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Continuous Plankton Records

The Distribution of Young Sebastes Marinus (L.).

by

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INTRODUCTION

Regular sampling in the Atlantic with the Hardy Continuous Plankton Recorder was extended beyond the original western limit of 20°W longitude when British, Dutch and Norwegian weather ships took over Ocean Weather Station 'ALFA' (62°N, 33°W) in 1955 and subsequent years (see Fig. 1). The area sampled was increased in 1957 by the addition of a route from Iceland towards New York. This route originally sampled the first 450 miles southwest from Reykjavik, but was extended, first to 900 miles, and then as far as the Newfoundland Banks, in 1959 and 1960. Although it is convenient to plot the results in statistical rectangles, particularly when records are combined, it must be emphasised that the records were obtained along lines followed by the towing vessels as illustrated in Figure 1.

DISTRIBUTION

Plankton Recorder Data.

The young stages of the large Redfish, Sebastes marinus (L.), were found in relatively large numbers in Recorder samples to the west of 20°W longitude during the months April to July. A few young stages of the small Redfish, Sebastes viviparus Kr., were taken off the coasts of Iceland and in the Norwegian Sea in June and July of some years. These occurrences are indicated by the open triangles in Figure 2, which shows the average abundance and distribution of all the young Sebastes taken by the Recorder survey (at the standard depth of 10 metres) during the months April to July in the years 1955 to 1960. The largest numbers of S. marinus were found along a line over the western slope of the Reykjanes Ridge, over depths of from 500 to more than 1000 fathoms: there was no sampling to the southeast of this line except in the area close to Iceland. An apparently separate patch occurred off the eastern edge of the Newfoundland Banks in April, 1960; the first occasion on which sampling in this month extended as far.

The seasonal distribution of all S. marinus in the Recorder samples to the west of the British Isles is shown in Figure 3 for each of the months April to July. Results from all the years 1955 to 1960 were combined to construct these charts. In April the distribution appeared to be mainly along the western slope of the Reykjanes Ridge, and off the eastern edge of the Newfoundland Banks. In May the largest numbers still occurred along the western slopes of the Ridge, but there was some spreading of the distribution further north and east, with larger numbers on the whole than in April. Relatively few were taken in June, and the distribution was more

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scattered, mainly to the eastward of the Ridge. In July, although the total numbers were still low, there was a patch of these young stages sou of Cape Farewell (Greenland) about which the Recorder sampling provided no antecedent information. The vessel on the Iceland-New York service took a more northwesterly track in July 1959 and 1960, using the Belle Isle Strait once this had opened for shipping. This patch of young S. marinus was composed of larger individuals only, none of the small post-extrusion stages being present.

Other Data.

The period of occurrence of young redfish appeared to be generally similar in all the areas from which results were available, so the combination of Recorder material with that of other workers seemed permissible. Published results from American, Newfoundland, Icelandic, Danish, Norwegian and Russian sources were combined to construct the chart of distribution of "young redfish" shown in Figure 4. The Recorder results, along with thos from Icelandic and Danish sources, were for S. marinus, and show three broad categories of abundance with blacked-in symbols (based on a conversion of the results to a common scale). Results from Newfoundland and Russian sources are shown by open symbols, of no numerical significance, as uncertaint of specific identity, a mixture of species, or lack of numerical assessme precluded any more precise indication than the presence of absence of "young redfish". A mixture of S. marinus and S. mentella is to be expected in the north Norwegian Sea and Barents Sea, where the area of greatest abundance of early post-extrusion stages lies between the parallels of 70° and 75°N latitude, from 13°E to 17°E longitude (Corlett, 1961). Presumably (see Templeman 1959) mentella type young should be found among catches off the Newfoundland area, but the specific identity of "young redfish" of the Gulf of St. Lawrence, the Nova Scotian Shelf, and the Gulf of Maine seems less certain, and the distribution in these areas, which are continuous with that shown south of Newfoundland, are not shown in this chart but may be seen in detail in Figures 11 to 15 of Templeman's account (1959). The eastern limit of the distribution in the Barents Sea is slightly further east than is shown in the figure. The impression conveyed by Figure 4 is that of a broad belt of young stages occurring all the way from the Gulf of Maine to the Barents Sea. There are extensions into the Davis Strait and Denmark Strait areas, and the continuity between the Atlantic and the Norwegian Sea distributions is narrowed, or possibly even broken, in the area round the Faroes. It is important to note, however, that the distribution shown is of all stages from extrusion to the end of the pelagic phase, so that drift and dispersal may have masked such boundaries between different populations as may be discovered by more detailed investigations. The areas of distribution of the young stages plotted by Taning (1949) are outlined on Figure 4; the extension of the present records outside Tåning's boundaries (in the Norwegian and Labrador Seas) confirm his speculations about the extent of the distribution, but there is a pressing need for information on the extent of the distribution in the central North Atlantic.

Hydrography.

A detailed comparison with hydrography has yet to be attempted, but there are superficial similarities between the distributions shown in Figures 3 and 4 and the long-term mean surface isotherms published by Krauss (1958). The majority of the young redfish in April and May were taken in areas with mean surface temperature between 3° and 7°C. Rogalla (1959) reviews the hydrographic conditions in the open oceans in relation to fishery prospects, and shows an illustration (his Fig. 2, taken from Dietrich, 1958) which outlines the boundaries of the Gulf Stream and its branches. There is a superficial resemblance between the pattern of distribution of young redfish in April and May (Fig. 3) and the northwest boundary of the Gulf Stre system. This may be reflection of the temperature limits for extrusion (Tåning, 1949, suggested a range of 3° to 8°C). Tåning's suggested distribution in this area, which was based on sampling in earlier years and in

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June and July also, corresponds less precisely, but this might be expected if the temperature requirements later in the season are less restricted, or may result from the dispersal of young in the later months. The occurrences of some of the June and July Recorder catches in areas with mean surface temperatures (Krauss 1958) exceeding 8°C point to this possibility

EXTRUSION AND GROWTH

Plankton Recorder Data.

The earliest occurrences in the Recorder survey of apparently newly extruded S. marinus were on 2nd, 9th and 10th April, but very few were caught in the first half of this month. In the second half of April these early stages were numerous and were also taken, along with larger sizes, in fair numbers up to the end of May: none were taken in June or July. It seems probable that the period of extrusion in the area between Iceland and Newfoundland may last for six to eight weeks, but does not extend later than the end of May.

The mean lengths calculated for catches of the young stages take in different parts of the area appeared to fit into a common seasonal pattern of size distribution, so that it seemed reasonable to combine the Recorder material from the years 1955 to 1960 to examine the size distribution for all the catches between Faroe and Newfoundland. The percentage size compositions of these catches are shown as histograms in Figure 5,[1] where the period April to July is split up into half months. The points to note are (a) the persistence of the recently extruded stages up to the end of May, and (b) the apparent acceleration in the rate of increment in length after the end of May.

Very few individuals exceeding 27 mm in length were caught; a finding in agreement with many other observations, where generally the maximum sizes taken pelagically have not exceeded 25 mm in length.

The mean sizes of all specimens of S. marinus taken in the Recorder survey in each half month of the period April to July are plotted in Figure 6, and a smooth curve has been drawn through the points, showing the rate of length increment throughout the season.

It seems important to emphasise here that Figure 6 is not, in the strict sense, a growth curve for young S. marinus; it gives an indication of the changes in mean length of the young stages caught at 10 metres throughout the period of their occurrence. It includes, therefore, the cumulative bias resulting from continuing extrusion, natural mortality, drift, and dispersal. The mean sizes of individual catches at various times in the period 1955 to 1960 all group closely to the curve when examined separately and it is believed that this curve may be more representative of the characteristics of the oceanic population than that shown by Einarsson (1960), whose rather low figure for June seems to be aberrant, possibly due to restricted sampling in this month, in which his samples were mainly coastal

Other Data.

The mean sizes of young redfish determined by many workers over the whole area of distribution illustrated in Figure 4 suggested that the characteristics of growth in length might be very similar in all areas, and a comparison of all the published information plotted on a common time scale seemed desirable. This is shown in Figure 7, where the curve of Figure 6 is repeated and extended to conform with the other observations available: different symbols are used to distinguish measurements from different areas. Of the observations lying below the curve in June, one is the low Icelandic

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1) The total number of young in each period is shown in a circle.

figure already mentioned, and three, (with one in the first half of July also) are figures from the Barents Sea, where extrusion is stated to be about a fortnight later than in the Atlantic (Corlett, 1961). If allowance is made for these differences, the majority of the observations group fairly satisfactorily about the suggested curve with two exceptions, both from the Gulf of Maine. The observations about 55-57 mm in April are considered to be one year old fish, but the group in July and August below about 10mm do not appear to agree with the remainder. The possibility that these represent a later spawning species in the Gulf of Maine, possibly S. viviparus or a closely allied form, is suggested by the similarity of their size increment curve with that of Icelandic S. viviparus shown below the main curve in Figure 7. With this exception there appear to be fewer differences between widely separated populations in respect of mean sizes than might have been expected from their geographical separation.

FLUCTUATIONS AND ABUNDANCE

Fluctuations in abundance from year to year were noted, and an attempt at assessing these was made by comparing the April and May catches within the rectangular area (see Figure 1) southwest of Iceland for each of the years 1955 to 1960. The rather limited results so far available seem hardly sufficient to support fine descriminations between years, especially in the light of sampling variations, but the year 1958, when exceptional low numbers were caught, may perhaps be noted as a possible "marker" for later studies on recruitment to the adult stock. The paucity of young stages everywhere in the central and western Atlantic in this year seems adequately confirmed (ICNAF Newsletter, 1958). The possibility that the 1958 brood was unsuccessful over the whole area of redfish distribution is supported by the results of studies on the abundance of various year-classes in the Barents Sea in 1960 by Surkova (1960) , who shows that the 1958 year-class was very poorly represented in comparison with those for 1959, 1957 and 1956.

The numbers taken by the Continuous Plankton Recorder appeared large in comparison with those of other species of young fish. In the area of their distribution as shown in Figure 2 the mean number of young S. marinus in April was 9.5×10^6 under each Km.^{2}. In May the figure rose to a mean level of 13.0×10^6 under each Km.^{2}, falling to 4.5×10^6 in June and to 2.5×10^6 in July. These figures are based on relatively conservative calculations derived from Recorder catches at 10 metres, on the assumption that the distribution extends only to a depth of 50 metres, (Täning, 1949), and a uniform distribution prevails over this depth range, although the only available study of depth distribution suggests that these young were "many times more abundant at 20 metres than at all other depth combined" (Kelly and Wolf, 1959).

These assessments of abundance represent the mean conditions over the whole area of occurrence of young S. marinus, and may be compared with Täning's suggestion (1949) of well over half a million per Km.^{2} for the fringes of the area, and a figure of "several million" inferred from Einarsson's results (1960). Both these workers had only limited material from Both these workers had only limited material from the Irminger Sea, and in April and May, so that the June and July figures from the Recorder material are in reasonable agreement. It is thought, however, that the Recorder figures for April and May may be in no respect unrealistic, when the distribution of the catches throughout the half month periods is inspected (see Figure 5). In those parts of the area where the largest numbers were caught in April and May the local abundance has been estimated to be of the order of $100 \text{ to } 120 \times 10^6$ under each Km.^{2} for that time and place. This figure is broadly comparable with the catch of 3795 young in a 10 minute haul with the Petersen young fish trawl in the Denmark Strait in 1903 (Schmidt, quoted by Täning, 1949). It is difficult to estimate the volume of water filtered in this haul, but it seems likely that it represented between 100 and 200×10^6 young Sebastes marinus under each Km.^{2}.

The impression which remains, however, conservatively these speculative assessments of abundance are viewed, is of the presence of extremely

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large numbers of young stages, about which very little information appears to be available at present. In view of the apparent advantage conferred by the viviparous habit of Sebastes, it seems possible that mortality of the early stages may be less serious than it is in fish whose eggs hatch freely in the sea. However, there is a need for careful investigation of Sebastes during the early months of life, both by frequent quantitative sampling at sea and (because it would help to resolve most of the major problems of taxonomy, growth rate, and scale and otolith interpretation) by rearing experiments in laboratory tanks.

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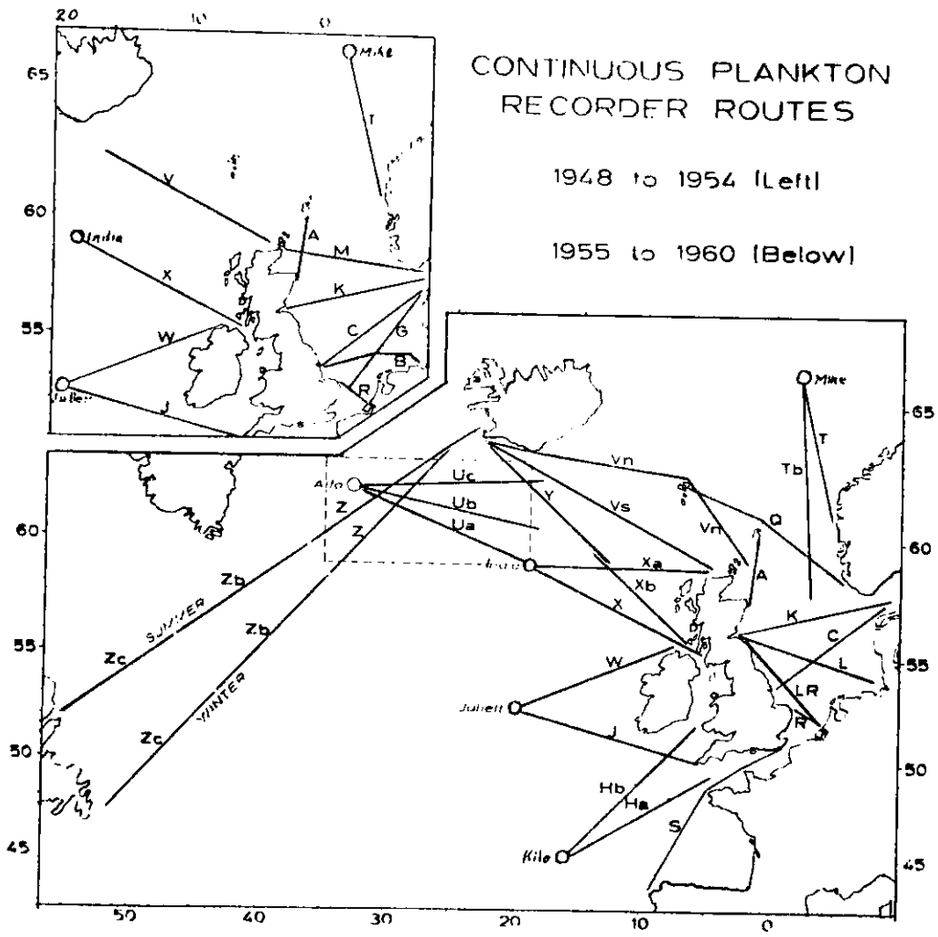

Figure 1. Chart showing the Continuous Plankton Recorder routes available during the years 1948 to 1954 (upper left) and 1955 to 1960. The letters identify the routes, and the phonetic alphabet the weather ship stations. Some routes are alternatives, not always available concurrently. The rectangular area outlined in broken line is that used for comparisons of abundance in different years.

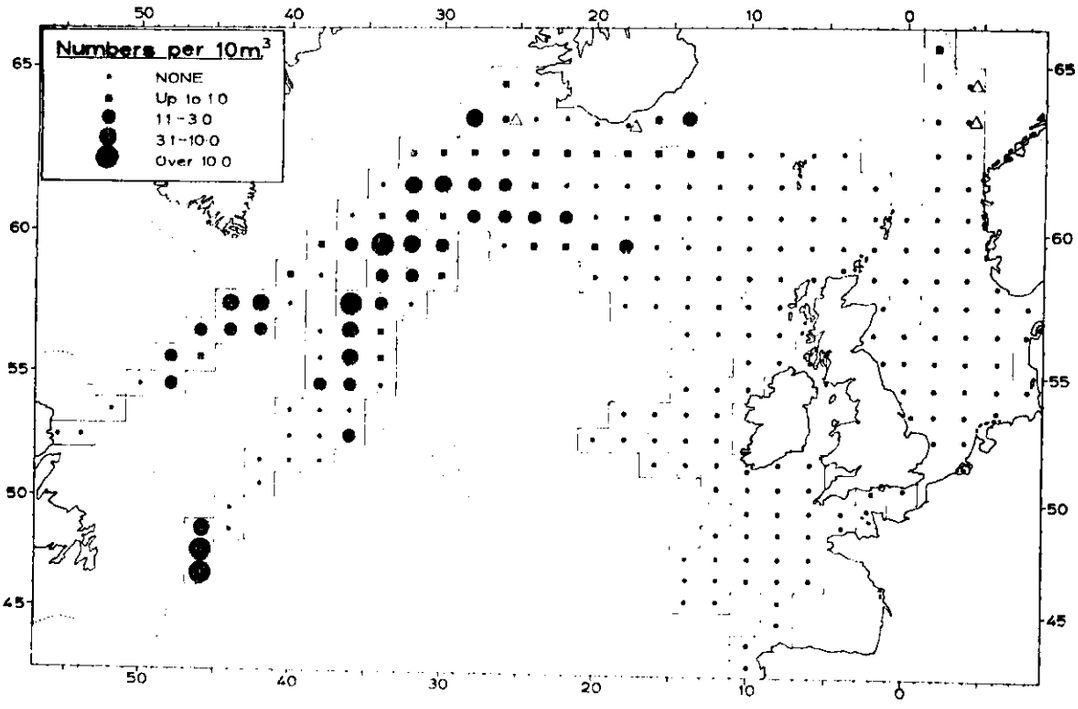

Figure 2. Chart showing the average abundance and distribution of young Sebastes marinus taken by the Continuous Plankton Recorder survey at the depth of 10 metres during the months of April to July in the years 1948 to 1960. The symbols indicate the mean numbers of young stages per $10m^3$ in each statistical rectangle in which samples have been taken. Sampling west of 35°W longitude is limited to 1959 and 1960. The only depth contour shown is that for 1000 fathoms. Occurrences of S. viviparus are shown by open triangles.

Henderson. Sebastes. I.C.N.A.T. 1961.

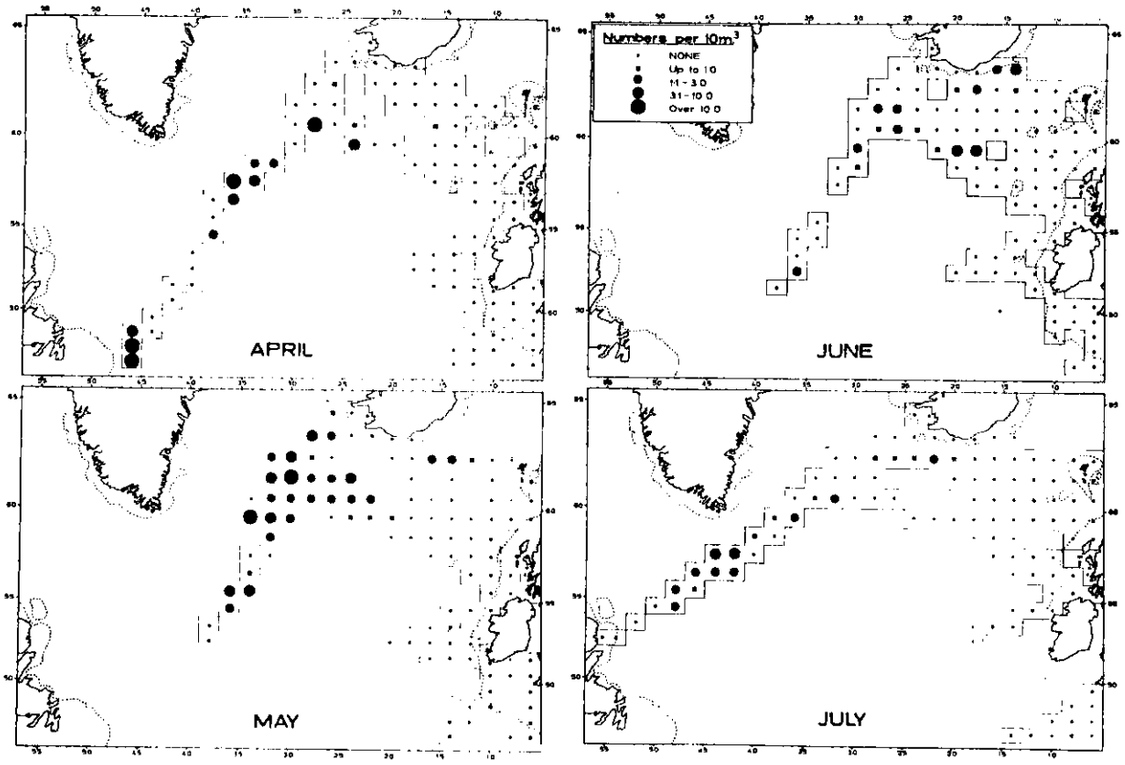

Figure 3. Charts showing the average abundance and distribution of young Sebastes marinus taken by the Continuous Plankton Recorder survey at the depth of 10 metres in each of the months April to July. Results from all the years 1955 to 1960 were combined to construct these charts. The symbols indicate the mean numbers of young stages per $10m^3$ in each statistical rectangle in which samples have been taken. Recorder sampling to the east of 5°W longitude is not shown.

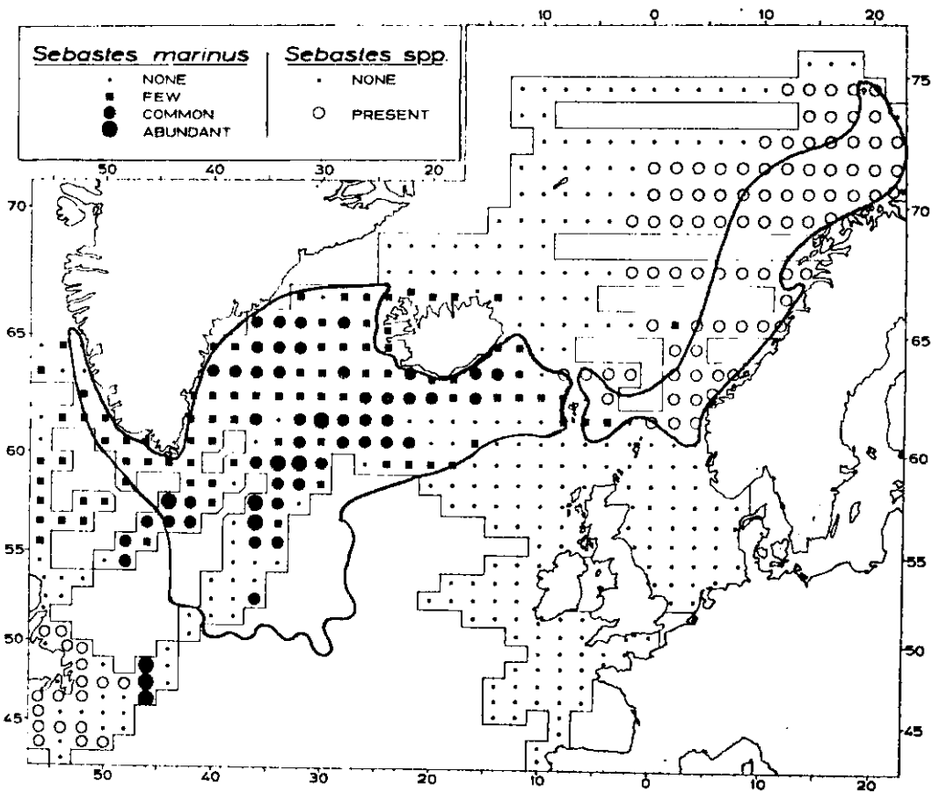

Figure 4. Chart showing the distribution of young stages of Sebastes spp. in north Atlantic and adjacent waters from Newfoundland to the Barents Sea based on all available published material. The solid symbols (based on conversion of results to a commo scale) show S. marinus. The open symbols (no scale of abundance) show Sebastes spp. excluding S. viviparus. Tåning's (1949) plotted area of distribution is shown in outlir

Henderson. Sebastes. I.C.N.A.F. 1961.

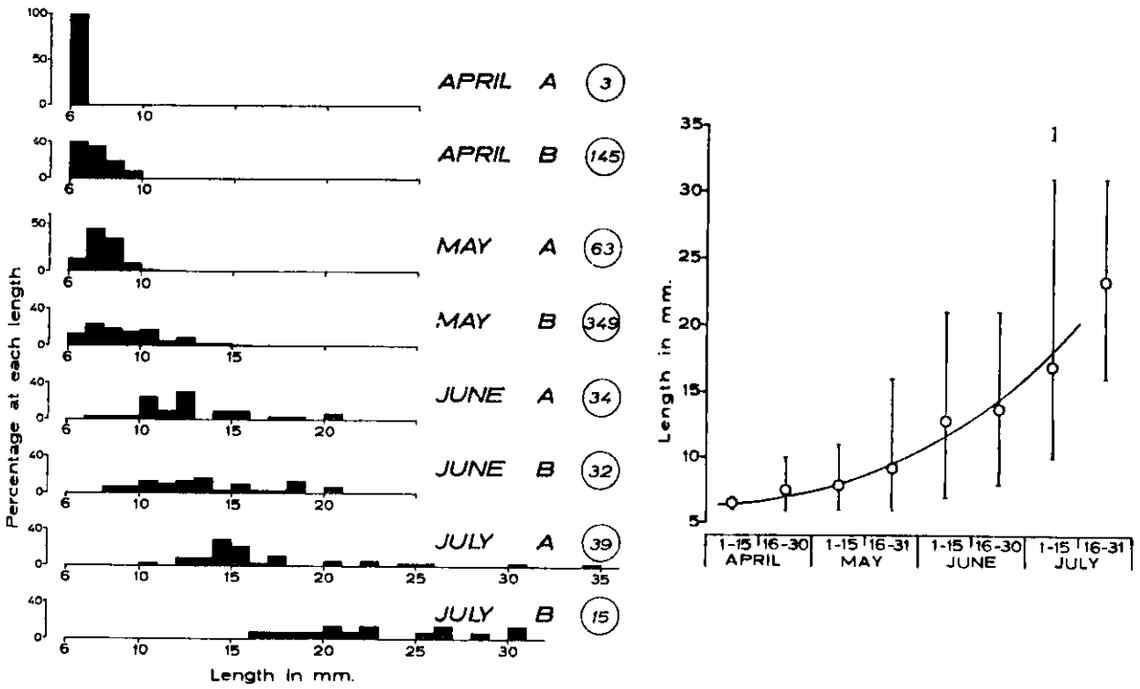

Figure 5. Histograms showing the percentage size composition of all catches of young S. marinus west of the British Isles in each half month period from April to July. The f month periods are indicated as A = 1st to 15th and B = 16th to 30th or 31st.

Figure 6. Graph showing the mean lengths of S. marinus in all Recorder samples in half month periods from April to July. The material from the years 1955 to 1960 was combined to determine the mean length for each period; the range of sizes is indicated by the vertical lines.

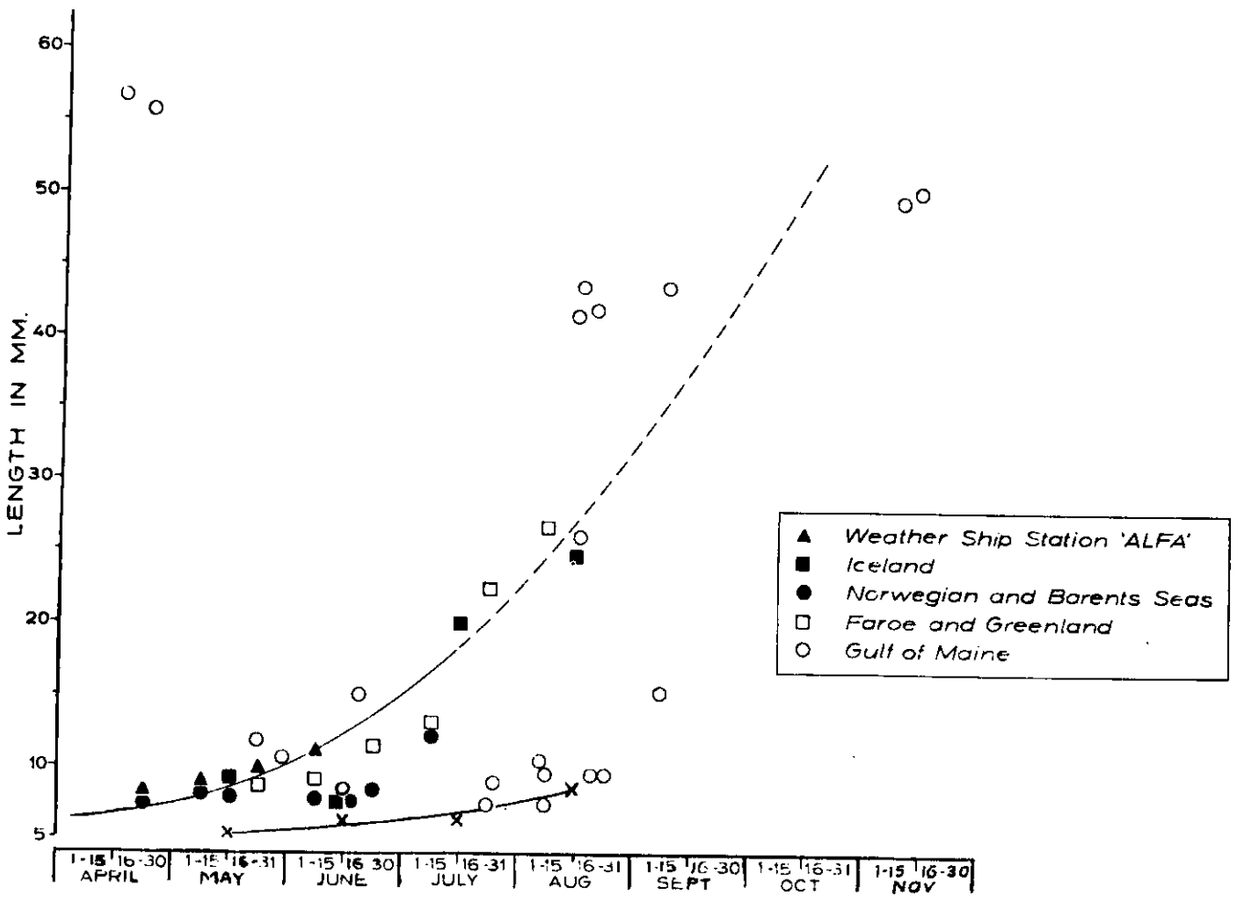

Figure 7. Graph showing the mean lengths of catches of young Sebastes marinus and Sebastes spp. at various dates from all areas from which published information was available. The curve for Recorder catches (Fig. 6) is repeated and extended to conm with other observations later in the season. Different symbols are used to distinguish between various areas, and Einarsson's 'growth curve' for S. viviparus off Iceland is added for comparison (four points shown by crosses for the months May to August).

Henderson. Sebastes. I.C.N.A.F. 1961.