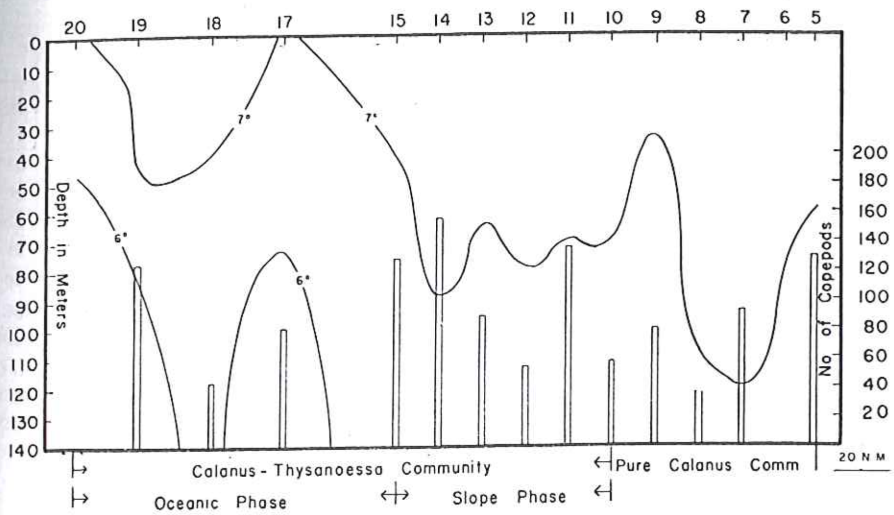


Fig. 16. *Zooplankton communities, number of copepods and temperature conditions of the upper layers in the section between stations A/5 and A/20 1955.*

Note: (a). The predominance of *Calanus* in adolescent copepodite stages. (b). Net phytoplankton scarce.

Stations 11—29. The *Calanus-Thysanoessa* Community. Fig. 16 —17 (see also App. C, I—II).

This community had the greatest extension of all the zooplankton communities in the Irminger Sea. It was characterized by the predominance of *Calanus* and the constant presence of *Thysanoessa longicaudata*. *Calanus* was found in all stages of development. *Thysanoessa* was mainly in the calyptopis and early furcilia stages. Stramin-net samples show that adult *Th. longicaudata* were extremely abundant, although only occassionally caught in the Indicators. The samples indicate that the community could be divided into three phases:

A. The Eastern Slope Phase (Stats. 11—15).

Temperature in upper layers was uniform, 6.5°—7.5° C. *Calanus* numbers were relatively high, especially in the hauls from 30 m.

Note: (a). The preponderance of *Calanus*. (b). The presence of *Thysanoessa longicaudata*. (c). The presence of crustacean eggs, nauplii and *Calanus* juv. (d). The abundance of net phytoplankton. (e). The copepods were pale or coloured light-red.

B. The Oceanic Phase (Stats. 16—27).

An intrusion of colder water (<6° C) was found at stations 17 and 20, but in the upper layers the temperature was still about 7° C. An intrusion

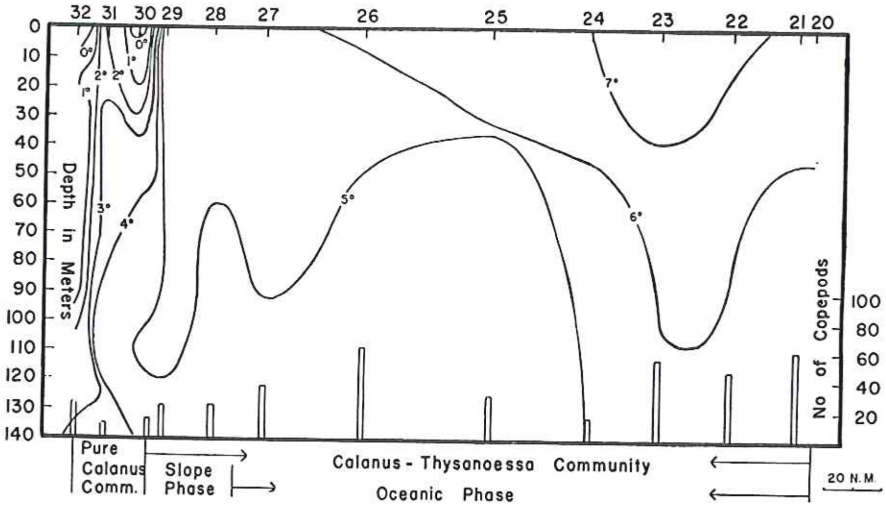


Fig. 17. *Zooplankton communities, number of copepods and temperature conditions of the upper layers in the section between stations A/20 and A/32 1955.*

of <5° C water was found west of station 25, and in the western part of this area the temperatures of the upper layers were between 4.5° C and 6° C.

Note: (a). The predominance of *Calanus* in intermediate and adolescent stages. (b). The presence of *Thysanoessa.* (c). Moderate quantities of phytoplankton. (d). Copepods light-red or red in colour.

C. The Western Slope Phase. (Stats. 28—29).

These stations were near the cold water of the East Greenland current, but temperatures were still between 5° and 5.6° in the uppermost layers.

Note: (a). The preponderance of juvenile *Calanus.* (b). The presence of *Thysanoessa.* (c). The abundance of net phytoplankton. (d). The light colour of the copepods.

Stations 30—34. The Pure *Calanus* Community. (Cf. Stats. 5—10). Fig. 17—18 (see also App. C, III).

It is thought that this was the same slope community as encountered at Stats. 5—10, but in a much earlier stage of development, eggs, nauplii and earlier copepodite stages of *Calanus* being predominant. The temperatures of the upper layers were between 0° and 3° C. Strong vertical temperature changes were observed.

Note: (a). Preponderance of juvenile *Calanus.* (b). Absence of *Thysanoessa.* (c). Abundance of net phytoplankton. (d). Surface layers poor in organisms.

Stations 35—37. The *Calanus-Thysanoessa* Community, Western Slope Phase (Cf. Stats. 28—29). Fig. 18 (see also App. C, III).

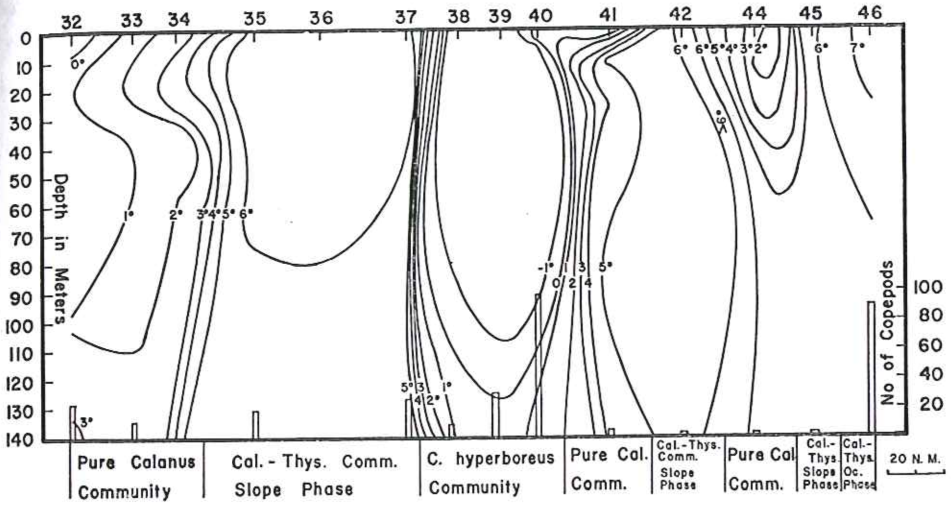


Fig. 18. *Zooplankton communities, number of copepods and temperature conditions of the upper layers in the section between stations A/32 and A/46 1955.*

A tongue of warm Atlantic water (>6° C) intruded into the flank of the East Greenland current.

Note: (a). Nauplii and juvenile stages of *Calanus.* (b). Presence of *Thysanoessa longicaudata.* (c). Abundance of net phytoplankton. (d). Surface layers poor in organisms.

Stations 38—40. The *Calanus hyperboreus* Community. Fig. 18 (see also App. C, III).

A tongue of very cold water (<÷1° C) from the East Greenland Current, was traversed. The arctic *Calanus hyperboreus* characterized these samples.

Note: (a). Nauplii and juvenile stages of *C. hyperboreus.* (b). Absence of *Thysanoessa longicaudata.* (c). Scarcity of net phytoplankton.

Station 41. The Pure *Calanus* Community. (Cf. Stats. 5—10 and 29—33). Fig. 18 (see also App. C, III).

Intermediate temperatures and strong vertical temperature changes were observed.

Note: (a). Nauplii and juvenile stages of *Calanus.* (b). Absence of *Thysanoessa longicaudata.* (c). Very low numbers.

Station 42. The *Calanus-Thysanoessa* Community. Western Slope Phase. (Cf. Stats. 28 and 35—37). Fig. 18 (see also App. C, III).

Warm Atlantic water was found in the upper layers.

Note: (a). Juvenile *Calanus.* (b). Presence of *Thysanoessa longicaudata.*

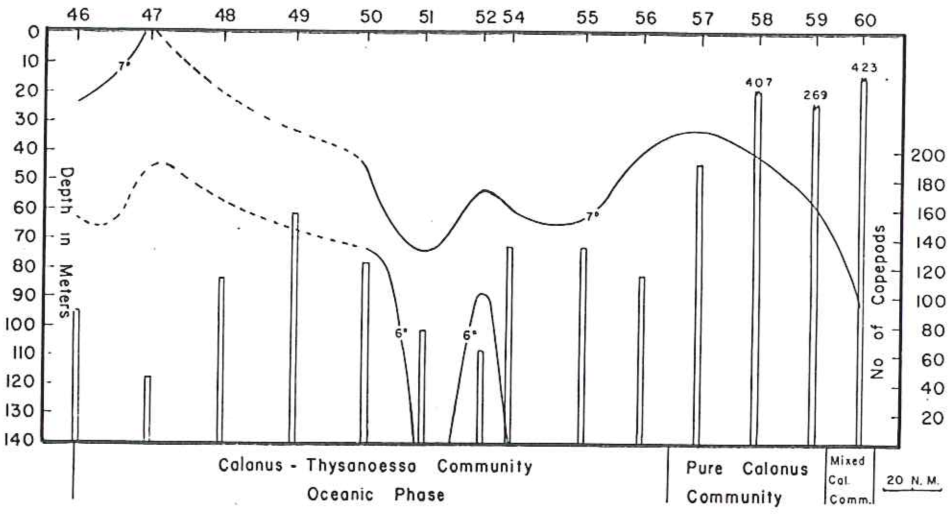


Fig. 19. *Zooplankton communities, number of copepods and temperature conditions of the upper layers in the section between stations A/46 and A/60 1955.*

(c). Abundance of net phytoplankton. (d). No organisms in the surface layer. (e). Very low numbers.

Stations 43—44. The Pure *Calanus* Community. (Cf. Stats. 5—10, 29—33 and 41). Fig. 18 (see also App. C, III).

Intermediate temperature and vertical temperature changes were observed.

Note: (a). Nauplii and juvenile stages of Calanus. (b). Absence of *Thysanoessa longicaudata.* (c). Few organisms in the surface layer. (d). Numbers very low.

Station 45. The *Calanus-Thysanoessa* Community. Western Slope Phase. (Cf. Stats. 28, 35—37 and 42). Fig. 18 (see also App. C, IV).

The station was near the border of the cold water.

Note: (a). Juvenile stages of Calanus. (b). Presence of *Thysanoessa longicaudata.* (c). Abundance of net phytoplankton. (d). Low numbers.

Stations 46—56. The *Calanus-Thysanoessa* Community. Oceanic Phase. (Cf. Stats. 16—27). Fig. 19 (see also App. C, IV).

The warm Atlantic water was encountered. Temperatures are between 5.5° and 7.9° C in the upper layers. Intrusions of colder water (<6° C) were in the western part of the section, which seem to correspond to those observed in the southern section.

Note: (a). The dominance of intermediate and adolescent copepodite stages of *Calanus.* (b). Constant presence of *Thysanoessa longicaudata.* (c). Scarcity of net phytoplankton. (d). High *Calanus* numbers. (e). Copepods red or light-red in colour.

A slope phase of this community was not developed in the eastern side of this area, probably because the phytoplankton area did not extend so far north.

Stations 57—59. The Pure *Calanus* Community. (Cf. Stats. 5—10, 29—33, 41, 43—44). Fig. 19 (see also App. C, IV).

Temperatures in the upper layers were uniform, 6.5°—7.7° C. The community was confined to the shelf waters.

Note: (a). The dominance of adolescent *Calanus*. (b). Absence of *Thysanoessa longicaudata*. (c). Scarcity of net phytoplankton. (d). Copepods light-red in colour.

Station 60. The Mixed *Calanus* Community. (Cf. Stats. 3—4). Fig. 19 (see also App. C, IV).

Temperatures very uniform.

Note: (a). Dominance of *Calanus* in adolescent stages. (b). Presence of larvae of *Thysanoessa inermis* and *Meganyctiphanes norvegica*.

In the region between the SW-coast of Iceland and the ice border off East Greenland the following zooplankton communities have been identified.

I. The Icelandic Coastal Communities.

These communities were found inside Faxa Bay and Breida Bay and will not be treated here.

II. The Mixed *Calanus* Community.

This community was confined to the inner part of the continental shelf off SW-Iceland. It was characterized by the abundance of *Calanus* with the frequent occurrence of *Temora*, larvae of *Thysanoessa inermis*, *Meganyctiphanes norvegica* and various neretic organisms.

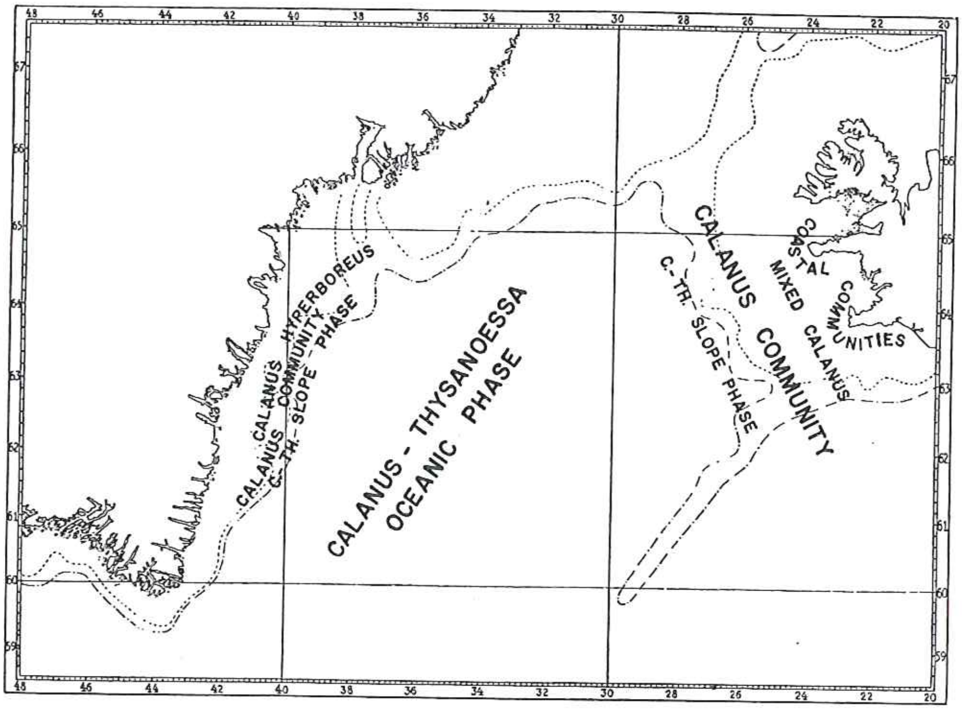
III. The Pure *Calanus* Community.

This community was found over the outer parts of the continental shelf on both sides of the Irminger Sea, but it developed earlier in Icelandic than in East Greenland waters. It was characterized by its uniformity of composition, *Calanus finmarchicus* being the only important component.

IV. The *Calanus-Thysanoessa* Community.

The community was characterized by an abundance of *Calanus finmarchicus* and the constant presence of larvae of *Thysanoessa longicaudata*. The young stages of *Sebastes marinus* were confined to this community.

It inhabited the whole central area of the Irminger Sea and can be divided



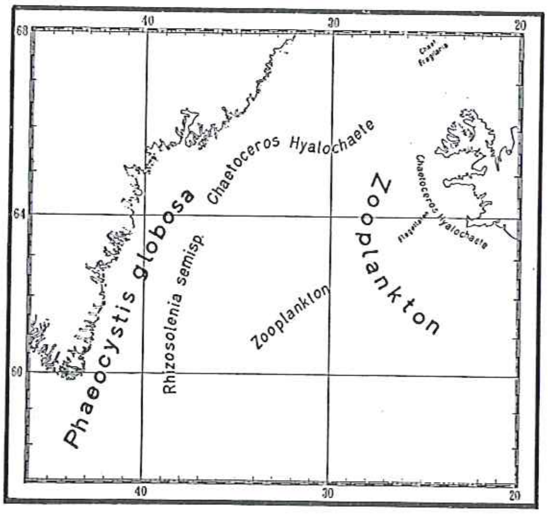


Fig. 20 a. *Schematic distribution of zooplankton communities in the Irminger Sea.*

— 20 b. *Schematic distribution of microplankton communities in the Irminger Sea. (From* Gillbricht *1959, fig. 3. p. 262).*

into two main phases which seem to be related to the abundance of phytoplankton.

1. The Slope Phase, which was found in the marginal areas of its distribution, above the continental slope, where the phytoplankton was very abundant.

2. The Oceanic Phase, over the great depths of the Irminger Sea, where phytoplankton was only moderately abundant.

V. The *Calanus hyperboreus* Community.

This community was confined to the cold East Greenland Current and was characterized by the presence of the arctic copepod *Calanus hyperboreus*.

The communities seem related to:

A. Depth of the sea, i. e., shallow water communities (the coastal communities), the shelf communities (the mixed and pure *Calanus* communities) and slope and deep water community (the *Calanus-Thysanoessa* community).

B. Temperature, i. e., an arctic community *(Calanus hyperboreus)* and boreal communities (all the other communities).

The phases seem mainly related to abundance of nutrients, phytoplankton and temperature conditions.

At the time of this investigation the phytoplankton maximum was passed in the Icelandic shelf areas, but at the lower temperatures in the East Greenland waters, the production was only beginning. Adolescent *Calanus* characterized the former, and juvenile stages the latter area.

In the slope waters vigorous production was taking place, while in the central part of the Irminger Sea it was not so far advanced.

(b). *Comparison with other investigations.*

The general pattern in the distribution of the zooplankton communities is very similar to that established by Gillbricht (1959) for the microplankton communities (see fig. 20). We are most probably dealing with different aspects of the same communities because the methods of sampling are so very different, nevertheless the distribution of the microplankton communities is clearly reflected in the Plankton Indicator catches of net phytoplankton and juvenile stages of copepods.

The present results also confirm Joseph's (1959) identification of the main production centres by means of turbidity measurements. In June 1955 he found two main areas rich in plankton (see fig. 21). One was situated south-west of Iceland, where he assumes that „an intermittent upwelling of deepsea water, rich in nutrients, takes place" (l. c., p. 258). The other area extends along the Polar Front in the western part of the Irminger Sea, where vertical turbulence brings a great amount of nutrients to the surface.

If we compare our results with Joseph's conclusions it will be seen that the former centre of turbidity is clearly indicated at stations 11—16, where the discs were clogged by diatoms. Gillbricht's main zooplankton community is situated in the same area as the microcomponents of the zooplankton, and the nauplii and earliest copepodite stages of copepods were extremely abundant in this area of great production.

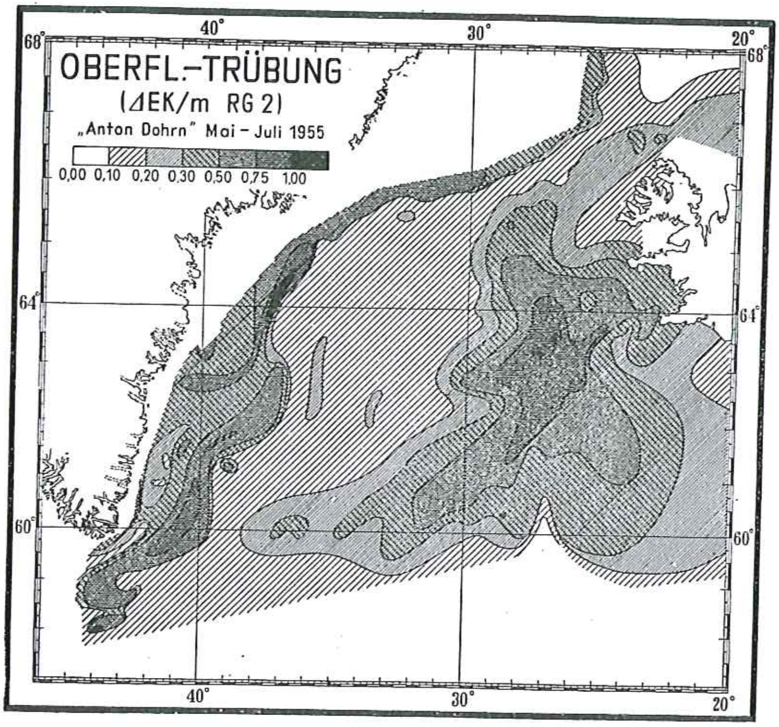


Fig. 21. *Turbidity values in the Irminger Sea in May—July 1955. (From* Joseph *1959, fig. 19, p. 250).*

The Polar Front turbidity area is also clearly reflected in our series. The net phytoplankton was very abundant at stations 28—45, with the exception of stations 38—40 where truly arctic conditions were encountered and production had presumably not yet started. This production area was also characterized by the predominance of juvenile stages of copepods, but the numbers were lower than in the former area.

Our analysis indicates that larger diatoms were not abundant in the central area of the Irminger Sea and according to Gillbricht's results this applies to the phytoplankton generally. Evidently the production starts later in the central parts of the region.

A curious fact emerges from the records kept on the colour of copepods. The colour reflects their condition, changing from white to dark-red with increasing oil content. Where rich phytoplankton was present, as indicated by larger diatoms, the copepods were whitish or very pale, without oildrops or with tiny oildrops only. Where net phytoplankton was scarce or absent the copepods were coloured light-red, red or dark-red and contained much oil. This is not an isolated observation, because we have noticed the same phenomenon time and again during summer in North and East Icelandic waters.

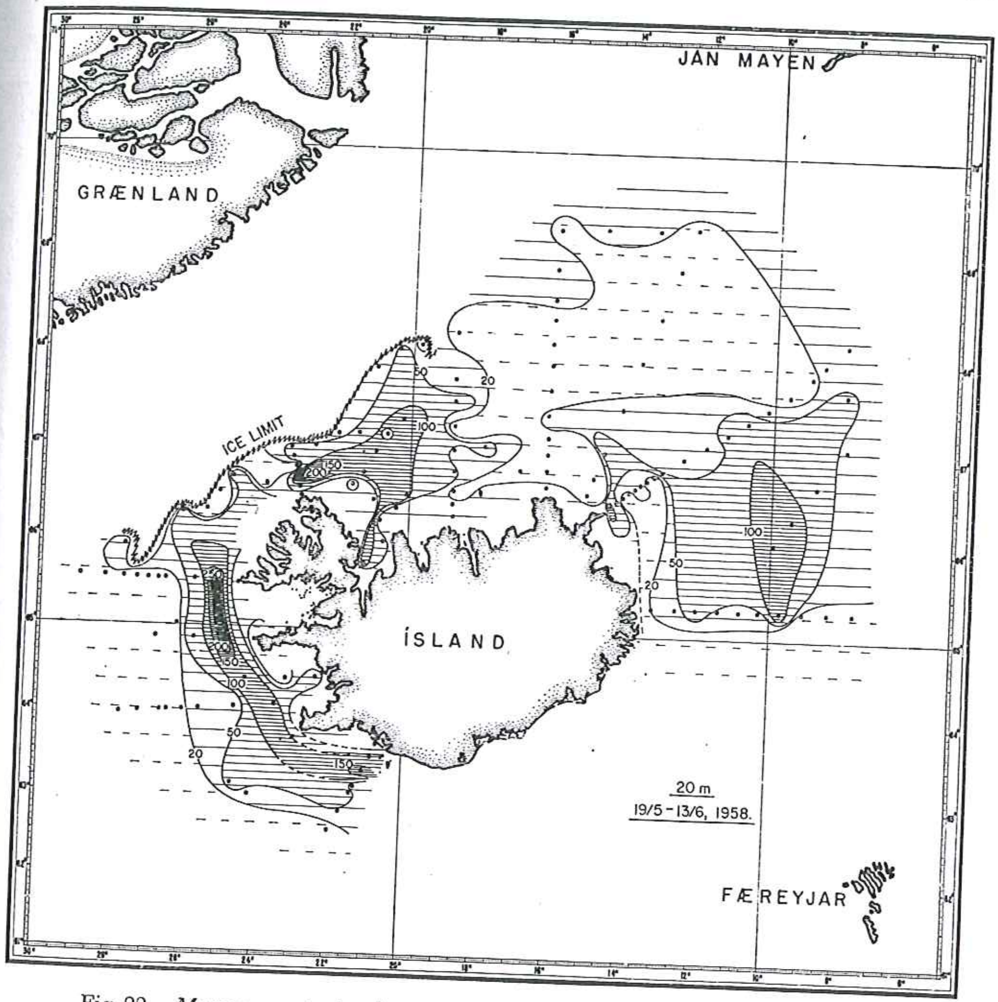


Fig. 22. *Measurement of primary production in Icelandic waters at the end of May (west coast waters) and in June (north and east coasts) 1958. Production rate (10^{-4} mg C/l/hour) in 20 m depth. (From* Thórdardóttir, *1960).*

During our survey in the Irminger Sea the copepods were actually in much better condition in the central area, where phytoplankton quantities were moderate, than in the slope waters where the production was vigorous.

This brings us to Gillbricht's important conclusion: „Das Zooplankton lebt also offenbar von den Zerfallsproducten einer in ihrer Masse längst verschwundenen Phytoplanktonbevölkerung“ (l. c., p. 271).

When investigating the food of euphausids in Icelandic waters and the Irminger Sea I came to a similar conclusion (Einarsson, 1945, p. 157): „I have in vain sought corroborative evidence to the effect that the species feed especially on phytoplankton. I have never found phytoplankton as a dominating food item either in the stomachs or in the „baskets" of the adults.... As far as I can judge the food consists mostly of „detritus". In the „baskets" of the three species of *Thysanoessa* blackish debris was frequently found with recognizable remains of Crustacea." Recently these conclusions have been confirmed by PONOMAREVA (1955) as regards four species of Pacific euphausids and by FISHER and GOLDIE (1959) for *Meganyctiphanes norvegica.* The detailed study of FISHER and GOLDIE showed that „the main food items in decreasing order of importance were organic debris and inorganic detritus, Crustacea, dinoflagellates, diatoms, algae, fern sporangia and dipteran egg membranes." (l. c., p. 310).

However, there is a clear relation between the main centre of production and the occurrence of juvenile stages of copepods and many other invertebrates. While the above statements may be true about some organisms, as for instance adult euphausids and calanoids, live phytoplankton may sustain a great wealth of juvenile stages which serve as food for the fish fry.

At present the sequence in the development of the phytoplankton populations is inadequately known. Annual, seasonal or even monthly variations may prove of paramount importance for the production of food organisms for the young stages of *Sebastes.* THÓRDARDÓTTIR (1960) has shown that in late May to early June 1958, the main centre of productivity was located in the shelf waters off the west coast of Iceland, while the slope and oceanic waters showed low values (see fig. 22). As described above the situation was quite different in 1955 when slope and oceanic waters off the south-west coast were a proliferous centre of production. It is evident that if the young stages of *Sebastes* depend for livelihood on some organisms which are confined to areas of high productivity the conditions of 1958 would have been highly critical, because the centre of production was located outside the spawning area. Thus the delayed development of phytoplankton in slope and oceanic waters in 1958, perhaps due to lower sea temperatures in that year, or to slighter upwelling of deep water, may well be the main cause of the paucity of the *Sebastes* fry in 1958, and we shall have to ask what constitutes the food of the *Sebastes* fry.

(c). *The food of the young stages of Sebastes marinus.*

I have made only a cursory examination of this topic, but some prelimary results are worth noting because the literature does not contain any references to this subject as far as I know.

The stomach contents were examined in 30 specimens of each size group with the following result:

Length of fry 8—14 mm.

Station A55/16; 28/5 1955: Pos. 63° 16′ N — 29° 43′ W: Depth 2100 m. 20.00 hours.

6 out of 30 stomachs were empty. Only 3 stomachs were filled with food, but moderate quantities were found in the rest.

The main bulk of the food consisted of Gastropod larvae *(Spiratella* sp.). Other items included: Copepods eggs and nauplii, several elliptical eggs (unidentified) and one stomach contained a copepodite stage II of *Calanus*, which almost filled the stomach cavity.

The remaining size groups were all drawn from the same sample, taken at station 1145: 14/8 1949: Pos. 63° 31′ N — 22° 06′ W. Depth 229 m. 00.45 hours.

Length of fry 15—25 mm

All stomachs examined were filled with food, which consisted exclusively of copepod eggs.

Length of fry 25—35 mm.

The stomachs were full of food.

The smaller specimens of this size group had eaten copepod eggs exclusively. Some of the 30—35 mm. specimens had also taken these, but others had eaten only copepodite stages of *Calanus*, 1—5 individuals each. Either the stomachs were filled with copepod eggs or they contained copepodites, but a mixture of the two items was not observed.

Length of fry 35—45 mm.

Most of the stomachs contained food or the remains of partly digested food.

The main food item was copepodite stages of *Calanus* or small copepods *(Pseudocalanus)*. The remnants of euphausid larvae could be recognized by their characteristic eyes. A specimen, 43 mm in length, contained one adolescent *Meganyctiphanes norvegica*, 15 mm. in length, which filled the stomach.

It appears that the *Sebastes* young are selective feeders; at least they prefer food of a certain size category, about 150 μ, whether it be gastropod larvae, copepod eggs or other eggs of similar size. In the first size group examined the gillrakers had not appeared, but they begin developing at about 15 mm. and this enables larvae up to a size of about 30 mm. to retain their ability to filter feed. Then they begin to take bigger food items exclusively. But even smaller sizes may occasionally swallow surprisingly large food items.

This sequence in the feeding habits of the *Sebastes* fry is the same as Lebour found for a number of fish larvae (for instance cf. *Clupea harengus*, Lebour (1919—22, pp. 459—463).

Larval gastropods were extremely abundant in the Irminger Sea in late May 1955, when the 8—14 mm. *Sebastes* larvae were caught and adult *Spiratella balea* and *S. helicina* were very common in the *Calanus-Thysanoessa* community as our analyses show. However, I did not count the larval stages of gastropods, because they were only retained by the net when it was wholly or partly clogged by smashed *Aglantha*. But my notes contain special references to great numbers of larval gastropods at stations A55/18, 21, 22 and 23.

From station 1145, 14/8 1949, which yielded the size groups 15—45 mm we have a Hensen net sample available. According to an analysis of 1/10 of this sample, which Mr. Ingvar Hallgrímsson, M. Sc., was kind enough to make, the numbers and composition were as follows:

Species		*Number*	*Species*	*Number*
Calanus finmarchicus ..	St. I	36	Other copepods	10
	— II	60	Copepod nauplii	12
	— III	216	*Spiratella helicina*	6
	— IV	392	*Spiratella balea*	14
	— V	38	*Evadne nordmanni*	2
	— VI ♀	25	*Verruca stroemia*	1
Temora longicornis		340	Echinoderm larvae	17
	♀	94	Medusae	20
Pseudocalanus minutus		74	Indeterminate	7
	♀	12		
Oithona atlantica		19		
	♀	5	Total	1430

It will be seen that this is what we have called the Mixed *Calanus* Community, with *Temora* well represented. The Hensen net does not filter the copepod eggs which were found so abundantly in the stomachs of the *Sebastes* fry, but it is evident from the stage composition of *Calanus* that vigorous spawning has occurred some time prior to the middle of August, the majority of the animals originating in this spawning having reached stages III and IV. Either this spawning is still continuing at the time of sampling or a new spawning is commencing. Mature females of *Temora, Pseudocalanus* and *Oithona* were also found, which indicates that these species were also spawning.

We may perhaps conclude from this example that the young stages of *Sebastes* depend heavily upon the propagation of copepods in July and August. This may explain the sudden increase in the growth rate in July, which I had difficulties in explaining in any other way at the beginning of this study (see page 14).

(d)). *Accompanying species in the macroplankton.*

In a preceding chapter it was stated that the *Sebastes* fry were confined to the oceanic zooplankton community termed the *Calanus-Thysanoessa* com-

TEXT TABLE 2.

A table showing the species composition of young stages of fish caught in the Irminger Sea together with the fry of *Sebastes marinus*. Stramin-net hauls with 15 and 65 m. of wire out. Numbers per 30 min. haul.

SPECIES	*Area-A*		*Area-B*		*Total*	*%*
	July	*Aug.*	*July*	*Aug.*		
No. of hauls	*4*	*11*	*34*	*9*	*58*	
Sebastes marinus	159	504	2810	925	4398	92.71
Motella sp.	15	2	73	..	90	1.90
Gadus callarias	..	..	74	1	75	1.58
Rheinhardtius hippoglossoides	48	2	22	..	72	1.52
Benthosema glaciale	..	..	35	..	35	0.74
Hippoglossoides platessoides	..	..	29	..	29	0.61
Molva byrkelange	..	..	11	..	11	0.23
Mallotus villosus	..	..	9	1	10	0.21
Anarhichas sp.	..	..	2	1	3	0.06
Brosme brosme	..	..	3	..	3	0.06
Melanogrammus aeglefinus	..	..	3	..	3	0.06
Gadus sp.	..	..	2	..	2	0.04
Hippoglossus hippoglossus	..	..	2	..	2	0.04
Cyclopterus lumpus	..	..	..	2	2	0.04
Sebastes viviparus	..	..	1	..	1	0.02
Pollachius virens	..	..	1	..	1	0.02
Myctophum arcticum	..	..	1	..	1	0.02
Triglops pingeli	..	..	..	1	1	0.02
Liparis sp.	..	..	1	..	1	0.02
Cottus sp.	..	..	..	1	1	0.02
Indeterminate	..	..	3	..	3	0.06
	222	508	3082	932	4744	99.98

munity. Although a dominant component, *Calanus finmarchicus* is not restricted to this community and *Thysanoessa longicaudata* must by considered the main characterizing species, being frequent both in the silk and stramin-net catches. The most notable organisms caught in the stramin-net, with *Th. longicaudata* and the fry of *Sebastes marinus* were *Aglantha digitale* and *Spiratella balea*.

Now it is of great interest to determine the quantitative importance of the *Sebastes* fry in relation to the fry of other fishes.

For this purpose I have selected 58 stations where the stramin-net was towed with 15 and 65 metres of wire out. *Sebastes marinus* fry were present in all these hauls and with them occurred the species listed in text table 2. The numbers given are per 30 minute's haul as each net was towed for 15 minutes. The data are arranged according to area and month.

The fry of *Sebastes marinus* account for more than 90% of the catches.

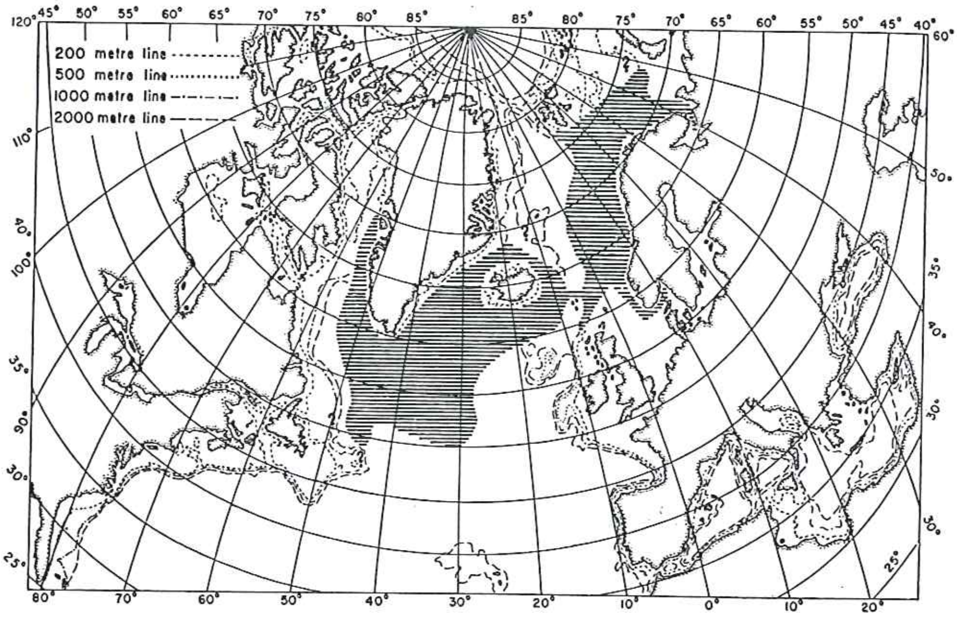


Fig. 23. *Distribution of redfish,* Sebastes marinus, *in the Northeast Atlantic, Iceland and Greenland. (From* Templeman, *1959, fig. 39, p. 63).*

The remaining species can be divided into two categories. First, truly oceanic species, e. g., *Hippoglossus hippoglossus, Molva byrkelange, Reinhardtius hippoglossoides, Benthosema glaciale* and *Myctophum arcticum.* Second, shelf species, brought out into the Irminger Sea with the currents, e. g. *Gadus callarias, Pollachius virens, Melanogrammus aeglefinus, Hippoglossoides platessoides, Mallotus villosus, Sebastes viviparus* and *Cyclopterus lumpus.*

Only the species of the first catagory belong to the oceanic community, and from the numbers given it is clear how dominant the *Sebastes* fry are. *Benthosema glaciale* is probably the only species of any quantitative significance. However, the deeper layers have as yet been insufficiently investigated, and there the young stages of myctophids and *Hippoglossus hippoglossus* may be more abundant than the present analysis, which is based on hauls from the upper layers, indicates.[1])

1) It may be pertinent here to mention that several of the bathypelagic boreal fishes constitute an important item in the diet of adult *Sebastes marinus.*

I shall here briefly give the main results of an analysis of the food of adult *Sebastes marinus* which I made in August 1954 on Jónsmið (Approx. position: 64° 50′ N — 35° W. Depth 190—210 fathoms), which we had just discovered as a high grade fishing area for *Sebastes* (Einarsson, 1954).

Most of the stomachs examined were empty, but by inspecting great numbers on three occasions, I ascertained the following:

1. *Sebastes marinus* feeds late at night and during morning. At noon newly swallowed

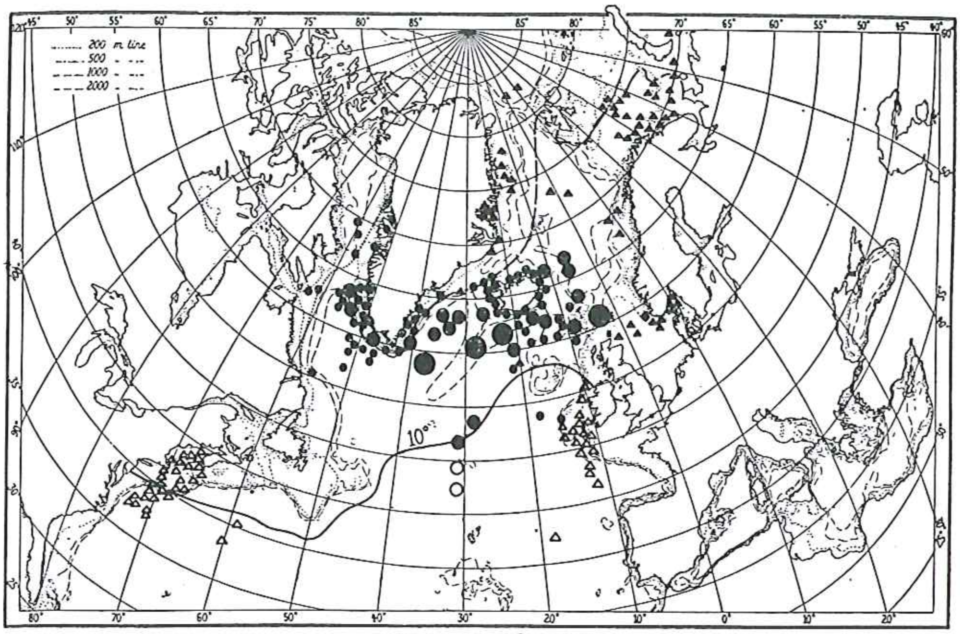


Fig. 24. *Distribution and abundance of* Thysanoessa longicaudata *in the North Atlantic. (From* EINARSSON, *1945, fig. 57, p. 120).*

The euphausids constitute another dominant part of the macroplankton. The euphausid fauna of the Irminger Sea has been analysed quantitatively (EINARSSON, 1945, pp. 90—94, tables 26 and 28), and *Thysanoessa longicaudata* is the main species. Two other species of euphausids propagate in the boreal waters of the Northern Atlantic, viz. *Meganyctiphanes norvegica* and *Thysanopoda acutifrons,* the latter species being bathypelagic in its adult phase. All these species probably play an important role as food items for juvenile, adolescent and adult *Sebastes.*

food could still be found, but later in the day and as late as 21.00 hours only much digested food was found in the stomachs.

2. I brought back with me a collection of food items found in the stomachs, which DR. GERHARD KREFFT of Hamburg, kindly identified for me (see KOTTHAUS and KREFFT, 1957). Quantitatively the species composition was found to be as follows:

Benthosema glaciale	170	specimens
Stomias boa ferox	16	—
Cyclothone braueri	8	—
Argyropelecus hemigynnus	1	—

All these species are bathypelagic and with them only small quantities of euphausids and pandalids were found. BOLDOVSKY'S (1944) investigations in the Barents Sea show, however, that crustaceans are of major importance as food, locally or periodically, and this is undoubtedly also true for the Irminger Sea.

It is remarkable how the general distribution of *Thysanoessa longicaudata* agrees with that of *Sebastes marinus,* which TEMPLEMAN (1959) has described in such exellent detail. Figs. 23 and 24 illustrate this. It is also noteworthy that the heaviest catches of *Th. longicaudata* were recorded in the Reykjanes-ridge area, where Danish (HANSEN and ANDERSEN, 1959) and Scottish investigators (HENDERSON, 1959) located the greatest concentrations of *Sebastes* larvae.

As previously shown (EINARSSON, 1945, pp. 59—63) the southern boundary of *Thysanoessa longicaudata* follows the subpolar convergence. This boundary may be characterized by the course of certain isotherms, different according to the depth level used. The 10° surface isotherm for May, which I used, corresponds closely with the 8° isotherm at 200 m. which TÅNING (1949) used as a criterion.

In view of the fact that the *Sebastes* fry play such an outstanding role in boreal oceanic waters, further studies must be awaited with the greatest interest as they may provide answers to several general problems in the ecology of fish larvae. In coastal waters we are faced with a diversity of fish fauna and frequently the ecological relationships are so complicated that progress in understanding the causes of successes and failures of year-broods has been slow. In *Sebastes* we have a species which occupies a large spawning area in which it constitutes about 90% of the total larval stock, and great variations in the strength of year-broods have been established. Consequently, further studies on the *Sebastes* larvae are not only of immense value for the solution of the *Sebastes* problem, but may hold the key to solutions of a more general nature, which may help us to understand better the intricate problems in coastal waters.

V. SEBASTES VIVIPARUS Kr.

(1) Distribution.

The young stages of *S. viviparus* were sorted out of the same series of stramin-net hauls, which have been discussed in the preceding chapter on *S. marinus.*

Distribution charts for each month, April to September, were prepared (Figures 25—30) and the frequency noted in the same manner as for *marinus.*

In April no *viviparus* fry were found.

In May *viviparus* fry were found in five localities off the south-east coast, where the spawning seems to begin first, and in one locality in Faxa Bay, in depths of 100—200 m.

In June the main occurrences were found off the west coast, inside the

TEXT TABLE 3.

Size distribution of *Sebastes viviparus* fry according to month and area.

	MAY			JUNE			JULY					AUGUST				
mm	*S*	*W*	*Total*	*S*	*W*	*Total*	*S*	*W*	*N*	*E*	*Total*	*S*	*W*	*N*	*E*	*Total*
17	..	..	..	..	..	..	1	..	..	..	1	..	..	..	..	..
16	..	..	..	..	..	..	3	..	..	..	3	..	..	..	..	..
15	..	..	..	..	..	..	1	2	..	..	3	..	..	1	..	1
14	..	..	..	..	..	..	6	..	..	..	6	1	1	..	..	2
13	..	..	..	..	..	..	14	1	1	..	16	6	..	..	..	6
12	..	..	..	..	..	..	16	2	1	..	19	..	2	1	..	3
11	..	..	..	1	..	1	29	3	1	..	33	1	1	1	..	3
10	..	..	..	..	1	1	47	9	2	..	58	1	5	..	1	7
9	..	..	..	..	6	6	81	22	5	..	108	4	7	..	1	12
8	..	..	..	1	79	80	107	69	3	..	179	1	6	..	..	7
7	..	..	..	10	111	121	248	152	2	2	404	5	8	..	..	13
6	4	..	4	35	89	124	442	313	3	..	758	9	4	..	..	13
5	9	1	10	33	114	147	479	200	..	..	679	..	..	1	3	4
4	..	..	..	..	4	4	108	2	..	..	110	..	..	..	..	..
Total	13	1	14	80	404	484	1582	775	18	2	2377	28	34	4	5	71
Av. size	5.31	5.00	5.29	5.68	6.42	6.32	6.40	6.31	8.72	7.00	6.39	8.79	8.53	10.75	6.80	8.63

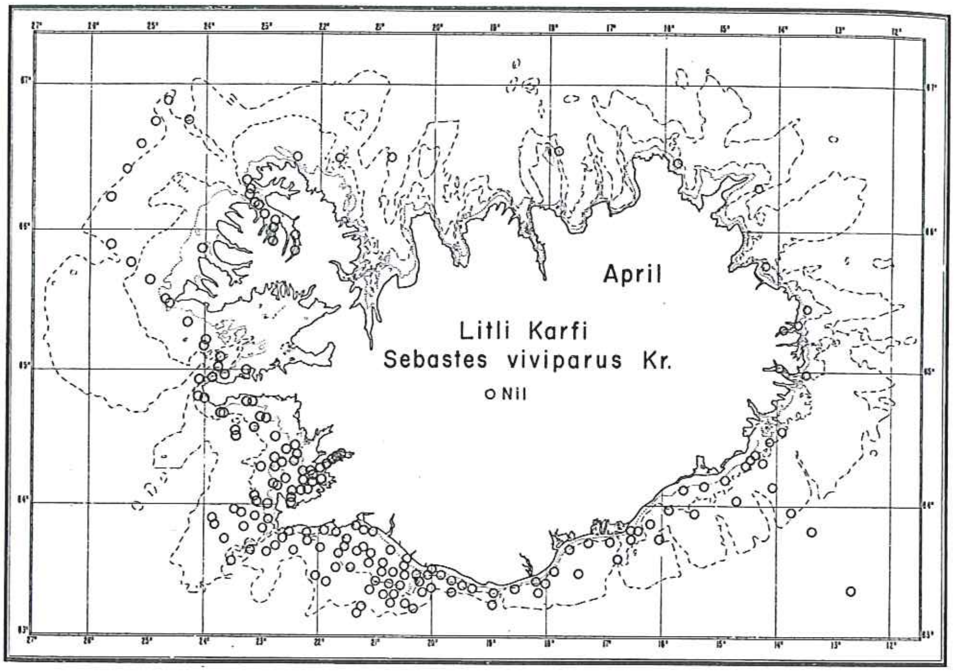


Fig. 25. *Frequency and distribution of young stages of* Sebastes viviparus *around Iceland in April. Numbers caught in 30 min. stramin-net hauls.*

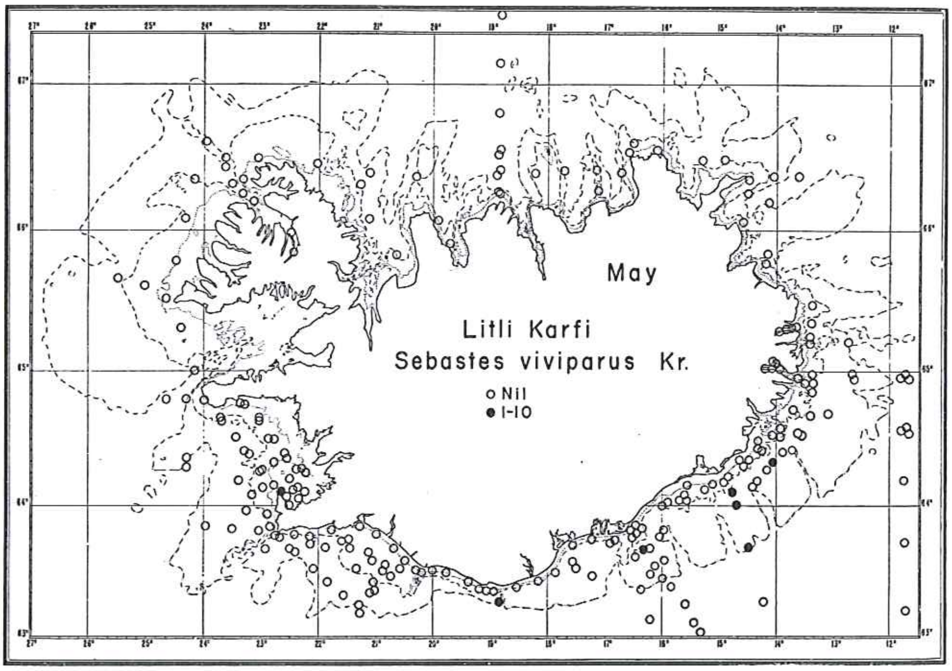


Fig. 26. *Frequency and distribution of young stages of* Sebastes viviparus *around Iceland in May. Numbers caught in 30 min. stramin-net hauls.*

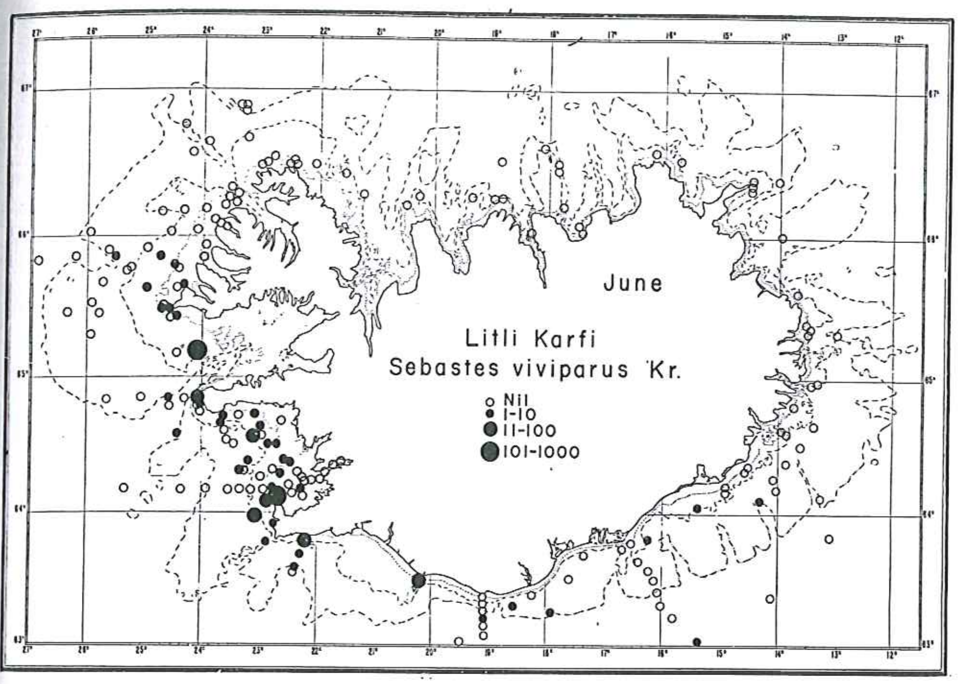


Fig. 27. *Frequency and distribution of young stages of* Sebastes viviparus *around Iceland in June. Numbers caught in 30 min. stramin-net hauls.*

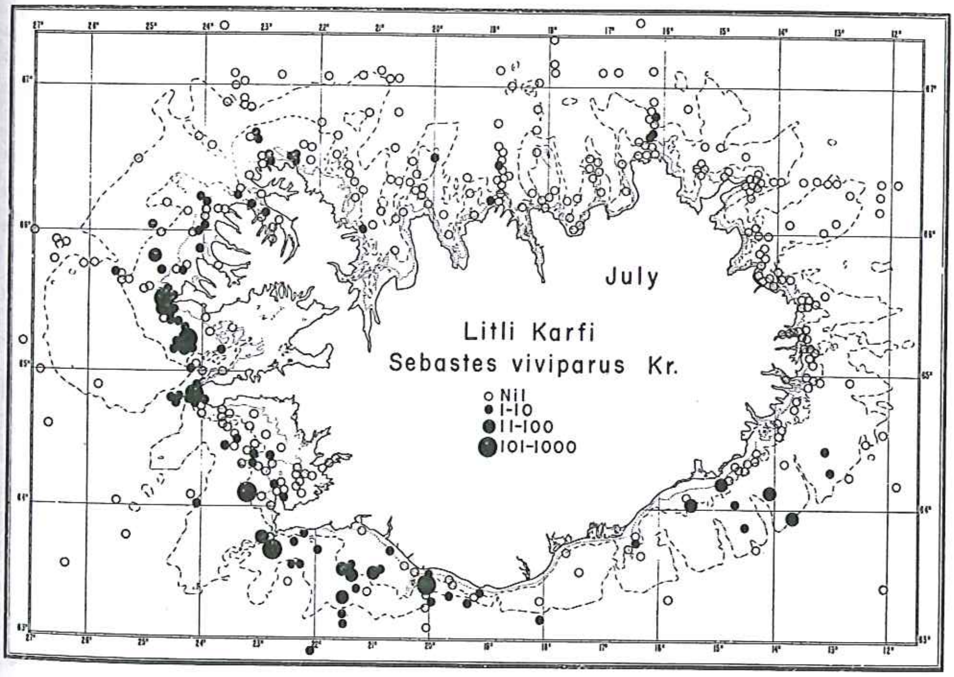


Fig. 28. *Frequency and distribution of young stages of* Sebastes viviparus *around Iceland in July. Numbers caught in 30 min. stramin-net hauls.*

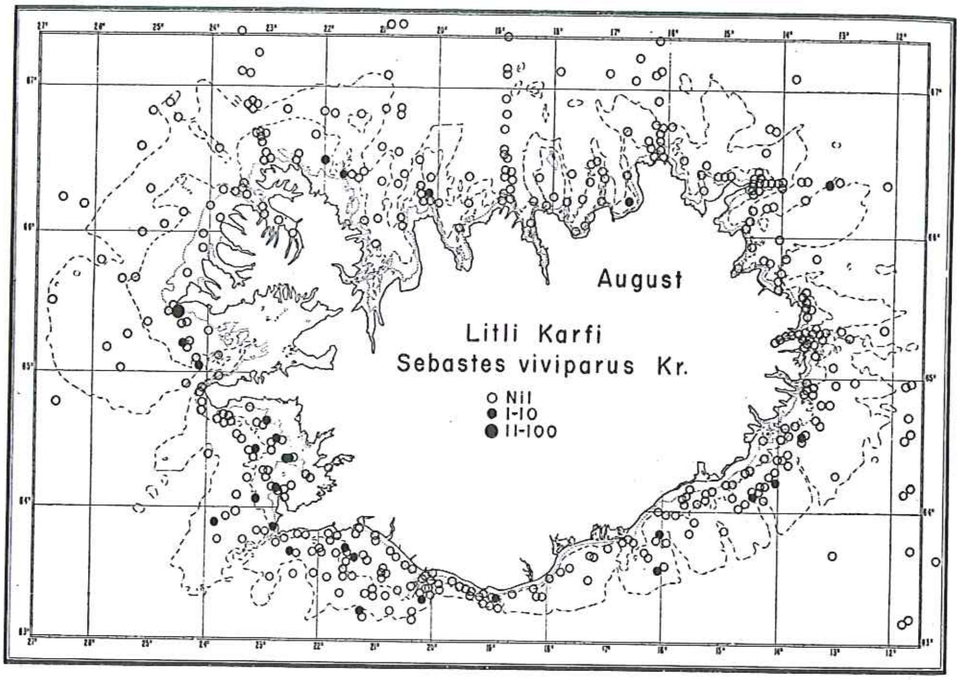


Fig. 29. *Frequency and distribution of young stages of* Sebastes viviparus *around Iceland in August. Numbers caught in 30 min. stramin-net hauls.*

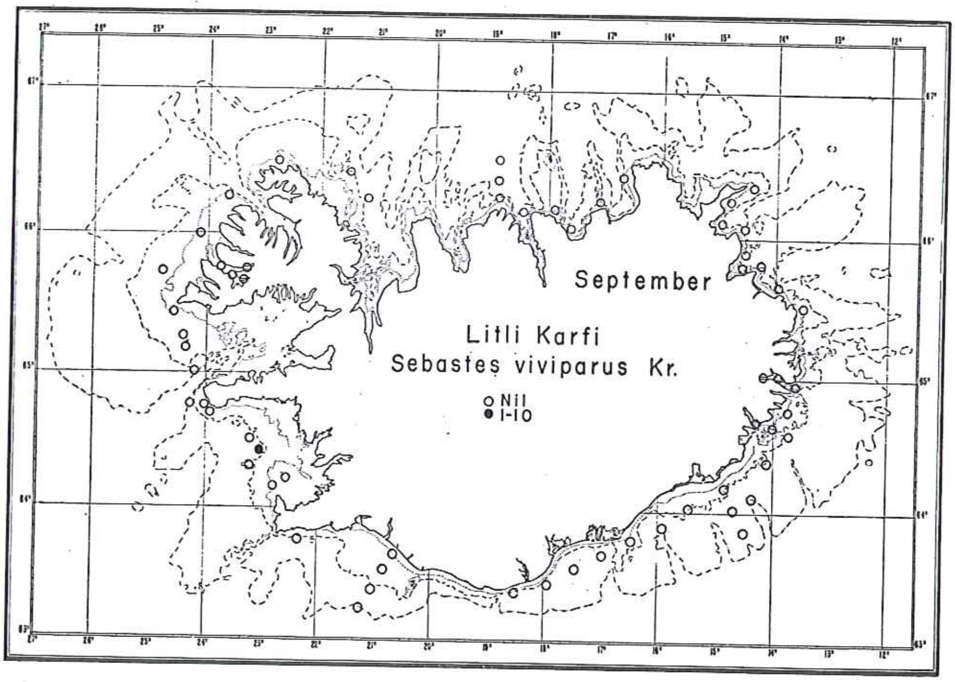


Fig. 30. *Frequency and distribution of young stages of* Sebastes viviparus *around Iceland in September. Numbers caught in 30 min. stramin-net hauls.*

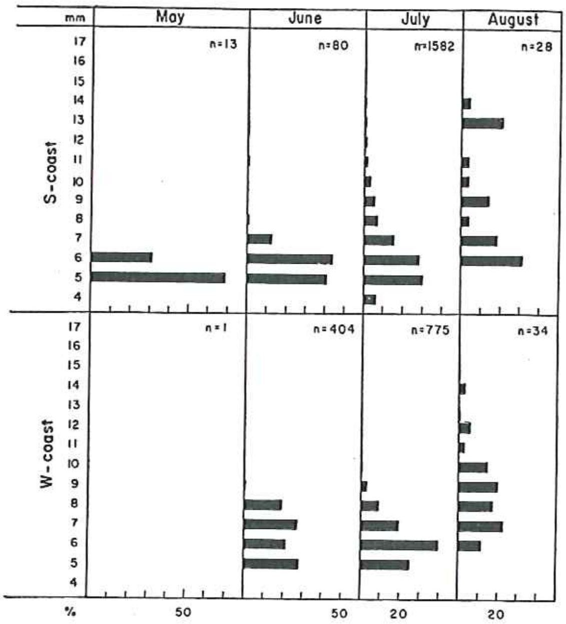


Fig. 31. *Size distribution of young stages of* Sebastes viviparus *as percentages in millimetre groups, according to month and area.*

100 m depth contour, but smaller numbers were recorded along the south coast eastwards to Hornafjord, viz., to the boundary between warm Atlantic water and cold sub-arctic water.

In July drifting from the west coast waters was observed, eastward along the north coast, but the main occurrences were still to be found off the west coast, inside the 200 m contour. Relatively large numbers were also found off the south coast, especially in the western part of the area.

In August the same general distribution pattern was encountered, but the numbers caught were everywhere very low.

In September a single specimen was captured in Faxa Bay.

Thus, *Sebastes viviparus* is a typical boreal species, „spawning" on the banks, mainly between the 50 and 200 m depth contours.

(2) **Abundance.**

Sebastes viviparus has a low breeding intensity in Icelandic waters (see text table 1). The general abundance of the young stages (number per station) is exceedingly low in May, August, and September. Only in June and July, which must be considered the main breeding season, do we find, on an average, 3—4 specimens per haul. The concentrated abundance is never high, but reaches, on an average, 14—20 specimens per positive haul. The highest numbers recorded in single hauls were 242 specimens off the south coast and 188 off the west coast.

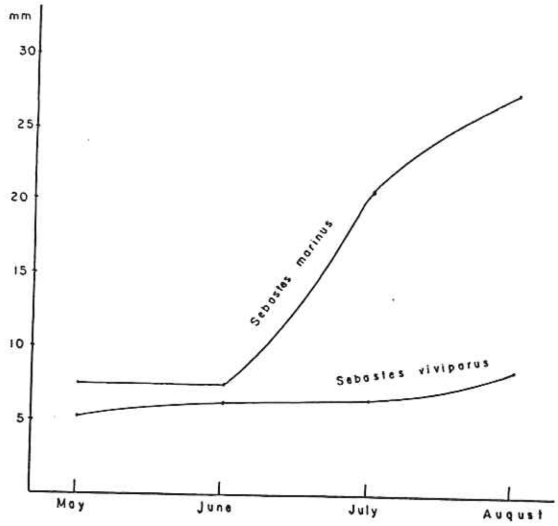


Fig. 32. *Comparison of growth of young stages of* Sebastes marinus *and* Sebastes viviparus, *based on the average size in Icelandic south and west coast waters.*

(3) **Size.**

Measurements of the young stages of *viviparus* are given in text table 3, and arranged according to month and area. The measurements are shown graphically in figure 31 as percentages in each mm. group.

On expulsion, the *viviparus* fry is 4—5 in length, slightly smaller than the *marinus* fry. The „spawning" begins in May, gathers momentum in June, and reaches its peak in the beginning of July.

The „spawning" seems to start off the south-east coast spreading westwards to the west coast. It comes to an end off the north and east coasts in August, but the „spawning" intensity is exceedingly low in these areas.

The growth of the young stages is extremely slow, the average increase in size is about 3 mm from May to August.

The pelagic phase is of short duration. Already in August the young stages seem to seek deeper layers. The ultimate size is then only 17 mm, and the average size about 8.6 mm. Probably this species has a lower rate of growth in the pelagic phase than any other species of fish in Icelandic waters.

(4) **Comparative Remarks.**

Although both *S. marinus* and *S. viviparus* are boreal species, they differ widely in their distribution, abundance and size, the former being an oceanic species, and perhaps the most abundant fish in the northern Atlantic, while the latter is a coastal species and rather scarce.

During the first summer of life the growth is strongly different, as demonstrated in figure 32, which is based on the average sizes observed in Icelandic waters off the south and west coasts.

S. marinus and *S. viviparus* are undoubtedly very close relatives, as seen by the slight morphological differences in both juvenile and adult phases. Whereas the environment of young stages of *marinus* stimulates growth, the fry of *viviparus* live in much poorer conditions.

SUMMARY

1. The paper is based on stramin-net material collected by Danish and Icelandic research ships 1903—1939 and 1948—1952 from 1787 stations, situated mainly in Icelandic waters and the Irminger Sea. Echo-records from the area south and west of Iceland during 1954—1958 were examined. Plankton Indicator samples, taken in the Irminger Sea in late May to early June 1955, were studied. The stomach contents of young stages of *Sebastes marinus* were investigated.

2. For the separation of the fry of *S. marinus* and *S. viviparus*, TÅNING's criteria were used, i. e., the black tail spot in the small individuals and the differences in head armature in the larger specimens. Photographs of the differences are given in Plates I and II. No tailspots were observed in the *S. marinus* fry, and no difficulties were encountered in the separation of the two species in Icelandic waters.

3. Distribution charts were prepared for each month April—September for Icelandic waters and for July and August for the Irminger Sea.

4. Photographs of selected samples of echo-records from the years 1954—1958 are given in an appendix. Plankton collections support the view that the traces in 5—30 m. depth are mainly due to the presence of *S. marinus* larvae.

5. The echo-traces could perhaps be evaluated quantitatively. According to the results discussed large numbers of *S. marinus* larvae were present in the Irminger Sea in 1954, 1955 and 1957, rather few in 1956 and very few in 1958. In the area south of Reykjanes which was investigated 1956—1958, the larvae were abundant in 1956, few in 1957 and very few in 1958. 1958 was an extremely poor year in both areas.

6. Detailed measurements of *marinus* larvae are given in an appendix. During May and June the length lay within the narrow range of 5 to 15 mm., with average sizes 9.29 and 7.63 mm. respectively. In July the range increased very rapidly upwards to 38 mm. and in August to about 60 mm. The average size for July was 20.20 mm. and for August 24.95 mm. Although a slight indication of modality was observed, it is thought that all the young stages of *Sebastes* caught by the stramin-net during summer belong to the O-group. It is suggested that food conditions may explain the sudden increase in growth rate in July. The spawning seems of long duration, as small larvae were found as late as July.

7. The size variations indicate a strong effect of environmental factors on the rate of growth in different years.

8. It is pointed out that the expulsion of young *S. marinus* occurs mainly outside the 1000 m contour. Although the temperature requirements postu-

lated by TÅNING (3—8.5° C. in 200—500 m. depth) are fulfilled fry may be absent or very scarce. This is supported by hydrographic data. An alternative hypothesis is postulated.

9. Analyses of Plankton Indicator samples from 2 m., 15 m. and 30 m. depths at 60 stations in the Irminger Sea are given in an appendix. The following communities were identified and characterized: (a) The Mixed *Calanus* Community. (b) The Pure *Calanus* Community. (c) The *Calanus Thysanoessa* community, with a slope phase and an oceanic phase. (d) The arctic *Calanus hyperboreus* community. The young stages of *Sebastes marinus* are exclusively confined to the *Calanus-Thysanoessa* community.

10. The results of the zooplankton studies are compared with the investigations of GILLBRICHT and JOSEPH, made in the Irminger Sea in 1955. The conclusions are thought to be mutually confirmatory.

11. Although adult calanoids and euphausids seem to feed on decaying matter, live phytoplankton seems to sustain a great wealth of juvenile stages of invertebrates which serve as food for the fish fry. Annual or monthly variations in the location and onset of phytoplankton production are thought to be the main factor governing the size of the year-brood of *Sebastes marinus* and the translocation of the production centre in 1958 to the shelf waters, as shown by THORDARDÓTTIR may explain the paucity of *Sebastes* fry in that year.

12. The young *Sebastes* are selective feeders. Specimens, 8—14 mm. in length, caught in the Irminger Sea in May, fed mainly on juvenile gastropods *(Spiratella sp.)* but also on copepod eggs and crustacean eggs of a similar size, about 150 μ. The gillrakers begin developing at about 15 mm. size and the larvae retain their ability to filter this size category of organisms to about 30 mm. size. Samples from the middle of August showed them to feed exclusively on copepod eggs. Then they begin to take larger food items exclusively, copepodites, small copepods and even adult euphausids. Even small specimens may occasionally swallow surprisingly large food items. It is concluded that the young *Sebastes* depend largely upon the propagation of copepods in July and August and an onset of copepod spawning in July may explain the sudden increase in growth of the larvae.

13. The fry of *Sebastes marinus* account for about 90% of the fish fry caught in the upper layers of the Irminger Sea. Accompanying species of the macroplankton are discussed. It is pointed out how closely *Sebastes marinus* and *Thysanoessa longicaudata* agree in distribution.

14. Because of their relatively simple nature, it is thought that further studies of the *Sebastes marinus* larvae may contribute to elucidating the more intricate problems in coastal waters.

15. Distribution charts for the months April—September are given for the fry of *Sebastes viviparus*. It is a boreal „spawner", breeding inside the 200 m. depth contour off the south and west coast of Iceland. The breeding in-

tensity is low. The „spawning“ begins in May, gathers momentum in June and reaches its peak in the beginning of July. At the peak about 20 specimens were caught per 30 minutes positive haul and 3—4 specimens per station, on an average. The growth of the young stages is extremely slow, the average increase in size is about 3 mm. from May to August.

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APPENDICES

Appendix A (pp. 52—59). Routes of echo-surveys off south and west Iceland at the end of May and the beginning of June during the years 1954—1958, with estimates of the strength of traces and selected samples of the echo-records.

Appendix B (pp. 60—63). Size distribution of the fry of *Sebastes marinus*.

Appendix C (pp. 64—67). Composition of zooplankton in the Irminger Sea at the end of May and the beginning of June 1955. Analysis of Plankton Indicator catches.

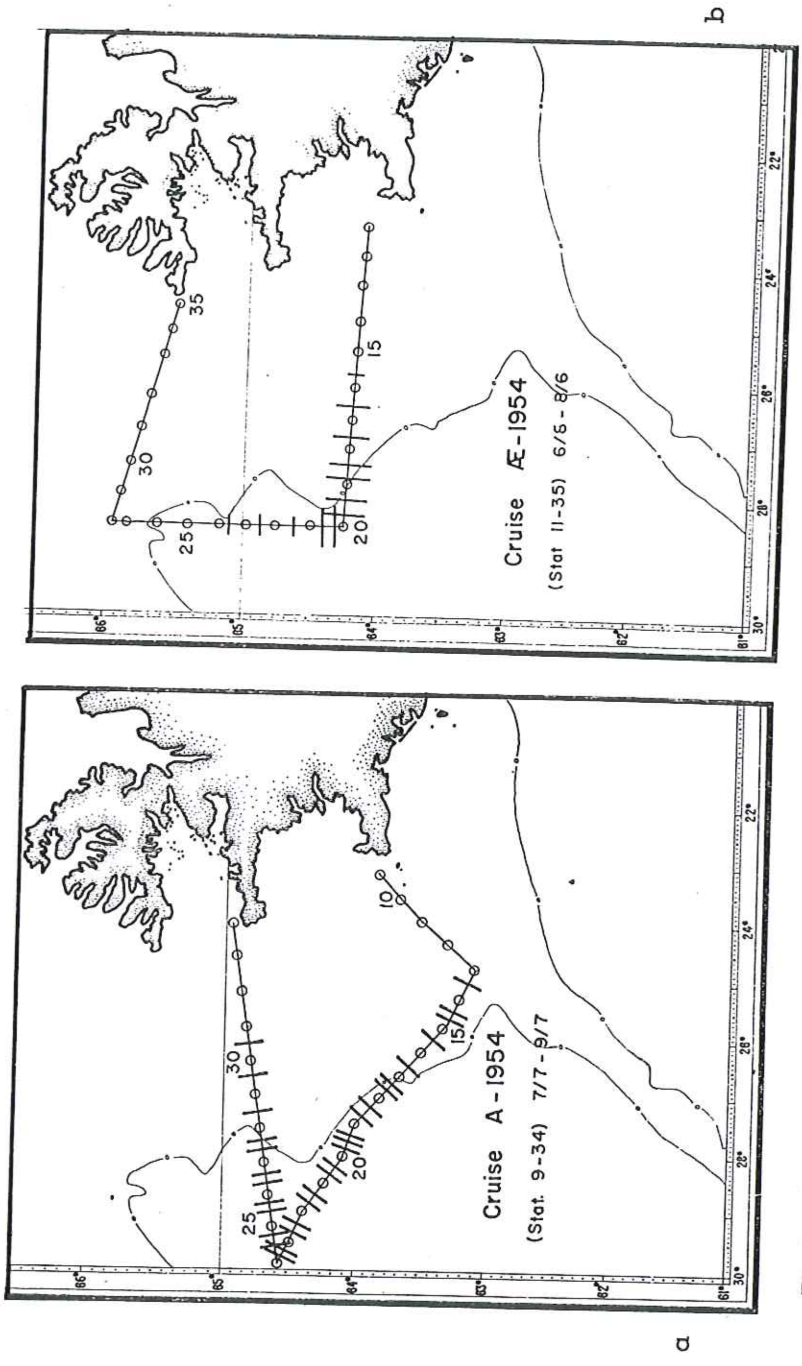

Fig. 1. a—b. *Routes of echo-surveys in the beginning of June and July 1954, with estimates of the strenght of traces.*

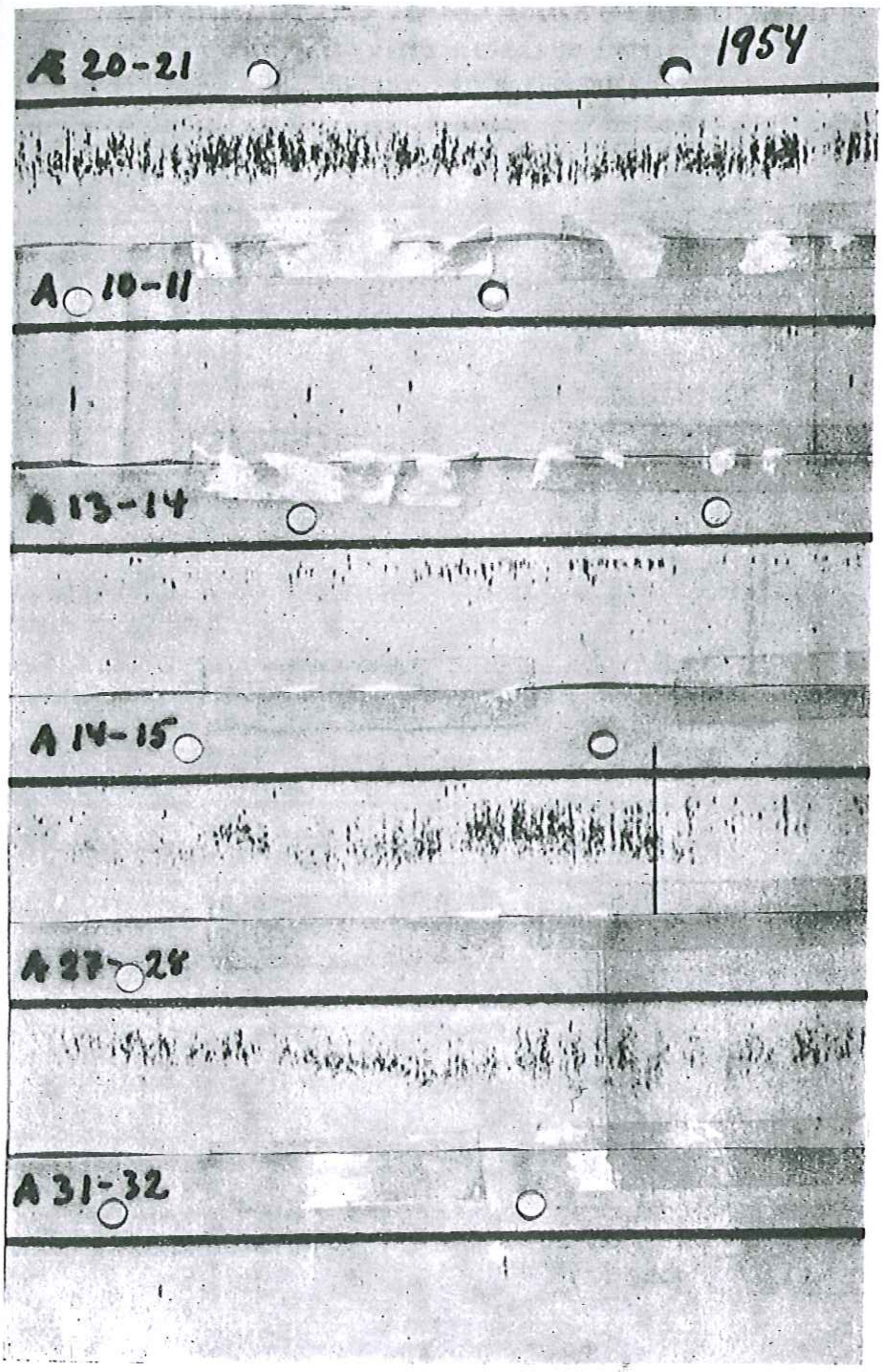

Fig. 1. c. *Selected samples of echo-records from the 1954-surveys.*

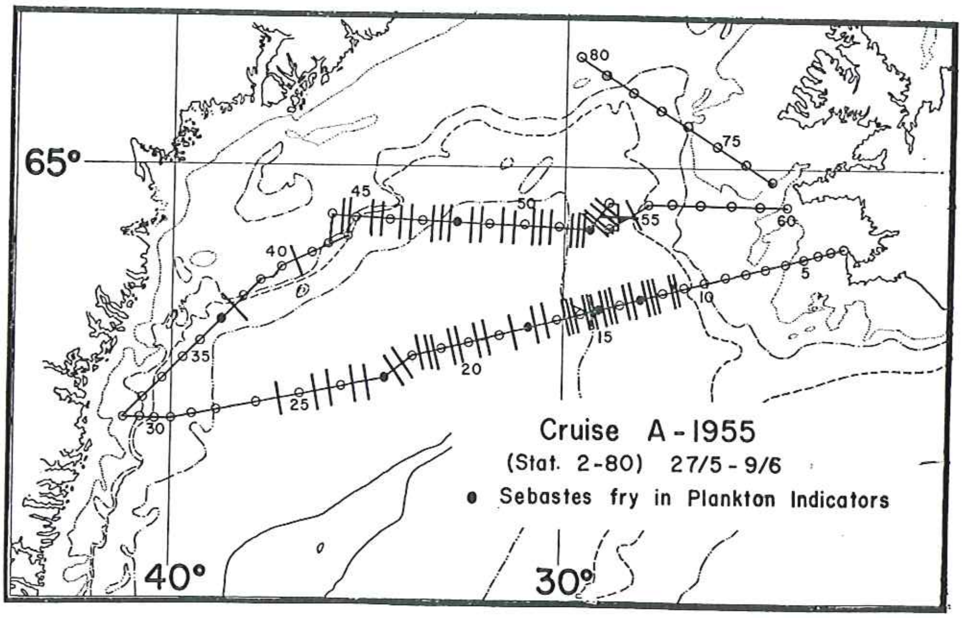

Fig. 2. a. *Route of the echo-survey at the end of May and the beginning of June 1955, with an estimate of the strength of traces.*

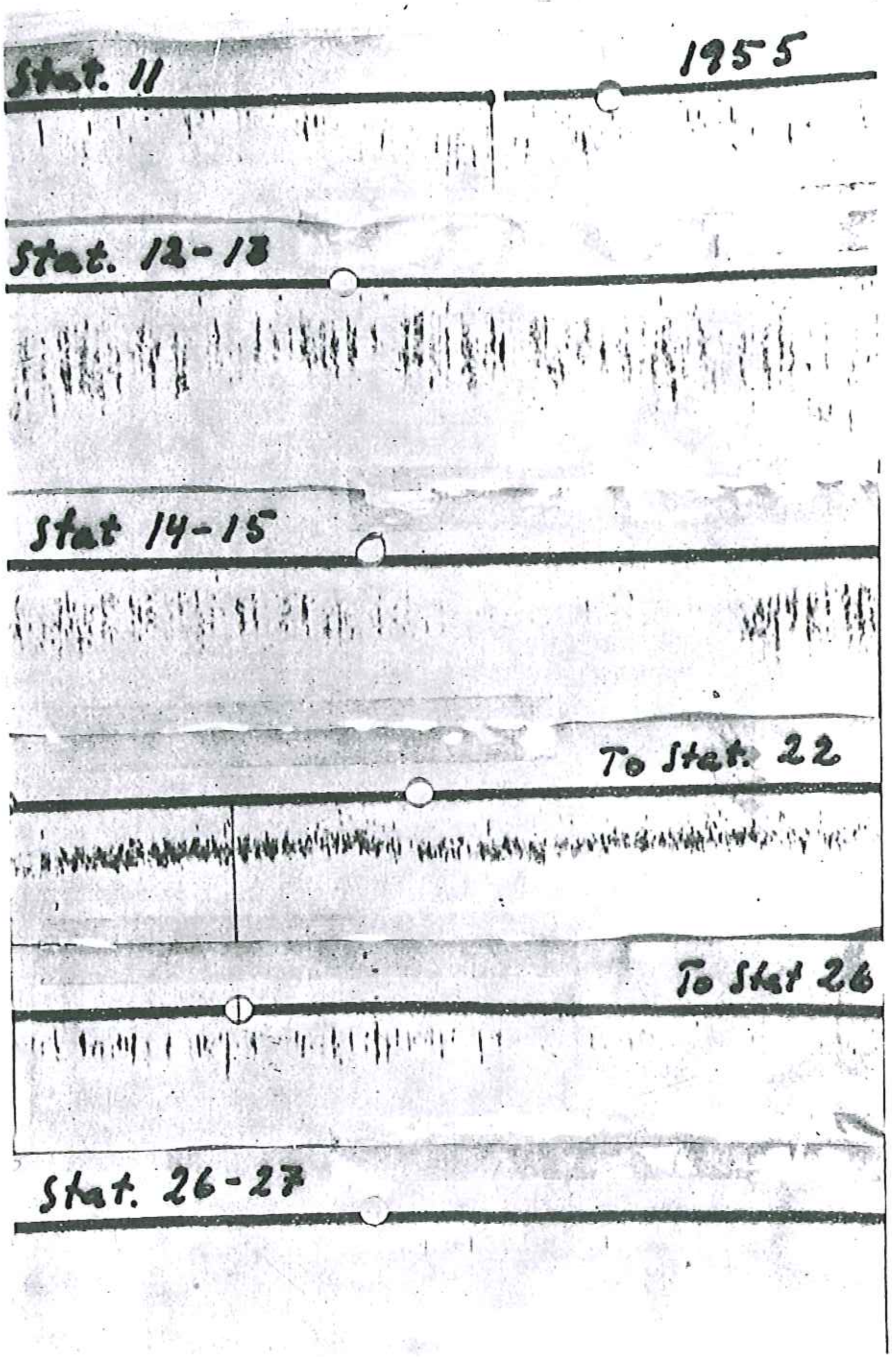

Fig. 2. b. *Selected samples of the echo-records from the 1955-survey.*

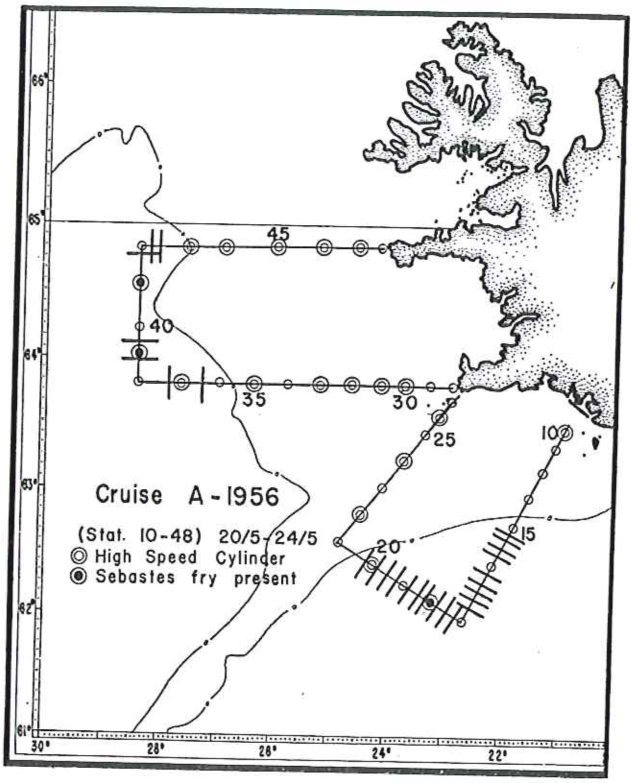

Fig. 3. a. *Route of the echo-survey at the end of May and the beginning of June 1956, with an estimate of the strength of traces.*

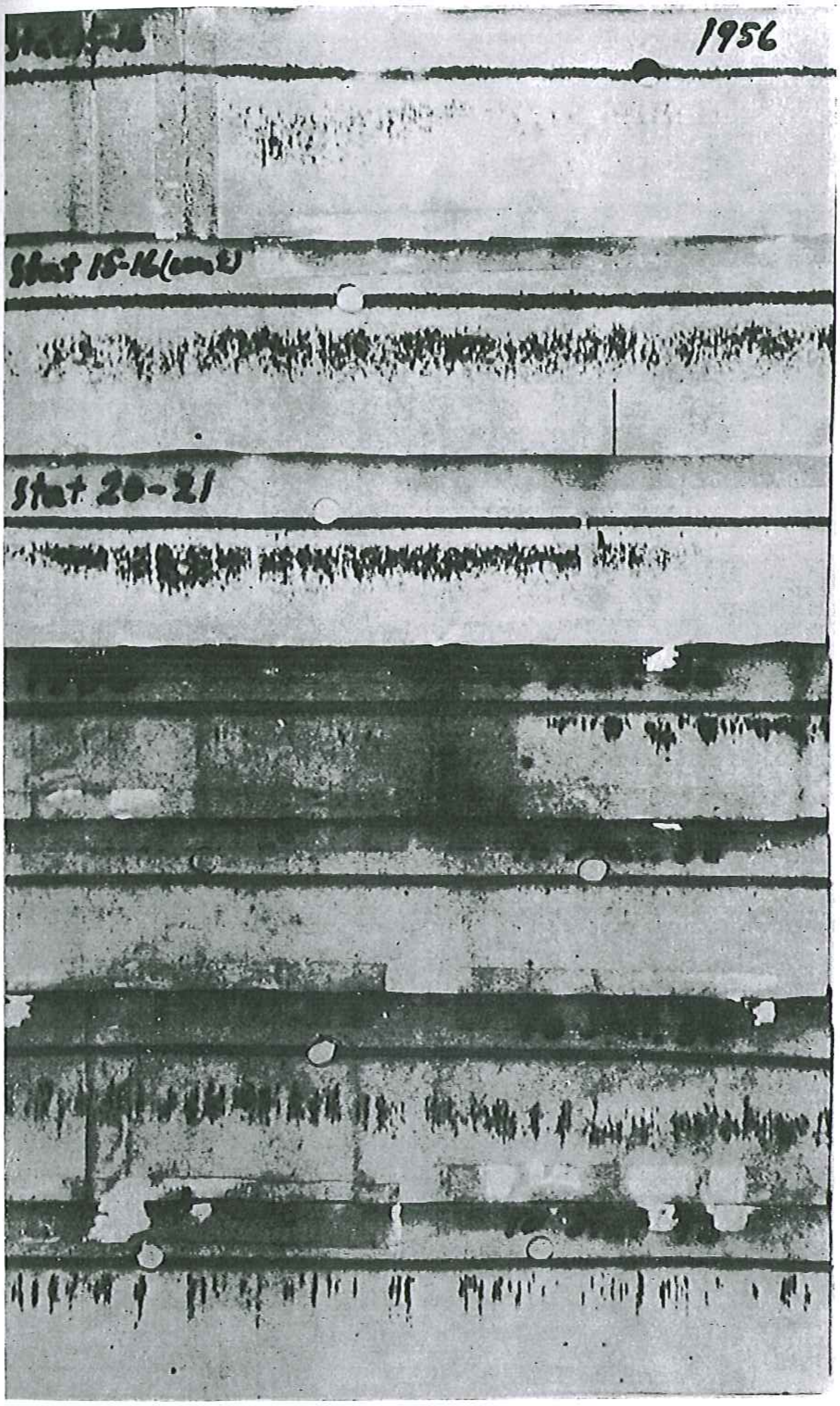

Fig. 3. b. *Selected samples from the echo-records of the 1956-survey.*

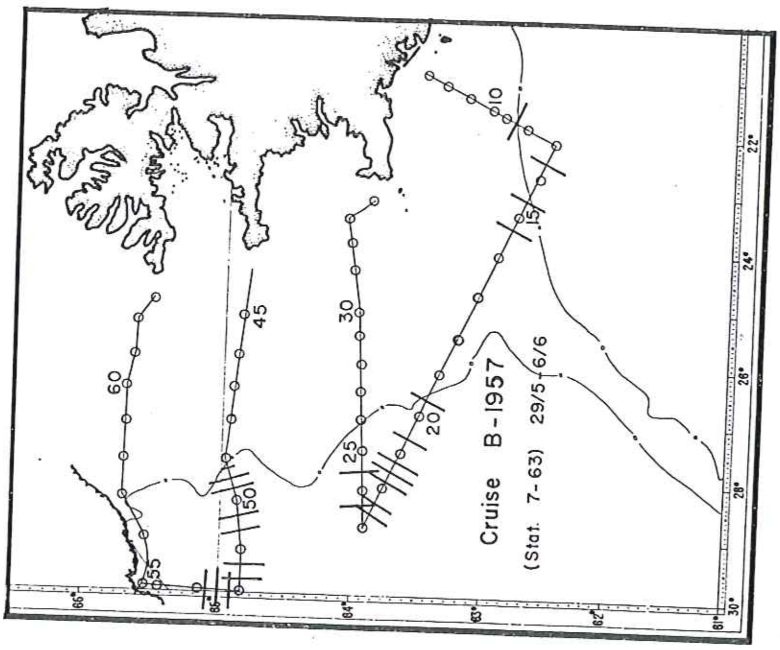

Fig. 4. a. Route of the echo-survey at the end of May and the beginning of June 1957, with an estimate of the strength of traces.

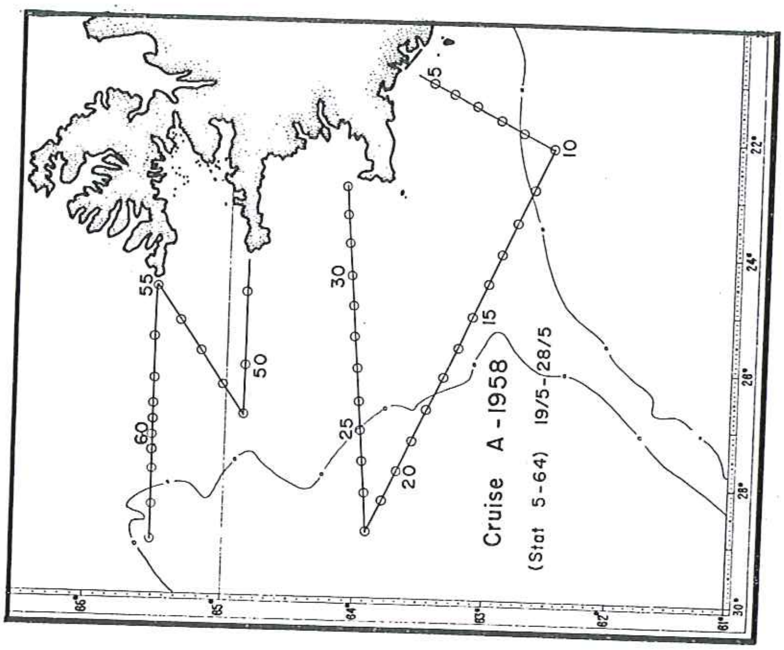

Fig. 5. Route of the echo-survey at the end of May 1958. No traces were observed.

No traces were observed.

of traces.

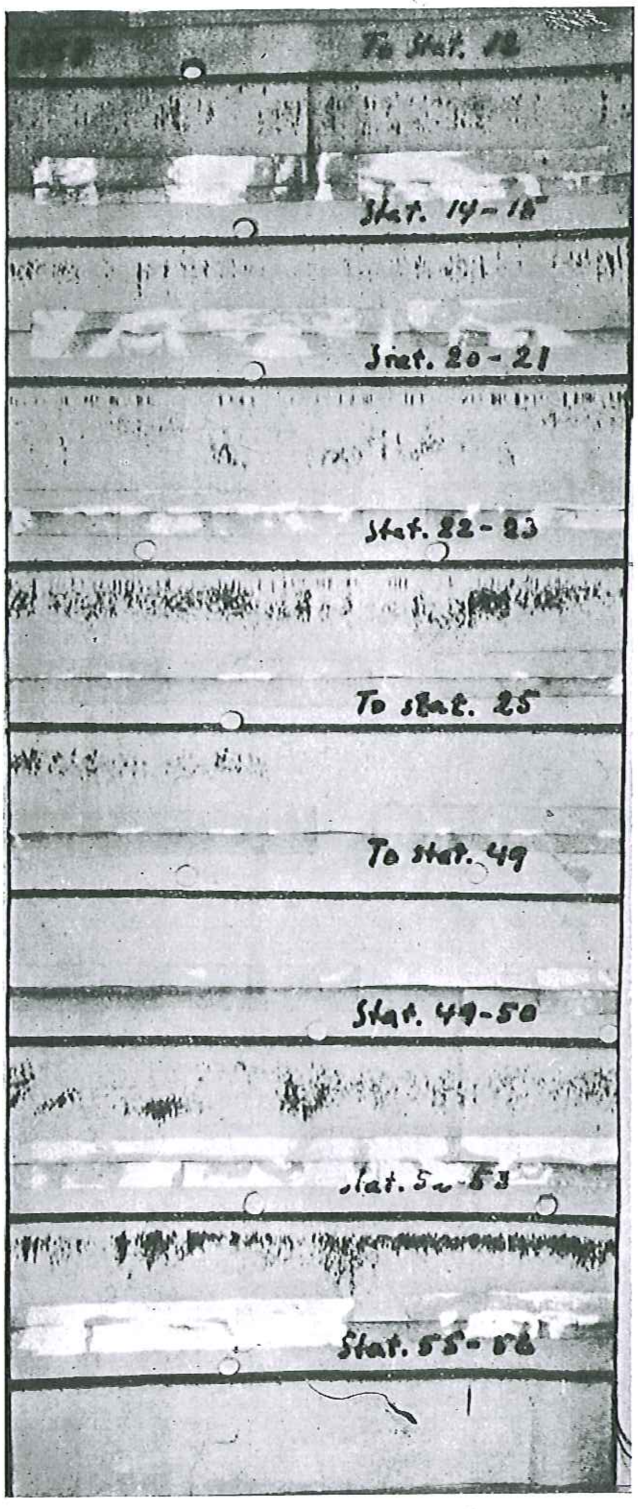

Fig. 4. b. *Selected samples from the echo-records of the 1957-survey.*

TABLE 1. **Size distribution of *Sebastes marinus***

	MAY				JUNE			
mm	*A*	*B*	*S*	*Total*	*S*	*W*	*N*	*Total*
62	..	..	..	..	..	..	..	..
61	..	..	..	..	..	..	..	..
60	..	..	..	..	..	..	..	..
59	..	..	..	..	..	..	..	..
58	..	..	..	..	..	..	..	..
57	..	..	..	..	..	..	..	..
56	..	..	..	..	..	..	..	..
55	..	..	..	..	..	..	..	..
54	..	..	..	..	..	..	..	..
53	..	..	..	..	..	..	..	..
52	..	..	..	..	..	..	..	..
51	..	..	..	..	..	..	..	..
50	..	..	..	..	..	..	..	..
49	..	..	..	..	..	..	..	..
48	..	..	..	..	..	..	..	..
47	..	..	..	..	..	..	..	..
46	..	..	..	..	..	..	..	..
45	..	..	..	..	..	..	..	..
44	..	..	..	..	..	..	..	..
43	..	..	..	..	..	..	..	..
42	..	..	..	..	..	..	..	..
41	..	..	..	..	..	..	..	..
40	..	..	..	..	..	..	..	..
39	..	..	..	..	..	..	..	..
38	..	..	..	..	..	..	..	..
37	..	..	..	..	..	..	..	..
36	..	..	..	..	..	..	..	..
35	..	..	..	..	..	..	..	..
34	..	..	..	..	..	..	..	..
33	..	..	..	..	..	..	..	..
32	..	..	..	..	..	..	..	..
31	..	..	..	..	..	..	..	..
30	..	..	..	..	..	..	..	..
29	..	..	..	..	..	..	..	..
28	..	..	..	..	..	..	..	..
27	..	..	..	..	..	..	..	..
26	..	..	..	..	..	..	..	..
25	..	..	..	..	..	..	..	..
24	..	..	..	..	..	..	..	..
23	..	..	..	..	..	..	..	..
22	..	..	..	..	..	..	..	..
21	..	..	..	..	..	..	..	..
20	..	..	..	..	..	..	..	..
19	..	..	..	..	..	..	..	..
18	..	..	..	..	..	..	..	..
17	..	..	..	..	..	..	..	..
16	..	..	..	..	..	..	..	..
15	1	1	..	2	..	..	..	..
14	3	4	1	8	2	..	..	2
13	16	21	..	37	7	..	..	7
12	44	39	..	83	14	1	..	15
11	72	48	12	132	15	1	1	17
10	104	46	30	180	33	8	6	47
9	42	21	70	133	83	4	4	91
8	16	8	99	123	209	5	..	214
7	1	2	86	89	285	4	..	289
6	1	..	75	76	114	12	1	127
5	..	..	26	26	9	29	..	38
4	..	..	1	1	1	..	..	1
Total	300	190	400	890	772	64	12	848
Av. size	10.48	10.88	7.64	9.29	7.68	6.63	9.42	7.63

fry according to month and area. TABLE 1.

	JULY						AUGUST				
mm	A	B	S	W	N	Total	A	B	S	W	Total
62	..	..	..	..	..	..	..	..	1	..	1
61	..	..	..	..	..	..	..	..	..	..	..
60	..	..	..	..	..	..	..	..	..	..	..
59	..	..	..	..	..	..	..	..	1	..	1
58	..	..	..	..	..	..	..	..	1	..	1
57	..	..	..	..	..	..	..	..	..	..	..
56	..	..	..	..	..	..	..	..	..	..	..
55	..	..	..	..	..	..	..	..	..	..	..
54	..	..	..	..	..	..	..	..	..	..	..
53	..	..	..	..	..	..	..	..	2	..	2
52	..	..	..	..	..	..	..	..	..	..	..
51	..	..	..	..	..	..	1	..	..	..	1
50	..	..	..	..	..	..	..	..	1	..	1
49	..	..	..	..	..	..	..	..	2	..	2
48	..	..	1	..	..	1	..	..	1	..	1
47	..	..	..	..	..	..	..	..	1	3	4
46	..	..	1	..	..	1	..	..	3	1	4
45	..	..	..	..	..	..	..	..	3	..	3
44	..	..	..	..	..	..	..	..	2	..	2
43	..	..	..	..	..	..	..	..	8	..	8
42	..	..	..	..	..	..	..	1	2	2	5
41	..	..	..	..	..	..	..	..	9	..	9
40	..	..	..	..	..	..	..	1	11	..	12
39	..	..	..	..	..	..	..	..	4	..	4
38	..	..	1	..	..	1	..	..	5	..	5
37	..	..	..	1	..	1	..	..	3	..	3
36	..	..	2	1	..	3	1	2	8	..	11
35	..	..	1	2	..	3	..	..	7	..	7
34	..	1	3	1	..	5	1	..	9	..	10
33	..	..	10	2	..	12	..	1	10	..	11
32	..	1	13	2	..	16	2	1	5	..	8
31	..	6	10	3	..	19	2	1	15	..	18
30	..	3	5	10	..	18	1	3	16	1	21
29	1	10	11	20	..	42	7	6	21	..	34
28	2	19	7	15	..	43	4	3	15	..	22
27	6	32	6	25	..	69	5	19	27	..	51
26	4	51	12	26	..	93	7	22	41	..	70
25	4	108	11	28	..	151	5	51	36	..	92
24	5	207	18	53	..	283	3	67	42	..	112
23	11	306	31	59	..	407	1	78	27	..	106
22	18	518	68	62	..	666	1	69	28	..	98
21	25	589	55	55	..	724	2	63	16	..	81
20	19	627	57	67	..	770	..	60	8	..	68
19	20	495	48	61	..	624	..	41	6	..	47
18	10	371	45	43	..	469	..	30	3	..	33
17	8	172	30	17	..	227	..	10	3	..	13
16	5	79	17	14	..	115	..	1	3	..	4
15	2	49	13	3	..	67	..	..	8	1	9
14	2	52	8	6	1	69	..	..	6	..	6
13	3	71	21	4	..	99	..	..	11	1	12
12	7	78	10	18	1	114	..	..	4	..	4
11	14	44	10	27	..	95	..	..	2	..	2
10	13	16	4	18	2	53	..	..	1	..	1
9	1	11	2	8	2	24	..	..	..	..	..
8	..	4	4	1	1	10	..	..	..	..	..
7	..	1	1	1	..	3	..	..	..	..	..
6	..	..	..	..	..	..	..	..	..	..	..
5	..	..	..	..	..	..	..	..	..	..	..
4	..	..	..	..	..	..	..	..	..	..	..
Total	180	3921	536	653	7	5297	43	530	438	9	1020
Av. size	18.75	20.08	20.82	20.90	10.29	20.20	27.74	22.46	27.43	36.56	24.95

TABLE 2. **Size distribution of *Sebastes marinus***

	MAY				JUNE				
	S		*A*	*B*	*S*				*W*
mm	*1904*	*1905*	*1955*	*1955*	*1908*	*1924*	*1926*	*1952*	*1903*
51	..	..	..	..	..	..	..	..	..
50	..	..	..	..	..	..	..	..	..
49	..	..	..	..	..	..	..	..	..
48	..	..	..	..	..	..	..	..	..
47	..	..	..	..	..	..	..	..	..
46	..	..	..	..	..	..	..	..	..
45	..	..	..	..	..	..	..	..	..
44	..	..	..	..	..	..	..	..	..
43	..	..	..	..	..	..	..	..	..
42	..	..	..	..	..	..	..	..	..
41	..	..	..	..	..	..	..	..	..
40	..	..	..	..	..	..	..	..	..
39	..	..	..	..	..	..	..	..	..
38	..	..	..	..	..	..	..	..	..
37	..	..	..	..	..	..	..	..	..
36	..	..	..	..	..	..	..	..	..
35	..	..	..	..	..	..	..	..	..
34	..	..	..	..	..	..	..	..	..
33	..	..	..	..	..	..	..	..	..
32	..	..	..	..	..	..	..	..	..
31	..	..	..	..	..	..	..	..	..
30	..	..	..	..	..	..	..	..	..
29	..	..	..	..	..	..	..	..	..
28	..	..	..	..	..	..	..	..	..
27	..	..	..	..	..	..	..	..	..
26	..	..	..	..	..	..	..	..	..
25	..	..	..	..	..	..	..	..	..
24	..	..	..	..	..	..	..	..	..
23	..	..	..	..	..	..	..	..	..
22	..	..	..	..	..	..	..	..	..
21	..	..	..	..	..	..	..	..	..
20	..	..	..	..	..	..	..	..	..
19	..	..	..	..	..	..	..	..	..
18	..	..	..	..	..	..	..	..	..
17	..	..	..	..	..	..	..	..	..
16	..	..	..	..	..	..	..	..	..
15	..	..	1	1	..	..	..	..	..
14	..	..	3	4	..	..	..	2	..
13	..	..	16	21	..	..	..	6	..
12	..	..	44	39	..	..	1	12	..
11	..	12	72	48	1	..	..	9	..
10	..	29	104	46	3	1	4	18	..
9	..	67	42	21	23	4	26	27	..
8	..	99	16	8	48	40	50	68	..
7	6	79	1	2	51	95	95	44	1
6	48	27	1	..	34	29	36	14	7
5	21	2	..	..	3	2	4	..	29
Total	75	315	300	190	163	171	216	200	37
Av. size	5.80	8.07	10.48	8.42	7.41	7.11	7.35	8.54	5.24

fry according to month, area and year. TABLE 2.

	JULY														AUGUST			
	S					*W*			*A*		*B*				*S*		*A*	*B*
mm	*1903*	*1904*	*1927*	*1933*	*1938*	*1931*	*1932*	*1936*	*1931*	*1932*	*1931*	*1932*	*1936*	*1939*	*1949*	*1950*	*1933*	*1939*
51	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..
50	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..
49	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
48	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
47	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..
46	..	..	1	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..
45	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2	..	..	..
44	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2	..	..	..
43	..	..	..	..	..	..	..	..	..	..	..	..	..	..	8	..	..	..
42	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2	..	..	1
41	..	..	..	..	..	..	..	..	..	..	..	..	..	..	9	..	..	..
40	..	..	..	..	..	..	..	..	..	..	..	..	..	..	11	..	..	..
39	..	..	1	..	..	..	..	..	..	..	..	..	..	..	4	..	..	..
38	..	..	..	..	..	..	..	..	..	..	..	..	..	..	5	..	..	..
37	..	..	..	..	..	1	..	..	..	..	..	..	..	..	3	..	..	..
36	..	..	2	..	..	1	..	..	..	..	..	..	..	..	8	..	1	1
35	..	..	1	..	..	1	1	..	..	..	..	..	..	..	7	..	..	..
34	..	..	3	..	..	1	..	..	..	..	1	..	..	..	9	..	1	..
33	..	..	10	..	..	2	..	..	..	..	..	..	..	..	8	..	..	..
32	..	..	13	..	..	1	1	..	..	..	..	1	..	..	4	..	2	..
31	..	..	10	..	..	..	3	..	..	..	6	..	..	..	15	..	2	1
30	..	..	4	..	..	3	7	..	..	..	2	1	..	..	15	..	1	2
29	..	2	8	..	1	8	12	..	1	..	8	2	..	..	21	..	7	5
28	3	1	3	..	..	5	9	..	2	..	17	2	..	..	15	..	4	2
27	..	1	4	..	..	11	14	..	6	..	29	3	..	..	26	..	5	18
26	..	2	7	3	..	18	8	..	4	..	43	5	..	3	41	..	7	21
25	..	..	5	4	..	27	1	..	3	1	96	9	..	3	36	..	5	51
24	1	..	14	1	..	44	9	..	1	4	174	26	3	4	42	..	3	66
23	5	..	25	1	..	49	9	..	8	3	243	54	6	3	27	..	1	77
22	4	8	45	9	..	50	12	..	8	10	388	115	11	4	26	2	1	68
21	2	6	38	8	1	41	14	..	7	18	424	147	13	5	13	3	2	63
20	3	8	41	5	..	62	5	..	7	12	471	142	10	4	3	5	..	60
19	2	4	31	9	2	49	12	..	14	6	370	108	12	5	..	6	..	41
18	1	3	35	4	2	29	13	..	7	3	279	78	9	5	..	3	..	30
17	1	3	22	2	2	12	5	..	2	6	117	45	10	..	..	3	..	10
16	3	2	9	..	3	9	5	..	2	3	48	28	3	..	..	3	..	1
15	2	2	4	1	4	2	1	..	1	1	15	27	7	..	..	7	..	..
14	1	1	2	1	3	..	3	3	..	2	3	11	38	..	..	6	..	..
13	2	1	5	2	11	..	1	3	3	..	..	11	60	..	..	11	..	..
12	1	..	3	..	6	1	..	17	7	..	2	12	63	1	..	4	..	..
11	1	2	3	..	4	..	1	26	10	4	4	17	23	..	..	2	..	..
10	2	..	..	..	2	..	..	18	8	5	4	8	4	..	..	1	..	..
9	..	..	..	..	2	..	..	8	1	..	..	10	1	..	..	..	..	..
8	2	..	..	..	2	..	1	..	..	..	..	2	2	..	..	..	..	..
7	..	..	..	..	1	..	1	..	..	..	..	1	..	..	..	..	..	..
6	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
5	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Total	36	47	349	50	46	427	148	75	102	78	2744	864	275	37	365	56	43	518
Av. size	18.42	20.57	22.00	20.46	13.65	21.94	22.87	10.97	18.55	18.83	20.81	19.46	14.63	21.30	28.47	15.82	27.74	22.31

Tables showing the composition of zooplankton in the Irminger Sea 27. 5—3. 6, 1955. Plankton Indicators towed for 10 minutes. Speed: 8 knots.

TABLE I: STATIONS 3—15

Station	*Copepoda/Total*	*2 m depth*	*15 m depth*	*30 m depth*	*Tot. no.*	*Average number*	*Colour/Ph.plankton*	*Thysanoessa*	*Meganyctiphanes*	*Crust. eggs & naupl.*	*Decapod-larvae*	*Zoëa*	*Cirriped-larvae*	*Ostracoda*	*Spiratella helicina*	*Spiratella. balea*	*Clione*	*Communities*	*Remarks*
3	Cop.	28	..	237	265	132	L	..	..	..	..	..	..	..	..	..	..	*Mix. Cal.*	78 Evadne
	Tot.	124	..	300	424	212	rr	7	2	..	12	6	43	..	10	..	..		
4	Cop.	12	..	125	137	68	L	..	..	..	..	..	..	..	..	..	..		
	Tot.	18	..	133	157	75	rr	2	2	7	..	..	1	..	1	..	..		1 Evadne
5	Cop.	21	9	15	45	15	L/rr	..	..	..	..	..	..	..	..	..	..	*Pure Calanus*	Cal. ads.
7	Cop.	56	124	100	280	93	L/rr	..	..	..	..	..	..	..	..	..	..		Cal. ads.
8	Cop.	5	35	70	110	37	L/rr	..	..	..	..	..	..	..	..	..	..		Cal. ads.
9	Cop.	..	89	71	160	80	L/rr	..	..	..	..	..	..	..	..	..	..		Cal. ads.
10	Cop.	..	58	..	58	58	L/r	..	..	..	..	..	..	..	..	..	..		Cal. ads.
11	Cop.	..	179	96	275	137	L.	..	..	..	..	..	..	..	..	..	..	*Cal.-Th. Slope Phase*	Cal. juv.
	Tot.	..	181	202	383	192	c	2	1	2	..	..	..	..	2	..	..		& ads.
12	Cop.	36	..	71	107	54	L	..	..	..	..	..	..	..	..	..	..		Cal. juv. & ads.
	Tot.	46	..	86	132	66	cc	17	..	4	1	..	..	..	3	..	..		
13	Cop.	45	..	130	175	88	L.	..	..	..	..	..	..	..	..	..	..		Cal. juv. & ads.
	Tot.	45	..	139	184	92	cc	5	..	..	1	..	..	..	2	..	..		1 Sebastes
14	Cop.	150	..	159	309	155	L/r	..	..	..	..	..	..	..	..	..	..		Cal. juv.
	Tot.	153	..	199	342	171	cc	6	10	2	..	..	1	1	23	..	..		& ads.
15	Cop.	143	123	116	382	127	L/r	..	..	..	..	..	..	..	..	..	..		Cal. juv. & ads.
	Tot.	148	130	154	432	144	cc	37	..	1	..	..	..	1	9	1	..		1 Sebastes

Abbreviations:

St.: Station
Cop.: Copepods
Tot.: Total number
Av.: Average
Cl.: Colour of Copepods
(L: light, Lr: light-red, R: red)
Ph.: Phytoplankton
rr: very scarce, r: scarce,
+: common, c: abundant,
cc: very abundant

Cal.: Calanus
Juv.: Juvenile
Ads.: Adolescent
Mix.: Mixed
P.: Pure
Sl.: Slope
Th.: Thysanoessa
Hyp.: hyperboreus

TABLE II: STATIONS 17—28

Station	Copepoda/Total	2 m depth	15 m depth	30 m depth	Tot. no.	Average number	Colour/Ph.plankton	Thysanoessa	Meganyctiphanes	Crust. eggs & naupl.	Decapod-larvae	Zoëa	Cirriped-larvae	Ostracoda	Spiratella helicina	Spiratella balea	Clione	Communities	Remarks
17	Cop.	72	8	164	244	81	L	..	..	..	..	..	..	..	..	..	..	Calanus — Thysanoessa — Oceanic Phase	Cal. ads.
	Tot.	85	16	191	292	97	+	36	..	..	..	..	..	3	8	1	..		
18	Cop.	15	14	103	132	44	R	..	..	..	..	..	..	..	..	..	..		Cal. ads.
	Tot.	18	17	109	144	48	+	7	..	..	..	..	..	1	..	..	..		2 Sebastes
19	Cop.	83	129	171	383	128	L/r	..	..	..	..	..	..	..	..	..	..		Cal. ads.
	Tot.	83	144	227	454	151	+	62	2	..	..	..	..	..	2	4	..		1 Polychaet
21	Cop.	107	50	25	182	61	R	..	..	..	..	..	..	..	..	..	..		Cal. ads.
	Tot.	107	54	39	200	67	+	8	..	..	..	..	..	..	6	4	..		
22	Cop.	49	35	56	140	47	L	..	..	..	..	..	..	..	..	..	..		Cal. ads.
	Tot.	50	36	71	157	52	+	13	1	..	..	..	..	1	1	..	..		
23	Cop.	57	54	..	111	55	L	..	..	..	..	..	..	..	..	..	..		Cal. ads.
	Tot.	57	59	..	116	58	+	4	..	..	..	..	..	..	..	..	..		1 Sebastes
24	Cop.	..	30	..	30	15	L	..	..	..	..	..	..	..	..	..	..		Cal. ads.
	Tot.	3	34	22	59	20	+	28	..	..	..	..	..	..	..	1	..		
25	Cop.	36	35	21	92	31	L	..	..	..	..	..	..	..	..	..	..		Cal. ads.
	Tot.	41	45	24	110	37	r	11	..	..	..	..	..	4	1	2	..		
26	Cop.	154	7	27	188	63	L/r	..	..	..	..	..	..	..	..	..	..		Cal. ads.
	Tot.	155	9	37	201	67	+	9	..	..	..	..	..	..	1	2	..		
27	Cop.	66	20	21	107	36	L	..	..	..	..	..	..	..	..	..	..		Cal. ads.
	Tot.	68	23	56	147	49	+	29	2	..	..	..	..	4	1	3	..		
28	Cop.	17	34	18	69	23	L	..	..	..	..	..	..	..	..	..	..	C.-Th.-Sl.	Cal. juv. & ads.
	Tot.	19	49	24	92	31	c	13	..	..	..	..	..	1	..	2	..		4 Sagitta

TABLE III: STATIONS 29—44

Station	*Copepoda/Total*	*2 m depth*	*15 m depth*	*30 m depth*	*Tot. no.*	*Average number*	*Colour/Ph. plankton*	*Thysanoessa*	*Meganyctiphanes*	*Crust. eggs & naupl.*	*Decapod-larvae*	*Zoëa*	*Cirriped-larvae*	*Ostracoda*	*Spiratella helicina*	*Spiratella. balea*	*Clione*	*Communities*	*Remarks*
29	Cop.	39	..	28	67	22	L	..	..	..	..	..	..	..	..	..	..		Cal. juv.
	Tot.	43	3	29	75	25	cc	2	..	..	..	..	..	5	..	..	..		
30	Cop.	..	28	15	43	14	L	..	..	..	..	..	..	..	..	..	..		Cal. juv.
	Tot.	..	30	15	45	15	cc	1	..	..	..	..	..	1	..	..	..		
31	Cop.	..	1	25	30	10	L	..	..	..	..	..	..	..	..	..	..	*Pure Calanus*	Cal. juv.
	Tot.	..	6	30	36	12	cc	1	..	5	..	..	..	..	3	..	..		1 fishegg
32	Cop.	1	10	61	72	24	L	..	..	..	..	..	..	..	..	..	..		Cal. juv.
	Tot.	8	23	66	97	32	cc	..	..	24	..	..	..	..	..	..	..		
33	Cop.	17	13	18	48	16	L	..	..	..	..	..	..	..	..	..	..		Cal. juv.
	Tot.	22	13	20	55	18	r	..	..	7	..	..	..	..	..	..	..		
35	Cop.	20	14	22	56	19	L	..	..	..	..	..	..	..	..	..	..		Cal. ads.
	Tot.	27	29	33	89	30	c	16	1	1	..	..	..	3	6	6	..	*C.-Th.-Sl. Ph.*	
37	Cop.	14	43	20	77	26	L/r	..	..	..	..	..	..	..	..	..	..		Cal. juv. & ad
	Tot.	39	89	34	162	54	c	21	1	53	..	..	..	..	5	2	..		1 Sebastes
38	Cop.	1	22	15	38	12	L/r	..	..	..	..	..	..	..	..	..	..		Cal. hyp. juv.
	Tot.	2	22	16	40	13	rr	..	..	2	..	..	..	..	..	..	..		
39	Cop.	..	46	47	93	31	L/r	..	..	..	..	..	..	..	..	..	..	*Cal. hyp.*	Cal. hyp. juv.
	Tot.	22	48	62	122	41	rr	..	..	23	..	..	..	..	..	1	..		
40	Cop.	3	217	73	293	98	L	..	..	..	..	..	..	..	..	..	..		Cal. hyp. juv.
	Tot.	10	225	78	313	106	rr	..	..	20	..	..	..	..	..	..	..		
41	Cop.	..	2	6	8	4	L	..	..	..	..	..	..	..	..	..	..	*P. Cal.*	Cal. juv.
	Tot.	17	4	7	28	9	+	..	..	19	..	..	..	..	..	1	..		
42	Cop.	..	2	2	4	1	L	..	..	..	..	..	..	..	..	..	..	*C.-Th.-Sl.*	Cal. juv.
	Tot.	..	3	9	12	4	c	6	..	1	..	..	..	..	..	..	..		
43	Cop.	2	60	10	72	24	L	..	..	..	..	..	..	..	..	..	..		Cal. juv.
	Tot.	2	61	39	102	34	c	..	..	30	..	..	..	..	..	..	..		
44	Cop.	1	1	5	7	2	L	..	..	..	..	..	..	..	..	..	..	*Pure Cal.*	Cal. juv.
	Tot.	1	10	14	25	8	c	..	..	18	..	..	..	..	..	..	..		

Remarks

Cal. juv.
Cal. juv.
Cal. juv.
1 fishegg
Cal. juv.
Cal. juv.
Cal. ads.
Cal. juv. & ads.
1 Sebastes
Cal. hyp. juv.
Cal. hyp. juv.
Cal. hyp. juv.
Cal. juv.
Cal. juv.
Cal. juv.
Cal. juv.

TABLE IV: STATIONS 45—60

Station	Copepoda/Total	2 m depth	15 m depth	30 m depth	Tot. no.	Average number	Colour/Ph. plankton	Thysanoessa	Meganyctiphanes	Crust. eggs & naupl.	Decapod-larvae	Zoëa	Cirriped-larvae	Ostracoda	Spiratella helicina	Spiratella balea	Clione	Communities	Remarks
45	Cop.	..	..	5	5	2	L	..	..	..	..	..	..	..	..	..	..	C.-Th.-Sl.	Cal. juv.
	Tot.	..	2	10	12	4	cc	3	..	3	..	..	..	1	..	..	..		
46	Cop.	55	60	156	271	90	L/r	..	..	..	..	..	..	..	..	..	..	Calanus — Thysanoessa — Oceanic Phase	Cal. ads.
	Tot.	58	75	179	312	104	+	28	1	1	1	..	..	1	5	1	..		1 Sagitta
47	Cop.	49	61	21	131	44	L/r	..	..	..	..	..	..	..	..	..	..		Cal. ads.
	Tot.	55	70	28	153	51	r	13	2	2	..	1	..	..	1	..	2		
48	Cop.	62	75	200	337	112	L/r	..	..	..	..	..	..	..	..	..	..		Cal. ads.
	Tot.	75	108	247	430	143	r	52	14	1	..	..	..	15	2	3	4		
49	Cop.	182	179	109	470	157	L/r	..	..	..	..	..	..	..	..	..	..		Cal. ads.
	Tot.	187	207	182	576	192	r	86	3	..	..	..	..	5	8	1	3		
50	Cop.	159	104	106	369	123	R	..	..	..	..	..	..	..	..	..	..		Cal. ads.
	Tot.	161	124	172	457	152	rr	73	5	..	..	..	..	4	5	1	..		
51	Cop.	73	74	86	233	78	L/r	..	..	..	..	..	..	..	..	..	..		Cal. ads.
	Tot.	73	83	105	261	87	r	15	..	..	..	..	..	2	1	..	10		
52	Cop.	66	73	51	190	63	L/r	..	..	..	..	..	..	..	..	..	..		Cal. ads.
	Tot.	67	78	59	204	68	r	5	2	..	..	1	..	4	..	..	1		1 Sebastes
53	Cop.	242	209	112	563	188	L/r	..	..	..	..	..	..	..	..	..	..		Cal. ads.
	Tot.	242	213	125	580	193	rr	10	4	..	..	..	..	..	..	..	3		
54	Cop.	139	141	125	405	135	L/r	..	..	..	..	..	..	..	..	..	..		Cal. ads.
	Tot.	146	159	153	457	152	r	24	12	..	..	..	..	9	3	1	3		
55	Cop.	121	275	67	463	154	L/r	..	..	..	..	..	..	..	..	..	..		Cal. ads.
	Tot.	121	282	69	472	157	r	7	..	1	..	..	..	..	1	..	..		
56	Cop.	146	59	141	346	115	L/r	..	..	..	..	..	..	..	..	..	..		Cal. ads.
	Tot.	147	59	146	352	117	+	1	1	1	..	..	..	..	2	..	1		
57	Cop.	20	474	82	576	192	L/r	..	..	..	..	..	..	..	..	..	..	Pure Calanus	Cal. ads.
	Tot.	20	474	86	580	193	rr	..	..	..	..	..	..	..	3	1	..		
58	Cop.	521	292	409	1222	407	L/r	..	..	..	..	..	..	..	..	..	..		Cal. ads.
	Tot.	522	293	409	1224	408	rr	..	..	..	..	..	..	..	..	1	..		1 Ammodytes
59	Cop.	523	123	163	809	269	L/r	..	..	..	..	..	..	..	..	..	..		Cal. ads.
	Tot.	524	123	163	810	270	O	..	..	..	..	..	..	..	..	..	..		1 Mallotus
60	Cop.	..	335	511	846	423	L/r	..	..	..	..	..	..	..	..	..	..	Mix. Cal.	Cal. ads.
	Tot.	..	341	518	859	430	O	2	8	..	1	..	1	..	..	..	..		1 Clupea