CONSEIL PERMANENT INTERNATIONAL POUR
L'EXPLORATION DE LA MER

EXTRAIT

DU

RAPPORTS ET PROCÈS-VERBAUX, VOL. C, 1936

2.

The Importance of certain Plankton Animals as Indicators of Water Movements in the Western End of the English Channel.

By

F. S. Russell,

Naturalist at the Plymouth Laboratory of the Marine Biological Association.

The use of plankton animals as indicators of water masses has been one of the aims of plankton research for many years. Recently some of the animals which can be used to show the distribution of water masses at the western end of the English Channel have been determined.

A study of the Sagitta population off Plymouth shows that two species, *S. elegans* and *S. setosa*, may be found. At times these species occur together, while at times either one or the other species alone is present. It has now been established that these differences observed off Plymouth are because the two species of Sagitta are characteristic of two distinct water masses.

The periodic changes in the Sagitta population from the year 1930 to the beginning of 1935 are shown in Figure 1. The full details regarding this work have been published (Russell, 1935, b). The diagrams show clearly that the year 1930 was characterised by the predominance of *S. elegans*, and that this species continued to make up a large percentage of the catches until September, 1931, when *S. setosa* started to predominate. This dominance of *S. setosa* has continued up to the end of 1935, except for occasional small incursions of *S. elegans*. From examination of material from the south of Ireland and off the mouth of the Channel, kindly supplied by Mr. G. P. Farran and Dr. J. Le Gall, it was evident that *S. elegans* was characteristic off the mouth of the Channel and that the presence of this species off Plymouth in 1930 and 1931 was due to a large extension of this water into the Channel. This received further support from comparison with data obtained by Dr. J. N. Carruthers on the drift of water through the Straits of Dover. It was shown (Carruthers, 1934) that during 1930 and until August, 1931, the direction of flow had a strong easterly component. This condition then broke down synchronously with the predominance of *S. setosa* off Plymouth, which species has continued to predominate.

The occurrence or absence of *S. elegans* off Plymouth showed also an agreement with the occurrence or absence of dense patches of phytoplankton in the southern North Sea (Savage and Hardy, 1935). When *S. elegans* predominated off Plymouth the diatom patches were slight, but the presence of *S. setosa* off Plymouth coincided with heavy diatom outbursts in the southern North Sea.

The above information suggested that the changes in the Sagitta population off Plymouth were dependent on the strength of flow of Atlantic water into the North Sea from the north, *S. elegans* occurring off Plymouth when that flow was slight (Fig. 2). This agrees with Carruthers' theory that "the Dover Straits current waxes and wanes through the year in a sort of buffer relationship with the current from the north" (Carruthers, 1934).

An examination of the plankton catches taken since 1930 at Plymouth showed that a number of other species were found to be associated with *S. elegans*, and that at times there were other animals which are probably characteristic of Atlantic water coming from the south west past Ushant or of a more southerly distribution than that in which *S. elegans* normally lives. It remained to prove that the distribution of the water masses at the Channel mouth could be clearly shown by an examination of plankton catches. In July, 1935, through the kindness of Col. E. T. Peel a cruise was made in his yacht "St. George" off the mouth of the Channel. The full results of this cruise have been published (Russell, 1936, a). The general distribution of the water masses as inferred from the plankton is shown in Figure 3. The water in which *S. elegans* and its associated fauna lived was distinctly marked off from Channel water, and a tongue of water extending up past Ushant was also indicated by a different plankton content. The differences in the plankton composition of the three types of water were immediately evident as soon as the catches came on board. As a result it is safe to assume that a study

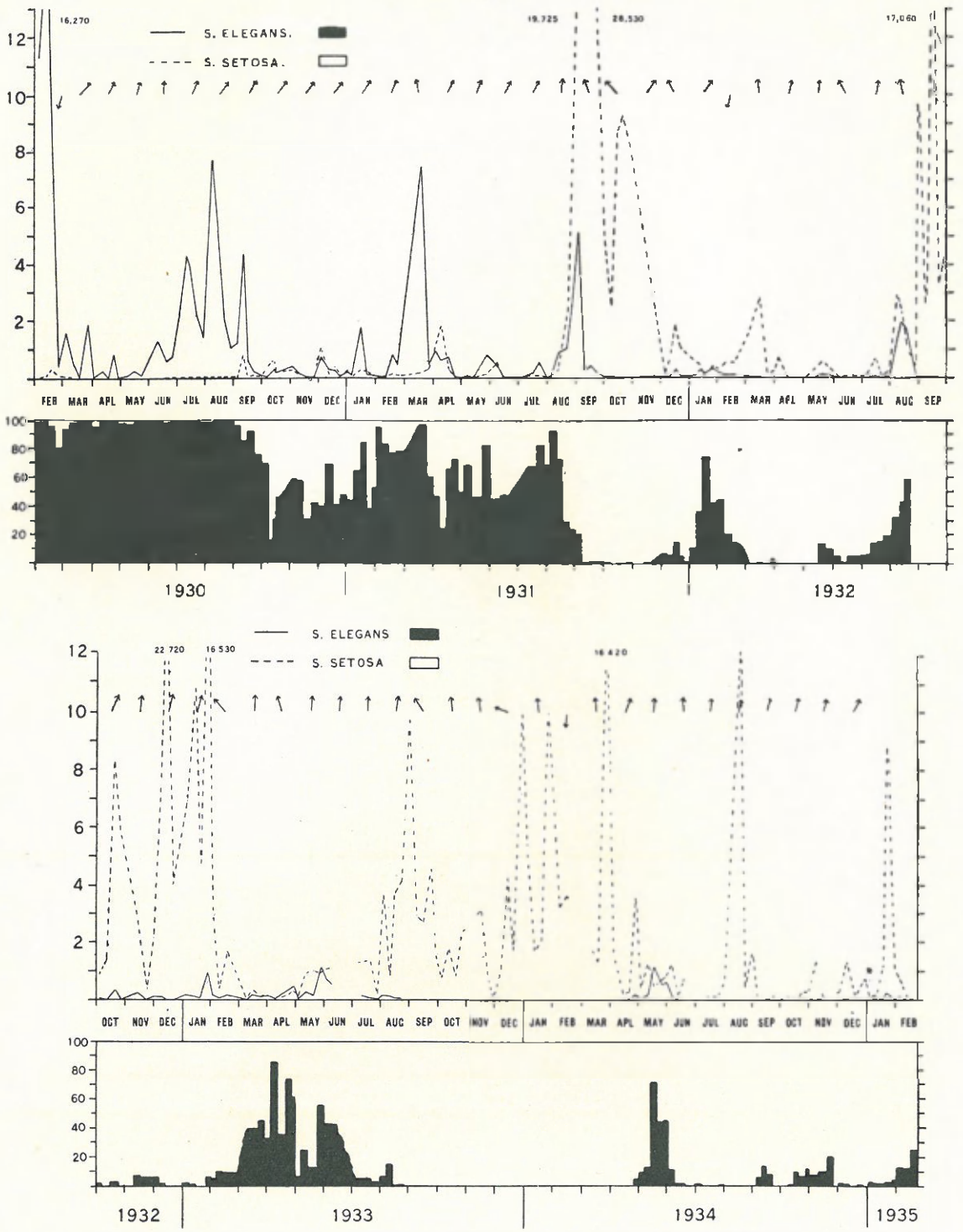

Fig. 1. Above, curves showing the actual abundance of *S. elegans* (———) and *S. setosa* (- - - - -) in half-hour oblique hauls with the 2-metre ring-trawl made usually at weekly intervals during the period February, 1930, to February, 1935. (The numbers are in thousands).
Below, the percentage composition of the Sagitta populations during the same period; *S. elegans*, black; *S. setosa*, white. At the top of the diagrams the arrows indicate the mean direction (true) of flow of water through the Straits of Dover for each month as indicated by the Carruthers' Current Meter working from the Varne Lightship. (After Russell, 1935, b, Figs. 1 & 2).

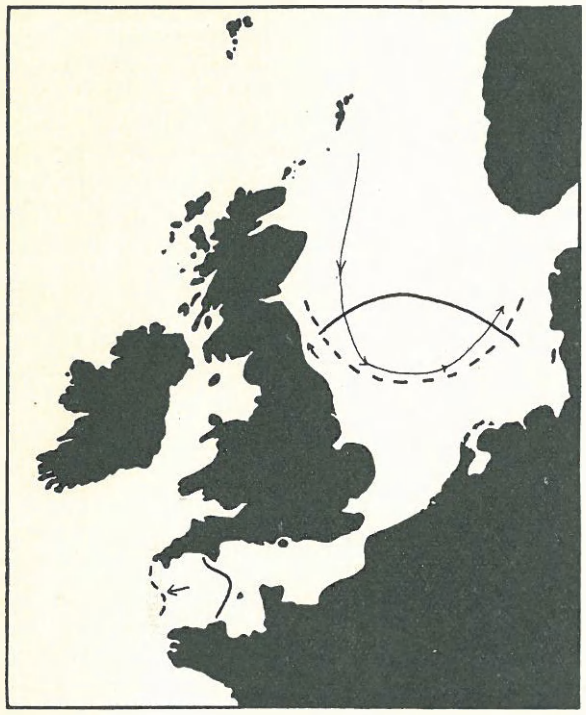

Fig. 2. Chart showing the hypothetical centre of distribution of *Sagitta setosa* in the North Sea and English Channel (unbroken line boundaries) and the change in distribution effected by an increase of flow of water from the north into the North Sea (broken line boundaries). (After Russell, 1935, b, Fig. 6).

of the distribution of certain plankton animals will prove a valuable practical aid in hydrographical work on the water movements at the western end of the Channel.

The salinity changes in the mouth of the Channel have been shown by Harvey (1934) to agree generally with the conditions of flow through the Dover Straits. In this respect it is possible that eventually the plankton indicators may be found to be associated with certain isohalines, but they have the added value that they add definition to the picture by showing up clearly the different bodies of water.

The indicators of use for this purpose are given below:

Atlantic "*elegans*" water. The medusa *Aglantha rosea* and *Cosmetira pilosella* (in summer only), the siphonophore *Stephanomia bijuga*, *Sagitta elegans* and *Sagitta serratodentata* (in years of strong flow into the Channel), the amphipod *Themisto gracilipes*, the pteropod Clione, and Euphausian adults and larvae (when occurring in large numbers). This plankton appears to be very rich in quantity and is of a high fat content.

Channel water. Probably the only true indicator is *Sagitta setosa* when present. The water is also characterised by an absence of the *elegans* indicators, and by a poor plankton content.

?Water south of "*elegans*" water. The medusa Liriope, the Siphonophore Muggiaea, ?Noctiluca, Salps and Doliolids. The indicators of this water need to be worked out in more detail.

The distribution of the water masses as shown by the plankton in July, 1935, (Figure 3) agrees well with what might be expected at certain times from our knowledge of the hydrography of this region. There is a high probability that the *elegans* water is that which is known to be in cyclonic circulation off the south of Ireland (Matthews, 1914; Lumby, 1925; and Harvey, 1930). A more detailed examination of the size of the Sagitta has also shown their value in indicating the movements of water in the Scillies—Land's End region, as it appears that young *S. elegans* may drift off in the surface layers from *elegans* water (Russell, 1936, a).

The changes in the Sagitta population off Plymouth have further shown remarkable agreement with fluctuations in the winter maxima of phosphate present in the water. The years in which *S. setosa*, indicating Channel water, predominate have been characterised by low winter phosphate values, and it appears probable that the *S. elegans* water, enriched by upwelling along the Atlantic slope, may have important effects when it enters the Channel. Agreement has at any rate been shown between the phosphate values and the abundance of young fish off Plymouth (Russell, 1935, a, and 1936, b), and there is the possibility that movements of herring and other fish may be linked with these water changes in the future.

The parallel between the winter maximum of phosphate and the number of young fish in the following year is worth emphasizing. The actual figures are given below (from Russell, 1936, b). The table shows the percentage deviation of the winter maximum each year from the mean phosphate content at E1 for the winters 1923—24 to 1934—35, and the numbers of the young of summer-spawning fish caught in half-hour oblique hauls with the 2-metre stramin ring-trawl expressed as the sums of the monthly average catches. The phosphate values have been determined by Dr. W. R. G. Atkins and Dr. L. H. N. Cooper.

Winter	Phosphate % deviation from mean	Year	Young fish
1923—24	+20	1924	696
1924—25	+ 2	1925	140
1925—26	+29	1926	909
1926—27	— 3	1927	170
1927—28	+17	1928	(no records)
1928—29	+17	1929	321
1929—30	(no records)	1930	403
1930—31	— 6	1931	230
1931—32	—21	1932	197
1932—33	— 9	1933	117
1933—34	—18	1934	79
1934—35	—26	1935	37

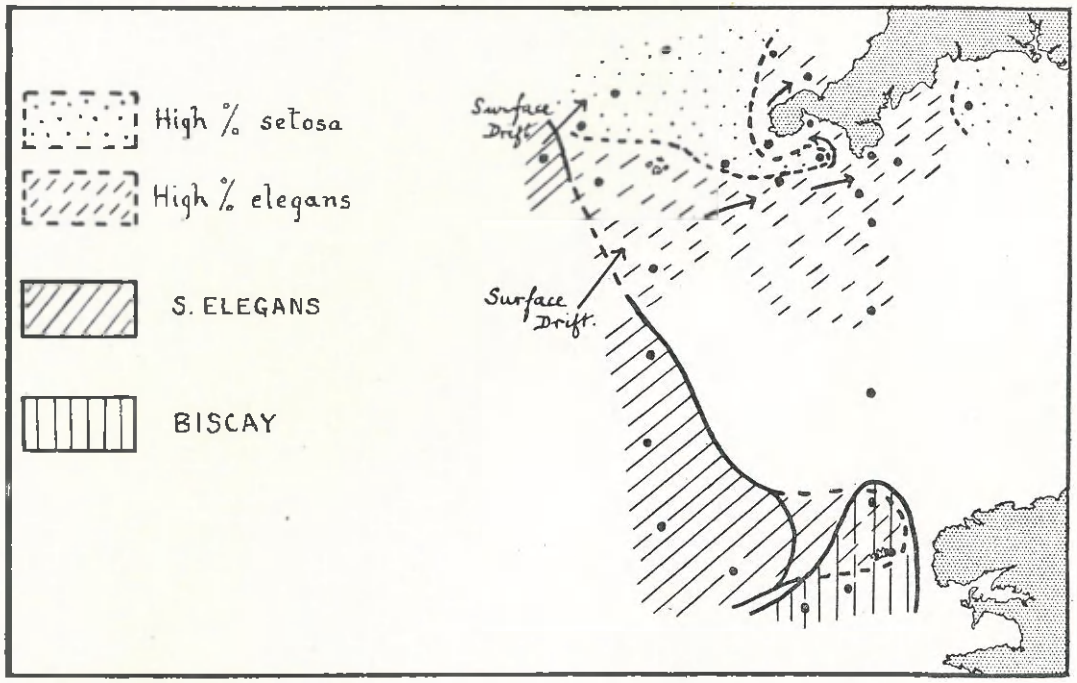

Fig. 3. Distribution of water masses in English Channel mouth region as inferred from collections of plankton made on Col. PEEL's yacht "St. George", July 1935. (After RUSSELL, 1936, a, Fig. 6). The area shown by dots or dashes is that in which a mixture of small individuals of *S. elegans* with *S. setosa* was found.

The only anomaly in this series of observations is the year 1932, when the young fish figure might have been expected to have been lower.

The winter 1929—30 when there were no phosphate records was marked by the presence of *S. elegans* water off Plymouth; if the premises be correct there should therefore have been a high phosphate content which would be in agreement with the large number of young fish in 1930.

References.

CARRUTHERS, J. N. 1934. Certain Fishery Applications of the results of researches on marine currents carried out from the Lowestoft Fisheries Laboratory. British Association Rep. Annual Meeting, 1934, Section D, pp. 325—326.

HARVEY, H. W. 1930. Hydrography of the Mouth of the English Channel, 1925—1928. Jour. Mar. Biol. Assoc., N. S., Vol. XVI, No. 3, pp. 791—820.

— 1934. Hydrography of the Mouth of the English Channel, 1929—1932. *Ibid.* Vol. XIX, No. 2, pp. 737—746.

LUMBY, J. R. 1925. The Salinity and Water Movements in the English Channel and Southern Bight during the Period 1920—1923. Min. Agric. Fish., Fish. Invest., Ser. II, Vol. VII, 1924, pp. 1—37.

MATTHEWS, DONALD J. 1914. The Salinity and Temperature of the Irish Channel and the Waters south of Ireland. Fisheries, Ireland, Sci. Invest., 1913, IV, pp. 1—26.

RUSSELL, F. S. 1935, a. The Seasonal Abundance and Distribution of the Pelagic Young of Teleostean Fishes Caught in the Ring-trawl in Offshore Waters in the Plymouth Area. Part II. Journ. Mar. Biol. Assoc., N. S., Vol. XX, No. 2, pp. 147—179.

— 1935, b. On the Value of Certain Plankton Animals as Indicators of Water Movements in the English Channel and North Sea. *Ibid.*, Vol. XX, No. 2, pp. 309—331.

— 1936, a. Observations on the Distribution of Plankton Animal Indicators made on Col. E. T. Peel's yacht "St. George" in the Mouth of the English Channel, July, 1935. *Ibid.*, Vol. XX, No. 3, pp. 507—522.

— 1936, b. The Seasonal Abundance of the Pelagic Young of Teleostean Fishes in the Plymouth Area. Part III. The year 1935, with a note on the conditions as shown by the occurrence of plankton indicators. *Ibid.*, Vol. XX, No. 3, pp. 595—604.

SAVAGE, R. E., and HARDY, A. C. 1935. Phytoplankton and the Herring, Part I. 1921 to 1932. Min. Agric. Fish., Fish. Invest., Ser. II, Vol. XIV, No. 2, pp.1—73.