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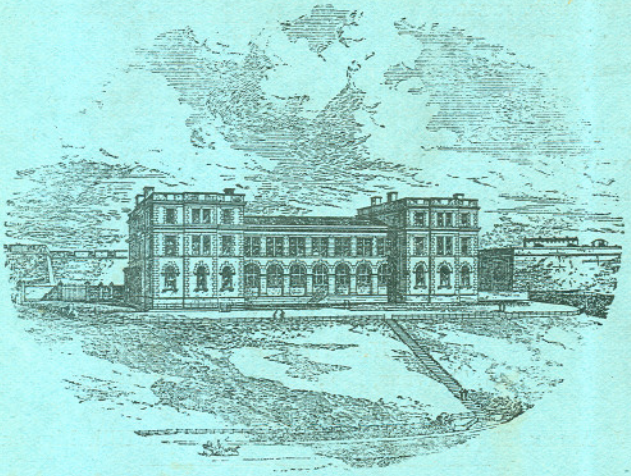

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Plankton Studies in Relation to the Western Mackerel Fishery.

By

G. E. Bullen.

With Six Charts (Plates XVIII–XXIII), two Figures in the Text and Tables I–V.

I. METHODS.

THE researches here described extended for intermittent periods over the years 1906 and 1907, and were primarily intended to embrace inquiry into the food problem of Pilchard, Herring, and Mackerel frequenting the western part of the English Channel. The observations now recorded form, therefore, a part of a wider series.

Most of the information referring to the condition of the fishery throughout the spring season of the two years was collected at Newlyn and Plymouth, by systematic inquiry amongst the fishermen. Other information was derived from the market reports of the *Fish Trades Gazette* and other journals, and from Mr. Mathias Dunn of Newlyn, who kept the fishery constantly under observation.

The samples of plankton and stomach material were obtained from various sources. Some were taken by myself at sea from fishing-boats or from the *Oithona*, others by fishermen; whilst a good deal of the stomach material was got from systematic collections made at Plymouth and Newlyn from catches landed at those ports. In addition to the plankton samples mentioned above, certain samples taken at the western stations during the international cruises were also examined and the results utilized.

The plankton was collected for the most part by a compound tow-net embodying in its construction Swiss bolting silk of two sizes of mesh, viz. (*a*) 18 holes per 1 cm., the average length of a hole being ·056 cm. and the average breadth being ·036 cm., and (*b*) 70 holes per 1 cm. The surface hauls were usually made for ten minutes. The contents of the net were filtered through a net-bag constructed of the fine silk mentioned above, and the product preserved in 5 % formalin.

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In the determination of the plankton samples, a general examination was first made under magnification $\times 48$ and $\times 160$ in a shallow trough. The phytoplankton was subsequently examined under coverslip with higher powers, $\times 520$ to $\times 824$, etc.

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II. THE WESTERN SPRING MACKEREL FISHERY.

THE factors, which influence the inshore migration of mackerel in greater or less abundance, have long been the subject of inquiry. That the purpose of spawning is the primary object of such migration has been admitted, but it still remains to show reasons for the greater or less extent of this migration, which from a commercial standpoint, under the present system of drift fishing, is equivalent to a good, bad, or indifferent season. Many previous authors have shown that

plankton forms the main food of mackerel during the shoaling season, and the examination of more than four hundred stomachs of mackerel taken in the British Channel and extreme western part of the English Channel, during the present investigations (1906–7), has shown agreement with this result. As suggested by several previous authors on the subject, it appears possible that from a study of this food some light may be thrown upon the factors which govern the fluctuations in the mackerel fishery during the spring shoaling season. The object of this paper, therefore, is to show, from the information and observations at our disposal, whether there is a demonstrable correlation between the distribution of plankton or mackerel food, and the extent of migration. It has already been stated that over four hundred stomachs have been examined during the present researches. These were taken in 1906–7 from fish caught in the Bristol Channel and in the English Channel from Plymouth to west of Scilly, during the three months which constitute the more important part of the spring fishery, viz. April, May, and June. The result of the analyses of these stomachs will be found in the Plankton and Food Tables which are appended. From an examination of these tables it will be seen that on no occasion has an instance occurred of material, other than plankton, being observed in the stomachs of fish caught during the shoaling season in the extreme western part of the area under consideration. In the eastern part, however (see Table V), it will be seen that the plankton forming the principal food was gradually supplemented, as the season advanced, with young fish and adult *Crystallogobius nilsoni*.

From information derived from the weekly market reports published in the *Fish Trades Gazette*, and from statements made to me by local fishermen at Plymouth and Newlyn, it would appear that, although drift fishing had been carried on in the Bristol Channel and elsewhere since the beginning of February until April in 1906 and 1907, the catches made were irregular and comparatively small. Fishermen and others agreed in stating that this was due to the fact, that there appeared to be no regular shoaling at the surface during these three months.

That mackerel did occur, however, in the inshore waters at this time at the surface is evinced by the fact that fair catches of hook fish were made constantly during the early months of the two years, as shown by the market reports, and by the writer's personal observations.

Fishermen seem to be agreed that shoaling mackerel will not take a bait: and a consideration of the above facts tends to suggest that in

these early spring months mackerel may be present at the surface but are disseminated over a wide area. A careful comparison of the plankton results for the February cruises, shown in the *Bulletins Conseil International pour l'exploration de la Mer*, shows that, at the western mid-Channel and Bristol Channel stations (E. 5 and E. 6, the only two falling within the fishing area), plankton generally has reached a minimum in comparison with other quarterly results. It is desirable at this point to state that, for the purpose of comparison in this and other cases, an arbitrary numerical value was substituted for the comparative signs employed in the tables, viz. + = 10, c = 100, cc = 500, the signs "r" and "rr" being disregarded. In the present instance comparison was made for all the years since the commencement of the international investigations, and this condition appeared to be invariably the same. This point is further supported by certain observations taken during the present investigations (Nos. 2, 3, 4, 5, 6, Table I).

These two main facts considered together cannot, however, be offered as sufficient evidence that mackerel do not shoal closely at the surface until there is a sufficiency of plankton to form food for their support without much individual effort, especially in view of the fact that mackerel are known to be shoaling densely at the bottom off Start Point in the early part of the year, and, as far as our present observations extend, are feeding there upon plankton. Possibly, however, it may be suggested reservedly that a lack of plankton may exercise a retarding influence upon the shoaling of fish already at the surface, which are disseminated over a wide area, of the presence of which evidence has already been given. Further, attention has already been drawn to the fact that in the Plymouth to Lizard area in 1907 larger food material was observed, in gradually increasing quantity as the season advanced, from the end of April onwards. Throughout July, 1907, from the writer's personal observations, the plankton in the Plymouth area was observed to decrease very materially in quantity. In the previous month, the tow-nettings brought to the Laboratory at Plymouth from within and outside the Sound for the use of students, and for the Plymouth plankton records taken weekly, were composed mainly of *Temora longicornis* in extreme abundance. During the first few days of July, within the first week, the Copepod in question, from being extremely abundant, rapidly disappeared from the tow-nettings, leaving the samples almost clear, for the time being, of animal life. No plankton observations were obtained from the western area during July, 1907; but, confining our attention to the Plymouth to Lizard area, it appeared that from all reports the shoals broke up at about this time and the hand-lining season commenced. It may, therefore, be sug-

gested, that, until individual effort on the part of the fish to secure food becomes necessary, the mackerel remain in shoals.

These results tend to support the theory that mackerel feed upon plankton only when shoaling.

Owing to a certain general similarity in the samples examined, it was found possible to tabulate the results of the analyses of the stomach material. These are given in the Plankton and Food Tables (III, IV, and V) which are appended. From nearly every position noted therein the contents of six stomachs were examined, and, by a system of adopting the highest comparative symbol placed against the different species throughout the series, a single sample was formed. This, in certain instances, is shown for comparison with a plankton sample collected on the same position as that from which the fish themselves were derived.

It has proved convenient to arrange the results in three separate tables, viz. Western Area, 1906; Western Area, 1907; and Plymouth to Lizard Area, 1907. Lack of observation in this latter area in the earlier year has prevented the formation of a separate table for 1906.

It will be seen that only those principal species, which occurred more or less regularly in the stomach contents, have been included in the tables. These comprise seven species of Copepods, viz. *Acartia clausi*, *Calanus finmarchicus*, *Centropages typicus*, *Metridia lucens*, *Paracalanus parvus*, *Pseudocalanus elongatus*, and *Temora longicornis*. An examination of the tables will show that of these species *Calanus finmarchicus*, *Pseudocalanus elongatus*, and *Temora longicornis* are the most important. The other species, although persistently occurring in stomach contents, are hardly of sufficient importance for purposes of comparison.

In addition to the Copepods there are included in the tables, Zoeae, *Sagitta bipunctata* and *Oikopleura dioica*. These species, together with the Copepods, constitute the principal forms of zooplankton observed in the stomach contents.

For the Plymouth to Lizard area it was found necessary to include young fish, or *Crystallogobius*. The last item for consideration, which is noted on every table as "Phytoplankton, chiefly *Phaeocystis globosa*," refers to the material largely found in mackerel stomachs in the early part of the season. This, upon examination, in many instances proved to be diatom detritus, consisting of the shells, spines, chromatophores, and the jelly-like substance associated with them, forming in a majority of cases a glairy mass of a dark green tint.* Associated with this material in a number of instances was a certain quantity of *Phaeocystis*

* For the exact diagnosis of the nature of this material the writer is indebted to Mr. A. J. Mason-Jones.

globosa, the exact proportion of which it was found impossible to gauge. In certain samples, however, owing to the absence of diatoms and other protophyta (Samples 68, 69, 93, 94, Tables III, IV), it was found possible to estimate the amount of *Phaeocystis* with more probability.

It may be mentioned that Cunningham,* in describing the early spring food of mackerel, remarks, "In some [stomachs] there occurred a quantity of the green slimy vegetable matter, which was then abundant in the sea."

During the examination of certain series of stomachs, instances have occurred where the contained food was deposited in layers (Samples Nos. 94, 120, 121, 123, 124, etc., Tables IV, V). Farran (*Report on Sea and Inland Fisheries, Ireland*, 1901, Part II, p. 122) records the same thing, and Mr. W. M. Tattersall informed the writer that he has frequently observed a similar condition in mackerel from the west of Ireland. Such a state of the stomach contents is specially obvious where the Pteropod *Limacina retroversa* (Flem.) occurs together with one or more species of Copepods, the dark colour of the former contrasting sharply with the bright orange tint of the latter. It has often been suggested that certain plankton organisms occur in shoals of varying extent. Now it is interesting to note in this connection, that many fishermen think that shoaling mackerel, when feeding, scarcely move at all, beyond maintaining their position against the current. The theory of the fish feeding, therefore, first in one shoal of plankton organism and then in another as they pass, may be suggested as an explanation of this phenomenon. The fact might also be due to the fish swimming first in one and then in another layer of water.

By an examination of the Food and Plankton Tables it will be seen that the plankton organisms occurring in the stomach contents are common also to tow-nettings taken on the same position. In a majority of cases also, the relative proportions of individual species are similar in both, or nearly so. Occasionally differences occur. But in the examination of the large mass of material which is generally found in a mackerel stomach when plankton is abundant, it is often difficult to decide the comparative proportion of one species to another. This fact, together with that of the method of treatment already explained (see p. 273), will account for the differences which are occasionally shown between the analyses of stomach contents and those of plankton samples from the same locality.

Although, however, certain species occurring in the tow-nettings are

* *Marketable Marine Fishes*, p. 313.

observed in the stomach material of fish from the same position, an exhaustive examination of a fair number of stomach samples has failed to show the presence of the same variety of organisms in the stomach, as occur in the tow-nettings taken on the same positions as the mackerel. Possibly this fact may be offered as additional evidence in support of the food-layer theory already mentioned.

In the early part of April, 1906, as in the two preceding months, an unprofitable fishery had been carried on in the Bristol Channel by the greater number of the steam drifters. From fishermen's reports this condition had, it appeared, continued since the commencement of the season without a single period of improved fishing. On the 20th of April, however, some good shoals were struck to the south-west of the Wolf by the sailing fleet. The greater number of the steam drifters at once left the Bristol Channel and commenced fishing in a semicircle to the south and south-west of Scilly. The result was that moderate but regular catches of ten thousand down were landed from this area, the fishing although light being general. The stomach contents of samples of these fish did not differ very materially from those of Bristol Channel fish (see Samples Nos. 66, 67, Table III).

A line of plankton samples was taken at this time from Plymouth to the fishing area south-west of the Wolf, the chief aim being the determination of the relative quantities of zooplankton and phytoplankton* present on the fishing area and adjacent waters. The analyses of the tow-nettings taken on 23rd and 24th April during this cruise (see Samples Nos. 11–20, Table I) are interesting when viewed in relation to the distribution of shoaling mackerel at the time. Briefly summarized, it appeared that from Plymouth to the Lizard phytoplankton in every example was in excess of zooplankton (Samples Nos. 11, 12, 13, and 20, Table I). In the single position in Mount's Bay where tow-nettings were taken this was also the case (Sample No. 19, Table I), whereas in samples taken, on the approach to the fishing area and actually on the ground (Samples Nos. 14–17), there was a rapid decrease in phytoplankton, leading to a reverse of the former condition, i.e. to an excess of zooplankton over phytoplankton. It may be mentioned that the excess of phytoplankton over zooplankton was largely, though not entirely, due to the presence in the samples of large quantities of *Phaeocystis globosa*, Scherffel.

* Throughout this paper the word "phytoplankton" must be understood as referring to the larger organisms, such as are recorded in the plankton tables of the International Bulletin. No investigations have been made on the minute plankton organisms which Lohmann has included under the term "microplankton."

From a comparison of the tables it will be seen that the reverse condition was not brought about entirely by the decrease of the *Phaeocystis*, but also by the increasing number of the Copepods in the samples.

During this cruise, through lack of time, only one position could be worked in the Bristol Channel (Sample No. 18, Table I), which showed phytoplankton in excess of zooplankton. The same condition was observed in a sample taken at Sevenstones five days later. The positions of the stations on this cruise and the general distribution of samples taken during April, 1906, can be readily understood on reference to the Distribution of Species Chart No. 1.

Throughout the early part of April, 1907, from the fishermen's reports it appeared that fairly regular catches had been landed from the Bristol Channel south-west of the Wolf, and also from twenty to thirty miles S.W. of the Lizard. Many fishermen declared, however, that the water lying within a ten-mile or wider limit from the coast from off Plymouth to Land's End, was in that particular condition which they termed "stinking," and of a most unsuitable condition for the presence of mackerel.*

In order to obtain observations in this affected area, and also to trace the varying proportions of zooplankton and phytoplankton on the fishing ground, a cruise was taken from Plymouth to ten miles S.W. of the Wolf, and from thence to twenty miles north of the Longships, somewhat earlier than in 1906, viz. April 16th, 17th. The analyses of the tow-nettings taken (see Samples Nos. 41–8, Table II) show a somewhat similar condition to that observed in 1906, with certain important exceptions. The main differences lie in the excess of phytoplankton extending farther westward past the Lizard (see Samples Nos. 41–5, Table II). This condition was largely due to *Phaeocystis;* zooplankton occurring in excess of phytoplankton only in the sample taken farthest west, viz. ten miles S.W. of the Wolf (No. 48, Table II). A more important feature, however, appears to lie in the conditions observed in the Bristol Channel samples (Nos. 46, 47, Table II), where zooplankton occurred decidedly in excess of phytoplankton. For a synoptic view of these observations, showing the positions of stations, the reader is referred to Distribution of Species Chart No. IV.

Now in drawing a comparison between the condition exhibited by the plankton and that by the fishery in April 1906 and 1907, it will be seen that in the former year, phytoplankton appearing in excess of zooplankton in the Bristol Channel, the fishery there was unprofitable; whereas the reverse obtaining S.W. of the Wolf, fair catches were

* See note on "Stinking Water," p. 289.

made there. In 1907, on the other hand, zooplankton was in excess of phytoplankton both in the Bristol Channel and also to the S.W. of the Wolf, in both of which areas good fishing was obtained. In considering these observations further, it is interesting to find that the most profitable fishing grounds lay outside the area in which phytoplankton predominated, which suggests that mackerel during the shoaling season prefer an animal to a vegetable diet, and may be met with in quantity where such food is abundant.

Further consideration of the Distribution of Species Charts IV to VI shows wider eastward distribution of shoaling mackerel as the season proceeded in 1907.

An examination of the Plankton Tables Nos. I and II shows, moreover, that throughout the season, during 1906, phytoplankton was always in evidence, whereas in 1907 it entirely disappeared from the beginning of May onward until the close of the season. The official statistics of monthly landings, published by the Board of Agriculture and Fisheries show that the fishery in 1906 was phenomenally bad, whereas that of 1907 was very good.

From these two facts it may be suggested that excess of phytoplankton in inshore waters retards or rather limits the eastern migration of the shoals first appearing west of Scilly.

An examination of the official statistics of mackerel landings serves to show that, in the month of May, the quantity of mackerel caught has reached a maximum for the four months forming the more important part of the spring fishery. The following table shows the figures from 1901–7 inclusive. The figures given represent the landings on the south and west coasts of England and Wales, which are significant for the western fishery, since comparatively few mackerel are taken elsewhere during the months dealt with.

Table showing Official Returns of Mackerel landed on the south and west coasts of England and Wales, from March to June inclusive, in the years 1901–7.

TOTAL IN HUNDREDWEIGHTS.

	1901.	1902.	1903.	1904.	1905.	1906.	1907.
March	23,340	8,145	22,492	78,866	63,570	9,260	18,769
April	39,041	73,384	60,190	62,241	152,972	28,779	43,107
May	169,020	169,857	152,753	199,884	378,157	108,273	222,151
June	70,005	77,889	65,005	108,822	53,215	49,743	57,383

As these figures are taken over a fair number of years it may be assumed that during May, under normal conditions, the fishery is at its height. In May also the maximum number of boats are generally

fishing, and during the latter part of the period considered there is no reason to suppose that the number of boats has greatly altered. The fluctuation, as shown by the official figures, in consideration of the usual fair-weather conditions during this month, is less liable to be influenced by causes other than the greater or less extent of migration.

On reference to the above table it will be seen that in May, 1906, the landings touched a minimum for the seven years; whereas, although the figures in no way compare with those of 1905, the May landings for 1907 are suggestive of a good season. The good May fishing of 1907 as opposed to the bad of 1906 forms a useful comparison when we come to consider plankton conditions of the same period in these two years.

From an examination of the daily market reports published in the *Fish Trades Gazette*, it would appear that in 1906 the fishery was gradually improving throughout May until the last week, when, after a short period of improved conditions, it began rapidly to decline, and remained depressed until the end of the season.

In 1907, from information derived from the same source, and from observations taken at Newlyn by Mr. W. Bygrave, it appeared that heavy landings of mackerel took place during the first and second weeks in May. The market was several times glutted; and there is every reason to suppose that, had not a short spell of bad weather intervened, in which the men temporarily lost sight of the shoals, the landings would have been considerably greater than they appear to be from the official statistics. However, despite the unfavourable comparison between the figures for May, 1905, and those of 1907, from all accounts there is every reason to consider the latter year to have been an excellent season.

In reviewing the plankton conditions generally, it should first be pointed out that throughout May, 1906, phytoplankton was present in fair quantity in every sample taken during the month on the fishing grounds (see Table I). In 1907, on the other hand, it had almost completely disappeared, and as may be seen from the Plankton Tables (Table II), zooplankton was represented by merely a few species of Copepods in extreme abundance. The comparative symbol "cc" shown on the tables for certain samples (Nos. 52, 53, 54, 55) hardly sufficiently indicates the large quantities of the species occurring in the sample.

In comparing the plankton conditions during May of these two years, it may be mentioned that a far greater number of observations were taken in 1907 than in 1906. It is desirable, therefore, in draw-

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II. THE WESTERN SPRING MACKEREL FISHERY.

THE factors, which influence the inshore migration of mackerel in greater or less abundance, have long been the subject of inquiry. That the purpose of spawning is the primary object of such migration has been admitted, but it still remains to show reasons for the greater or less extent of this migration, which from a commercial standpoint, under the present system of drift fishing, is equivalent to a good, bad, or indifferent season. Many previous authors have shown that

plankton forms the main food of mackerel during the shoaling season, and the examination of more than four hundred stomachs of mackerel taken in the British Channel and extreme western part of the English Channel, during the present investigations (1906–7), has shown agreement with this result. As suggested by several previous authors on the subject, it appears possible that from a study of this food some light may be thrown upon the factors which govern the fluctuations in the mackerel fishery during the spring shoaling season. The object of this paper, therefore, is to show, from the information and observations at our disposal, whether there is a demonstrable correlation between the distribution of plankton or mackerel food, and the extent of migration. It has already been stated that over four hundred stomachs have been examined during the present researches. These were taken in 1906–7 from fish caught in the Bristol Channel and in the English Channel from Plymouth to west of Scilly, during the three months which constitute the more important part of the spring fishery, viz. April, May, and June. The result of the analyses of these stomachs will be found in the Plankton and Food Tables which are appended. From an examination of these tables it will be seen that on no occasion has an instance occurred of material, other than plankton, being observed in the stomachs of fish caught during the shoaling season in the extreme western part of the area under consideration. In the eastern part, however (see Table V), it will be seen that the plankton forming the principal food was gradually supplemented, as the season advanced, with young fish and adult *Crystallogobius nilsoni*.

From information derived from the weekly market reports published in the *Fish Trades Gazette*, and from statements made to me by local fishermen at Plymouth and Newlyn, it would appear that, although drift fishing had been carried on in the Bristol Channel and elsewhere since the beginning of February until April in 1906 and 1907, the catches made were irregular and comparatively small. Fishermen and others agreed in stating that this was due to the fact, that there appeared to be no regular shoaling at the surface during these three months.

That mackerel did occur, however, in the inshore waters at this time at the surface is evinced by the fact that fair catches of hook fish were made constantly during the early months of the two years, as shown by the market reports, and by the writer's personal observations.

Fishermen seem to be agreed that shoaling mackerel will not take a bait: and a consideration of the above facts tends to suggest that in

these early spring months mackerel may be present at the surface but are disseminated over a wide area. A careful comparison of the plankton results for the February cruises, shown in the *Bulletins Conseil International pour l'exploration de la Mer*, shows that, at the western mid-Channel and Bristol Channel stations (E. 5 and E. 6, the only two falling within the fishing area), plankton generally has reached a minimum in comparison with other quarterly results. It is desirable at this point to state that, for the purpose of comparison in this and other cases, an arbitrary numerical value was substituted for the comparative signs employed in the tables, viz. + = 10, c = 100, cc = 500, the signs "r" and "rr" being disregarded. In the present instance comparison was made for all the years since the commencement of the international investigations, and this condition appeared to be invariably the same. This point is further supported by certain observations taken during the present investigations (Nos. 2, 3, 4, 5, 6, Table I).

These two main facts considered together cannot, however, be offered as sufficient evidence that mackerel do not shoal closely at the surface until there is a sufficiency of plankton to form food for their support without much individual effort, especially in view of the fact that mackerel are known to be shoaling densely at the bottom off Start Point in the early part of the year, and, as far as our present observations extend, are feeding there upon plankton. Possibly, however, it may be suggested reservedly that a lack of plankton may exercise a retarding influence upon the shoaling of fish already at the surface, which are disseminated over a wide area, of the presence of which evidence has already been given. Further, attention has already been drawn to the fact that in the Plymouth to Lizard area in 1907 larger food material was observed, in gradually increasing quantity as the season advanced, from the end of April onwards. Throughout July, 1907, from the writer's personal observations, the plankton in the Plymouth area was observed to decrease very materially in quantity. In the previous month, the tow-nettings brought to the Laboratory at Plymouth from within and outside the Sound for the use of students, and for the Plymouth plankton records taken weekly, were composed mainly of *Temora longicornis* in extreme abundance. During the first few days of July, within the first week, the Copepod in question, from being extremely abundant, rapidly disappeared from the tow-nettings, leaving the samples almost clear, for the time being, of animal life. No plankton observations were obtained from the western area during July, 1907; but, confining our attention to the Plymouth to Lizard area, it appeared that from all reports the shoals broke up at about this time and the hand-lining season commenced. It may, therefore, be sug-

gested, that, until individual effort on the part of the fish to secure food becomes necessary, the mackerel remain in shoals.

These results tend to support the theory that mackerel feed upon plankton only when shoaling.

Owing to a certain general similarity in the samples examined, it was found possible to tabulate the results of the analyses of the stomach material. These are given in the Plankton and Food Tables (III, IV, and V) which are appended. From nearly every position noted therein the contents of six stomachs were examined, and, by a system of adopting the highest comparative symbol placed against the different species throughout the series, a single sample was formed. This, in certain instances, is shown for comparison with a plankton sample collected on the same position as that from which the fish themselves were derived.

It has proved convenient to arrange the results in three separate tables, viz. Western Area, 1906; Western Area, 1907; and Plymouth to Lizard Area, 1907. Lack of observation in this latter area in the earlier year has prevented the formation of a separate table for 1906.

It will be seen that only those principal species, which occurred more or less regularly in the stomach contents, have been included in the tables. These comprise seven species of Copepods, viz. *Acartia clausi*, *Calanus finmarchicus*, *Centropages typicus*, *Metridia lucens*, *Paracalanus parvus*, *Pseudocalanus elongatus*, and *Temora longicornis*. An examination of the tables will show that of these species *Calanus finmarchicus*, *Pseudocalanus elongatus*, and *Temora longicornis* are the most important. The other species, although persistently occurring in stomach contents, are hardly of sufficient importance for purposes of comparison.

In addition to the Copepods there are included in the tables, Zoeae, *Sagitta bipunctata* and *Oikopleura dioica*. These species, together with the Copepods, constitute the principal forms of zooplankton observed in the stomach contents.

For the Plymouth to Lizard area it was found necessary to include young fish, or *Crystallogobius*. The last item for consideration, which is noted on every table as "Phytoplankton, chiefly *Phaeocystis globosa*," refers to the material largely found in mackerel stomachs in the early part of the season. This, upon examination, in many instances proved to be diatom detritus, consisting of the shells, spines, chromatophores, and the jelly-like substance associated with them, forming in a majority of cases a glairy mass of a dark green tint.* Associated with this material in a number of instances was a certain quantity of *Phaeocystis*

* For the exact diagnosis of the nature of this material the writer is indebted to Mr. A. J. Mason-Jones.

globosa, the exact proportion of which it was found impossible to gauge. In certain samples, however, owing to the absence of diatoms and other protophyta (Samples 68, 69, 93, 94, Tables III, IV), it was found possible to estimate the amount of *Phaeocystis* with more probability.

It may be mentioned that Cunningham,* in describing the early spring food of mackerel, remarks, "In some [stomachs] there occurred a quantity of the green slimy vegetable matter, which was then abundant in the sea."

During the examination of certain series of stomachs, instances have occurred where the contained food was deposited in layers (Samples Nos. 94, 120, 121, 123, 124, etc., Tables IV, V). Farran (*Report on Sea and Inland Fisheries, Ireland*, 1901, Part II, p. 122) records the same thing, and Mr. W. M. Tattersall informed the writer that he has frequently observed a similar condition in mackerel from the west of Ireland. Such a state of the stomach contents is specially obvious where the Pteropod *Limacina retroversa* (Flem.) occurs together with one or more species of Copepods, the dark colour of the former contrasting sharply with the bright orange tint of the latter. It has often been suggested that certain plankton organisms occur in shoals of varying extent. Now it is interesting to note in this connection, that many fishermen think that shoaling mackerel, when feeding, scarcely move at all, beyond maintaining their position against the current. The theory of the fish feeding, therefore, first in one shoal of plankton organism and then in another as they pass, may be suggested as an explanation of this phenomenon. The fact might also be due to the fish swimming first in one and then in another layer of water.

By an examination of the Food and Plankton Tables it will be seen that the plankton organisms occurring in the stomach contents are common also to tow-nettings taken on the same position. In a majority of cases also, the relative proportions of individual species are similar in both, or nearly so. Occasionally differences occur. But in the examination of the large mass of material which is generally found in a mackerel stomach when plankton is abundant, it is often difficult to decide the comparative proportion of one species to another. This fact, together with that of the method of treatment already explained (see p. 273), will account for the differences which are occasionally shown between the analyses of stomach contents and those of plankton samples from the same locality.

Although, however, certain species occurring in the tow-nettings are

* *Marketable Marine Fishes*, p. 313.

observed in the stomach material of fish from the same position, an exhaustive examination of a fair number of stomach samples has failed to show the presence of the same variety of organisms in the stomach, as occur in the tow-nettings taken on the same positions as the mackerel. Possibly this fact may be offered as additional evidence in support of the food-layer theory already mentioned.

In the early part of April, 1906, as in the two preceding months, an unprofitable fishery had been carried on in the Bristol Channel by the greater number of the steam drifters. From fishermen's reports this condition had, it appeared, continued since the commencement of the season without a single period of improved fishing. On the 20th of April, however, some good shoals were struck to the south-west of the Wolf by the sailing fleet. The greater number of the steam drifters at once left the Bristol Channel and commenced fishing in a semicircle to the south and south-west of Scilly. The result was that moderate but regular catches of ten thousand down were landed from this area, the fishing although light being general. The stomach contents of samples of these fish did not differ very materially from those of Bristol Channel fish (see Samples Nos. 66, 67, Table III).

A line of plankton samples was taken at this time from Plymouth to the fishing area south-west of the Wolf, the chief aim being the determination of the relative quantities of zooplankton and phytoplankton* present on the fishing area and adjacent waters. The analyses of the tow-nettings taken on 23rd and 24th April during this cruise (see Samples Nos. 11–20, Table I) are interesting when viewed in relation to the distribution of shoaling mackerel at the time. Briefly summarized, it appeared that from Plymouth to the Lizard phytoplankton in every example was in excess of zooplankton (Samples Nos. 11, 12, 13, and 20, Table I). In the single position in Mount's Bay where tow-nettings were taken this was also the case (Sample No. 19, Table I), whereas in samples taken, on the approach to the fishing area and actually on the ground (Samples Nos. 14–17), there was a rapid decrease in phytoplankton, leading to a reverse of the former condition, i.e. to an excess of zooplankton over phytoplankton. It may be mentioned that the excess of phytoplankton over zooplankton was largely, though not entirely, due to the presence in the samples of large quantities of *Phaeocystis globosa*, Scherffel.

* Throughout this paper the word "phytoplankton" must be understood as referring to the larger organisms, such as are recorded in the plankton tables of the International Bulletin. No investigations have been made on the minute plankton organisms which Lohmann has included under the term "microplankton."

From a comparison of the tables it will be seen that the reverse condition was not brought about entirely by the decrease of the *Phaeocystis*, but also by the increasing number of the Copepods in the samples.

During this cruise, through lack of time, only one position could be worked in the Bristol Channel (Sample No. 18, Table I), which showed phytoplankton in excess of zooplankton. The same condition was observed in a sample taken at Sevenstones five days later. The positions of the stations on this cruise and the general distribution of samples taken during April, 1906, can be readily understood on reference to the Distribution of Species Chart No. 1.

Throughout the early part of April, 1907, from the fishermen's reports it appeared that fairly regular catches had been landed from the Bristol Channel south-west of the Wolf, and also from twenty to thirty miles S.W. of the Lizard. Many fishermen declared, however, that the water lying within a ten-mile or wider limit from the coast from off Plymouth to Land's End, was in that particular condition which they termed "stinking," and of a most unsuitable condition for the presence of mackerel.*

In order to obtain observations in this affected area, and also to trace the varying proportions of zooplankton and phytoplankton on the fishing ground, a cruise was taken from Plymouth to ten miles S.W. of the Wolf, and from thence to twenty miles north of the Longships, somewhat earlier than in 1906, viz. April 16th, 17th. The analyses of the tow-nettings taken (see Samples Nos. 41–8, Table II) show a somewhat similar condition to that observed in 1906, with certain important exceptions. The main differences lie in the excess of phytoplankton extending farther westward past the Lizard (see Samples Nos. 41–5, Table II). This condition was largely due to *Phaeocystis;* zooplankton occurring in excess of phytoplankton only in the sample taken farthest west, viz. ten miles S.W. of the Wolf (No. 48, Table II). A more important feature, however, appears to lie in the conditions observed in the Bristol Channel samples (Nos. 46, 47, Table II), where zooplankton occurred decidedly in excess of phytoplankton. For a synoptic view of these observations, showing the positions of stations, the reader is referred to Distribution of Species Chart No. IV.

Now in drawing a comparison between the condition exhibited by the plankton and that by the fishery in April 1906 and 1907, it will be seen that in the former year, phytoplankton appearing in excess of zooplankton in the Bristol Channel, the fishery there was unprofitable; whereas the reverse obtaining S.W. of the Wolf, fair catches were

* See note on "Stinking Water," p. 289.

made there. In 1907, on the other hand, zooplankton was in excess of phytoplankton both in the Bristol Channel and also to the S.W. of the Wolf, in both of which areas good fishing was obtained. In considering these observations further, it is interesting to find that the most profitable fishing grounds lay outside the area in which phytoplankton predominated, which suggests that mackerel during the shoaling season prefer an animal to a vegetable diet, and may be met with in quantity where such food is abundant.

Further consideration of the Distribution of Species Charts IV to VI shows wider eastward distribution of shoaling mackerel as the season proceeded in 1907.

An examination of the Plankton Tables Nos. I and II shows, moreover, that throughout the season, during 1906, phytoplankton was always in evidence, whereas in 1907 it entirely disappeared from the beginning of May onward until the close of the season. The official statistics of monthly landings, published by the Board of Agriculture and Fisheries show that the fishery in 1906 was phenomenally bad, whereas that of 1907 was very good.

From these two facts it may be suggested that excess of phytoplankton in inshore waters retards or rather limits the eastern migration of the shoals first appearing west of Scilly.

An examination of the official statistics of mackerel landings serves to show that, in the month of May, the quantity of mackerel caught has reached a maximum for the four months forming the more important part of the spring fishery. The following table shows the figures from 1901–7 inclusive. The figures given represent the landings on the south and west coasts of England and Wales, which are significant for the western fishery, since comparatively few mackerel are taken elsewhere during the months dealt with.

Table showing Official Returns of Mackerel landed on the south and west coasts of England and Wales, from March to June inclusive, in the years 1901–7.

TOTAL IN HUNDREDWEIGHTS.

	1901.	1902.	1903.	1904.	1905.	1906.	1907.
March	23,340	8,145	22,492	78,866	63,570	9,260	18,769
April	39,041	73,384	60,190	62,241	152,972	28,779	43,107
May	169,020	169,857	152,753	199,884	378,157	108,273	222,151
June	70,005	77,889	65,005	108,822	53,215	49,743	57,383

As these figures are taken over a fair number of years it may be assumed that during May, under normal conditions, the fishery is at its height. In May also the maximum number of boats are generally

fishing, and during the latter part of the period considered there is no reason to suppose that the number of boats has greatly altered. The fluctuation, as shown by the official figures, in consideration of the usual fair-weather conditions during this month, is less liable to be influenced by causes other than the greater or less extent of migration.

On reference to the above table it will be seen that in May, 1906, the landings touched a minimum for the seven years; whereas, although the figures in no way compare with those of 1905, the May landings for 1907 are suggestive of a good season. The good May fishing of 1907 as opposed to the bad of 1906 forms a useful comparison when we come to consider plankton conditions of the same period in these two years.

From an examination of the daily market reports published in the *Fish Trades Gazette*, it would appear that in 1906 the fishery was gradually improving throughout May until the last week, when, after a short period of improved conditions, it began rapidly to decline, and remained depressed until the end of the season.

In 1907, from information derived from the same source, and from observations taken at Newlyn by Mr. W. Bygrave, it appeared that heavy landings of mackerel took place during the first and second weeks in May. The market was several times glutted; and there is every reason to suppose that, had not a short spell of bad weather intervened, in which the men temporarily lost sight of the shoals, the landings would have been considerably greater than they appear to be from the official statistics. However, despite the unfavourable comparison between the figures for May, 1905, and those of 1907, from all accounts there is every reason to consider the latter year to have been an excellent season.

In reviewing the plankton conditions generally, it should first be pointed out that throughout May, 1906, phytoplankton was present in fair quantity in every sample taken during the month on the fishing grounds (see Table I). In 1907, on the other hand, it had almost completely disappeared, and as may be seen from the Plankton Tables (Table II), zooplankton was represented by merely a few species of Copepods in extreme abundance. The comparative symbol "cc" shown on the tables for certain samples (Nos. 52, 53, 54, 55) hardly sufficiently indicates the large quantities of the species occurring in the sample.

In comparing the plankton conditions during May of these two years, it may be mentioned that a far greater number of observations were taken in 1907 than in 1906. It is desirable, therefore, in draw-

ing a close comparison, to consider only such observations as are common to the two years. These are furnished by the analyses of plankton samples taken at the mid-Channel and Bristol Channel stations (Stats. E. 5 and E. 6) during the May cruises of the International Plankton Investigations.

By the same method of comparison as adopted for other similar cases (see page 272) a curve was formed, showing the fluctuation of the principal zooplankton forming mackerel food. This curve (Fig. 1)

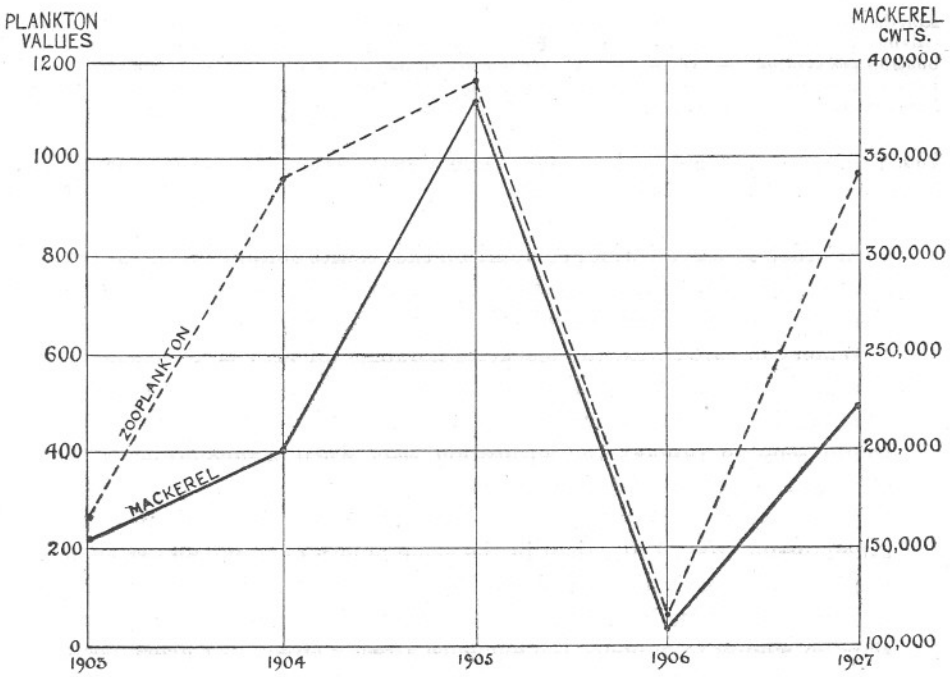


FIG. 1.—Curves showing, for the month of May, fluctuations in the quantities of mackerel landed, and of zooplankton observed at Stations E. 5 and E. 6.

Zooplankton: mean between Stations E. 5 and E. 6 for May—Dotted line.
Mackerel landed during May—Continuous line.

shows the results of a mean between the analyses of the samples taken in surface hauls at the two stations, the following species only being taken into consideration: *Acartia clausi*, *Calanus finmarchicus*, *Centropages typicus*, *Paracalanus parvus*, and *Pseudocalanus elongatus*.

TABLE SHOWING FLUCTUATION OF PRINCIPAL ZOOPLANKTON AT STATIONS E. 5 AND E. 6.

MAY CRUISES. YEARS 1903–7 INCLUSIVE. SURFACE HAULS ONLY.

FROM THE INTERNATIONAL BULLETINS.

The first column shows the comparative value sign, the second the adopted numerical value.

	1903				1904				1905				1906				1907			
	E.	5	E.	6	E.	5	E.	6	E	5	E.	6	E.	5	E.	6	E.	5	E.	6
Species.																				
Acartia clausi .	–	–	c	100	–	–	c	100	r	–	+	10	rr	–	r	–	c	100	cc	500
Calanus finmarchicus	c	100	c	100	cc	500	cc	500	cc	500	c	100	+	10	rr	–	cc	500	c	100
Centropages typicus	+	10	–	–	r	–	+	10	cc	500	rr	–	–	–	–	–	c	100	c	100
Paracalanus parvus	r	–	r	–	c	100	c	100	c	100	cc	500	+	10	rr	–	+	10	r	–
Pseudocalanus elongatus	c	100	c	100	c	100	cc	500	c	100	cc	500	c	100	rr	–	cc	500	+	10
Total num. value .	210		300		700		1210		1200		1110		120		0		1210		710,	
Mean value . .	255				955				1155				60				960			

In order to form a wider comparison the results obtained from all the May cruises since the commencement of the International Investigations in 1903 have been included in the present curve.

When compared with the mackerel landings for May as provided by the official statistics, it will be seen that the correlation between fluctuation of zooplankton and that of the fishery is very marked. This would tend to support the suggestion that when zooplankton is in abundance on the fishing grounds mackerel are numerous.

As already mentioned many more plankton observations were taken during May, 1907, than in the same month of 1906, and as such were actually derived from the fishing area, west and south-west of Scilly (see Samples Nos. 52–55, Table II), they are of value, tending as they do wholly to support the evidence already cited. At every position within the fishing area the samples taken during a ten-minute surface haul were bulky, being composed for the greater part of two or three species of Copepods, viz. *Acartia clausi*, *Calanus finmarchicus*, and *Pseudocalanus elongatus*, the two latter more particularly, to the almost complete exclusion of other organisms. At one position west of Scilly (S. 52, Table IV), a ten-minute surface tow-netting more than half filled a sample jar of capacity approximately 300 cc. with these two species, in comparatively even proportion. In connection with this fact it may be mentioned that a steam drifter fishing ten miles west of this position on the same night (May 16, 17) landed four lasts of fish at Newlyn the next morning.

It is perhaps unnecessary to cite further instances of a similar character. The Food and Plankton Tables and Fluctuation Curve

speak for themselves in support of the theory that the quantity of zooplankton occurring on the fishing grounds materially affects the fishing; the more food the more fish, and *vice versa*.

Before leaving the consideration of the present matter, it is desirable to draw attention to the relation of phytoplankton to zooplankton during May, for the years 1903–7 inclusive. This can best be done by an examination of a curve showing the fluctuation of phytoplankton at the same stations and formed by the same method (Fig. 2).

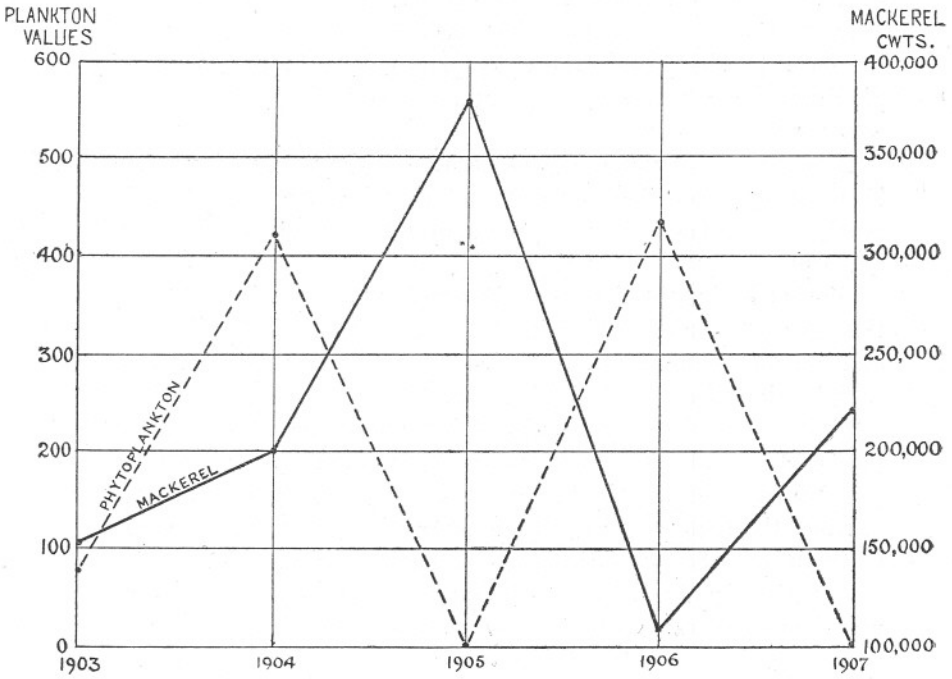


FIG. 2.—Curves showing, for the month of May, fluctuations in the quantities of mackerel landed and of phytoplankton observed at Stations E. 5. and E. 6.

Phytoplankton: mean between Stations E. 5 and E. 6 for May—Dotted line.
Mackerel landed during May—Continuous line.

In the present example, however, it was found necessary to take every species of phytoplankton into consideration. In this it will be seen there appears to be almost a direct inversion of the zooplankton curve. There is an exception, however, in 1903, in which year plankton generally is low.

We have seen that there appears to exist a marked correlation between fluctuation of zooplankton and that of the fishery. It will be admitted that the fluctuation of zooplankton need not necessarily entail

a diametrically opposite fluctuation of phytoplankton, but we shall not here attempt to discuss the causes which promote paucity or abundance of phytoplankton.

But little is known at present of the food of Copepods, and the inversion of the phytoplankton curve in comparison with that of zooplankton cannot be offered in any way as evidence that Diatoms, Peridiniales, and other comparatively large protophyta taken in tow-nettings are the food of Copepods. Therefore the paucity of phytoplankton correlating to a large extent with the abundance of mackerel (Fig. 2) need not at present be considered as other than additional evidence to show that where zooplankton is in excess of phytoplankton mackerel are more numerous—the subject of a former paragraph.

Briefly now to summarize the results of the present investigations. The following considerations are submitted as forming the principal points of correlation between the plankton and mackerel during 1906 and 1907.

(i) That during the three months forming the more important part of the spring mackerel fishing in the west part of the English Channel and Bristol Channel, viz. April, May, and June, mackerel appear to feed for the greater part on plankton.

(ii) That the plankton organisms observed in the stomach contents of mackerel are also to be found in tow-nettings taken on the same position from whence the fish are derived. Further, that in a majority of cases, the relative quantities or proportions of such species are also common to both tow-nettings and stomach samples.

(iii) That in April of the two years under present consideration, where zooplankton was in excess of phytoplankton mackerel were more numerous.

(iv) That the abundance or paucity of zooplankton during a certain number of years (1903–7) appears to be correlated with the greater or less abundance of mackerel.

III. THE "START" MACKEREL FISHERY.

I. GENERAL CONDITIONS IN 1907.

From the reports of fishermen at Plymouth and Newlyn, together with information derived from a fish salesman agent at Boulogne, it appeared that from the end of December, 1906, and throughout January, February, and the greater part of March, a regular and profitable trawl fishery for mackerel was carried on in an area of 20 to 40 miles S.S.W. to S.E. of Start Point.

Cligny, in a paper entitled "Les prétendues migrations du maquereau," has pointed out that the existence of mackerel congregated in dense shoals on the bottom in this particular area, was first brought to light during the winter of 1901, and that since that time a regular trawling industry for mackerel by means of a specially designed trawl has been carried on by the Boulogne fishermen, in the early spring.

In regard to this fishery, it has been stated by many fishermen at Plymouth that the best catches are made during the daytime, night trawling being often entirely unproductive.

From a consideration of this fact, the fishermen at first were of the opinion that the mackerel rose to the surface at night, and a certain number of boats shot drift-nets in the area where it was known that successful trawling during the day had been carried out. In every instance, however, the catches made at the surface were very light, and the practice was soon abandoned owing to the risk of damage to nets.

Toward the end of March, 1907, a Plymouth steam trawler, the *Condor*, was furnished with a special mackerel trawl, constructed in France; but losing this net on her first shot on the mackerel ground, an ordinary otter trawl was employed, with the result that a catch of nearly eight thousand mackerel was made, fish measuring 12½ to 14 in. in length. A Boulogne fisherman, who was superintending this fishing, expressed an opinion that had the trawl been a regular mackerel trawl, and the speed capability of the vessel greater, a far larger catch would have been made. This fishing was carried out, on a position roughly 25 miles S.W. of Start, on the 24th of March. Five days later a Brixham smack landed nine mackerel caught amongst other fish 20 miles S.E. of Start. From information received from Boulogne* it would appear that in 1907, throughout January, February, and the earlier part of March, the French trawling fleet, numbering nearly thirty vessels, were landing regular catches of sixty thousand down. During the third week of March, however, the catches rapidly decreased, until at the end of the month scarcely ten per cent of the former catches were landed, and the fishery was therefore discontinued.

Cligny, in the paper mentioned above, remarks on the close shoaling within certain limited areas on the ground in question, and this condition has been further evidenced during 1907 by statements made by the Boulogne fisherman in charge of the *Condor's* operations, who mentioned that of two vessels trawling within half a mile of each other, on a parallel course, the one would often obtain a large catch, whilst

* A series of telegrams giving daily market reports, for the use of which the writer is indebted to Mr. R. H. Palmer.

the other would fish lightly. The same fisherman, moreover, stated that he considered the shoals to lie parallel with the shore line.

[*Note.*—Amongst the fishing community at Plymouth and Newlyn a considerable diversity of opinion at one time existed in regard to the form and construction of the mackerel trawl. It may, therefore, be desirable to state that the writer was informed by Mr. Chant, the owner of the *Condor*, that the following details of construction, present in the net which was lost, constitute the essential points in which the mackerel trawl differs from an ordinary otter trawl.

Not being in a position to show the actual specifications of the trawl in question, Mr. Chant stated that the otter boards were heavier, the length of the foot rope was 92 feet (less than that of an ordinary otter trawl, which is usually 120 to 130 feet), and that the cod end was longer and bred of a finer mesh, viz. one inch. These points alone, he explained, constituted the difference in construction. The main point of the successful manipulation of the trawl, he stated, appeared to lie in the fact that, when trawling is proceeding at the pace of three miles an hour, the length of hawser employed should be five times the depth of the water.

With this length of hawser, he explained, together with the extra weight of the otter boards, there is no chance of the trawl leaving the ground, although it does not work so heavily as an ordinary trawl would, at the usual pace of two miles an hour.

Mr. Chant further stated that the mackerel taken by the *Condor* were caught in an ordinary otter trawl, the cod end of which had been backed with netting of a finer mesh.]

II. THE PHYSICAL AND BIOLOGICAL CONDITIONS OBSERVED ON THE START MACKEREL GROUND.

As a result of a series of observations taken from the *Oithona* at two positions on the mackerel trawling ground on March 27th, 1907, the following is a summary of the chief physical and biological conditions then observed within the area :—

First Position.—15 miles S.W. from Start Point.

Depth, 38 fathoms.

Condition of bottom, fine sand.

Temperatures: surface, 9·25°.
11 fathoms, 8·35°.
22 fathoms, 8·26°.
Bottom, 38 fathoms, 8·3°.

Second Position.—21 miles S. × W. ¾ W. of Start.
Depth, 39 fathoms.
Condition of bottom, coarse sand, fine gravel.
Temperatures: surface, 9·45°.
16 fathoms, 8·65°.
Bottom, 39 fathoms, 8·65°.

General condition of plankton* taken by coarse and fine nets:—

Bottom (39 fathoms). Four species of Copepods, chiefly *Temora longicornis*, not abundant; few other metazoa, including *Oikopleura dioica*, rare.

Phytoplankton in excess of zooplankton, composed largely of diatoms, *Lauderia borealis* and *Chaetoceras densum*, both common.

Fourteen other species of diatoms observed.

Surface plankton, similar in every respect to the bottom samples but slighter in bulk.

Petersen trawl samples from surface, midwater and bottom were composed largely of several species of amphipods: *Aphereusa bispinosa*, very abundant, *Bathyporeia pelagica*, rare, *Euthemisto gracillipes*, rare, *Monoculodes sp.*, rare, *Paratylus vedlomensis*, rare, *Stenothoë marina*, rare, *Urothoe elegans*, rare, etc. Schizopods, viz. *Anchialus agilis*, rare, *Gastrosaccus spinifer*, rare, *Mysidopsis angusta*, rare, and *M. gibbosa*, very rare. A fair number of post-larval fish were also taken, including *Clupea harengus*, plentiful, *Pleuronectes microcephalus*, common, *Solea variegata*, rare, etc.

An unsuccessful attempt was made to obtain mackerel in the otter trawl. The following species, however, were taken after a two hours' haul: *Arnoglossus laterna* and *A. megastoma*, *Callionymus lyra*, *Gadus minutus*, *G. luscus*, and *G. merlangus*, *Gobius quadrimaculatus*, *Pleuronectes platessa*, *Raia blanda*, *Rhombus laevis*, *Solea variegata*, and *S. lascaris*, *Trachinus draco*, *Trigla cuculus*, *T. gurnardus*, *T. hirundo*, and *T. lineata*, *Zeus faber*, together with several invertebrates.

III. GENERAL CONDITIONS OBSERVED IN STOMACHS OF MACKEREL TRAWLED ON THE START GROUND.

The contents of six stomachs were examined from the fish taken by the *Condor* on March 24th, 1907. A general determination based upon the six samples will be found in the Food and Plankton Tables (Table V), Sample No. 24. It is desirable, however, to describe the present material more particularly. In the six samples there appeared to be two distinct types of food, together with intermediate stages, in

* See Plankton Tables, Sample No. 38.

which the one converged into the other, forming, so to speak, a mixed sample. In one stomach only there occurred a pure zooplankton sample, consisting almost entirely of *Temora longicornis*; three other species of Copepods were observed in extreme scarcity, viz. *Centropages typicus*, *Paracalanus parvus*, *Pseudocalanus elongatus*, together with a few Caridid larvæ and Amphipod remains. This sample alone constituted the one extreme; the other, which may be considered as phytoplankton, was represented by three slight samples, which were composed mainly of a number of plankton diatoms (*Lauderia borealis* and *Chaetoceras densum* principally), together with a few bottom forms such as *Rhabdonema sp.*, forming with an indeterminable quantity of *Phæocystis globosa* a glutinous mass. Entangled in this material were observed also a few *Temora longicornis* and the three other species of Copepods above mentioned, together with a large number of *Oikopleura dioica*.

In the case of the two mixed samples, two slightly different types of food were observed. In the one *Temora longicornis* occurred fairly plentifully throughout the stomach contents, which otherwise were composed of the phytoplankton mass, as already described. In the second instance *Temora longicornis* formed an almost pure sample in a layer deposited above the phytoplankton. In connection with *Oikopleura dioica* it is interesting to note the following points. It occurred in greater abundance in the stomach samples showing phytoplankton and mixed material than it did in the tow-nettings taken from the *Oithona* (see Table No. II, Sample No. 38). Secondly, it was not observed at all in the sample composed entirely of *Temora longicornis;* and lastly in the mixed sample already referred to, where *Temora* was deposited in a layer, it did not occur amongst the Copepod material, but was plentiful in the lower layer of phytoplankton. These points alone in connection with *Oikopleura dioica* appear to constitute the sole difference existing between the plankton samples and stomach material.

CONCLUSION.

It has been suggested by several previous authors* that the migrations of the mackerel are not so extensive as hitherto generally supposed. Cligny, in the paper already referred to, states that, as far as his observations extend, mackerel return year after year, at the close of the shoaling season, to certain confined areas not far

* Allen, "Report on the Present State of Knowledge of the Habits and Migrations of Mackerel" (*Scomber scomber*), p. 26, *M.B.A. Journal*, vol. v. (N.S.).

Garstang, "On the Variation Races and Migrations of the Mackerel" (*Scomber scomber*), p. 286, *ibid.*

Cligny, *Les prétendues migrations du Maquereau.*

removed from the spawning grounds. At present only a few of these winter quarters are known to fishermen. Unless, therefore, certain other areas in the Channel exhibiting physical features common to the Start ground were thoroughly investigated, any attempt to suggest a reason for the preference of the fish for such particular spots would be based upon insufficient evidence.

In reviewing the foregoing observations upon the physical and biological conditions of the Start ground toward the close of the trawling season, it is desirable to draw attention to the following points: (1) that these bottom shoaling fish appeared to be feeding largely upon plankton; (2) that the plankton species observed in the stomach contents were common to the tow-nettings taken within the fishing area; (3) that *Oikopleura dioica* occurred in great abundance in stomach contents composed largely of phytoplankton, but in those containing a considerable quantity of zooplankton it was scarce, and further that, under the former circumstance, it was far more plentiful than in the tow-nettings taken within the fishing area; (4) that the tow-nettings taken on the bottom showed a greater bulk of material than those from the surface.

IV. FISHERMEN'S "SIGNS."

Amongst the west and east country fishermen there are generally recognized certain distinctive types of water in which mackerel are said to occur more or less abundantly. According to the men's statements, the colour and appearance of the water, its smell, and possibly upon occasion the presence of certain marine birds, comprise the only indications by which the drifter is guided in making choice of his position.

That these "signs," as they are termed, are the outcome of experience there can be no question, and the greater or less capability for interpreting them makes a better or worse fisherman. An instance occurred on one occasion when I was at Mevagissey, when one fisherman shot his nets a few miles to the landward of the rest of the pilchard fleet and secured a top catch; when questioned as to his reasons for doing so he explained that the signs at that particular position were altogether better than any that he had seen the previous night farther out. At other times I have heard a fisherman state that he could not hope for even a fair catch, as the class of water was entirely unsuitable, and on hauling nets this surmise has been found correct in every instance.

Before proceeding to treat the matter in detail it will be well to

summarize the result of systematic inquiry made amongst the fishermen in regard to their views upon the subject, and to detail the different characteristics of the various types of water as described by the fishermen themselves.

"*Stinking Water*" is of a dull leaden colour even in bright sunlight, so dense that a man looking over the side of a sailing drifter cannot see down to the keel. It possesses, according to the fishermen, a distinctly noxious smell, which has been described as similar to that of decaying seaweed. The men are agreed that mackerel are not to be found in such water; but one informant stated that scad or horse mackerel are often present in fair-sized shoals.

"*Grey Water*" is somewhat similar to the foregoing, but does not possess an unpleasant smell. Mackerel are never numerous in such water.

"*Blue*" and "*Green Water*" are both suitable for good shoals of fish. They differ, according to the fishermen, merely as regards colour. Both are so clear that the keel of the vessel can be seen distinctly. Both varieties are the usual types of water found in the western area in the early part of the season, right up to the first or second week in May. The fishermen are agreed in considering either type sufficiently promising to allow of fishing with some prospect of a fair catch.

"*Yellow Water*" is considered to be the best of any. This, according to the statement of many fishermen, exhibits the following characteristics. It seldom appears before the beginning of April, and more often not until the last week of that month. It is of a distinctly yellow tint, and rather dense when viewed either in sunlight or under a dull sky; often it appears in patches of greater or less extent. In certain years the sea west of Scilly has been almost entirely of this type of water. It appears, according to certain statements, to be teeming with "minute animal life." The fishermen agree in stating that the largest catches are always made in such water, and that it is not usual for an unproductive shot to be made, although, by the statement of several fishermen interrogated upon the point, it would appear that *light* catches are occasionally made in the best type of yellow water. Certain fishermen consider that the colour of the water is not due to the excreta of mackerel, but to the general colour of the "swarms of water fleas," whilst others on account of its density contend that it is coloured by excrement of mackerel.

Other "signs."—Apart from the characteristic of smell invariably associated with so-called 'stinking water," the generality of fishermen are agreed that a shoal of drift fish may be detected by their smell. This is more strongly pronounced in the case of pilchards, but, with

mackerel shoaling densely, the fishermen state that there is no mistaking it. An oily appearance at the surface of the water generally occurring in "splats," i.e. patches, is also said to be a sure indication of drift fish.

A milky appearance of the surface generally occurring in inshore waters, where there is no addition of china clay to the water, is associated by the fishermen with shoals of small mackerel, the milky appearance being due, it is stated, to excrement.

"Signs" of shoaling fish offered by the presence of sea-birds preying upon them occur more frequently, according to the fishermen's statement, in inshore waters, and the point is one which has already been described by previous writers, and need not therefore be discussed here.

COMPARISON OF "SIGNS" OFFERED BY DIFFERENT TYPES OF WATER WITH THE CONDITION OF PLANKTON OCCURRING IN SUCH WATER.

In order to endeavour to ascertain to what extent these colour "signs" are produced by plankton conditions, a number of plankton samples were taken for me in 1906–7 by fishermen, and labelled with reference to the particular type of water from which they were derived.

"*Stinking Water.*"—Sample No. 39, Plankton Tables, was taken by myself on April 10th, 1907, in an area of water termed by the fishermen "stinking," which, it was stated, extended from the Lizard to Land's End in a zone of varying width about ten miles or more from the shore. At the particular position at which it was taken, 6 miles N.W. × W. of Lizard, the fishermen were agreed in stating that the water was a fair sample of the "stinking" type, and that it would be useless to shoot in it. The colour and characteristics generally were in accordance with the description already given; but although the fishermen were agreed in saying that there was an obnoxious smell, I was unable myself to detect it. The analysis of the sample showed (by the method of comparison described in a former section) a moderate preponderance of phytoplankton over zooplankton, but the total bulk of the sample was comparatively small. As will be seen on reference to the Plankton Tables, the phytoplankton was mainly composed of diatoms, of which *Chaetoceras boreale* and *C. densum* were both common. *Phaeocystis globosa* appeared to be rare. The zooplankton comprised three Copepods, *Acartia clausi*, *Oithona similis*, and *Pseudocalanus elongatus*, moderately common. *Calanus finmarchicus* was rare.

"*Green Water.*"—It will be convenient at this point to compare the foregoing with another sample (No. 40, Plankton Tables) taken on the same date outside the "stinking water." This was at a position 16 miles

S.W. of Lizard, where a catch of 500 mackerel was made. The water appeared to be of a distinctly different type of a clear green tint. This was considered by the fishermen to be in every way suitable for the presence of shoaling fish. The examination of the sample showed the following points. Zooplankton was in excess of phytoplankton. This condition, however, was not brought about by a very pronounced decrease in the quantity of diatoms, but by the increased number of Copepods. *Calanus finmarchicus*, which was rare in the former sample, was common in the present one.

Between Samples 24 and 26, Plankton Tables, the former of which was taken by fishermen in "green water" and the latter in "blue," and from widely dissimilar positions, viz. 35 miles S.S.W. of Newlyn and 18 miles south of the Lizard, on May 5th and 10th respectively, there did not appear to be any striking points of difference. In each zooplankton was in excess of phytoplankton. The relative quantity of phytoplankton of the "green water" sample, however, was greater than that of the "blue water," although in the latter there was a slight quantity of *Phaeocystis globosa*, which was absent from the former. A greater variety of diatoms was observed in the "blue water" sample than in the "green," the higher proportion in the latter, already referred to, being due to two species, *Rhizosolenia alata* and *R. styliformis*, both plentiful.

In the main the zooplankton observed in each sample was similar. The Copepod *Temora longicornis*, however, occurred in the "blue water" sample, whilst it was absent from the "green"; but the more eastern distribution of the species described under a former heading would probably account for its absence in this sample of more western origin.

Samples 32 and 33, Plankton Tables, may be compared in a similar manner. They are taken later in the season, but present no striking dissimilarity.

No verified observations were taken in "grey water" except Sample 23, which, as stated in a footnote, would appear to be unreliable.

"*Yellow Water*."—In 1906, on May 20th, a sample was taken by fishermen in such water 40 miles S.W. of the Bishop. Unfortunately, however, the bottle containing the sample was broken in transit, and in consequence the exact nature of the plankton was difficult to determine. It appeared, however, to be composed very largely of the two Copepods *Calanus finmarchicus* and *Pseudocalanus elongatus*, and from the appearance of the remains it seemed to have been a very bulky sample.

This sample formed the sole observation from "yellow water" furnished by fishermen during 1906 and 1907. Throughout May, 1907,

however, when the sea west of Scilly was, according to the fishermen's statement, teeming with mackerel, "yellow water" was commonly met with on the fishing grounds. An examination of the Samples 50 to 57 (Plankton Table No. II), all of which were taken either adjacent to or on the fishing area during the international plankton cruise May, 1907, will serve to show that throughout the area covered the samples taken showed a certain similarity. Phytoplankton was entirely absent and the zooplankton was confined almost entirely to three or four principal forms, of which *Calanus finmarchicus* and *Pseudocalanus elongatus* were the most important.

At one station, 49° 49′ N. × 6° 59′ W. (Sample No. 52), the sea was considered to be of a decidedly yellow tint, according to the statement of Mr. D. J. Matthews, the leader of the expedition, and an analysis of the very bulky sample showed that it was composed almost entirely of the two species mentioned above, in almost equal abundance.

The possible inferences which may be drawn, therefore, from the consideration of the foregoing observations can be briefly summed up as follows:—

That in the "stinking water" sample, phytoplankton was in excess of zooplankton, but that there was no evidence to show from whence colour or smell were derived, beyond evidence of a negative character, which would tend to suggest that the smell did not arise from the condition of plankton. This suggestion is based upon the fact of an almost equal quantity of phytoplankton occurring in the case of the "green water" sample formerly referred to, "green water," according to the fishermen's statement, being invariably free from smell. The evidence offered by the analyses of "blue" and "green water" samples would suggest that the plankton taken in such water was of a type comprising a fair number of species in which, in the present examples, zooplankton was in excess of phytoplankton. From lack of observations, however, it cannot be suggested that this is always the case.

Finally, with regard to "yellow water," the somewhat conflicting opinions expressed by fishermen as to the causes which give rise to the colour, already explained, would suggest that the yellow tint is accounted for either by the presence of excrement arising from densely shoaling fish or from the presence in large numbers of certain Copepods. In view of the fact that several fishermen declare that light catches of mackerel may be taken in "yellow water," and the evidence offered by the analyses of certain plankton samples, it would appear to be more probable that the coloration arose from the latter cause. Were this view adopted, moreover, it would be strictly in accordance with the theory already discussed, of mackerel being abundant where food is plentiful.

TABLE No. I.—PLANKTON COLLECTED ON MACKEREL GROUNDS, 1906.

NOTE.—An asterisk thus * signifies sample collected by G. E. Bullen.

	FEB.						MAR.		APRIL														MAY										JUNE					
	1	12	12	13	14	24	12	24	10	21	23	23	23	23	24	24	24	24	24	26	26		1	5	10	10	15	18	19	19	23		5	7	8	13	17	23
	3 m. W. of Eddystone .	Sevenstones . .	8 m. S. of Newlyn . .	6 m. S.E. of Mousehole	9 m. S.S.W. of Mousehole .	Sevenstones . .	Sevenstones . .	Sevenstones . .	Sevenstones . .	20 m. S. of Wolf . .	6 m. S.W. of Looe .	7 m. S.W. of Dodman .	2 m. S.W. × S. of Lizard .	15 m. S.W. × S. of Lizard .	30 m. S.W. × S. ½ S. of Lizard	30 m. S.W. of Wolf . .	14 m. S.W. × W. of Wolf	10 m. N.W. ½ N. of Longships	5 m. S.S.W. ½ W. of Mousehole Point . .	8 m. E. ½ S. of Lizard .	Sevenstones . .	35 m. N. of Longships	12 m. S.S.W. of Wolf † .	35 m. S.S.W. of Newlyn .	Sevenstones . .	18 m. S. of Lizard .	Stat. E. 5 . . .	Stat. E. 6 . . .	50° 47′ N. × 6° 36′ W.	Stat. E. 7 . . .	Sevenstones . .		70 m. W.S.W. of Wolf .	60 m. S.W. × W. of Scilly .	Sevenstones . .	25 m. W. × S. of Bishop .	60 m. S.W. × W. of Bishop .	Sevenstones . .
	*			*	*					*	*	*	*	*	*	*	*	*	*	*																	
Diatomaceae. Sample No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31		32	33	34	35	36	37
Actinoptychus undulatus, Ehbg.	r	r	r	+	r	r	r	+	r	r	–	–	–	–	–	r	–	–	–	–	r	r	–	–	–	–	–	–	–	–	–		–	–	–	–	–	–
Asterionella japonica, Castr.	r	rr	r	r	+	+	r	r	rr	–	–	rr	+	+	–	–	–	+	+	r	r	–	–	–	–	–	–	–	–	–	–		–	–	–	–	–	–
Bacillaria paradoxa, Gmel.	–	rr	r	+	r	rr	r	–	r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–		–	–	–	–	–	–
Biddulphia alternans, V. Heurck	–	rr	rr	–	rr	–	–	–	rr	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–		–	–	–	–	–	–
mobiliensis, Bail.	c	r	+	c	c	+	+	+	+	–	–	–	–	–	–	–	–	–	–	–	r	–	–	–	–	rr	–	–	–	–	r		–	–	rr	–	–	–
Cerataulina Bergonii, Perag.	–	–	–	–	–	–	–	–	–	c	–	–	–	–	–	+	+	–	+	–	r	–	r	–	+	–	–	–	rr	–	+		–	–	rr	–	–	–
Chaetoceras boreale, Bail.	–	–	rr	–	r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	rr	r	–	–	–	–	–	–	+	–	–	–		–	–	–	–	–	–
contortum, Schütt	rr	–	–	–	r	–	–	rr	–	–	c	c	rr	rr	–	rr	–	r	c	c	r	–	–	–	–	–	rr	–	–	–	r		–	–	–	–	–	–
convolutum, Castr.	–	–	–	–	–	rr	rr	–	rr	–	–	–	–	–	–	–	–	–	–	–	rr	–	–	–	rr	–	rr	–	–	–	r		–	–	–	–	–	–
danicum, Cleve	+	rr	r	r	+	c	r	rr	+	rr	r	rr	rr	r	r	rr	rr	+	rr	r	+	r	–	–	–	–	–	–	–	–	–		–	–	–	rr	rr	–
debile, Cleve	+	–	r	–	r	–	rr	–	rr	–	–	+	r	+	r	–	r	+	+	+	+	rr	–	r	rr	–	–	–	–	–	r		–	–	r	–	–	–
decipiens, Cleve	rr	–	–	rr	+	rr	rr	–	+	–	+	+	+	r	r	r	r	+	+	+	r	r	–	–	–	–	rr	–	–	–	–		–	–	rr	–	–	–
densum, Cleve	r	–	–	–	–	rr	rr	–	r	–	+	+	+	+	rr	–	–	r	+	r	+	+	rr	r	+	rr	–	+	+	rr	r		–	–	r	rr	–	rr
lasciniosum, Schütt	–	–	–	rr	rr	–	–	–	–	–	–	–	–	rr	–	–	–	rr	–	–	–	–	–	–	–	–	–	–	–	–	–		–	–	rr	–	–	–
Schütti, Cleve	–	–	–	–	rr	r	rr	–	rr	–	–	–	rr	–	–	–	–	–	–	–	–	–	–	rr	–	–	–	–	–	rr	–		–	–	rr	–	rr	–
teres, Cleve	–	–	–	–	–	rr	rr	–	–	–	–	–	–	–	–	–	–	rr	–	–	–	–	–	–	–	–	–	–	–	–	–		–	–	–	–	–	–
Corethron hystrix, Hensen	r	rr	r	r	+	r	r	rr	rr	–	–	–	–	rr	–	–	–	–	–	–	–	–	–	–	–	–	rr	–	–	–	–		r	rr	–	–	–	–
Coscinodiscus concinnus, W. Sm.	–	r	rr	–	–	r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–		–	–	–	rr	–	–
Grani, Gough	r	–	–	–	–	–	–	–	rr	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–		–	–	–	–	–	–
excentricus, Ehbg.	+	c	+	+	+	+	+	+	+	rr	rr	rr	rr	–	–	rr	–	–	–	rr	r	–	–	–	rr	r	–	–	–	–	–		r	–	–	r	r	–
radiatus, Ehbg.	+	r	+	+	+	r	r	r	c	rr	r	r	r	r	r	+	r	r	r	–	r	–	rr	–	–	rr	r	rr	–	+	–		rr	–	–	r	rr	–
Ditylum Brightwelli, West	+	–	–	–	rr	r	+	r	+	–	rr	–	rr	–	–	–	–	rr	–	–	rr	–	–	–	–	–	–	–	–	–	–		–	–	–	–	–	–
Eucampia zodiacus, Ehbg.	–	–	–	rr	–	–	–	–	–	–	+	+	+	c	rr	–	+	+	+	c	r	+	–	–	r	–	–	r	+	–	r		–	–	+	–	–	r
Fragillaria oceanica, Gran.	–	–	rr	rr	rr	rr	–	–	–	–	–	–	–	r	+	+	rr	+	–	–	r	–	rr	–	–	–	–	–	–	–	–		–	–	+	–	–	r
Guinardia flaccida, Perag.	–	–	–	–	rr	–	rr	–	–	+	c	c	c	c	+	r	+	c	c	c	+	c	+	r	+	+	rr	r	c	–	+		–	–	+	–	–	r
Hyalodiscus stelliger, Bail	rr	+	+	+	+	c	+	+	+	–	–	–	–	–	–	–	–	–	–	–	r	–	–	–	r	rr	rr	–	–	–	–		–	–	r	–	–	rr
Lauderia borealis, Gran.	+	–	–	rr	rr	r	r	r	rr	+	r	–	r	c	c	c	c	+	r	+	+	+	c	rr	rr	c	–	r	+	cc	+		rr	–	+	rr	–	–
Leptocylindrus danicus, Cleve	–	–	rr	rr	rr	–	–	–	–	r	–	r	r	rr	–	–	r	r	+	+	–	–	–	–	–	–	–	–	–	–	–		–	–	–	–	–	–
Navicula, sp.	–	rr	–	–	rr	rr	rr	r	rr	r	r	rr	rr	–	rr	r	r	+	r	rr	rr	–	r	r	–	r	–	r	r	c	r		–	–	–	–	–	rr

Nitzschia seriata, Cleve	–	–	r	rr	r	–	–	–	rr	–	–	r	–	r	–	–	–	–	c	–	–	–	–	c	–	–	–	–	–	–	–	–	–	–	–	–	–
Nitzschia, sp.	+	–	–	–	–	–	–	–	–	c	c	c	c	+	r	r	c	c	r	c	c	c	–	–	rr	–	–	–	rr	–	r	–	–	–	–	–	–
Paralia sulcata, Cleve	+	+	+	+	+	+	+	+	r	r	rr	–	r	+	r	r	–	–	–	–	r	–	r	–	–	r	rr	rr	–	r	–	–	–	rr	–	–	–
Pleurosigma, sp.	r	rr	rr	r	+	rr	rr	–	rr	–	–	r	r	–	rr	rr	rr	–	–	rr	–	–	–	–	–	–	rr	rr	r	r	–	–	–	rr	–	–	–
Rhizosolenia alata, Brtw.	r	rr	+	c	+	rr	–	rr	r	c	c	+	r	+	c	+	+	r	+	c	+	c	c	c	r	+	c	c	+	cc	r	r	rr	r	c	r	r
delicatula, Cleve	–	–	–	–	–	–	rr	r	–	r	+	rr	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	rr	–	–	–
semispina, Hens.	–	rr	+	r	+	rr	r	r	+	c	+	+	+	c	+	+	+	+	c	c	+	+	rr	rr	+	+	+	+	c	cc	+	–	r	+	c	rr	–
setigera, Brtw.	rr	–	–	r	r	r	r	rr	+	+	r	r	rr	r	+	r	r	rr	–	rr	rr	r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
shrubsolei, Cleve	–	–	+	+	r	–	–	–	r	–	–	–	rr	+	+	r	+	+	+	+	+	+	+	+	r	r	–	r	rr	r	r	rr	rr	r	c	–	rr
Stolterfothi, Perag.	–	–	–	–	–	–	–	–	–	–	c	+	+	+	+	r	+	c	c	c	+	+	r	–	+	–	–	+	cc	rr	+	–	–	c	r	–	+
styliformis, Brtw.	–	–	–	–	–	–	–	–	rr	–	–	–	–	–	–	–	–	–	–	–	–	–	c	c	–	+	+	r	rr	c	rr	–	–	+	–	–	rr
hebetata, Hens.	–	–	–	–	–	–	rr	–	–	r	r	–	–	–	–	–	–	–	–	–	r	–	r	–	–	–	r	–	–	–	–	–	–	r	rr	–	r
Skeletonema costatum, Cleve.	+	–	–	rr	rr	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Streptotheca thamesis, Cleve	rr	–	+	r	+	+	r	r	c	r	–	–	–	–	–	–	–	–	–	–	r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Thalassiosira decipiens, (Grun.)	–	r	–	rr	–	r	r	rr	–	–	–	–	–	–	rr	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
gravida, Cleve	–	–	rr	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Nordenskïoldii, Cleve	–	–	–	rr	–	–	rr	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Thalassiothrix nitzschioides, Grun.	+	+	r	r	+	rr	+	+	+	–	rr	–	–	r	–	rr	–	–	–	–	r	–	–	–	–	–	rr	rr	–	rr	–	rr	–	–	rr	–	–
Peridiniales.																																					
Ceratium furca, Clap. and Lach.	–	–	–	–	–	–	–	–	r	–	–	rr	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
fusus, Ehbg.	c	–	rr	r	rr	–	–	rr	+	+	c	c	+	+	r	r	+	r	+	+	r	r	r	–	–	r	rr	rr	r	–	rr	rr	–	r	–	rr	rr
horridum, Cleve	–	–	–	–	–	–	–	–	–	–	rr	r	+	+	r	–	r	–	r	r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
longipes, Bail.	+	–	–	–	–	–	rr	rr	rr	r	+	+	+	+	rr	–	+	rr	+	+	r	–	r	rr	rr	–	–	–	rr	rr	r	–	–	r	–	–	r
tripos, O. F. Mull.	c	–	–	–	–	–	–	rr	rr	r	+	+	r	r	–	r	rr	–	r	+	r	r	–	–	–	–	rr	–	–	r	–	r	–	rr	rr	r	rr
Dinophysis acuta, Ehbg.	–	–	–	–	–	–	–	–	rr	–	–	–	rr	–	–	rr	rr	–	–	rr	–	–	–	–	–	rr	–	–	–	–	–	–	–	rr	–	–	rr
acuminata, Clap. and Lach.	–	–	–	–	–	–	–	–	–	rr	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	rr	–	–	–	–	–	–	–
rotundata, Clap. and Lach.	+	–	–	–	–	–	–	–	–	rr	–	–	rr	–	–	–	–	–	–	rr	–	r	rr	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Diplopsalis lenticula, Bergh.	–	–	–	–	rr	–	–	–	–	–	rr	–	rr	–	–	rr	–	–	–	rr	–	–	rr	–	–	–	–	–	–	–	r	–	–	–	–	–	r
Peridinium conicum, Gran.	r	–	–	rr	rr	rr	rr	–	rr	+	+	+	+	+	r	+	r	rr	r	r	rr	–	–	–	–	–	–	–	r	rr	–	rr	–	–	r	–	rr
depressum, Bail.	r	–	–	rr	–	–	–	–	–	–	+	c	c	+	–	r	+	+	+	+	r	rr	r	rr	–	–	rr	–	+	r	rr	–	–	+	–	–	+
ovatum, Pouchet	–	–	–	–	–	–	rr	–	+	–	–	–	rr	–	–	–	–	–	–	–	–	–	–	rr	–	–	–	–	r	+	rr	–	–	rr	–	–	r
pallidum, Östf.	r	–	–	–	–	–	–	–	+	rr	r	+	+	r	–	r	+	r	+	+	r	r	–	–	–	–	rr	–	rr	c	–	rr	–	–	r	–	–
Steini, Jörg.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	rr	–	–	–	–	–	–	–	rr
Prorocentrum micans, Ehbg.	r	–	–	–	rr	–	–	–	rr	rr	–	r	r	–	–	–	–	–	–	rr	–	rr	–	–	–	–	–	–	rr	–	–	–	–	–	–	–	–
Protophyta cetera.																																					
Dictyocha fibula, Ehbg.	rr	–	–	r	rr	rr	rr	–	r	–	–	rr	–	rr	–	–	rr	–	rr	–	rr	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Distephanus speculum, Ehbg.	–	–	–	rr	rr	–	–	–	–	–	–	–	–	rr	–	rr	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Halosphaera viridis, Schmitz	–	r	+	+	+	r	+	+	+	+	r	+	r	rr	r	+	c	+	r	r	+	+	–	+	+	+	r	r	r	r	r	rr	r	rr	r	–	–
Phaeocystis globosa, Scheffel	rr	–	–	–	–	–	–	–	?	c	cc	cc	cc	+	r	r	c	cc	c	cc	cc	cc	–	–	–	+	–	–	–	–	+	r	–	–	–	–	–
Trochiscia Clevei, Lemm.	–	–	–	–	–	–	–	–	–	–	–	–	r	–	–	–	rr	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Trichodesmium (?) contortum, Wille.	–	+	–	–	–	–	–	r	–	+	+	r	+	r	+	r	r	r	r	r	–	+	–	–	–	–	–	–	–	–	–	+	+	–	r	+	–

† An unreliable sample taken by fishermen.

TABLE No. I.—*Continued.*

	FEB.						MAR.		APRIL																		MAY																		JUNE					
	1	12	12	13	14	24	12	24	10	21	23	23	23	23	23	24	24	24	24	24	24	26	26		1	5	10	10	15	18	19	19	23		5	7	8	13	17	23	
NOTE—An asterisk thus * signifies sample collected by G. E. Bullen.	3 m. W. of Eddystone	Sevenstones	8 m. S. of Newlyn	6 m. S.E. of Mousehole	9 m. S.S.W. of Mousehole	Sevenstones	Sevenstones	Sevenstones	Sevenstones	20 m. S. of Wolf	6 m. S. of Looe	7 m. S.W. of Dodman	2 m. S.W.×S. of Lizard	15 m. S.W.×S. of Lizard	30 m. S.W.×S. ¼ S. of Lizard	30 m. S.W. of Wolf	14 m. S.W.×W. of Wolf	10 m. N.W.¼ N. of Longships	5 m. S.S.W. ½ W. of Mousehole Point	8 m. E. ½ S. of Lizard	Sevenstones	35 m. N. of Longships		12 m. S.S.W. of Wolf †	35 m. S.S.W. of Newlyn	Sevenstones	18 m. S. of Lizard	Stat. E. 5	50° 47′ N. × 6° 26′ W.	Stat. E. 6	Stat. E. 7	Sevenstones		70 m. W.S.W. of Wolf	60 m. S.W.×W. of Scilly	Sevenstones	25 m. W.×S. of Bishop	60 m. S.W.×W. of Bishop	Sevenstones	
	*			*	*	*				*	*	*	*	*	*	*	*	*	*	*	*																									
Protozoa. Sample No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23		24	25	26	27	28	29	30	31	32	33	34	35	36	37	
Tintinnopsis beroidea, Stein	+	rr	–	r	r	–	–	–	rr	–	–	–	–	–	–	–	–	–	–	–	–	–	–		–	–	–	rr	rr	rr	rr	–	–	–	–	rr	–	–	
Noctiluca miliaris, Suriray	–	–	–	–	–	–	–	–	–	–	r	c	r	r	–	–	–	rr	r	+	–	–	–		–	–	–	–	–	r	–	–	–	–	r	–	–	r	
Caelenterata.																																								
Muggiaea atlantica, Cunn.	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–		–	–	–	–	–	–	–	–	–	–	–	–	–	–	
Pleurobrachia pileus, Fabr.	rr	–	–	–	–	–	–	–	–	–	r	–	+	rr	r	r	r	rr	+	r	–	–	–		–	+	–	–	–	rr	–	r	–	–	rr	–	–	rr	
Corymorpha nutans, Sars	–	–	–	–	–	–	–	–	–	–	–	rr	r	rr	r	r	r	rr	r	r	–	–	–		–	–	–	r	–	–	–	–	–	–	–	–	–	–	
Euchilota pilosella, Forbes	–	–	–	–	–	–	–	–	–	–	–	–	–	–	r	–	–	–	–	–	–	–	–		–	–	–	–	r	–	rr	rr	–	–	–	r	–	–	
Euphysa aurata, Forbes	–	–	–	–	–	–	–	–	–	–	–	–	rr	r	+	r	r	rr	rr	rr	r	–	–		–	r	rr	–	rr	r	–	–	r	rr	–	rr	r	–	
Hybocodon prolifer, Agassiz	–	–	–	–	–	–	–	–	–	–	–	–	rr	–	r	rr	r	–	r	rr	–	–	r		+	–	–	+	–	–	rr	–	–	–	–	–	–	–	
Laodice calcarata, Agassiz	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	+	r	–	–	–	–	–	–		–	–	–	–	+	–	–	–	–	–	–	–	–	–	
Margellium octopunctatum, Sars	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	rr	–	–	rr	–	rr	–	–		–	–	–	r	–	–	–	rr	–	–	–	–	rr	–	
Obelia nigra, E. T. Browne	–	–	–	–	–	–	–	–	–	–	r	+	+	+	+	+	+	+	+	r	r	–	–		–	r	r	r	–	+	+	r	–	–	–	–	–	–	
Obelia sp.	–	–	–	–	–	–	–	–	–	+	r	+	+	+	+	c	+	+	r	+	–	rr	–		–	–	rr	r	–	rr	rr	r	–	–	–	–	–	–	
Phialidum temporarium, E. T. Browne	–	–	rr	–	rr	–	–	–	–	+	r	+	+	+	+	+	+	+	+	+	r	r	–		–	–	rr	r	r	+	r	–	rr	–	–	–	–	–	
Sarsia prolifera, M. Sars	–	–	–	–	–	–	–	–	–	–	r	+	r	r	rr	–	–	–	–	–	–	–	–		–	–	–	–	–	–	–	–	–	–	–	–	–	–	
Arachnactes Bournei, Fowler	–	–	–	–	–	–	–	rr	–	r	–	–	rr	–	–	–	rr	rr	r	r	r	rr	–		–	–	–	r	–	–	–	–	–	–	–	–	–	–	
Echinodermata.																																								
Auricularia	–	–	–	–	–	–	–	–	rr	–	+	+	r	rr	–	–	–	–	r	+	–	–	–		–	–	–	r	rr	–	–	rr	–	–	–	–	–	–	
Bipinnaria	–	–	–	–	–	–	–	–	–	–	r	r	–	rr	r	–	rr	–	r	r	–	–	–		–	–	–	–	–	–	–	–	–	–	–	–	–	–	
Echinopluteus	rr	–	–	–	–	–	–	–	–	–	r	+	–	rr	r	–	–	–	r	+	–	–	–		–	–	–	–	–	–	–	rr	–	–	–	–	–	r	
Ophiopluteus	r	–	–	–	–	–	–	rr	–	–	r	+	r	rr	–	r	–	r	r	+	–	–	–		–	rr	–	–	rr	–	rr	–	rr	–	–	–	–	–	+	
Vermes.																																								
Annelida larvae	rr	–	r	rr	rr	–	rr	rr	rr	+	+	+	+	+	+	+	+	+	+	+	+	+	–		rr	r	r	rr	rr	rr	r	r	–	–	–	–	rr	–	
Sagitta bipunctata, Quóy and Gaim.	+	c	c	+	+	c	+	+	–	c	c	c	+	c	c	c	c	+	r	r	+	+	r		+	+	+	c	c	+	c	+	+	r	rr	+	+	r	
Tomopteris helgolandica, Greef	–	–	rr	r	rr	–	–	–	–	–	–	–	rr	–	–	–	–	–	–	–	–	–	–		–	–	–	–	–	–	–	–	–	–	–	rr	–	–	

Crustacea copepoda.																																					
Acartia Clausi, Giesb	r	−	−	rr	−	rr	rr	rr	+	+	+	c	c	c	c	c	c	+	c	+	+	+	r	+	rr	r	rr	rr	r	c	+	rr	rr	c	rr	rr	r
Anomalocera Pattersoni, R. Temp.	−	−	−	−	−	−	−	rr	rr	rr	−	−	−	rr	r	r	−	rr	−	−	r	−	r	rr	−	−	rr	−	−	−	−	−	rr	rr	−	rr	−
Calanus finmarchicus, Gunn	r	c	+	+	+	+	+	+	r	+	+	+	+	+	c	c	+	+	+	c	+	+	r	c	cc	c	c	c	+	+	+	cc	cc	+	cc	cc	c
Candacia pectinata, Brady	−	−	−	−	−	−	−	−	−	rr	r	rr	r	+	+	+	+	+	r	+	rr	rr	−	rr	−	rr	−	−	rr	r	−	rr	−	r	−	rr	rr
Centropages typicus, Kroyer	+	rr	−	−	rr	−	r	r	r	r	r	r	r	+	+	r	r	r	c	r	r	rr	−	r	rr	−	rr	rr	rr	r	r	r	−	c	+	−	+
Corycaeus anglicus, Lubb.	+	−	−	−	−	−	−	−	rr	rr	+	r	r	+	rr	−	rr	+	+	+	−	−	−	rr	−	−	−	−	rr	r	−	−	−	−	−	−	+
Euterpe acutifrons, Dana	−	−	−	−	−	−	−	−	−	rr	−	−	−	−	−	−	−	−	−	−	−	rr	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
Isias clavipes, Boeck	−	−	−	−	−	−	−	−	−	−	rr	rr	−	−	−	−	−	−	−	rr	−	−	−	−	−	−	−	−	−	−	−	−	r	−	−	−	−
Metridia lucens, Boeck	−	−	rr	r	r	−	−	−	−	r	−	−	−	rr	+	c	c	c	+	r	+	+	−	r	r	rr	+	+	rr	−	rr	r	r	−	r	−	−
Microsetella atlantica, Brady	−	−	−	−	−	−	−	−	−	rr	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	r	−
Oithona nana, Giesb	−	−	−	−	−	−	−	−	−	rr	+	+	r	−	r	+	r	r	rr	rr	r	r	−	r	rr	r	−	−	−	−	rr	r	+	rr	+	−	r
plumifera, Baird	−	−	−	−	−	−	−	−	−	−	−	−	−	−	rr	rr	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
similis, Claus.	−	−	rr	r	rr	r	r	r	r	r	r	+	r	rr	rr	r	rr	−	−	r	r	rr	−	rr	r	rr	c	rr	rr	+	r	rr	r	r	r	rr	r
Paracalanus parvus, Claus.	+	rr	+	+	+	r	r	r	rr	+	+	+	+	+	+	+	+	+	r	+	+	+	−	+	+	r	+	+	rr	c	+	+	+	rr	+	+	+
Parapontella brevicornis, O. F. Mull.	−	−	−	−	−	−	−	−	−	−	−	rr	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	rr	−	−	−
Pseudocalanus elongatus, Boeck.	+	r	+	+	+	r	+	+	−	c	c	+	c	+	+	+	+	+	+	+	+	+	−	c	+	+	c	cc	+	c	+	c	cc	r	cc	c	+
Temora longicornis. O. F. Mull.	r	rr	−	−	−	−	−	−	−		+.	r	+	r	r	−	rr	+	+	+	−	rr	−	−	−	+	−	rr	r	rr	+	−	−	r	−	−	−
Crustacea cetera.																																					
Anchialis agilis, G. O. Sars	−	−	−	−	rr	−	−	−	−	−	r	−	−	−	−	rr	−	−	−	−	−	−	−	−	−	−	−	−	−	rr	−	−	−	−	−	−	−
Apherusa Clevei, G. O. Sars	−	−	−	rr	−	−	−	−	−	r	−	−	−	r	+	rr	r	−	−	−	−	−	−	r	−	r	−	−	−	rr	−	−	−	−	−	−	−
Carididae larvae	−	rr	−	rr	rr	r	−	−	−	r	−	−	+	+	c	c	+	+	rr	r	c	c	−	+	r	+	−	−	−	−	r	r	−	−	r	r	rr
Cirripedia larvae	−	−	−	rr	rr	−	−	rr	rr	+	r	r	r	rr	rr	r	rr	+	r	r	rr	rr	rr	−	−	−	−	−	rr	−	−	−	−	−	−	−	−
Euthemisto gracillipes, Norman	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	rr	−	−	−	−	rr	rr	rr	−	−	−	rr	−	−	−	−	rr	−	−	−	rr	−
Evadne Nordmanni, Loven	−	−	−	−	rr	−	−	−	−	−	c	c	+	+	r	−	+	c	c	+	−	−	r	rr	−	+	−	−	rr	r	r	−	−	−	+	r	r
Nauplius	r	rr	r	r	+	+	+	+	r	c	c	+	−	rr	−	r	r	r	r	r	r	−	−	+	+	r	+	rr	r	+	+	+	+	+	+	+	r
Nictyphanes Couchii, Bell	−	−	−	−	−	−	rr	+	−	−	−	−	−	−	−	rr	−	−	−	−	−	−	−	−	−	−	−	rr	−	−	−	−	−	−	−	−	−
Podon intermedius, Lilljeb.	−	−	−	−	−	−	−	−	−	−	+	+	+	+	rr	−	r	+	+	+	r	−	−	−	rr	r	−	−	−	rr	r	−	−	r	r	−	r
Zoeae	−	rr	−	rr	rr	r	r	r	−	r	r	r	+	+	+	c	+	+	r	+	+	+	−	+	+	c	r	+	+	+	r	r	−	−	−	rr	r
Megalopa stage	−	−	−	−	−	−	−	−	−	rr	−	−	−	rr	rr	r	−	−	−	−	rr	rr	rr	−	−	−	−	rr	rr	−	−	−	−	−	−	−	−
Mollusca.																																					
Clione limacina	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	rr	−	−	−	−	−	−	rr	rr	−	−	−	−	−
Gasteropoda larvae	−	−	−	−	−	rr	rr	r	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	r	−	−	−	−	−	rr	−	−	rr	−	−	−
Lamellibranchiata larvae	+	−	+	r	r	rr	r	r	−	rr	−	−	−	−	r	−	r	−	−	−	rr	−	−	−	r	−	−	−	−	−	r	−	−	rr	−	r	−
Limacina retroversa, Flem.	−	r	r	+	+	r	−	−	−	r	−	r	r	r	+	r	rr	−	r	r	rr	rr	−	r	−	rr	rr	rr	rr	r	rr	r	cc	−	r	c	r
Tunicata.																																					
Oikopleura dioica, Fol.	c	−	+	+	+	rr	+	c	+	+	c	+	+	c	c	+	+	+	+	+	+	r	r	c	+	c	rr	r	r	r	+	r	−	r	rr	r	r
Vertebrata.																																					
Fish ova	−	−	c	r	+	rr	rr	r	+	r	r	r	r	r	+	r	r	r	rr	r	rr	r	rr	r	rr	+	rr	rr	rr	rr	r	+	+	+	+	r	−
larvae	−	−	+	rr	rr	−	−	rr	−	r	r	r	r	+	+	+	+	+	r	r	r	rr	rr	−	−	+	−	rr	−	rr	rr	−	−	rr	−	−	−

† An unreliable sample taken by fishermen.

TABLE No. II.—PLANKTON COLLECTED ON MACKEREL GROUNDS, 1907.

NOTE.—An asterisk thus * signifies sample collected by G. E. Bullen.

	MARCH	APRIL										MAY											JUNE		
	26	10	10	16	16	16	16	16	17	17	17	9	16	16	17	17	17	17	17	18	21	29	31	4	6	14
	21 m. S.×W. ¾ W. of Start	6 m. N.W.×W. of Lizard	16 m. S.W. of Lizard	12 m. S. ½ W. of Looe	17 m. S.×W. of Dodman Point	15 m. S. of the Lizard	5½ m. S.W. ¼ W. of Lizard	1½ m. S.×W. ½ W. of Runnelstone	10 m. N. ¾ W. of Longships	20 m. N. of Longships	10 m. S.W. of Wolf	28 m. W.×S. of Bishop	Stat. E. 30	Stat. E. 6	49° 49′ N.×6° 59′ W.	49° 48′ N.×7° 10′ W.	Stat. E. 25	49° 24′ N.×6° 36′ W.	Stat. E. 5	Stat. E. 7	18 m. W.N.W. of Bishop	55 m. S.W. of Mousehole	60 m. W.S.W. of Wolf	30 m. W.S.W. of Bishop	50 m. S.W. of Wolf	55 m. S. of Newlyn
Sample No.	* 38	* 39	* 40	* 41	* 42	* 43	* 44	* 45	* 46	* 47	* 48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63
Diatomaceae.																										
Asterionella japonica, Castr.	–	–	r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Bacillaria paradoxa, Gmel.	–	–	rr	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Biddulphia mobiliensis, Bail.	r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Cerataulina Bergonii, Perag.	–	r	rr	rr	–	rr	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Chaetoceras boreale, Bail.	–	c	+	+	+	+	+	+	r	r	rr	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
contortum, Schütt	+	r	+	r	rr	rr	r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
convolutum, Castr.	–	–	rr	rr	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
danicum, Cleve	+	–	–	+	r	r	r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
debile, Cleve	rr	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
decipiens, Cleve	+	r	r	r	c	+	c	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
densum, Cleve	cc	c	+	c	c	c	c	+	+	r	rr	–	–	–	–	–	–	–	–	–	–	–	–	–	rr	–
Schütti, Cleve	rr	–	–	–	–	–	rr	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
teres, Cleve	rr	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Corethron hystrix, Hensen	r	–	r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Coscinodiscus excentricus, Ehbg.	+	–	r	–	–	–	–	–	–	–	–	–	rr	–	–	–	–	–	–	–	–	–	–	–	–	–
Grani, Gough	–	–	–	–	–	rr	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
oculus iridis, Ehbg.	–	–	rr	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
radiatus, Ehbg.	+	–	rr	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Ditylum Brightwellii (West)	–	–	–	–	–	rr	r	–	–	–	rr	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Eucampia zodiacus, Ehbg.	–	–	–	–	rr	–	–	–	–	–	rr	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Guinardia flaccida (Castr.)	–	–	rr	–	–	rr	+	rr	rr	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Hyalodiscus stelliger, Bail.	–	–	–	rr	–	–	–	rr	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Lauderia borealis, Gran.	cc	+	c	c	c	+	+	–	–	–	r	–	–	rr	–	–	–	–	–	–	–	–	–	–	–	i

Nitzschia seriata, Cleve	–	r	–	c c	r r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Nitzschia sp.	+	r r	r r	r r	c	c	c	c	c	–	c	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Paralia sulcata (Ehbg.)	–	–	r r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Pleurosigma sp.	–	–	–	–	r r	–	r r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Rhizosolenia alata, Btw.	–	+	+	r r	–	r r	r r	–	–	–	r r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
delicatula, Cleve	–	r r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
hebetata, Bail.	–	r r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
semispina, Hensen	–	+	r	–	r	r	r	–	–	r r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
setigera, Btw.	r	–	–	–	–	r r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Shrubsolei, Cleve	+	+	r	+	r	r	r r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Stoltefothii, Perag.	r	r	r	r r	r r	+	r	r	r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Skeletonema costatum (Greve.)	–	–	–	r r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Streptotheca thamesis, Shrub.	–	–	–	–	–	r r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Thalassiosira decipiens (Grun.)	–	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
gravida, Cleve	r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Nordenskiöldii, Cleve	–	–	r r	–	–	r r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Thalassiothrix nitzschioides, Grun.	r r	r r	+	–	–	r r	r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	r r	–
Peridiniales.																										
Ceratium furca (Ehbg.)	–	r r	–	–	r r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
fusus (Ehbg.)	–	+	+	–	+	+	+	r r	r r	r r	–	–	r	–	–	–	–	–	–	–	–	–	–	–	–	–
longipes (Bail.)	–	r	r	r	r	r	r	r r	r r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
tripos (O. F. Mull)	–	r	+	r	+	+	+	–	–	r r	–	–	r	–	–	–	–	–	–	–	–	–	–	–	–	–
Dinophysis acuta (Ehbg.)	–	–	r r	–	r r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
rotundata (Clap and Lachm.)	–	–	r r	–	–	r r	r r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Vanhöffeni	–	–	–	–	r r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Diplopsalis lenticula, Bergh.	–	–	–	–	r	–	–	–	–	–	r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Gonyaulax polygramma, Stein.	–	–	–	–	–	–	–	r r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Peridinium conicum, Gran.	–	+	+	–	r r	+	+	+	r	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
depressum, Bail.	–	r	r	r	+	+	+	+	+	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
ovatum, Pouchet.	–	–	–	–	r r	r	r	r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
pallidum, Ostf.	–	r	r	–	–	r	+	+	r	–	+	–	–	–	–	–	–	–	–	r r	–	–	–	–	–	–
Steini, Jörg.	–	–	r r	–	–	r r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Prorocentrum micans, Ehbg.	–	r	–	–	r r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Protophyta cetera.																										
Dictyocha fibula, Ehbg.	r r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Distephanus speculum (Ehbg.)	r r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Halosphaera viridis, Schmitz.	–	–	–	r r	–	–	r	r	–	–	–	r	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Phaeocystis globosa, Scherffel.	+	r	r	c c	c c	c c	c c	c	c	c	c c	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

TABLE No. II.—*continued.*

NOTE.—An asterisk thus * signifies sample collected by G. E. Bullen.

	MARCH	APRIL										MAY											JUNE		
	26	10	10	16	16	16	16	16	17	17	17	9	16	16	17	17	17	17	17	18	21	29	31	4	6	14
	21 m. S.×W. ¾ W. of Start	6 m. N.W.×W. of Lizard	16 m. S.W. of Lizard	12 m. S. ½ W. of Looe	17 m. S.×W. of Dodman	15 m. S. of Lizard	5½ m. S.W. ¼ W. of Lizard	1½ m.S.×W.½W.of Runnelstone	10 m. N. ¾ W. of Longships	20 m. N. of Longships	10 m. S.W. of Wolf	28 m. W.×S. of Bishop	Stat. E. 30	Stat. E. 6	49° 49′ N.×6° 59′ W.	49° 48′ N.×7° 10′ W.	Stat. E. 25	49° 24′ N.×6° 36′ W.	Stst. E. 5	Stat. E. 7	18 m. W.N.W. of Bishop	55 m. S. of Mousehole	60 m. W.S.W. of Wolf	30 m. W.S.W. of Bishop	50 m. S.W. of Wolf	55 m. S. of Newlyn
	*	*	*	*	*	*	*	*	*	*	*															
Protozoa. Sample No.	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63
Noctiluca miliaris, Suriray	–	–	–	rr	r	rr	r	rr	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Tintinnopsis beroidea, Stein	–	rr	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Caelenterata.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Arachnactis Bournei, Fowler	–	–	–	–	–	rr	–	rr	rr	–	rr	–	–	–	–	–	–	–	–	–	rr	–	–	–	–	–
Beroe ovata (Esch.)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	rr	–	–	–	–	–	–	–	–
Corymorpha nutans, M. Sars.	–	–	–	–	–	–	–	–	rr	–	–	rr	–	–	–	–	–	–	–	–	–	rr	–	–	rr	–
Euchilota pilosella, Forbes	–	–	–	–	–	rr	–	–	–	–	–	–	rr	–	–	–	–	r	–	–	–	–	–	–	rr	–
Euphysa aurata, Forbes	–	–	–	r	–	–	–	–	–	–	–	rr	r	–	–	–	–	–	–	–	–	–	–	–	–	–
Dipurena halterata, Forbes	–	–	–	–	–	–	–	–	–	rr	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Hybocodon prolifer, Agass.	–	–	–	–	–	–	–	–	r	r	r	rr	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Laodice calcarata, Agass.	–	–	–	–	–	–	–	rr	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Margellium octopunctatum, Sars.	–	–	–	r	r	r	–	–	rr	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Margelis sp.	–	–	–	–	–	–	–	rr	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Obelia nigra, E. T. Browne	–	–	–	r	rr	rr	rr	r	r	r	–	–	–	rr	–	–	–	–	–	–	r	–	–	–	–	–
Obelia, sp.	–	–	–	rr	–	–	rr	–	–	–	–	–	–	–	–	–	–	–	–	–	rr	–	–	–	–	–
Phialidium cymbaloideum, Van Bened.	–	–	–	–	rr	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
temporarium, E. T. Browne	–	–	–	r	rr	rr	rr	rr	rr	–	r	rr	–	rr	–	–	–	–	–	–	–	–	–	–	rr	–
Pleurobrachia pileus, Flem.	–	–	–	rr	–	–	rr	–	rr	rr	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Sarsia prolifera, Forbes	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	rr	–	–	rr	–

Vermes.																										
Annelida larvae	rr	–	–	+	r	r	r	r	r	r	r	–	–	–	–	–	–	–	–	–	r	–	–	–	–	–
Sagitta bipunctata Quoy. and Gaim.	r	–	r	+	+	rr	–	r	+	+	+	r	+	+	–	–	+	+	+	+	r	+	r	+	+	+
Tomopteris helgolandica, Greeff.	–	–	–	rr	–	–	–	r	–	rr	rr	–	–	–	–	–	–	–	rr	–	–	–	–	–	–	–
Crustacea. Copepoda.																										
Acartia Clausi, Giesbr.	–	+	+	+	c	c	+	+	r	+	+	r	+	c	r	c	r	+	+	+	c	rr	–	rr	rr	r
Anomalocera Pattersoni, Templt.	rr	–	–	–	rr	rr	–	–	–	r	–	rr	rr	-	–	–	–	–	–	r	rr	rr	–	–	+	r
Calanus finmarchicus, Gunn	r	rr	c	+	r	c	rr	cc	c	c	cc	cc	cc	+	cc	cc	cc	+	cc	c	c	cc	cc	cc	cc	c
Candace pectinata, Brady	–	–	–	–	–	rr	–	rr	rr	rr	rr	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Centropages typicus, Kröyer	+	r	–	+	+	r	r	rr	r	r	r	rr	r	+	–	r	–	r	r	c	r	rr	rr	rr	–	–
Corycaeus anglicus, Lubb.	–	–	–	–	r	+	r	–	+	rr	r	r	–	rr	–	–	–	–	–	–	–	–	–	–	–	–
Euterpe acutifrons (Dana)	–	–	–	–	–	rr	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Isias clavipes, Boeck.	–	–	–	–	–	–	–	rr	–	–	–	–	–	–	–	–	–	–	rr	–	rr	–	–	–	–	–
Metridia lucens, Boeck.	–	–	[illegible]	–	–	–	–	r	r	+	r	r	c	+	–	r	+	r	+	–	rr	r	+	r	r	r
Oithona nana, Giesbr.	–	rr	rr	–	–	–	–	–	–	–	–	–	–	–	–	rr	rr	rr	rr	r	r	–	–	–	rr	–
similis, Claus.	–	+	r	rr	r	rr	+	rr	–	–	–	r	r	rr	–	r	–	–	rr	+	rr	r	–	rr	+	r
Paracalanus parvus, Claus.	–	r	r	+	r	+	+	r	r	r	r	r	r	r	r	r	r	r	+	r	+	c	+	+	+	c
Pseudocalanus elongatus, Boeck.	+	+	r	c	c	c	+	+	+	c	c	c	cc	c	cc	cc	cc	cc	cc	cc	cc	c	c	+	+	c
Temora longicornis, O. F. Mull	c	–	–	c	c	c	+	c	c	+	+	–	–	+	–	rr	+	r	rr	c	rr	rr	–	–	rr	r
Crustacea cetera.																										
Anchialus agilis, G. O. Sars.	–	–	–	–	–	–	–	–	–	–	–	–	rr	–	–	–	–	–	–	–	rr	–	–	–	–	–
Apherusa Clevei, G. O. Sars.	–	–	–	–	–	–	–	–	–	rr	rr	–	–	–	–	–	–	–	–	rr	–	–	–	–	–	–
Carididae larvae	rr	–	–	r	r	r	–	+	+	+	+	+	+	+	–	–	r	r	+	+	r	+	rr	rr	rr	r
Cirripedia larvae	–	+	r	–	+	+	c	r	+	+	+	–	rr	rr	–	–	–	–	–	–	–	–	–	–	–	–
Euthemisto gracillipes, Norman	–	–	–	–	–	–	–	rr	–	–	–	–	–	–	–	–	–	–	–	–	rr	–	–	rr	rr	rr
Evadne Nordmanni, Loven	–	r	–	+	c	c	+	+	rr	rr	rr	rr	+	cc	–	rr	–	–	–	–	rr	–	–	–	–	–
Nauplius	–	+	+	–	rr	–	c	–	r	r	–	+	+	+	–	c	+	+	+	+	+	+	r	r	+	+
Nictyphanes Couchii, Bell.	–	–	–	–	–	–	–	–	–	–	–	–	rr	–	–	–	–	–	–	–	–	–	–	–	rr	–
Podon intermedius, Lilljeb.	–	–	–	r	r	–	–	–	–	–	–	–	rr	–	–	–	–	–	–	–	–	–	–	–	–	–
Zoeae	r	rr	rr	+	r	r	–	+	+	+	+	+	–	r	–	r	–	+	r	r	r	+	rr	r	r	r
Zoeae, Megalopa stage	–	–	–	r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	rr	rr	–	–	–	–
Mollusca.																										
Gasteropoda larvae	–	–	–	–	rr	rr	–		–	–		–	–	–	–	–	–	–	–	–	–	–	–	rr	–	–
Lamellibranchiata larvae	–	–	–	–	rr	–	–		–	–		–	–	–	–	–	–	–	–	–	–	rr	–	–	–	–
Limacina retroversa, Flem.	–	r	–	–	–	–	–	rr	–	rr		rr	–	–	–	–	–	–	rr	–	–	+	–	–	r	–
Tunicata.																										
Oikopleura dioica, Fol.	r	r	r	+	+	rr	r	rr	r	+	r	r	r	–	–	–	–	–	–	r	c	–	–	–	–	rr
Vertebrata.																										
Fish ova	r	–	–	–	r	rr	rr	rr	rr	rr	rr	rr	rr	r	–	–	–	–	r	rr	rr	rr	–	–	–	rr
Fish larvae	rr	–	–	–	rr	r		r	r	rr	rr	–		r	–	–	–	–	–	rr	–	rr	–	–	–	–

TABLE No. III.—FOOD AND PLANKTON TABLE. WESTERN AREA, 1906.

MONTH	FEBRUARY								MARCH		APRIL												MAY																		JUNE							
DATE	12	12	12	13	14	14	24		12	24	10	19	21	21	23	23	24	24	24	24	26	26	26	1	5	10	10	10	15	16	18	19	19	23		5	5	7	7	8	13	13	17	17	23	
Positions where samples were taken.	8 m. S. of Newlyn	8 m. S. of Newlyn	Sevenstones	6 m. S.E. of Mousehole	9 m. S.S.W. of Mousehole	9 m. S.S.W. of Mousehole	Sevenstones		Sevenstones	Sevenstones	Sevenstones	56 m. N.N.W. of S. Ives Head	20 m. S.W. of Wolf	20 m. S.W. of Wolf	15 m. S.W.×W. of Lizard	30 m. S.W.×W. ½ W. of Lizard	30 m. S.W. of Wolf	14 m. S.W.×W. of Wolf	10 m. N.W. ½ N. of Longships	5 m. S.S.W. ½ W. of Mousehole	Sevenstones	35 m. N. of Longships	35 m. N. of Longships	12 m. S.S.W. of Wolf*	35 m. S.S.W. of Bay	18 m. S. of Lizard	18 m. S. of Lizard	10 m. S.S.E. of Bishop	Sevenstones	Stat. E. 5	50 m. W.×S. of Wolf	50° 47′ N.×6° 36′ W.	Stat. E. 6	Stat. E. 7	Sevenstones		70 m. W.S.W. of Wolf	70 m. W.S.W. of Wolf	60 m. S.W.×W. of Scilly	60 m. S.W.×W. of Scilly	Sevenstones	25 m. W.×S. of Bishop	25 m. W.×S. of Bishop	60 m. S.W.×W. of Bishop	60 m. S.W.×W. of Bishop	Sevenstones	
S=Stomach. P=Plankton sample.	P	S	P	P	P	S	P		P	P	P	S	P	S	P	P	P	P	P	P	P	S		P	P	P	S	S	P	P	S	P	P	P	P		P	S	P	S	P	P	S	P	S	P	
Sample No.	3	64	2	4	5	65	6		7	8	9	66	10	67	14	15	16	17	18	19	21	22	68	23	24	26	69	70	25	27	71	28	29	30	31		32	72	33	73	34	35	74	36	75	37	
Species—																																															
Acartia Clausi Giesbr	–	–	–	rr	–	–	rr		rr	rr	+	r	+	+	c	c	c	c	c	c	+	r	rr	r	+	r	–	rr	r	rr	rr	rr	r	c	+		r	r	r	r	c	rr	r	rr	r	r	
Calanus finmarchicus Gunn	+	+	c	+	+	rr	+		+	+	r	+	+	+	c	c	c	+	+	+	+	r		r	c	c	c	+	cc	c	cc	c	+	+	+		c	c	c	c	+	c	c	c	c	c	+	
Centropages typicus Kroyer	–	–	rr	–	rr	–	–		r	rr	r	rr	r	rr	+	+	r	r	+	c	r	rr	–	–	r	rr	–	+	rr	rr	rr	rr	r	r	+		r	–	–	rr	c	+	r	r	rr	+	
Metridia lucens Boeck	rr	r	–	r	r	rr	–		–	–	–	r	r	r	rr	+	c	c	c	+	+	+	r	–	r	rr	–	–	r	+	r	+	rr	–	rr		r	r	r	r	–	r	+	r	rr	–	
Paracalanus parvus Claus.	+	rr	rr	+	+	–	r		r	r	rr	cc	+	c	+	+	+	+	+	r	+	+	r	–	+	r	r	r	+	+	+	+	rr	c	+		+	+	+	cc	rr	+	cc	+	+	+	
Pseudocalanus elongatus Boeck	+	+	r	+	+	rr	r		+	+	–	cc	c	+	+	+	+	+	+	r	+	+	r	–	c	+	+	r	+	+	c	+	cc	c	+		c	+	c	cc	r	+	cc	c	c	+	
Temora longicornis O. F. Mull	–	–	rr	–	–	–	–		–	–	–	rr	–	rr	r	r	–	r	+	+	–	rr	–	–	–	+	r	+	+	–	rr	r	rr	+		–	–	–	–	r	–	–	–	–	–	
Zoeae	–	–	rr	rr	rr	rr	r		r	r	–	r	r	–	+	+	c	+	+	r	+	+	c	rr	+	c	c	r	c	r	+	+	+	+	r		r	rr	–	rr	–	–	r	rr	r	r	
Sagitta bipunctata Quoy and Gaim	c	–	c	c	+	r	c		+	+	–	+	c	r	+	c	c	c	+	r	+	+	rr	r	+	+	r	cc	+	c	r	c	+	c	+		+	r	r	r	r	+	r	+	r	r	
Oikopleura dioica Fol	+	c	–	c	+	+	rr		+	c	+	r	+	cc	c	c	c	+	+	+	r	r	–	r	c	c	c	+	c	rr	r	r	r	r	+		r	r	–	rr	r	rr	r	+	rr	r	
Phytoplankton chiefly Phaeocystis globosa Scherffel	–	c	–	–	–	c	–		–	–	–	rr	c	cc	+	r	r	c	c	cc	c	cc	cc	–	–	+	c	–	–	–	–	–	–	–		r	–	–	–	–	–	–	–	–	–	
No. of Fish taken in "hundreds." (Hundred=120 Fish.)	–	–	–	–	–	–	$\frac{1}{5}$		–	–	–	20	50	–	–	–	–	–	–	–	–	–	30	–	–	–	–	–	–	–	–	–	–	–		–	20	–	–	–	–	30	–	–	–	

TABLE No. IV.—FOOD AND PLANKTON TABLE, WESTERN AREA, 1907.

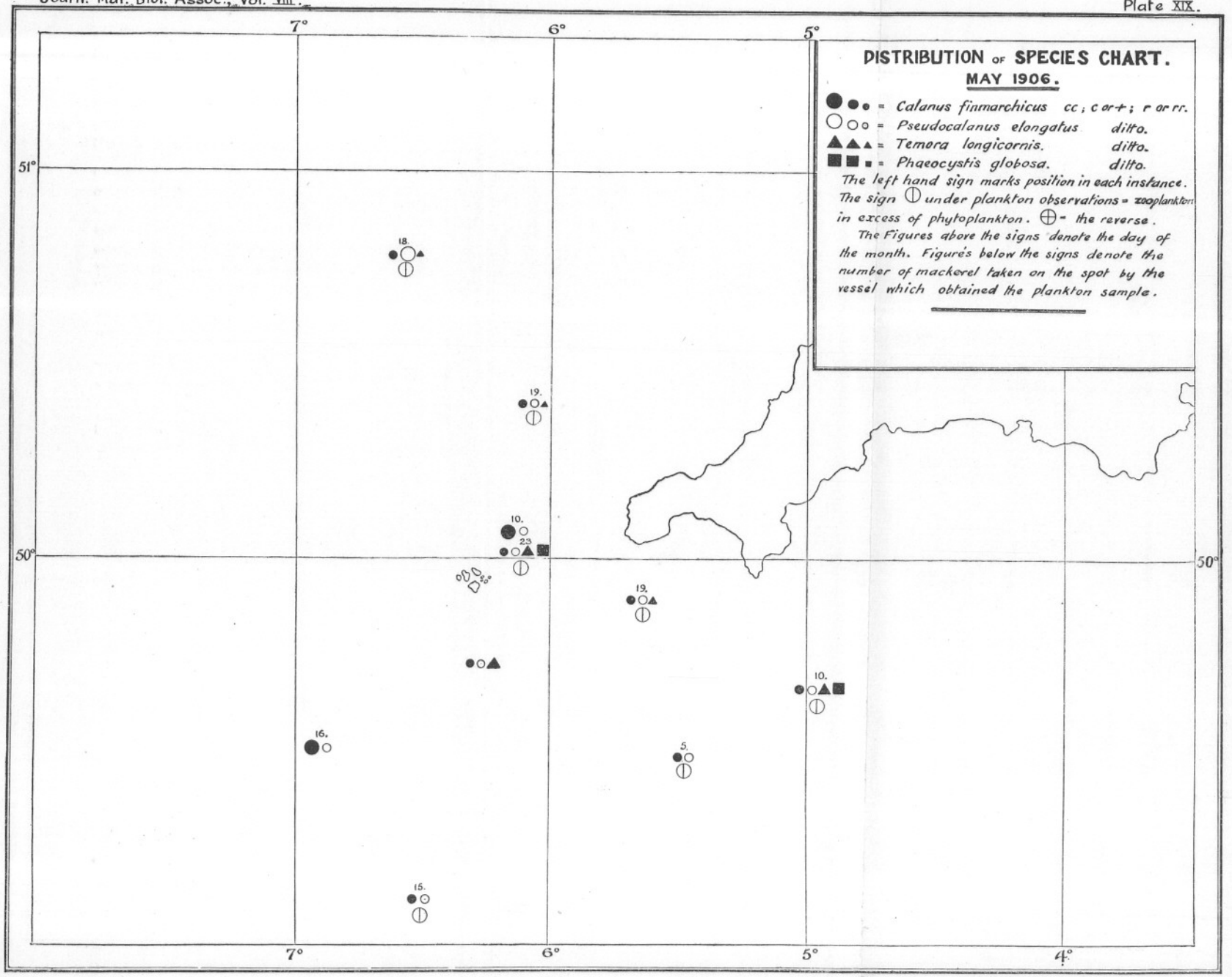
MONTH	APRIL																				
DATE	3	4	5	5	5	6	9	9	10	11	12	12	12	13	16	16	16	16	17	17	30
Positions where samples were taken.	3 m. N.W. of Longships	46 m. N.N.W. of Longships	40 m. N.W. of Longships	55 m. N. of Longships	35 m. N. of Longships	45 m. N.×E. of Longships	16 m. N.N.W. of Longships	18 m. S.W. of Bishop	16 m. S.W. of Lizard	16 m. S.W. of Lizard	65 m. N.N.W. of Longships	50 m. N.N.W. of Longships	60 m. N.×W. of Longships	80 m. W.S.W. of Wolf	15 m. S. of Lizard	5½ m. S.W. ¼ W. of Lizard	1½ m. S.×W. ½ W. of Runnelstone	10 m. N. ¾ W. of Longships	20 m. N. of Longships	10 m. S.W. of Wolf	50 m. S.S.W. of Wolf
S = Stomach sample. P = Plankton ditto.	S	S	S	S	S	S	S	S	P	S	S	S	S	S	P	P	P	P	P	P	S
Species— Sample No.	76	77	78	79	80	81	82	83	40	84	85	86	87	88	43	44	45	46	47	48	89
Acartia Clausi Giesbr.	–	–	–	–	rr	–	–	rr	+	r	–	–	–	rr	c	+	+	r	+	+	–
Calanus finmarchicus Gunn	r	r	r	rr	r	r	r	r	c	+	c	r	–	+	c	rr	cc	c	c	cc	cc
Centropages typicus Kröyer	–	–	–	–	rr	–	–	rr	–	–	–	–	–	rr	r	r	rr	r	r	r	–
Metridia lucens Boeck	–	–	–	–	–	–	rr	–	–	–	rr	rr	–	–	–	–	r	r	+	r	rr
Pseudocalanus elongatus Boeck	r	r	r	r	r	r	rr	r	r	+	+	r	–	c	c	r	+	+	c	c	cc
Temora longicornis O. F. Muller	–	–	–	–	–	–	r	–	–	–	–	–	–	–	c	r	c	c	+	+	–
Zoeae	–	–	–	–	–	–	rr	rr	rr	rr	rr	rr	–	c	r	–	+	+	+	+	–
Sagitta bipunctata Quoy & Gaim	–	–	–	–	–	–	–	–	r	–	–	–	–	–	rr	–	r	+	+	+	–
Oikopleura dioica Fol.	cc	cc	cc	cc	cc	cc	r	cc	r	r	r	rr	–	–	rr	r	rr	r	+	r	–
Phytoplankton chiefly Phaeocystis globosa Scherffel	cc	cc	cc	cc	cc	cc	rr	cc	r	–	–	–	–	–	cc	cc	c	c	c	cc	–
No. of fish taken in "hundreds" (Hundred = 120 fish.)	¾	3	1	2½	1	½	3	2½	–	5	50	–	5	120	–	–	–	–	–	–	40

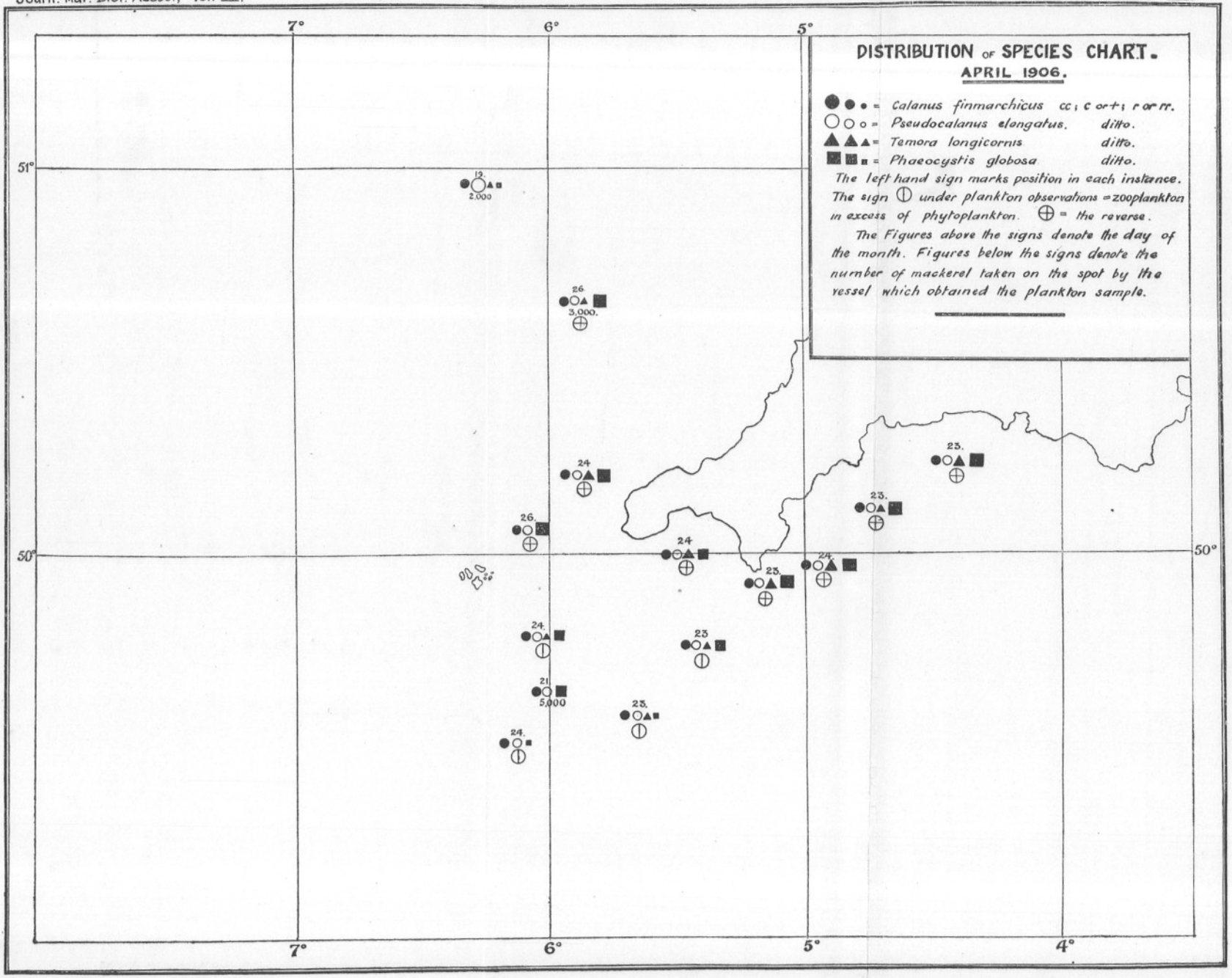
MONTH	MAY																													
DATE	1	1	1	1	1	2	2	9	9	14	14	17	17	17	17	17	17	17	18	18	18	19	21	23	23	23	29	30	31	31
Positions where samples were taken.	30 m. W. of Bishop	60 m. W.S.W. of Wolf	35 m. W.×S. of Bishop	30 m. W.×N. of Bishop	40 m. S.S.W. of Kinsale	28 m. S.W. of Bishop	14 m. S. of Bishop	28 m. W.×S. of Bishop	28 m. W.×S. of Bishop	6 m. W.S.W. of Bishop	50 m. S.W.×S. of Mousehole	42 m. S.W. of Wolf	40 m. W. of Bishop	20 m. S.W. of Scilly	Stat. E. 30.	Stat. E. 6	49.49 N.×6.57 W.	49.48 N.×7.10 W.	Stat. E. 25	49.24 N.×6.36 W.	Stat. E. 5.	Stat. E. 7	18 m. W.N.W. of Bishop	35 m. S.W. of Wolf	30 m. S.W. of Mousehole	60 m. S.W. of Mousehole	55 m. S. of Mousehole	45 m. S.W.×S. of Newlyn	60 m. W.S.W. of Wolf	60 m. W.S.W. of Wolf
S = Stomach sample. P = Plankton ditto.	S	S	S	S	S	S	S	P	S	S	S	S	S	S	P	P	P	P	P	P	P	P	P	S	S	S	P	S	P	S
Species— Sample No.	90	91	92	93	94	95	96	49	97	98	99	100	101	102	50	51	52	53	54	55	56	57	58	103	104	105	59	106	60	107
Acartia Clausi Giesbr.	–	–	–	rr	–	rr	rr	r	rr	rr	+	r	r	r	+	c	r	c	r	+	+	+	c	+	+	+	rr	rr	–	rr
Calanus finmarchicus Gunn	cc	c	cc	cc	c	cc	cc	cc	cc	cc	c	cc	cc	cc	cc	+	cc	cc	cc	+	cc	c	c	cc	r	c	cc	cc	cc	cc
Centropages typicus Kröyer	r	–	–	–	–	–	–	rr	–	rr	–	–	–	–	r	+	–	r	–	r	r	c	r	+	+	+	rr	rr	rr	rr
Metridia lucens Boeck	rr	–	rr	rr	–	rr	rr	r	rr	r	–	r	r	r	c	+	–	r	+	r	+	–	rr	+	+	r	r	rr	+	r
Pseudocalanus elongatus Boeck	c	+	cc	cc	c	cc	cc	c	cc	cc	c	cc	cc	cc	cc	c	cc	cc	cc	cc	cc	cc	cc	cc	c	cc	c	cc	c	cc
Temora longicornis O. F. Muller	rr	rr	r	–	rr	–	–	–	–	–	c	–	–	–	–	+	–	r	+	r	rr	+	rr	r	cc	+	rr	–	–	–
Zoeae	–	–	–	–	cc	–	–	+	r	r	r	+	rr	+	–	r	–	r	r	+	+	r	r	r	r	r	+	r	rr	rr
Sagitta bipunctata Quoy & Gaim	–	–	–	–	–	rr	–	–	–	–	–	–	–	–	+	+	–	–	+	+	+	+	r	rr	–	+	+	–	r	rr
Oikopleura dioica Fol.	–	+	rr	rr	rr	–	–	r	–	–	–	–	–	–	r	–	–	–	–	–	–	–	c	–	–	–	–	–	–	–
Phytoplankton chiefly Phaeocystis globosa Scherffel	–	–	–	+	c	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	c	–	–	–	–	–	–
No. of fish taken in "hundreds" (Hundred = 120 fish.)	200	400	400	90	50	300	200	–	100	120	100	–	400	300	–	–	–	–	–	–	–	–	–	20	7	20	–	40	–	14

MONTH	JUNE					
DATE	1	3	4	6	14	14
Positions where samples were taken.	45 m. S.W. of Bishop	55 m. W.S.W. of Wolf	30 m. W.S.W. of Bishop	50 m. S.W. of Wolf	55 m. S. of Newlyn	55 m. S. of Newlyn
S = Stomach sample. P = Plankton ditto.	S	S	P	P	P	S
Species— Sample No.	108	109	61	62	63	110
Acartia Clausi Giesbr.	rr	–	rr	rr	r	rr
Calanus finmarchicus Gunn	+	cc	cc	cc	c	cc
Centropages typicus Kröyer	–	r	rr	–	–	r
Metridia lucens Boeck	r	–	r	r	r	+
Pseudocalanus elongatus Boeck	c	cc	+	+	c	cc
Temora longicornis O. F. Muller	c	r	–	rr	r	–
Zoeae	+	r	r	r	r	+
Sagitta bipunctata Quoy & Gaim	rr	–	+	+	+	+
Oikopleura dioica Fol.	–	–	–	–	rr	–
Phytoplankton chiefly Phaeocystis globosa Scherffel	–	–	–	–	–	–
No. of fish taken in "hundreds" (Hundred = 120 fish.)	7	90	–	–	–	30

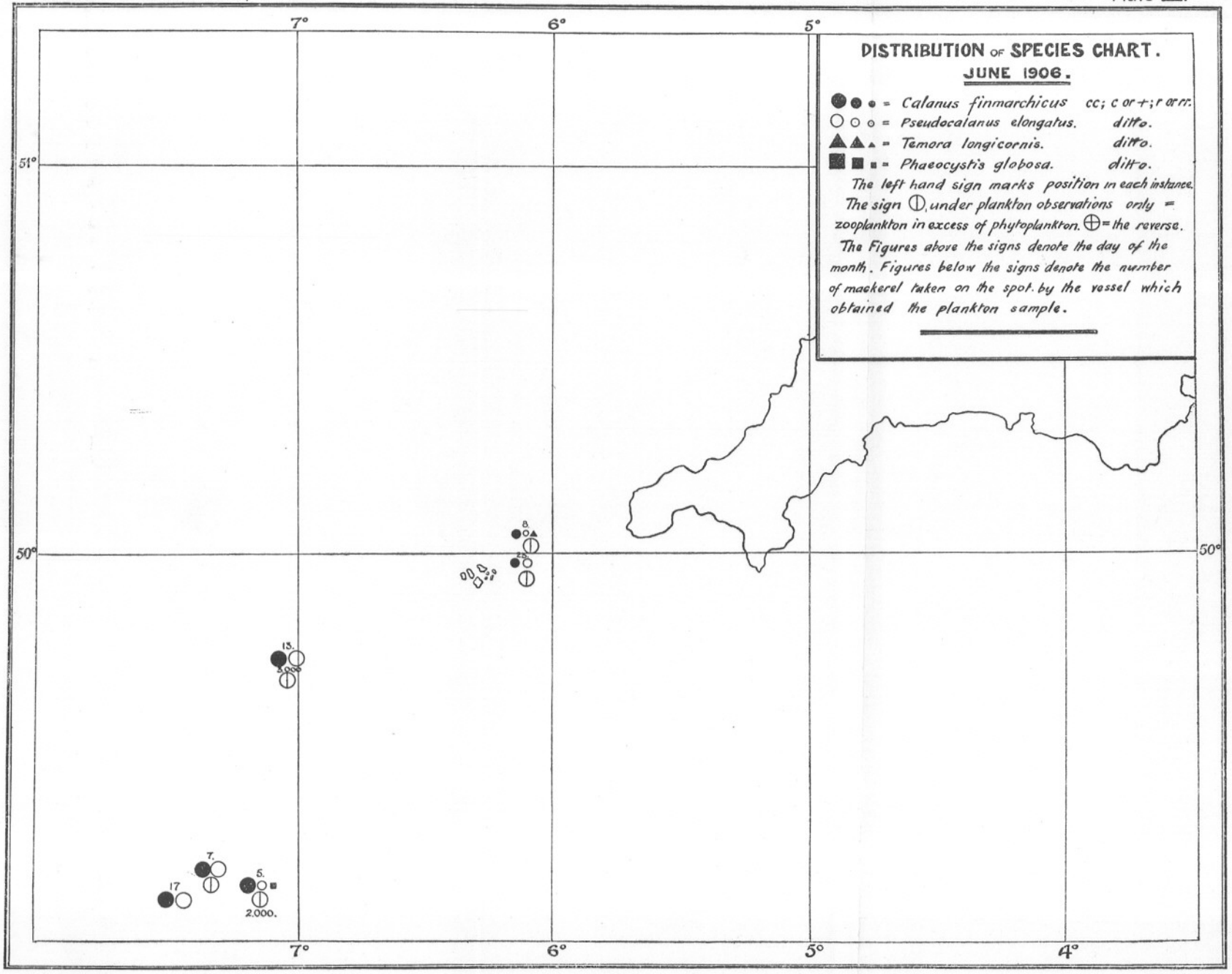
TABLE No. V.—FOOD AND PLANKTON TABLE. PLYMOUTH TO LIZARD AREA, 1907.

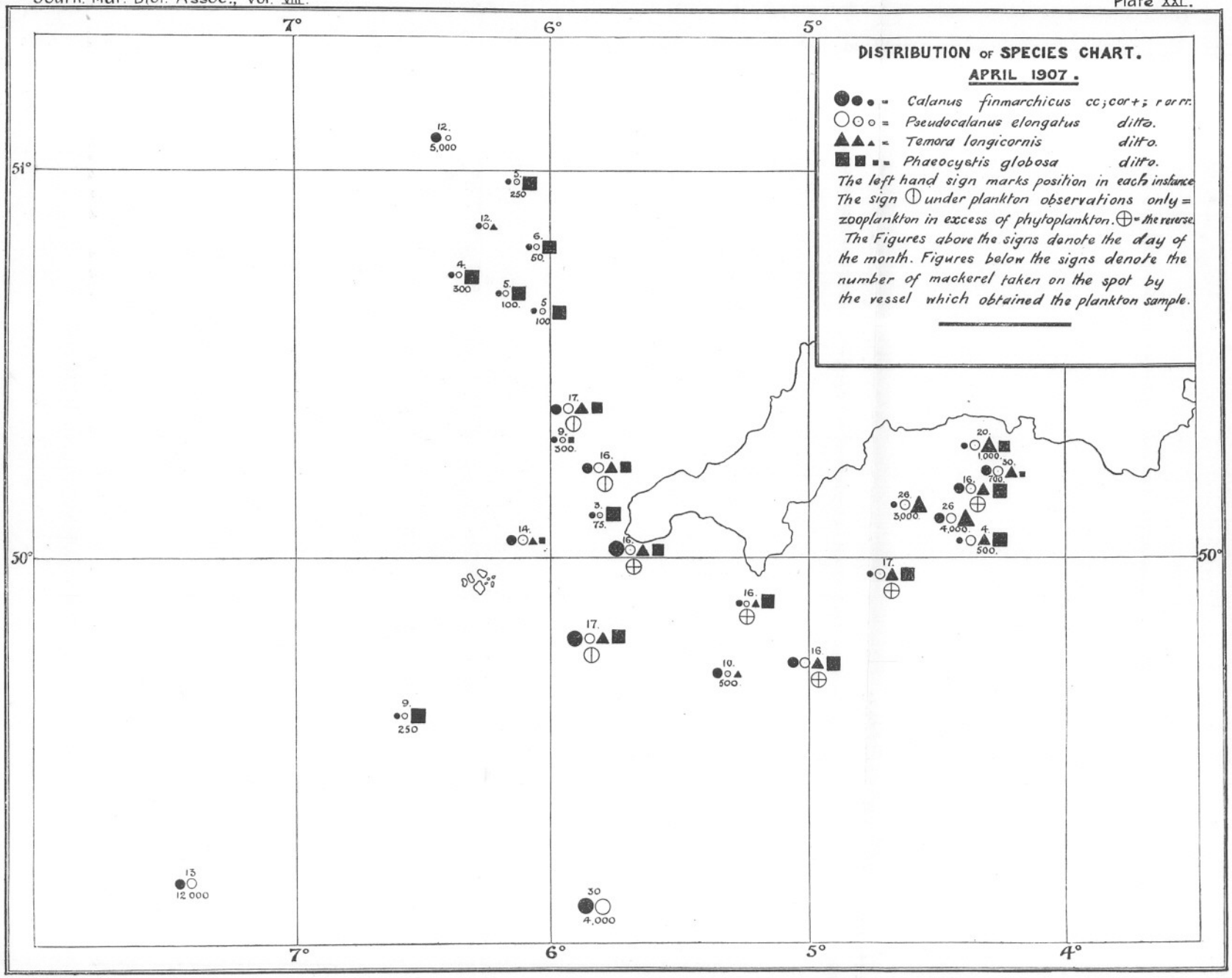
MONTH	MAR.		APRIL									MAY										JUNE											JULY	
DATE	24	26	4	4	16	20	26	26	27	27	30	6	6	13	17	17	24	27	28	28	30	3	14	14	15	17	17	17	19	19	21	24	16	18
Positions where samples were taken.	25 m. S. of Start (on Ground)	21 m. S.×W. ¾ W. of Start	10 m. S.W. of Eddystone	12 m. S. of Lizard	12 m. S. ½ W. of Looe	5 m. S. of Looe	8 m. S. of Dodman Point	15 m. S.E. of Dodman Point	17 m. S.×W. of Dodman Point	8 m. S.W. of Eddystone	Near the Eddystone	3 m. off Downderry	4 m. S.E. of Looe	6 m. N.W. of Eddystone	3 m. W.N.W. of Eddystone	5 m. E.S.E. of Eddystone	6 m. W.×S. of Eddystone	50 m. S.W. of Eddystone	40 m. S.W.×S. of Eddystone	9 m. E.S.E. of Eddystone	40 m. S.E. of Start	30 m. S.W. of Eddystone	4 m. S. of Eddystone	12 m. S.E. of Eddystone	10 m. S. of Eddystone	12 m. W. of Eddystone	7 m. S.E.×E. of Eddystone	12 m. S. of Eddystone	4 m. S.S.E. of Eddystone	8 m. S.E. of Eddystone	10 m. S.S.W. of Eddystone	20 m. S.W. of Eddystone	Off Penlee (from Seine)	Off Portwrinkle (from Seine)
S=Stomach. P=Plankton	S	P	S	S	P	S	S	S	P	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
Sample No.	111	38	112	113	41	114	115	116	42	117	118	119	120	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140	141
Species.																																		
Acartia Clausi, Giesbr.	rr	–	–	–	+	+	+	+	c	+	r	rr	rr	–	rr	–	–	rr	–	rr	rr	–	–	–	–	–	–	–	–	–	–	–	–	–
Calanus finmarchicus, Gunn	–	r	r	–	+	r	r	+	r	r	+	c	+	+	rr	+	–	+	+	+	r	+	+	rr	rr	–	–	–	rr	+	rr	r	–	–
Pseudocalanus elongatus, Boeck.	rr	+	+	–	c	+	+	+	c	+	+	+	+	+	r	+	–	+	+	+	r	+	+	r	r	–	–	–	r	rr	rr	rr	–	–
Temora longicornis, O. F. Mull.	cc	c	c	–	c	cc	cc	cc	c	cc	c	cc	cc	cc	cc	cc	cc	c	cc	cc	cc	c	c	cc	cc	–	c	rr	c	r	c	cc	–	–
Zoeae.	rr	rr	–	–	+	r	–	rr	r	r	r	c	+	+	r	cc	cc	–	+	c	r	c	cc	rr	c	–	c	cc	+	r	–	c	–	–
Sagitta bipunctata, Quoy and Gaim.	–	r	–	–	+	r	–	–	+	–	r	+	c	cc	r	–	–	cc	r	–	–	cc	–	–	–	–	–	–	–	–	–	–	–	–
Oikopleura dioica, Fol.	cc	r	cc	–	+	rr	–	–	+	–	rr	rr	–	–	–	–	–	rr	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Young Fish or Crystallogobius	–	–	–	–	–	–	–	–	–	–	rr	rr	rr	c	–	r	c	–	c	+	–	–	c	r	r	cc	+	cc	c	c	+	–	cc	cc
Phytoplankton, chiefly Phaeocystis globosa Scherffel	cc	+	cc	–	cc	+	–	–	cc	–	r	c	–	–	–	–	–	c	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
No. of Mackerel taken in "hundreds". (Hundred=120 fish)	60	–	5	5	–	10	30	40	–	40	7	–	10	10	–	–	10	–	12	½	8	8	8	5	4	25	30	75	5	25	10	25	20	50


7°
6°
5°
4°
51°
50°
DISTRIBUTION OF SPECIES CHART.
MAY 1906.
= Calanus finmarchicus cc; c or +; r or rr.
= Pseudocalanus elongatus ditto.
= Temora longicornis. ditto.
= Phaeocystis globosa. ditto.
The left hand sign marks position in each instance.
The sign ⊕ under plankton observations = zooplankton in excess of phytoplankton. ⊕ = the reverse.
The Figures above the signs denote the day of the month. Figures below the signs denote the number of mackerel taken on the spot by the vessel which obtained the plankton sample.
18.
19.
10.
23
19.
10.
16.
5.
15.


DISTRIBUTION OF SPECIES CHART.
APRIL 1906.
● ● ● = Calanus finmarchicus cc; c or +; r or rr.
○ ○ ○ = Pseudocalanus elongatus. ditto.
▲ ▲ ▲ = Temora longicornis ditto.
■ ■ ■ = Phaeocystis globosa ditto.
The left hand sign marks position in each instance.
The sign ⊕ under plankton observations = zooplankton in excess of phytoplankton. ⊕ = the reverse.
The Figures above the signs denote the day of the month. Figures below the signs denote the number of mackerel taken on the spot by the vessel which obtained the plankton sample.
7°
6°
5°
4°
51°
50°
12.
2,000
26.
3,000.
24.
26.
24.
23.
23.
24.
24.
23.
24.
23.
21.
5,000
23.
24.

To face p. 302.


7°
6°
5°
4°
51°
50°
DISTRIBUTION OF SPECIES CHART.
JUNE 1906.
= Calanus finmarchicus cc; c or +; r or rr.
= Pseudocalanus elongatus. ditto.
= Temora longicornis. ditto.
= Phaeocystis globosa. ditto.
The left hand sign marks position in each instance.
The sign ⊕, under plankton observations only = zooplankton in excess of phytoplankton. ⊕ = the reverse.
The Figures above the signs denote the day of the month. Figures below the signs denote the number of mackerel taken on the spot by the vessel which obtained the plankton sample.
8
29
13.
3,000
7.
17
5.
2,000.


7°
6°
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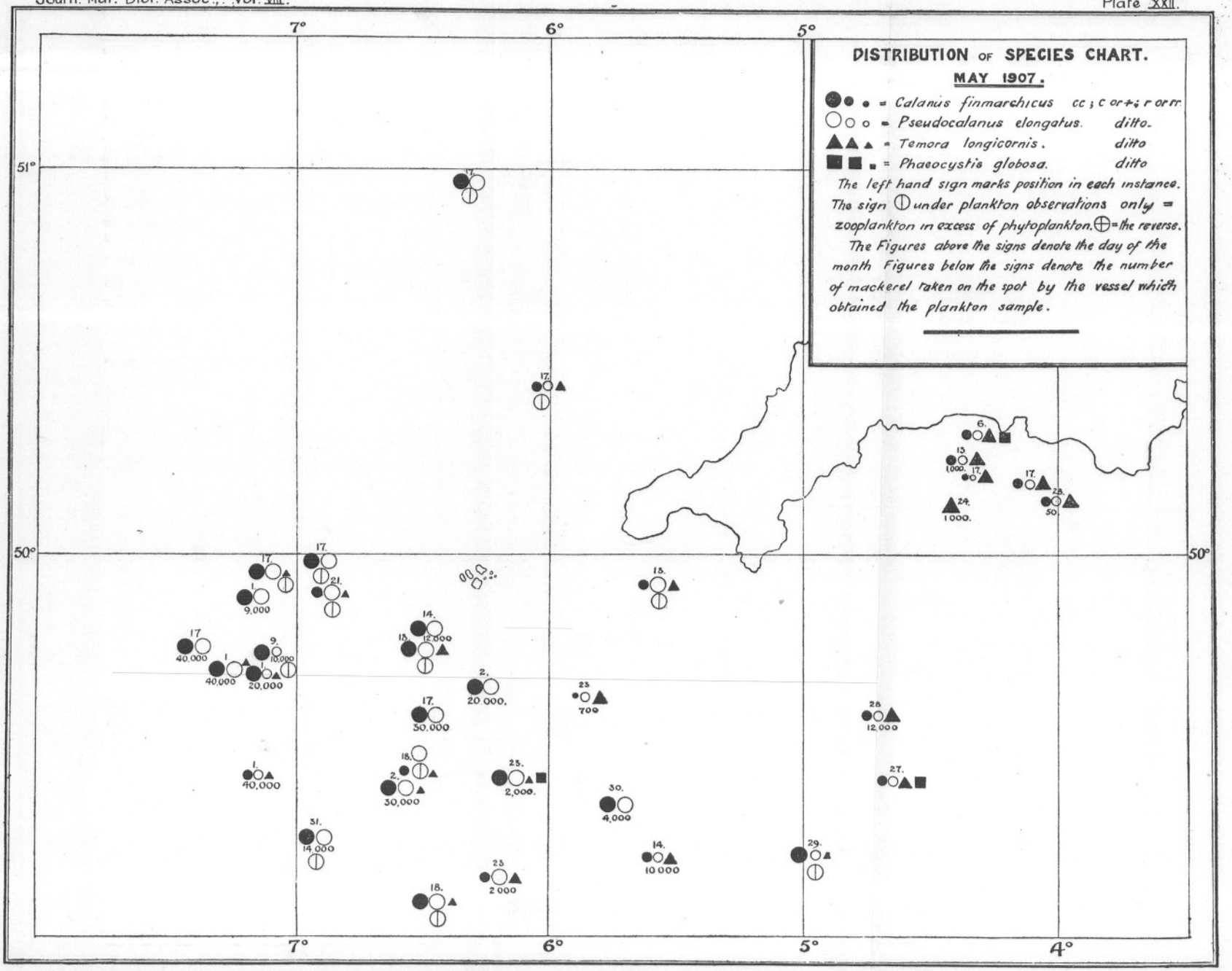
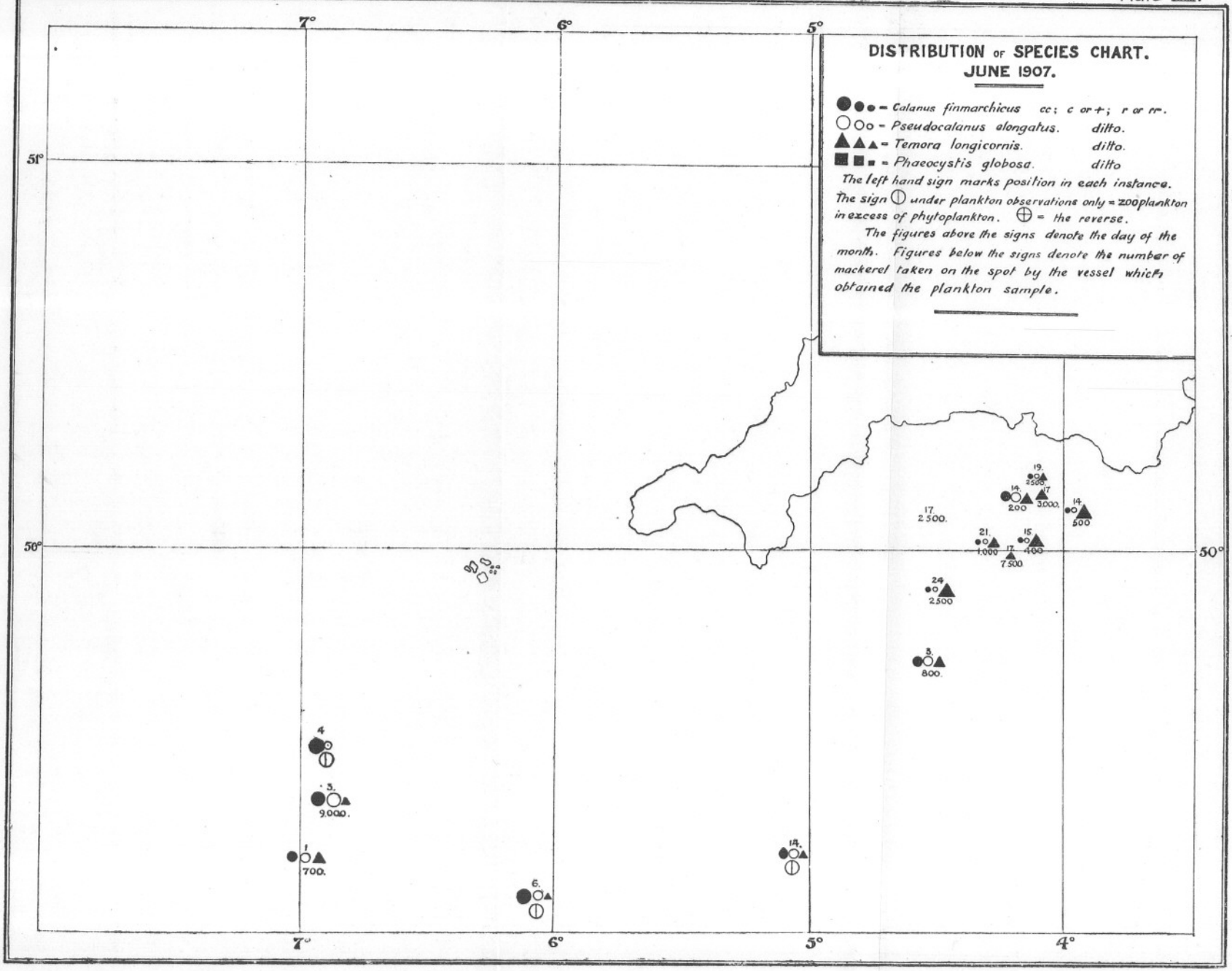
DISTRIBUTION OF SPECIES CHART.
APRIL 1907.
= Calanus finmarchicus cc; cor+; r or rr.
= Pseudocalanus elongatus ditto.
= Temora longicornis ditto.
= Phaeocystis globosa ditto.
The left hand sign marks position in each instance
The sign ⊕ under plankton observations only = zooplankton in excess of phytoplankton. ⊕ = the reverse.
The Figures above the signs denote the day of the month. Figures below the signs denote the number of mackerel taken on the spot by the vessel which obtained the plankton sample.
12. 5,000
5. 250
12.
6. 50.
4. 300
5. 100.
5. 100
17.
9. 300.
16.
3. 75.
14.
16.
20. 1,000
30. 700
16.
26. 3,000
26 4,000
4. 500.
17.
16.
17.
16.
10. 500
9. 250
13 12,000
30 4,000


DISTRIBUTION OF SPECIES CHART.
MAY 1907.
● ● ● = Calanus finmarchicus cc ; c or + ; r or rr
○ ○ ○ = Pseudocalanus elongatus. ditto.
▲ ▲ ▲ = Temora longicornis. ditto
■ ■ ■ = Phaeocystis globosa. ditto
The left hand sign marks position in each instance.
The sign ⊕ under plankton observations only = zooplankton in excess of phytoplankton. ⊕ = the reverse.
The Figures above the signs denote the day of the month Figures below the signs denote the number of mackerel taken on the spot by the vessel which obtained the plankton sample.
7°
6°
5°
4°
51°
50°
17.
9,000
21.
14.
12,000
40,000
9.
10,000
20,000
2.
20,000.
23.
700
30,000
18.
30,000
25.
2,000.
28.
12,000
27.
30.
4,000
31.
14,000
14.
10,000
29.
25.
2,000
18.
6.
13.
1,000.
24.
1,000.
50.


7°
6°
5°
4°
51°
50°
DISTRIBUTION OF SPECIES CHART.
JUNE 1907.
●●● - Calanus finmarchicus cc; c or +; r or rr.
○○○ - Pseudocalanus elongatus. ditto.
▲▲▲ - Temora longicornis. ditto.
■■■ - Phaeocystis globosa. ditto
The left hand sign marks position in each instance.
The sign ⊖ under plankton observations only = zooplankton in excess of phytoplankton. ⊕ = the reverse.
The figures above the signs denote the day of the month. Figures below the signs denote the number of mackerel taken on the spot by the vessel which obtained the plankton sample.
19.
14.
17.
3,000.
200
14.
500
17.
2,500.
21.
1,000
15.
400
17.
7,500
24.
2,500
5.
800.
4
3.
9,000.
1
700.
6.
14.

On an Experiment in the Keeping of Salmon (*Salmo salar*) at the Plymouth Laboratory.

By

L. R. Crawshay, M.A.,

Assistant Director.

With Plate XXIV.

For the past two and a half years (1906–8) some salmon, which were reared at the Endsleigh Fishery, have been kept under observation in the aquarium of the Plymouth Laboratory.

In sending these fish as smolts to the Laboratory, the Duke of Bedford wished more particularly to obtain information on two questions: firstly, the character of the food of the salmon during its sojourn in the sea, and secondly, the period of that sojourn intervening between the smolt and grilse stages. These and other points of interest that have arisen will be considered in order in giving a general account of the experiment.

The smolts were brought from Endsleigh at two years old, and introduced into the aquarium in two lots (of twenty and thirty) on February 6th and March 1st, 1906, respectively. The actual weight and measurement were not taken at the time, but Mr. E. C. Rundle informs me he has ascertained that the average weight may be placed at 4–5 oz. and the average length at 8–10 inches. The fish have been largely under the charge of Mr. A. J. Smith, and it is upon his detailed notes that the present account is based.

For the accommodation of the smolts, one of the aquarium tanks was emptied and brought into communication with the fresh-water supply, the water being led into the tank by means of a rubber hose-pipe, and kept running.

The first twenty smolts were put into this tank on February 6th, 1906, and allowed to remain in the fresh water for two days. Transference to sea-water was then effected very gradually, at a rate of inflow increasing from day to day, as follows:—

February 8th, 11.45 a.m. Fresh water 1000 cc. per 15 seconds
Sea „ „ „ 75 „
„ 9th, 10.30 a.m. . . Density of water in tank 1·001
Fresh water 1000 cc. per 35 seconds
Sea „ „ „ 75 „
„ 10th, 10.30 a.m. . . Density of water in tank 1·005
Fresh water 1000 cc. per 47 seconds
Sea „ „ „ 31 „
„ 12th, 10.0 a.m. . . Density of water in tank 1·016
Fresh water 1000 cc. per 60 seconds
Sea „ „ „ 31 „
„ 13th, 10.30 a.m. . . Density of water in tank { Top 1·017 / Bot. 1·018
Temp. 46° F.
„ 14th . . . . Density of water in tank 1·018
Fresh water shut off
Sea „ 1000 cc. per 31 seconds
„ 15th . . Two more jets of sea water turned on. (One smolt died.) . . . . . .
„ 16th, 10.0 a.m. . . Density of water in tank 1.027

The water having now approximately reached the normal salinity of the water in the reservoirs, the supply was connected up with the general circulation, i.e. nine days after the transference began. The digestive tract of the smolt that died on the 15th was found to be quite empty. Feeding on the whole had been fairly good. On February 27th these nineteen smolts were removed to a larger tank. On March 1st the second lot of smolts, thirty in number, were brought from Endsleigh, and placed in fresh water in the tank now vacated by the others. Their transference to sea water was completed in about one-third of the time occupied for that of the preceding lot, and as follows:—

March 5th . . Fresh water 1000 cc. per 18 seconds
Sea „ „ „ 33 „
„ 6th . . . . . Density of water in tank 1·007
Fresh water 1000 cc. per 30 seconds
Sea „ „ „ 10 „
„ 7th . . . . . Density of water in tank 1·015
Fresh water supply turned off
Sea water 1000 cc. per 10 seconds
„ 8th . . . . . Density of water in tank 1·026
Supply connected up with general circulation.

The transference of the second lot was therefore completed in three

days. Before it began, one of the smolts jumped from the fresh-water tank, over the barrier, into the sea-water tank adjoining. It was left in sea water afterwards, and suffered no harm. The same thing happened to a second individual on the first night after the change began (March 5th).

On March 10th this second lot of smolts was put into the large tank with the others. This tank, which now contained forty-nine smolts, was used throughout to accommodate the survivors as long as the salmon remained at the Laboratory. Its inside dimensions are 15·7 feet in length, 9 feet in width, and 4·4 feet in depth of water, giving a capacity of 621 cubic feet. It was fed by eight jets, giving a total normal inflow of about 385 cc. per second, and its position, partly screened from the direct light by a dark-coloured blind, is such that its lighting may be described as moderately low and constant. The back, the ends, and the floor of the tank are formed of slate, and all uprights or other portions of the framework are similarly dark in colour. Air was supplied entirely by the force of the water from the several jets striking the surface, which was sufficient to carry the fine air-bubbles nearly or quite to the bottom of the tank.

Feeding.—The smolts were fed twice a day, and often three times. On the first day or two the food given them was broken biscuit and prepared fish and flesh foods previously soaked, of the same kind as that used at Endsleigh. This was then varied with raw bullock's liver cut into small pieces, and the preference for this latter soon became so strong that the other was very shortly discarded altogether. This was the case with both lots of smolt. When the transference to sea water was about half completed, it was found that the common inter-tidal marine worms of the genus *Nereis* (*N. diversicolor*) were taken very readily. About the time of the completion of the change a distinct loss of appetite was shown by several of the smolts for a few days. But, on the whole, feeding was fairly good during the interval, and this was particularly the case with the second lot, where the transference was brought about more rapidly. After the change to sea water, liver was taken with the same readiness as previously. *Nereis* was at times taken when liver was refused, but beyond this little preference was shown between the two.

Experiments in feeding with marine animals other than *Nereis* gave entirely negative results. Among others, trials were made on several occasions with the following species:—*

* It is to be regretted that herring was never tried. But the keeping of young herring alive for any length of time, even when they are obtainable, is a matter of very great difficulty.

Living Shrimps (*Crangon*).
„ Prawns (*Palaemon*).
„ *Pandalus annulicornis* and *P. brevirostris*.
Cut Squid (*Loligo*).
„ Scallop (*Pecten*).
Living Pollack (*Gadus pollachius*), about 2 inches long.
„ Gobies (*Gobius minutus* and *G. ruthensparri*).
Cut Plaice (*Pleuronectes platessa*).

The salmon were seen by Dr. Allen to take hold of some of the shrimps, though afterwards releasing them, and to show a certain interest in some of the small fish. But there was no evidence of their having swallowed any of these objects of food, and the only conclusion to be drawn is that they entirely refused them. Two of the smolts were kept for some time in a separate tank with two bass as companions, the only food offered them being shrimps, prawns, and gobies. Although the latter experiment was not conclusive, no evidence that any of these had been eaten by the salmon was obtained. On the first two or three days, while the smolts were still in fresh water, it was once or twice observed that fragments of the prepared foods (not liver) were picked up by them after reaching the bottom of the tank; but this never occurred afterwards, and even the living *Nereis*, which happened to reach the bottom, were allowed to remain there crawling about, without the salmon paying any attention to them. In marked contrast to this, some Rainbow Trout (*Salmo irideus*), which the Duke of Bedford has also sent to the Laboratory from Endsleigh, will commonly follow their food to the bottom, and continue to pick it up for some time after it has settled. These Rainbows, too, easily adapt themselves in sea water to the cut Squid (*Loligo*), and some other foods ordinarily given to the marine fishes.

First Spawning, 1906–7.—Signs of approaching maturity became apparent in the smolts towards the end of October, 1906, i.e. eight months after they were first passed into sea water. On October 31st and November 1st it was observed that scarcely any food was taken, and in some cases what was taken into the mouth was discarded again. During the previous week the fish had been growing darker in colour. They began to frequent the bottom of the tank and to lie there heavily. One of them lost the upright position, and died in a day or two afterwards (November 4th). It was accordingly decided to pass sixteen of the more advanced ones into fresh water. The process was begun on November 6th, and the change was made in a very similar manner to the reverse one in the preceding March. The time allowed

was from two to three days, and the whole of them were thus transferred to fresh water by November 15th. On November 9th, shortly after the change to fresh water, one of the males died. The testis was found to be nearly mature. The weight of this fish was very nearly 1 lb., and the length 13¾ inches. During this period one of the fish jumped from the fresh-water tank into a tank of sea water adjoining (cp. p. 305). After thirty-six hours it was put back into the fresh-water tank direct without any ill effects arising.

November 26th. All of the grilse were examined by Mr. McNicol, who has charge of the Duke of Bedford's Fishery. Apart from the deaths that had been recorded, it was found that five of the fish were missing. It can only be surmised that these had from time to time jumped over the barrier into the large adjoining tank and fallen victims to the turbot, nurse-hounds, and other large fish that occupied it. The number that remained was now thirty-five. Seven females were spawned on this day (November 26th), and the ova fertilized. The remainder were spawned on December 11th. Nearly the whole of these fertilized ova were taken to Endsleigh and there hatched under normal conditions both as regards numerical proportion and the period between fertilization and hatching. They were not kept under observation for long after hatching, and there was apparently no unusual feature arising in regard to size or otherwise in connection with their development. A few ova were retained at the Laboratory and hatched under tap water, but these did not long survive the feeding stage following absorption of the yolk-sac, owing no doubt merely to the unsuitable condition of the water supply with its irresistible tendency to nurture the growth of fungus and other vegetable organisms.

As regards feeding during this period of spawning, very little food was taken between the last week in October and the two respective dates of spawning, November 26th and December 11th, though feeding did not entirely cease for more than a day or so at a time. Within a few days after spawning, there was a marked change in this respect and by December 22nd the total consumption amounted to about ¾ lb. of liver per day, the weight of the fish at this time averaging about 1½ lb. Feeding continued at much the same point till the middle of February. It was then decided to turn the fish, numbering thirty-five, over to sea water, and this was done between February 19th and 20th. The change proved to be an unfortunate one, and the salmon at once ceased feeding. Between February 21st and 26th, seven of them died—five males and two females. These were found to still contain a quantity of ripe milt and ova respectively. Between February 25th

and 26th they were therefore returned to fresh water, and remained thus till March 15th. This change quickly brought about a return to feeding. On March 6th the daily consumption reached ¾ lb. of liver and a supply of *Nereis*, and the amount did not fall appreciably below this figure afterwards.

The return to sea water was made between March 15th and 19th, one female, which was found to be incompletely spawned, being lost in the process. Of the succeeding period in sea water in the spring and summer of 1907 there is little to record of interest. The food consumption rose steadily to 3 lb. of liver per day at the middle of May, and continued at about this point till the middle of August. From the latter date it began to fall, and on September 17th it dropped to ¾ lb.

At the end of September the salmon had to be moved, in order that the tank might be repaired. They were very susceptible to injury in handling, and four of them died before they were finally settled in their own tank.

Second Spawning, 1907–8. — The salmon, twenty-one in number, were transferred to fresh water between October 1st and 5th, about six weeks earlier than in the preceding year, feeding having by this time all but ceased. After this time and up to the date of spawning they continued to take a fair quantity of *Nereis* with some irregularity, but little or no liver was taken.

About half of them were spawned on November 15th, seven on November 29th, one on December 13th, and one on January 3rd. A large number of the fertilized ova were kept and hatched at the Laboratory, but the larvæ barely attained at most the complete absorption of the yolk-sac. How far the underlying causes were to be attributed to the inadequate conditions of the water supply as in the previous year, it is difficult to say, but two points were particularly noticeable in this case: (1) a common difficulty in rupturing the egg-membrane, and (2) a general weakness in the embryonic circulation which hindered communication with the distal portion of the yolk-sac and retarded its absorption. In consequence of the latter difficulty a constriction arising in the yolk-sac was the direct cause of death in the large majority of cases, and the two points taken together suggested a general sickliness that had been transmitted from the parents.

Attacks of fungus, which began to affect the salmon in the early part of December, 1907, had later assumed such proportions, with fatal results to several of the fish, that it was decided to transfer the remainder of them to sea water at an early date, and this was done between January 7th and 8th, 1908. Three deaths that occurred

within two days after the latter date may be attributed entirely to bad cases of fungus, and its attendant disease, too far gone to remedy, and apparently no ill effects resulted from this early return to sea water beyond a falling off in feeding for a few days afterwards.

Growth.—As previously stated the weight of the smolts when they were brought to the Laboratory in February and March, 1906, may be placed at 4 to 5 oz., and the length at 8 to 10 inches. On September 28th, 1906, one fish, taken as representing the average, weighed 1 lb. 8½ oz., and measured 16 inches in length. On November 26th, 1906, twenty-seven fish were weighed prior to spawning, but not measured. The weights of these fish were as follows:—

No.	Weight.		Sex.	Condition.
	lb.	oz.		
(1)	0	14	female	mature
(2)	1	3	,,	immature
(3)	1	4	,,	mature
(4)	1	4	male	,,
(5)	1	6	female	,,
(6)	1	6	,,	,,
(7)	1	6	,,	immature
(8)	1	6	male	mature
(9)	1	6	female	,,
(10)	1	6	,,	,,
(11)	1	6	,,	,,
(12)	1	6	male	,,
(13)	1	6	,,	immature
(14)	1	8	female	mature
(15)	1	8	male	immature
(16)	1	8	female	? spawned
(17)	1	10	,,	mature
(18)	1	10	male	nearly mature
(19)	1	12	female	mature
(20)	1	12	,,	immature
(21)	1	12	,,	mature
(22)	1	12	,,	,,
(23)	1	12	male	nearly mature
(24)	1	14	,,	immature
(25)	1	14	female	,,
(26)	1	14	,,	mature
(27)	2	0	,,	barren

It is remarkable that the above weights give an average which is exactly the same as the weight of the fish selected for trial on September 28th, viz. 1 lb. 8½ oz. It is quite conceivable that this particular fish chosen on that occasion slightly exceeded the true average, but it is evident that the average increase of weight in the two months' interval must have been very small. On the same

occasion (November 26th) seven of the females were weighed after spawning, with the following results:—

	lb.	oz.
(*a*)	1	2
(*b*)	1	4
(*c*)	1	4
(*d*)	1	4
(*e*)	1	8
(*f*)	1	9
(*g*)	1	10

These give an average of 1 lb. 6 oz. nearly. The weights cannot be compared individually with those taken before spawning, since to obviate as far as possible excessive physical strain on the fish the weights before and after spawning were not taken in any definite sequence. If, however, the average weight 1 lb. 6 oz. be compared with that of the twelve mature females enumerated in the first list (thus omitting No. 1 for obvious reasons), namely 1 lb. 8·5 oz., the average weight of spawn removed works out at 2½ oz., or 10·2 per cent of the average weight of fish. Assuming, on the other hand, that the females spawned were the seven heaviest of the mature females in the first list, then the latter give an average weight of 1 lb. 10½ oz., and the highest possible average weight of spawn removed would thus be 4½ oz., or 17 per cent of the average weight of fish.

On November 15th, 1907, i.e. at the time of the second spawning, the weights were again taken of seven fish, of which the females were weighed both before and after spawning. These were as follows:—

Males	(1)	2 lb. 8 oz.		
	(2)	2 „ 8 „		
Females	(1).	Before spawning, 2 lb. 10 oz.	After spawning,	1 lb. 14 oz.
	(2)	„ 2 „ 10 „	„	1 „ 12 „
	(3)	„ 2 „ 12 „	„	1 „ 14 „
	(4)	„ 3 „ 0 „	„	2 „ 4 „
	(5)	„ 3 „ 0 „	„	2 „ 2 „

The average weight of these five females at this date is therefore 2 lb. 12·8 oz., while the average weight of spawn removed from them is 13·2 oz. This weight of spawn thus constitutes as much as 29·5 per cent of the average total weight, and amounts in one individual (No. 2) to one-third of the total weight of the fish. On June 19th, 1908, four of the salmon were weighed and measured as representing an average sample of the twelve that remained at the Laboratory. The figures obtained were:—

	Weight. lb.	oz.		Length. inches.
(1) . . .	3	2	...	19
(2) . . .	3	4	...	19½
(3) . . .	4	0	...	20¼
(4) . . .	5	0	...	22½

It must, however, be mentioned that the weight given for the last fish, 5lb., is inconsistent with a subsequent test two months later, in which the heaviest fish weighed 4 lb. 8 oz. There is no ground for supposing that an error occurred in the reading, but it is difficult to understand such a loss of weight in the interval, and it is safer to omit these four weights in considering the average rate of growth.

It was subsequently decided by the Duke of Bedford that as little information was likely to be added by retaining the salmon any longer at the Laboratory they should be liberated. On August 20th, 1908, the remainder were therefore marked and turned out into the sea, outside the Plymouth Breakwater. Some of them were already showing signs of approaching maturity for the third time, and in one of them that died before being liberated the ovary was much developed. Including this last individual, the weight of these eleven fish at this date was as follows:—

	Weight. lb.	oz.		Length. inches.
(1) . . .	2	4	...	17
(2) . . .	2	8	...	19
(3) . . .	3	1	...	19
(4) . . .	3	8	...	19
(5) . . .	3	7	...	20
(6) . . .	4	0	...	21
(7) . . .	4	0	...	21
(8) . . .	4	1	...	21
(9) . . .	4	1	...	21
(10) . . .	4	3	...	21
(11) . . .	4	8	...	22

giving an average weight of 3 lb. 9½ oz., and an average length of 20 inches.

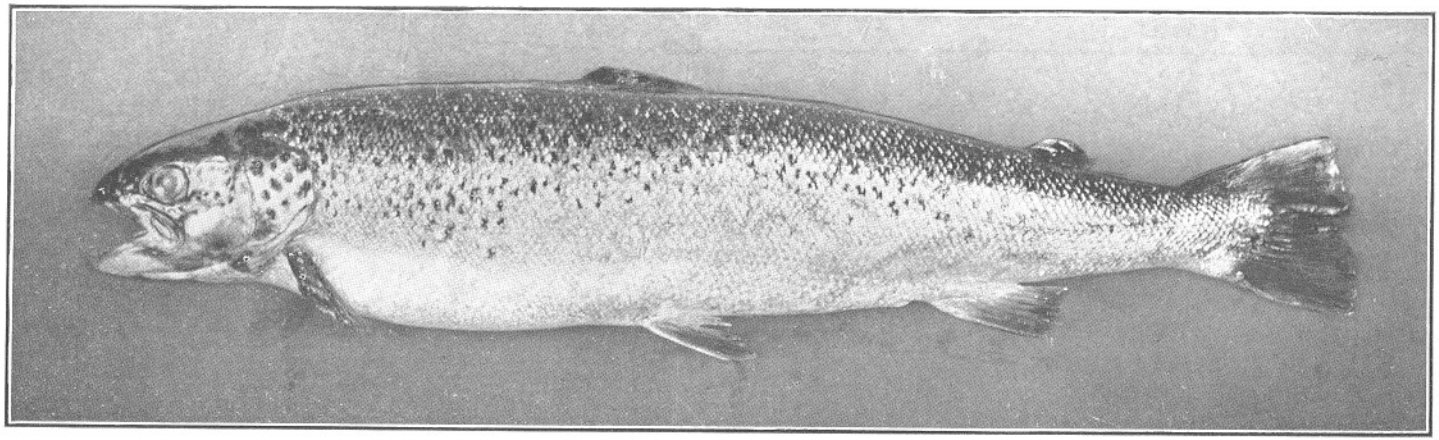
Summarizing the above data, the following show the averages of growth at intervals, during the period of about two years and a half, in which the salmon were kept at the Laboratory:—

Date.	Approx. Age.	Average Weight. lb.	oz.		Average Length. inches.
1906. Feb. to March ...	2 years ...	0	4½	...	9
„ Sept. 28th ...	2 7/12 „ ...	1	8½	(approx.)	16 (approx.)
„ Nov. 26th ...	2¾ „ ...	1	8½	...	—
1907. „ 15th ...	3¾ „ ...	2	12	...	—
1908. Aug. 20th ...	4½ „ ...	3	9½	...	20

The average rates of growth per month, from the smolt stage in February and March, 1906, are therefore:—

For nine months to November 26th, 1906	. .	2·2 oz. per month.
„ twelve „ „ „ 15th, 1907	. .	1·6 „ „
„ nine „ „ August 20th, 1908	. .	1·5 „ „

It only remains to mention that the form which the salmon assumed was quite an abnormal one. The silvery colour of the smolts after entering sea water was not retained, but the dorsal region became dark and much spotted. This tendency increased till ultimately the greater part of the region above the lateral line was much darkened and the spots increased in size and in number, extending over the whole length of the body, and in places considerably below the lateral line, being especially large and prominent about the head and gill-covers. The accompanying figure (Plate XXIV.) illustrates these points in the female, weighing about 4 lb., which died on August 20th, 1908, the date on which the remainder of the salmon were liberated. The flesh of this fish was found to have no appearance of the normal "salmon" colour, but was of a pale brownish white.



SALMON (*SALMO SALAR*).

To face p. 312.

On the Genus Cumanotus.

By

Sir Charles Eliot, K.C.M.G.

(See Eliot on *Coryphella beaumonti* in Notes on some British Nudibranchs, *Journ. Mar. Biol. Assoc.*, vol. vii., No. 3, June, 1906, pp. 361–3; and Nils Odhner on *Cumanotus laticeps* in Northern and Arctic Invertebrates, iii. *Opisthobranchia. Kngl. Svenska Vetenskapsakademiens Handlingar. Band* 41, No. 4, 1907, pp. 29, 80, and 101–2).

In describing (l.c.) *Coryphella beaumonti* as a new species, I pointed out that in many important characters it differs markedly from the other known *Coryphellæ*, and might be made the type of a new genus. But I did not create a new genus, thinking it might be well to examine further specimens, both of this animal and of allied forms, before deciding on its place in the classification. In the next year Odhner created (l.c.) the genus *Cumanotus*,* to which *Coryphella beaumonti* is certainly referable, and which is shown by his researches to be well characterized. It is allied to *Coryphella* inasmuch as it has unperfoliate rhinophores, tentacular angles to the foot, a triseriate radula and denticulate jaws; but it also possesses the following special characters: (1) The oral tentacles are very small and connected by a cutaneous fold which runs across the head; (2) there are several (at least, as many as three) rows of cerata in front of the rhinophores; (3) the verge is deeply grooved, and there is a bursa copulatrix, the entrance to which bears on its upper and lower margin a circular pad, armed on the periphery with twelve small cones terminating in hooks.

In the specimen which I dissected, the reproductive organs were much contracted, and I supposed these cones to be an armature on the male genitalia, such as is not uncommon in aeolids; but a dissection of more specimens, as well as an examination of the animals in life, has shown that Mr. Odhner is perfectly correct in describing the arrangement as two pads placed at the entrance of the bursa copulatrix. I have not seen the animals alive myself, but Mr. L. R. Crawshay, who observed their movements in the tanks of the Plymouth Laboratory, writes to me that: "Though in appearance the arrangement suggests

* He says it is from κῦμα, a wave, and νῶτον, back; but if so, would not *Cymanotus* be the more usual form?

that the hooked pads are associated with the ♂ rather than with the ♀ organ . . . at the same time, what was observed in the Laboratory points strongly to the conclusion that they are really ♀ clasping organs. If the organs of the one individual are called A (♂), B (♀), and of the other, X (♂), Y (♀), what was observed was as follows: The two individuals were placed right to right with the complete apparatus of both extended and approximating. The base of A (♂) was grasped laterally by an upward extension (i.e. presumably the pads) on both sides of Y (♀), and the base of X (♂) was similarly grasped by upward lateral extensions of B (♀). In each case a sort of peristaltic movement on the part of B (♀) and Y (♀) occurred. As the grasp of B (♀) and Y (♀) extensions relaxed, the flow of spermatozoa from X (♂) and A (♂) respectively was distinctly visible, while as the grasp of the extensions closed round the base of X (♂) and A (♂), the flow of spermatozoa was checked." As far as I am aware, a female clasping organ of this kind has not yet been recorded among Nudibranchs, but it is possible that in some other genera of aeolids its nature may have been misunderstood.

It is doubtful whether *Cumanotus beaumonti* and *Cumanotus laticeps* are specifically the same. The identity is not improbable, but Odhner's specimens (judging from the figures) had lost all the cerata. *Cumanotus beaumonti* is remarkable for having a short truncated body and extremely long snaky cerata, but when these have fallen off the Plymouth specimens look very like Odhner's figures, and have the margin of the foot similarly expanded. There may also be differences in the denticulation of the jaws and lateral teeth. But these are slight divergences, and hardly of specific value unless associated with others. Still, until a complete specimen of the Norwegian form has been examined it is safer not to unite the two species, and provisionally I think the genus may be tabulated as follows:—

Cumanotus, Odhner, 1907.

1. *C. beaumonti* (Eliot), 1906.
2. *C. laticeps*, Odhner, 1907.

If the species are united the name *beaumonti* has priority.

I hope to publish figures of the living *C. beaumonti* in a supplement to Alder and Hancock's *British Nudibranchiate Mollusca*, which will soon be issued by the Ray Society.

C. laticeps is known by four specimens obtained at Sörvær, in the extreme north of Norway, in 5–10 fathoms of water. *C. beaumonti* has been captured at Plymouth, twice in Barn Pool and on several occasions in Jennycliffe Bay, at a depth of 2–5 fathoms, and though far from common, appears to be a resident and not merely a visitor.

Note on a Hermaphrodite Cod (*Gadus morrhua*).

By

A. E. Hefford, B.Sc.,

Assistant Naturalist at the Plymouth Laboratory.

With one Figure in the Text.

On February 27th, the roe of a cod having a testicular portion attached was received at the Laboratory from Messrs. Moodys and Kelly, of Grimsby. It had been taken from a cod caught by a steam trawler fishing in Icelandic waters. Owing to the rough removal of the organs from the fish on the trawling ground, the genital ducts were missing and the region of their origin was ruptured, while the testis had been somewhat damaged in the course of its long journey to Plymouth.

Fig. 1 shows a drawing of the organs seen from the ventral side. The female element predominates, the ovaries appearing quite normal and functional, with unripe ova at a stage of development which suggests that spawning should occur in about two to four months. The left ovary is $6\frac{1}{2}$ inches long and the right one $6\frac{1}{4}$ inches—a practically symmetrical condition. The testicular portion is connected with the left ovary by a duct a quarter to half an inch long, enclosed by a continuation of the fibrous covering of the ovary, the point of connection being very near to the median line and about a quarter of an inch behind the anterior extremity of the median ovarian mass. The form of the testis is rather rosette-like and frilled, but much less lobulated than a normal testis. The length of the longest lobe of the rosette measured from the duct is about 3 inches. It is now rather broken, however, and the original length was probably a little greater.

Internally the testis duct is longitudinally ridged, one of these ridges widening into a valve-like flap near the small aperture which leads into the lumen of the ovary. The testis is in a well-developed but unripe condition. Owing to maceration in the course of transit—on the trawler it was kept in ice and then sent through the post to

Plymouth wrapped up in paper in a box—the tissue is not suitable for microscopic examination. It is probable, however, that the male organ would be functional, and that when ripe its products would pass to the exterior *via* the testis duct and the ovary. Owing to the ruptured condition of the right ovary in the region corresponding to the testis

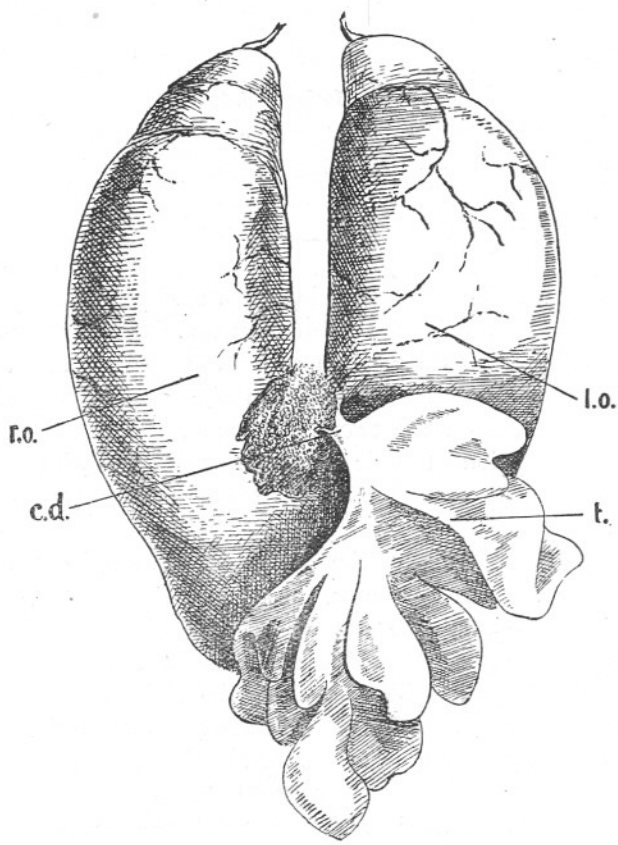


FIG. 1.—Hermaphrodite Gonad of Cod.

r.o., right ovary; l.o., left ovary; t., testis; c.d., testis duct.

duct attachment on the left, I am not able to say with absolute certainty that the above-mentioned is the only testicular part, though there is extremely little doubt but that the whole of the genitalia were removed from the fish, the ruptured portion being the result of tearing away the roe from its duct to the exterior.

Other examples of hermaphroditism in cod have been described by Howes,* Masterman,† Williamson,‡ etc.

Masterman gives a tabular list of eleven cases for comparison, including his own observation and those cited by Howes. In all these the ovarian organ preponderates. Great diversity is shown in the position of the testis, which may be single or in as many as three distinct and separately attached parts. In Williamson's two cases, one presents a perfectly symmetrical form with a small testis attached to the anterior end of each ovary, while the other is completely asymmetrical, the right gonad being an ovary and the left a testis, the two uniting in the anal region and having a common genital aperture. My specimen presents a further variation in the position of the testis. In the relatively large size of the testicular portion it is also peculiar.

* G. B. Howes, "Hermaphrodite Genitalia of the Codfish," etc. (*Journ. Linn. Soc.*, xxiii., p. 539).

† Masterman, "On Hermaphroditism in the Cod" (*Thirteenth Annual Report of the Fishery Board for Scotland*, Part III, for the year 1894, p. 297).

‡ Williamson, "On Two Cases of Hermaphroditism in the Cod" (*Twenty-fourth Annual Report of the Fishery Board for Scotland*, Part III, for the year 1905, p. 290).

Note on a Conger with Abnormal Gonad.

By

A. E. Hefford, B.Sc.

With one Figure in the Text.

Among a sample of seven small Conger, from 58 to 77 cm. in length, obtained from the Plymouth Fish Quay on 31st March, one was found with unsymmetrical reproductive organs. The other six were immature females with the normal pair of ovaries. The abnormal specimen has a right gonad quite similar to the ovaries of females at the same stage of maturity. It is bandlike in form, extending along the whole length of the abdominal cavity. The inner or left side is covered with smooth peritoneal epithelium (mesoarium). The greater part of the surface of the right (outer) side is raised into transverse lamellæ containing the as yet little-developed ova embedded in fat-tissue. For about one to two millimetres from its free edge, the organ consists of a strip of fat-tissue quite free from germinal cells, and there is a similarly constituted longitudinal fold—here and there divided into a subsidiary one—extending parallel to and about 2 mm. from the free edge and bordering the lamellated germinal area. The ovary is 17·5 cm. long, its greatest width 12 mm., and the widest part of the lamellated area is about 7 mm.

The left gonad is a sterile ovary, the transverse germinal ridges being quite absent. Along the line of attachment there is a narrow longitudinal ridge of fat-tissue, fairly well developed anteriorly, but becoming discontinuous towards the hinder end; then a narrow strip of bare peritoneal epithelium (the area which is normally covered with the egg-bearing lamellæ); and along the free edge are folds of fat-tissue similar to those occurring in the normal ovary.

I am indebted to Mr. J. T. Cunningham for his kindness in examining and giving his opinion upon this specimen.

It is interesting to note that this abnormal individual was the sixteenth Conger examined by me since March 14th with the object of

obtaining a male specimen; but up to this time only females had been found. The sizes ranged from 92 to 58 cm., ten of them being less than 76 cm. (2 ft. 6 inches) which is the limiting size given by Cun-

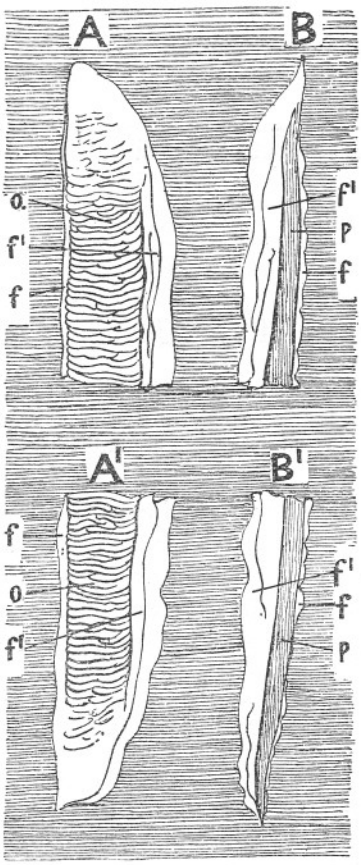


FIG. 1.—Abnormal Gonad of Conger.

A, anterior; A^1, posterior end of right (normal) gonad.
B, anterior; B^1, posterior end of left (abnormal) gonad.
o, egg-bearing lamellæ; f, fat-tissue along attachment edge of ovary; f^1, fat-tissue along the free edge of ovary.
p, peritoneal tissue (mesoarium).

ningham* for male Conger. Subsequently I have obtained two males, of 61 cm. (24 inches) and 50 cm. (20 inches) out of twenty trawl-caught Conger ranging from 77 to 50 cm. in length.

* J. T. Cunningham, "On the Reproduction and Development of the Conger" (*Journ. M.B.A.*, vol. ii, N.S., p. 31).

Marine Biological Association of the United Kingdom.

Report of the Council, 1907-8.

The Council and Officers.

Four ordinary and one special meetings of the Council have been held during the year, at which the average attendance has been ten.

All the meetings have been held in the rooms of the Royal Society at Burlington House, and the Council desire again to express their thanks to the Royal Society for the use of these rooms.

Committees of the Council have visited and inspected the Laboratories at Plymouth and Lowestoft, and have reported favourably on the condition of buildings and boats.

The Committee on Fishery Investigations, appointed by the Treasury to inquire into the future conduct of such investigations in the United Kingdom, have visited the Plymouth and Lowestoft Laboratories and inspected the steam-trawler *Huxley*. Evidence was given before this Committee on behalf of the Association by Sir E. Ray Lankester, Dr. A. E. Shipley, Mr. J. A. Travers, Prof. G. C. Bourne, Dr. G. H. Fowler, Dr. H. R. Mill, Dr. E. J. Allen, Prof. W. Garstang, and Mr. D. J. Matthews.

The Laboratories.

A number of necessary repairs to the building and to the aquarium tanks at the Plymouth Laboratory have been carried out during the year, and a new centrifugal pump has been fitted for circulating the sea-water through the tanks. The main laboratory, the library and other portions of the building have been colour-washed.

The work of the Lowestoft Laboratory has been conducted in the same house as last year.

The Boats.

The steam-trawler *Huxley*, which has been for five years hired by the Association for the work of the English section of the International Investigations, has now been purchased upon favourable terms by the Marine Biological Association from her owner, Mr. G. P. Bidder.

Both the *Huxley* and the *Oithona*, the corresponding boat at Plymouth, were laid up during the winter months, and after undergoing full surveys were put into a condition of proper repair.

The sailing-boat *Anton-Dohrn* was used for the collecting work at Plymouth during the winter.

The Staff.

At the end of September, 1907, Dr. Walter Garstang resigned the post of Naturalist in Charge of Fishery Investigations, which he had occupied since 1897, in order to take up professorial duties at the University of Leeds. The Council did not feel justified in making a new appointment to his post, until H.M. Government had decided to continue the British share of the International Investigations for a further term of years. The Council desires to record its appreciation of the valuable help rendered to the work by Dr. Allen, the Director, in undertaking temporarily the difficult task of superintending both the Laboratories. Since Prof. Garstang's retirement Dr. Allen has resided chiefly at Lowestoft, and visited Plymouth when necessary. Mr. L. R. Crawshay has been promoted to be Assistant Director of the Plymouth Laboratory, and Mr. J. O. Borley to be Assistant Director of the Lowestoft Laboratory. Mr. A. E. Hefford has been transferred from Lowestoft to Plymouth, where he is specially engaged in the study of fishes and fishery questions. Mr. A. J. Mason-Jones, M.SC., of the University of Birmingham, has succeeded Mr. W. Bygrave as Assistant Naturalist for Plankton in connection with the International Investigations.

Mr. E. W. Nelson has been temporarily employed at Plymouth during the year.

Occupation of Tables.

The following Naturalists have occupied tables at the Plymouth Laboratory during the year:—

W. C. De Morgan, London (Crustacea).
J. C. Simpson, Cambridge (Echinodermata).
C. H. O'Donoghue, London (Hydrozoa).
A. J. Grove, Birmingham (Protozoa).
F. W. Gamble, D.SC., F.R.S., Manchester (Colour Physiology of Fishes).
G. W. Smith, B.A., Oxford (Sacculina).

F. J. Bridgeman, London (Development of Porifera and Elasmobranchii).
R. D. Laurie, M.A., Oxford (Crustacea. Biometrical Study).
E. T. Browne, B.A., London (Cœlenterata).
W. Bygrave, B.A., Cambridge (Plankton).
J. R. Davidson, Plymouth (Plankton Larvæ).
J. C. F. Fryer, Cambridge (General Zoology).
E. S. Goodrich, M.A., F.R.S., Oxford (Thymus of Fishes).
R. L. Robinson, London (General Zoology).
R. M. Richards, London (General Zoology).
Miss W. Coward, Manchester (General Zoology).
Miss H. L. M. Pixell, B.Sc., London (Ferments of Digestive Tract of Elasmobranchii).
Sir Charles Eliot, K.C.M.G., Sheffield (Nudibranchiata).
Miss A. Isgrove, B.Sc., Manchester (Eledone).
H. M. Fuchs, Brighton (General Zoology).
Mrs. O. A. Meritt Hawkes, M.Sc., Birmingham (Embryology and Nervous System of Elasmobranchii).
H. H. Bloomer, Birmingham (Psammobia).
G. H. Grosvenor, B.A., Oxford (General Zoology).

Twenty-five students attended a course of study in Marine Biology conducted at the Laboratory during the Easter vacation by Mr. G. H. Grosvenor.

The Library.

The thanks of the Association are due for the following books and current numbers of periodicals presented to the Library during the past year:—

Académie Imp. des Sciences de St. Pétersbourg. Bulletin.
American Museum of Natural History. Bulletin.
—— Memoirs.
—— Report.
American Microscopical Society. Transactions.
American Philosophical Society. Proceedings.
Armstrong College. Calendar.
Australian Museum. Memoirs.
—— Records.
—— Report.
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—— An Account of the Crustacea of Norway, etc.; by G. O. Sars.
Bernice Pauahi Bishop Museum, Honolulu. Occasional Papers.
—— Fauna Hawaiiensis.
Board of Agriculture and Fisheries. Annual Report of Proceedings under the Salmon and Freshwater Fisheries Acts.
—— Report of Proceedings of 16th Annual Meeting.
Boston Society of Natural History. Proceedings.
Bristol Naturalists Society. Proceedings.
British Association for the Advancement of Science. Report.
British Museum. National Antarctic Expedition, 1901–4. Natural History.
Brooklyn Institute of Arts and Sciences. Science Bulletin.
Brown University. Contributions from the Anatomical Laboratory.

Budgett Memorial Committee. The Work of John Samuel Budgett.
Bulletin Scientifique de la France et de la Belgique.
Cairo Zoological Gardens. Report.
—— Additions to the Menagerie.
The Cancer Research Fund. Scientific Reports on the Investigations.
Cardiff Incorporated Chamber of Commerce Report.
The Carnegie Institution. Publications.
College of Science, Tokyo. Journal.
College voor de Zeevisscherijen. Verslag van den Staat der Nederlandsche Zeevisscherijen.
Colombo Museum. Spolia Zeylanica.
The Commissioners of Fisheries, N.S. Wales. Report.
Conchological Society of Great Britain and Ireland. Journal of Conchology.
Conseil perm. internat. pour l'Exploration de la Mer. Bulletin des Résultats acquis pendant les Courses Périodiques.
—— Publications de Circonstance.
—— Rapports et Procès-Verbaux des Réunions.
Cuerpo de Ingenieros de Minas del Peru. Boletin.
Danish Biological Station. Report to the Board of Agriculture.
Kgl. Danske Videnskabernes Selskab. Oversigt.
—— Skrifter.
Dept. of Agriculture, etc., Ireland. Reports.
Dept. of Commerce and Labor, U.S.A. Report of the Commissioner of Fisheries.
Dept. of Fisheries, N.S. Wales. Additions to the Fish-Fauna of New South Wales. By D. G. Stead.
—— Note on a small Collection of Fishes from Suwarow Island. By D. G. Stead.
—— Preliminary Note on the Wafer (*Leptoplana australis*). By D. G. Stead.
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Deutscher Fischerei Verein. Zeitschrift für Fischerei.
Deutscher Seefischerei Verein. Mitteilungen.
Falmouth Observatory. Meteorological and Magnetic Reports.
La Feuille des Jeunes Naturalistes.
Field Museum of Natural History. Annual Report.
—— Publications.
Finnlandische Hydrographisch-Biologische Untersuchungen.
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Fishery Board of Scotland. Annual Report.
Fiskeri-Beretning, 1905–6.
Fiskerinäringen i Sverige, Åtgärder. 1906.
Flodevigens Udklaekningsanstalts. Bidrag. 1892–1907.
Government Museum, Madras. Report.
Hertfordshire Museum Report.
R. Irish Academy. Proceedings.
Kansas University. Science Bulletin.
Kommission zur wissenschaftlichen Untersuchung der Deutschen Meere, etc. Wissenschaftliche Meeresuntersuchungen.
Kommissionen for Havundersögelser, Copenhagen. Meddelelser, series Fiskeri, Hydrografi, Plankton.
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Kgl. Norske Videnskabernes Selskab. Skrifter.
Kgl. Vetenskaps Societeten, Upsala. Stadgar.
—— Bibliographia Linnaeana. By J. M. Hulth.
Laboratoire Biologique de St. Pétersbourg. Bulletin.
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—— Quarterly Report on the Scientific Work.
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—— The Commercial Possibilities of West Africa. By Viscount Mountmorres.
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—— Monthly Pilot Charts, Indian Ocean and Red Sea.
R. Microscopical Society. Journal.
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Musée du Congo. Annales.
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Museo Nacional, Montevideo. Anales.
Museum für Meereskunde, Berlin. Führer.
Museum of Comparative Zoology, Harvard College. Bulletin.
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—— Harvard University Museum : Its Origin and History. By A. Agassiz.
—— Louis Agassiz. 1896. By W. James.
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Natural History Society of New Brunswick. Bulletin
Naturforschende Gesellschaft in Basel. Verhandlungen.
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—— Catalogus der Bibliotheek.
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New York Zoological Society. Bulletin.
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Scottish Oceanographical Laboratory. Some Results of the International Ocean Researches. By J. Hjort.
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Senckenbergische naturforschende Gesellschaft, Frankfurt. Bericht.
—— Katalog der Reptilien-Sammlung im Museum.
—— Katalog der Batrachier-Sammlung im Museum.
—— Katalog der aus dem palaarktischen Faunengebiet beschriebenen Säugetiere.
—— Katalog der Vogelsammlung im Museum.
—— Reiseerinnerungen aus Algerien und Tunis. Von Dr. W. Kobelt.
Smithsonian Institution. Annual Report of the U.S. National Museum.
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—— Arkiv för Zoologie.
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United States National Museum. Bulletin.
—— Proceedings.
University of California. Publications. Zoology, Physiology, Botany.
University of Pennsylvania. Contributions from the Zoological Laboratory.
—— University Bulletins.
—— Catalogue.
—— Contributions from the Botanical Laboratory.
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Zoological Society of Japan. Annotationes Zoologicæ Japonenses.
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—— Reports of the Council and Auditors.
Zoological Museum, Copenhagen. The Danish Ingolf-Expedition.
Zoologischen Museum, Berlin. Bericht.
—— Mitteilungen.

To the authors of the Memoirs mentioned below the thanks of the Association are due for separate copies of their works presented to the Library :—

Borley, J. O. Marine Zoology. A History of Yorkshire.
Brown, E. T. A Revision of the Medusæ belonging to the Family *Laodiceidæ*.
—— On the Freshwater Medusa, *Limnocnida tanganicæ*, discovered in the river Niger by the late J. S. Budgett.
—— The Medusæ of the Scottish National Antarctic Expedition.
Buchanan, F. The Time taken in passing the Synapse in the Spinal Chord of the Frog.
Bullen, G. E. Notes upon Hydroids observed in Aberdeen Trawl Refuse.
Cépède, C. Contribution à l'étude de la nourriture de la Sardine.
—— Quelques remarques sur la nourriture de la Sardine.
—— Myxosporidies des Poissons des Alpes Françaises.
Clark, J. Marine Zoology. A History of Cornwall.
Cligny, A. La Truite de Mer.
—— Les Prétendues Migrations du Hareng.
—— Repeuplement des Rivières du Pas de Calais.
Cotton, A. D. Some British Species of *Phæophyceæ*.
Cunningham, J. T. On *Kalpidorhynchus arenicolæ*, a new Gregarine, parasitic in *Arenicola ecaudata*.
Dahl, Knut. The Scales of the Herring as a means of determining Age, Growth, and Migration.
Darbishire, A. D. On the Direction of the Aqueous Current in the Spiracle of the Dogfish ; together with some Observations on the Respiratory Mechanism in other Elasmobranch Fishes.
—— Some Tables for illustrating Statistical Correlation.
—— Recent Advances in Animal Breeding and their Bearing on our Knowledge of Heredity.

Dendy, A., and Hindle, E. Some Additions to our Knowledge of the New Zealand Holothurians.

Dollo, L. *Notolepis Coatsi*, Poisson pélagique nouveau reucueilli par l'Expédition Antarctique Nationale Ecossaise. Note préliminaire.

Edwards, C. L. The Holothurians of the North Pacific Coast of North America collected by the *Albatross* in 1903.

—— The Order of Appearance of the Ambulacral Appendages in *Holothuria floridana*, Pourtalès.

Eliot, C. On the Nudibranchs of Southern India and Ceylon, with special Reference to the Drawings by Kelaart and the Collections belonging to Alder and Hancock preserved in the Hancock Museum at Newcastle-on-Tyne.

—— Mollusca. Pteropoda.

—— Nudibranchs from New Zealand and the Falkland Islands.

—— Nudibranchs from the Indo-Pacific, III.

Eliot, C., and Evans, T. J. *Doridœides gardineri*. A Doridiform Cladohepatic Nudibranch.

Fenchel, A. Ueber *Tubularia larynx*, Ellis. *T. coronata*, Abildgaard.

Gardiner, J. S. Investigations in the Indian Ocean. Second Report of the Committee.

—— The Percy Sladen Trust Expedition to the Indian Ocean in 1905. I. II. Description of the Expedition.

Hartmeyer, R. Beiträge zur Meeresfauna von Helgoland, XV. Die Ascidien von Helgoland.

—— Ein Beiträg zur Kenntnis der Japanischen Ascidienfauna.

Helland-Hansen, B. Current Measurements in 1906.

Hewitt, C. G. A Preliminary Account of the Life-history of the Common House Fly (*Musca domestica*, L.).

Hickson, S. J. Obituary Notice of Sir Michael Foster.

—— The Differentiation of Species of Cœlenterata in the Shallowwater Seas.

—— Note on *Caligorgia flabellum* from Port Phillip.

Hickson, S. J., and Gravely, F. H. Cœlentera. II. Hydroid Zoophytes.

Hjort, J. Nogle Resultater af den Internationale Havforskning.

Hodgson, T. V. Pycnogonida. National Antarctic Expedition.

—— Pycnogoniden. Hamburger Magalhaensische Sammelreise.

—— The Pycnogonida of the Scottish National Antarctic Expedition.

Holt, E. W. L., and Byrne, L. W. New Deep-sea Fishes from the South-west Coast of Ireland.

Horst, R. On a New Cubomedusa from the Java-Sea.

—— On a large *Penella*-species from the Moluccas.

Juday, C. Ostracoda of the San Diego Region. II.—Littoral Forms.

—— Cladocera of the San Diego Region.

—— A Study of Twin Lakes, Colorado, with Especial Consideration of the Food of the Trouts.

Kofoid, C. A. New Species of Dinoflagellates.

—— The Limitations of Isolation in the Origin of Species.

—— Dinoflagellata of the San Diego Region. III.—Descriptions of New Species.

—— Current Zoological Literature.

Lambe, L. M. Note on the Occurrence of a Supernumerary Tooth in a Dog.

Loisel, Gustave. Rapport sur une Mission Scientifique dans les Jardins et Établissements zoologiques publics et privés du Royaume-uni de la Belgique et des Pays Bas.

M'Intosh, W. C. Notes from the Gatty Marine Laboratory.

Man, J. G. de. Diagnosis of New Species of Macrurous Decapod Crustacea from the "Siboga-Expedition." II.

—— Sur Quelques Espèces Nouvelles ou peu connues de Nématodes libres habitant les Côtes de la Zélande.

Maréchal, J. Sur l'ovogénèse des Sélaciens et de quelques autres Chordatés. I.

Meek, A. Report on the Scientific Investigations. Northumberland Sea Fisheries Committee.

Murray, J. "Scotia" Collections. Note on Microscopic Life in Gough Island, South Atlantic Ocean.

—— Arctic Rotifers, collected by Dr. William S. Bruce.

Norman, A. M. On some British Polyzoa.

—— Notes on the Crustacea of the Channel Islands.

—— Some species of Leptocheirus, a Genus of Amphipoda.

—— The Celtic Province, Its Extent and its Marine Fauna.

Pavillard, M. J. Sur les *Ceratium* du Golfe du Lion.

Philippi, E. "Spermatophoren" bei Fischen.

Pixell, H. L. M. On the Morphology and Physiology of the Appendix digitiformis in Elasmobranchs.

Rathke, Jens. Afhandling om de Norske Fiskerier og Beretninger om Reiser i Aarene, 1795–1802, for at Studere Fiskeriforhold, M.V.

Reed, T. E. The Sex Cycle of the Germ Plasm.

Ricciardi, L. L'Unità delle Energie Cosmiche.

Shipley, A. E. Walter Frank Raphael Weldon. 1860–1906.

—— The late Prof. Sir Michael Foster, K.C.B.

—— Sea Fisheries.

Todd, R. A. Marine Zoology. A History of Devonshire.

Thornely, L. R. Report on the Marine Polyzoa in the Collection of the Indian Museum.

Tregelles, G. F. Sea Anemones and Corals of Cornwall.

Trybom, F. Ichthyologische Beobachtungen auf den Laichplätzen der Lachse und Meerforellen im Unterlauf des Flusses Dalelf in Schweden.

—— Markierungen von Lachsen und Meerforellen im Ostseegebiete.

Trybom, F., and Schneider, G. Das Vorkommen von "Montées" und die Groesse der Kleinsten Aale in der Ostsee und in deren Fluessen.

—— Die Markierungsversuche mit Aalen und die wanderungen gekennzeichneter Aal in der Ostsee.

Walker, A. O. Amphipoda. National Antarctic Expedition.

Weber, S. E. Polygenesis in the Eggs of the Culicidæ.

—— Mutation in Mosquitoes.

General Work at Plymouth Laboratory.

Several reports on the material collected by the *Huxley* from the north side of the Bay of Biscay in August, 1906, have been published in the Journal, whilst others are still in preparation.

Mr. Crawshay and Mr. Worth have published in the Journal (vol. viii., No. 2) detailed reports on the nature of the bottom deposits found in the English Channel between the Eddystone and the fifty-fathom line, as a result of the dredging operations carried out in 1906. The biological reports dealing with these dredgings are not yet complete.

A large number of hauls have been made in the Channel during the year with a Petersen young-fish trawl, which has proved very successful in capturing larval, post-larval and young stages of fishes. Mr. A. E. Hefford is engaged in the study of this material, and is also studying the different aspects of the fisheries in the south-western district.

Mr. G. E. Bullen has continued his study of the food of the mackerel and other migratory fishes, and has prepared a report on the subject which will soon be published in the Journal.

Mr. E. W. Nelson has continued a series of experiments, which had been commenced by Dr. E. J. Allen, on "pure cultures" of Planktonic Diatoms and Algæ, in connection with the rearing of pelagic larvæ of fish and invertebrata.

Mr. C. L. Walton was temporarily engaged at the Laboratory from October to January, devoting his time chiefly to the study of the local Actiniæ, and an account of some of his observations has been published in the last number of the Journal.

An exhibit of tow-nets, trawls, dredges, etc., is being shown by the Association in the Hall of Science at the Franco-British Exhibition.

The International Fishery Investigations.

The following is a summary of the work done, and of the conclusions arrived at by the scientific staff working under the direction of the Council.

Section I.—**NORTH SEA WORK.**

A. WORK OF THE S.S. "HUXLEY."

Trawling Investigations.—From June 1st, 1907, to the end of May, 1908, the *Huxley* made 9 voyages, in the course of which 176 hauls of the commercial trawls were made, together with 347 hauls of various smaller nets and other gear. The total number of voyages made by the *Huxley* from the commencement of the investigations to the present date is 99; the total number of hauls made with commercial trawls is 1254, that with smaller gear 1153.

In the spring of this year trawling investigations, which it is proposed to repeat at quarterly intervals throughout the year, were carried out at certain selected positions and along a line already trawled in the spring of 1905 and 1906 and the summer of 1905. In this work the ordinary commercial trawls, the Beam trawl covered with fine meshed netting as described in the last report, and various smaller nets, were used, the hauls being made as strictly comparable in time and place as is possible under the unavoidable difficulties of marine work.

Dredging Investigations.—Extensive series of hauls with Dredge, Conical Dredge and Agassiz trawl were made in the months of June, July and August in the deep water west of the Dogger and on the rough ground between Flamborough Head and Lowestoft and west of 3° E. long. In April similar work was carried out on different grounds between 52° and 53° N. lat.

In voyages 98 and 99 a small trawl with very coarse canvas netting, specially designed for the capture of small fish and crustacea, has been used with success.

Fish Measured.—Over 75,000 fish were measured during the year. As in past years, the entire catch was measured on nearly all occasions. The details as to the number of plaice, haddock and other species are as follows:—

		Plaice.	Haddock.	Others.	Totals.
1902–7	Voyages 1–90	107,614	47,240	253,293 ...	408,147
1907–8	Voyages 91–98	32,350	1,273	41,954 ...	75,577
	Totals	139,964	48,513	295,247 ...	483,724

Measurements of plaice accompanied by observations on maturity were also carried out, both at sea on a Lowestoft fishing-smack and at the Lowestoft market. In this way 1810 plaice were dealt with at sea in January, while in the observations on the market, which were made almost daily in November and December and at intervals throughout the first quarter of 1908, 10,786 plaice were examined.

Marking Experiments.—During the past year 2159 plaice and 15 other fish have been marked and set free. Of the marked plaice, 1430 were transplanted from the Dutch and Danish coastal grounds to the southern shoals of the Dogger Bank in May, 1908, with a view of obtaining information as to their rate of growth in 1908–9.

The more noteworthy of the remaining experiments were directed towards ascertaining the movements of plaice in autumn in the deeper water bordering the Dogger Bank, and of the spent plaice which were leaving the spawning grounds in the southernmost portions of the North Sea in spring. With these objects 278 plaice were marked at various positions round the Dogger Bank in August, 1907, and 190 plaice, including spent females of 35–40 cm. in length, were marked near Smith's Knoll Light Vessel in March, 1908.

Of the plaice marked from June 1st, 1906, to May 31st, 1907, 387 or 18·7 % were returned before June 1st, 1908. Of the fish marked in the year 1905–6, 25·6 % were returned before June 1st, 1907. These percentages are only comparable in a rough sense, since the times elapsing between the various experiments and the 31st of May following do not necessarily correspond in the two years. The difference is, how-

ever, worthy of notice. It seems to be due to the small number of transplanted fish recovered, the returns from the Fisher Bank being particularly small. Nearly two-thirds of all the fish marked were taken to the Dogger Bank, Great Fisher Bank and Little Fisher Bank: the percentages of these recovered before June 1st, 1907, were 15·1 %, 10·1 % and 2·5 % respectively, while of the fish marked in the ordinary marking experiments 34·6 % were caught again.

The conditions under which they were captured being in some respects unfavourable, there is reason to think that the transplanted fish were not very strong; this, together with the differences of intensity of fishing in the areas covered by the work of the two years, probably accounts for the different rates of recapture. Of the 749 fish transplanted in April and May, 1907, to the Dogger Bank, 15 were recovered after an interval of 12 months, and show an average yearly growth of 11·1 cm. Four fish were recovered a year after liberation on the Great Fisher Bank, having increased in length by 5·0–10·7 cm. Only one fish of those set free on the Little Fisher Bank was recaptured after the same period; this had grown 4·6 cm.

During the year, 9 turbot, 3 cod and 3 latchets were also marked, and the following marked fish were returned: 33 thornback rays, 17 soles, 10 cod and 3 brill. Considering the small number of fish marked, and the fact that practically all were marked before June, 1907, the proportions of cod and thornbacks returned in the current year seem to indicate that the mark is fairly suitable for work with these fish. Of 295 soles marked in the year 1906–7 about 6 % were recaptured before June 1st, 1908.

Vitality Experiments.—The plaice caught in 14 hauls of the commercial trawl were examined with a view to the estimation of the proportion that would survive under various conditions of trawling, if returned to the sea either at once or after certain periods on deck. The number of plaice dealt with in these experiments is 16,163, each of which had to be examined separately.

Marked Coconuts.—In September, 1906, 859 coconuts were put overboard in the North Sea. 142 of these nuts have now been recovered. In many cases the wire by which the label is fastened to the nut is found to be much worn, indicating a considerable amount of motion at the sea bottom on which the nut rested.

B. LABORATORY WORK.

Maturity of Plaice.—During the past year the investigations with regard to the age and size of plaice at maturity in different parts of the North Sea and English Channel, and also those on the distribution of

spawning plaice, have been continued. The results show that, on an average, female plaice are first mature when at the end of their sixth year on the grounds around the Dogger Bank, at the end of their fifth year in the southern part of the North Sea, and at the end of their fourth year in the western part of the Channel. Males, on an average, mature a year earlier than the females.

There is evidence to show that spawning takes place particularly in the deep water off the Yorkshire coast and at the southern end of the North Sea, but not in the region of the Leman Banks or on the Dogger Bank. Spawning off Yorkshire appears to occur later than on the southern spawning ground.

The examination of 123 otoliths suggests that local and sexual differences are reflected in the otolith, owing to a diminution of growth at maturity. The data are not however considered to be as yet sufficient for the satisfactory substantiation of this conclusion.

The material for this research consists in observations on the size and maturity of 13,247 plaice, in 4,106 of which the age was determined from the otoliths.

Observations on Plaice in the Barents Sea.—By the kindness of Messrs. Hellyer, a member of the staff was enabled to make a voyage to the Barents Sea in a Hull trawler, in August last. In the course of this voyage 2,146 male and 2,365 female plaice were measured.

The "average size at first maturity," i.e. the length at which 50 % are mature, was found to be about 40 cm. for female plaice from the Barents Sea; which is the same as for those from the central grounds of the North Sea. Whereas, however, in the Barents Sea the great majority of the plaice caught on the voyage were considerably above this "average size at first maturity," and had therefore spawned once at least, the majority of plaice examined in the North Sea were below it, most of them not having spawned at all before being caught. The North Sea thus is in the condition which theoretically should result from the overfishing of such a plaice population as that of the Barents Sea.

The rate of growth of the Barents Sea plaice appears to be slow, possibly owing to the low temperature (about 2° F. above freezing point) which prevails.

There is some evidence that the plaice migrate towards Atlantic water for spawning purposes, as do those of Iceland.

An account of this voyage appears in the Journal of the Association, vol. viii., p. 71.

Vitality of Trawl-caught Plaice.—A report has been prepared

on the results of the experiments carried out on this matter by the *Huxley*. The fish tested were derived from 12 Otter- and 16 Beam-trawl hauls of different duration. The catches varied in nature and weight. Each catch was tested in sections, batches of fish being placed in tanks of circulating sea-water after various periods of exposure; the total number of such batches was 89.

Consideration of the data obtained leads to the conclusion that few of the small plaice captured in the process of commercial trawling would survive if returned to the sea immediately after they reached the deck; while if returned, as in practice they would be returned, after the fishermen had dealt with the marketable catch, the percentage surviving would be extremely small.

The Otter trawl is found to injure a far greater proportion of the fish than the Beam trawl, though probably the very long hauls of the latter which are quite commonly taken by the sailing vessels using these trawls would produce the same effect as the hauls with the Otter trawl. Long hauls, the presence of *Medusæ* in the net, hot sunshine during the time the fish are on deck and probably heavy catches are all detrimental to the fish.

Migration of Cod.—A brief report on this subject has also been completed.

It is based on the 252 cod marked on the *Huxley* and the 42 recaptures recorded up to the date of writing. Most of the recaptures, constituting 13 % of the healthy fish liberated, took place within six months of liberation.

The fish below 60 cm. in length appear to have remained in water of depth similar to that in which they were first caught, and had not travelled far. Most of those which had moved some distance from the liberation point were recaptured south or west of it.

The number of these is however small. Fifteen cod which remained for more than three months at liberty showed an average rate of growth of 1·5 cm., but afforded no indications of different growth rates at different seasons.

Food of Fishes.—Since the conclusion of the second report on this subject the stomachs of 2,040 fish, belonging to 24 species have been examined and their contents identified. The total number of fish subjected to examination during the investigations is 11,866, drawn from 39 species.

Invertebrate Fauna.—The preparation of a report on the distribution of invertebrates in the North Sea, based on the operations of the *Huxley*, is in progress. The report will deal with 2,168 hauls made before the end of 1907.

Bottom Deposits.—During the year the collection of bottom samples has been increased by 161, and is now 549. All those collected before the end of 1907 have been classified by reference to type specimens and graded by the use of sieves with holes ranging from 15·0 to 0·5 mm. diameter. The percentage of silt has also been estimated in each case, and the shells present have been identified.

In certain typical samples the chief minerals have been determined. Elementary chemical examination of these samples is proceeding.

Taken as a whole the material shows that wide areas exist over which the condition of the bottom is exceedingly uniform, and that these areas are confined to the central and eastern parts of the North Sea: west of 2° E. long. the ground is extremely irregular and for the most part coarse in texture. The distribution of considerable quantities of the various grades of deposits on the offshore grounds can be defined with some confidence in the south part of the North Sea.

C. FISHERMEN'S RECORDS.

There has been no change in the method of carrying out the collection and examination of fishermen's records.

A report on the records of the catches of plaice and soles obtained from Lowestoft smacks has been completed. It deals with 4,929 hauls, made in the years 1903–6, and shows that the average catch of plaice per six hours' fishing, by the three boats whose records are considered, markedly declined during this period. The catch of soles also declined, though after 1905 the decrease was very small. No conclusion as to the cause of this general decline in the years considered has been reached.

The catches of turbot and brill have been treated in a similar manner, that of turbot showing a continuous decline, that of brill falling until 1905, and then rising; the numbers of these two species caught are not, however, great.

The treatment of the Grimsby records, obtained from steam-trawlers, is proceeding. 13,535 hauls made in the years 1904–7 have been tabulated by areas, and the monthly average catches of turbot, brill, and soles determined together with that of plaice for 1905.

Section II.—HYDROGRAPHIC AND PLANKTON WORK IN THE ENGLISH CHANNEL.

During the past twelve months the hydrographic investigations have been carried out according to the programme of recent years, and the quarterly cruises have been extended into the Irish Channel nearly as far north as the Smalls. A large number of samples of water have been received from outside sources, while the establishment of a regular weekly sailing between Plymouth and Brest by the G.W.Ry. Co. has

made it possible to obtain surface samples every fortnight on this line, so that a continual record can be kept of the surface changes over the whole of the English Channel.

During the month of August, 1907, salinities were, on the whole, somewhat low. At the south-west extremity of the area investigated the water was of the same composition from top to bottom, which is somewhat unusual at this season; to the north of this, however, at about sixty miles true south of the Scilly Islands, a distinct division into layers of different origin was found, and this condition could be traced in a northerly direction to the Smalls Lighthouse.

The November cruise showed that the waters of the Irish Channel were becoming more homogeneous, while in the western part of the English Channel a more pronounced division into layers of varying salinity had appeared. The investigations in the eastern area had to be considerably curtailed owing to continued bad weather.

During December, 1907, the surface conditions, as shown by samples received from liners and cross-channel steamers, were decidedly abnormal. Irregular patches of water of very high salinity appeared to the south-west, off the Cornish coast, while the salinity between Newhaven and Caen fell to below 34 parts per thousand. During January and February the high salinity water advanced eastward, and there is reason to suppose that in April it had reached the line joining the Isle of Wight and Havre. The low salinities found between Newhaven and Caen during December were not found in January, and it is probable that they were due to a thin surface layer which would be quickly obliterated by mixing.

During the year samples of Plankton were taken in the usual manner on the four quarterly cruises, and also at regular intervals at Plymouth, and at light-vessels on the English and Irish coasts. Samples were also taken each week, midway between Plymouth and the Channel Islands, from the s.s. *Devonia*. The records of species taken on the quarterly cruises are published in the Bulletin of the International Council.

The samples taken during the August cruise at one station in the Bristol Channel (E. 30) contained pieces of a peculiar Siphonophore, apparently *Lychnagalma*, Haeckel. This was also found off Ushant in November. The appearance of two small Protozoans, *Dictyocysta elegans*, Ehrb., and *Dictyocysta mitra*, Haeck., at the Western Stations in November are of interest in connection with the peculiar hydrographic conditions of the English Channel and the North Sea during that month. These organisms, according to Brandt, have a distinctly Atlantic distribution.

Published Memoirs.

The following papers, either wholly or in part the outcome of work done at the Laboratory, have been published elsewhere than in the Journal of the Association :—

COTTON, A. D.—*Some British Species of Phaeophyceæ.* Journal of Botany, vol. 45, 1907, pp. 368–373.

DARBISHIRE, A. D.—*On the Direction of the Aqueous Current in the Spiracle of the Dogfish ; together with some Observations on the Respiratory Mechanism in other Elasmobranch Fishes.* Linn. Soc. Journ. Zool., vol. 30, 1907, pp. 86–94.

HODGSON, T. V.—*Pycnogonida.* National Antarctic Expedition. Natural History, 1907.

HODGSON, T. V.—*The Pycnogonida of the Scottish National Antarctic Expedition.* Trans. Roy. Soc., Edinburgh, vol. 46, Part I., 1908.

MACBRIDE, E. W.—*Some Points in the Development of Ophiothrix fragilis.* Proc. Roy. Soc., Ser. B., vol. 79, pp. 440–445.

MACBRIDE, E. W.—*The Development of Ophiothrix fragilis.* Quart. Journ. Micr. Sci., vol. 51, 1907, pp. 557–606.

SMITH, GEOFFREY.—*The fixation of the Cypris Larva of Sacculina carcini (Thompson) upon its Host, Carcinus maenas.* Quart. Jour. Micr. Sci., vol. 51, 1907, pp. 625–632.

WOODLAND, W.—*Studies in Spicule Formation*, VII. *The Scleroblastic development of the Plate-and-Anchor Spicules of Synapta, and the Wheel Spicules of the Auricularia Larva.* Quart. Journ. Micr. Sci., vol. 51, pp. 483–509.

Donations and Receipts.

The receipts for the year for the ordinary work of the Association include the grants from His Majesty's Treasury (£1000) and the Worshipful Company of Fishmongers (£400), Special Donations (£40), Annual Subscriptions (£96), Rent of Tables in the Laboratory (£85), Sale of Specimens (£400), Admission to Tank Room (£134).

Vice-Presidents, Officers, and Council.

The following is the list of gentlemen proposed by the Council for election for the year 1908–9 :—

President.

Sir RAY LANKESTER, K.C.B., LL.D., F.R.S.

Vice-Presidents.

The Duke of ABERCORN, K.G., C.B.
The Duke of BEDFORD, K.G.
The Earl of ST. GERMANS.
The Earl of DUCIE, F.R.S.
Lord AVEBURY, F.R.S.
Lord TWEEDMOUTH, K.T.
Lord WALSINGHAM, F.R.S.
The Right Hon. A. J. BALFOUR, M.P., F.R.S.
The Right Hon. JOSEPH CHAMBERLAIN, M.P.
The Right Hon. AUSTEN CHAMBERLAIN, M.P.
Sir EDWARD BIRKBECK, Bart.
A. C. L. GÜNTHER, Esq., F.R.S.
Sir JOHN MURRAY, K.C.B., F.R.S.
Rev. Canon NORMAN, D.C.L., F.R.S.
EDWIN WATERHOUSE, Esq.

Members of Council.

G. L. Alward, Esq.
Prof. T. W. Bridge, Sc.D., F.R.S.
W. T. Calman, Esq., D.Sc.
Prof. A. Dendy, D.Sc., F.R.S.
Sir Charles Eliot, K.C.M.G.
G. Herbert Fowler, Esq., Ph.D.
F. W. Gamble, D.Sc., F.R.S.
Prof. Walter Garstang, D.Sc.
S. F. Harmer, Esq., Sc.D., F.R.S.
E. W. L. Holt, Esq.
J. J. Lister, Esq., F.R.S.
H. R. Mill, Esq., D.Sc.
P. Chalmers Mitchell, Esq., D.Sc., F.R.S.
Prof. D'Arcy W. Thompson, C.B.

Chairman of Council.

A. E. Shipley, Esq., D.Sc., F.R.S.

Hon. Treasurer.

J. A. Travers, Esq.

Hon. Secretary.

E. J. Allen, Esq., D.Sc.

The following Governors are also members of the Council:—

G. P. Bidder, Esq., M.A.
G. L. Denman, Esq. (Prime Warden of the Fishmongers' Company).
E. L. Beckwith, Esq. (Fishmongers' Company).
G. C. Bourne, Esq., D.Sc. (Oxford University).
A. E. Shipley, Esq., F.R.S. (Cambridge University).
Prof. W. A. Herdman, D.Sc., F.R.S. (British Association).

Dr. *Statement of Receipts and Payments for*

		£ s. d.	£ s. d.
To Current Income :—			
H.M. Treasury		1,000 0 0	
Fishmongers' Company		400 0 0	
Annual Subscriptions		96 11 0	
Rent of Tables		85 2 0	1,581 13 0
„ Extraordinary Receipts :—			
Donations :—			
E. T. Browne, Esq.	£5 0 0		
Per Dr. A. E. Shipley	35 0 0	40 0 0	
Composition Fee		15 15 0	
Hire of Steam Boats :—			
S.S. *Huxley*	£600 0 0		
S.S. *Oithona*	50 0 0	650 0 0	705 15 0
,, Balance :—			
Loan from Bank		700 0 0	
Less :—			
Cash at Bank	£437 5 7		
Cash in hand	18 19 11	456 5 6	243 14 6
NOTE.—This balance is apportioned as follows :—			
General Account, overdrawn		396 15 10	
Less Repairs and Renewals Account in credit		153 1 4	
		£243 14 6	
			£2,531 2 6

Examined and found correct,

(Signed) N. E. WATERHOUSE, A.C.A. L. W. BYRNE.
HUGH ROBERT MILL.

24th June, 1908.

the Year ending 31st May, 1908. **Cr.**

	£ s. d.	£ s. d.
By Balance from last year, viz. :—		
Loan from Bank	400 0 0	
Less Cash at Bank £69 1 0		
Cash in hand 20 11 4	89 12 4	310 7 8
,, Current Expenditure :—		
Salaries and Wages—		
Director	200 0 0	
Assistant Director	206 13 9	
Naturalist	139 11 8	
Salaries and Wages	687 13 0	1,233 18 5
Travelling Expenses		53 10 2
Library		104 4 1
Journal	50 15 6	
Less Sales of Journal	10 2 8	40 12 10
Buildings and Public Tank Room—		
Gas, Water, and Coal	122 7 9	
Stocking Tanks, Feeding, etc.	42 15 2	
Maintenance and Renewals	110 19 2	
Rent of Land, Rates, Taxes, and Insurance	35 12 1	
	311 14 2	
Less Admission to Tank Room	134 10 11	177 3 3
Laboratory, Boats, and Sundry Expenses—		
Stationery, Office Expenses, Printing, etc.	128 2 4	
Glass, Chemicals, and Apparatus £151 15 1		
Less Sales 52 9 9	99 5 4	
Purchase of Specimens	56 2 8	
Maintenance and Renewal of Boats, Nets, Gear, etc. £253 3 5		
Less Sales 5 9 5	247 14 0	
Insurance of Steamers—		
S.S. *Huxley* (half-year) 82 19 1		
S.S. *Oithona* 25 5 5	108 4 6	
Coal and Water for Steamers	130 19 6	
	770 8 4	
Less Sales of Specimens, etc.	400 10 6	369 17 10
Bank Interest		12 14 5
,, Extraordinary Expenditure :—		
On account of purchase of S.S. *Huxley*, including expenses of Vendor reimbursed by Agreement (the balance of the purchase price is secured by a Mortgage of the vessel repayable by annual instalments)		228 13 10
		£2,531 2 6

*

Marine Biological Association of the United Kingdom.

LIST
OF
Governors, Founders, and Members.

1ST OCTOBER, 1908.

* Member of Council. † Vice-President. ‡ President.

Ann. signifies that the Member is liable to an Annual Subscription of One Guinea.

C. signifies that he has paid a Composition Fee of Fifteen Guineas in lieu of Annual Subscription.

I.—Governors.

The British Association for the Advancement of Science, *Burlington House, W.* £500
The University of Oxford £500
The University of Cambridge..... £500
The Worshipful Company of Clothworkers, 41, *Mincing Lane, E.C.* £500
The Worshipful Company of Fishmongers, *London Bridge, E.C.* £8505
Bayly, Robert (the late) £1000
Bayly, John (the late) £600
Thomasson, J. P. (the late) £970
G. P. Bidder, Esq., *Cavendish Corner, Cambridge* £1400

II.—Founders.

1884 The Corporation of the City of London £210
1884 The Worshipful Company of Mercers, *Mercers' Hall, Cheapside* .....£341 5*s.*
1884 The Worshipful Company of Goldsmiths, *Goldsmiths' Hall, E.C.*..... £100
1884 The Royal Microscopical Society, 20, *Hanover Square, W.*..... £100
1884 The Royal Society, *Burlington House, Piccadilly, W.* £350
1884 The Zoological Society, 3, *Hanover Square, W.*..... £100
1884 Bulteel, Thos., *Radford, Plymouth* £100
1884 Burdett-Coutts, W. L. A. Bartlett, 1, *Stratton Street, Piccadilly, W.*.... £100
1884 Crisp, Sir Frank, Treas. Linn. Soc., 17, *Throgmorton Avenue, E.C.* ... £100
1884 Daubeny, Captain Giles A., *The Vicarage, Tottington, Bury, Lancs.* ... £100
1884 Eddy, J. Ray, *The Grange, Carleton, Skipton* £100
1884 Gassiott, John P. (the late) £100
‡1884 Lankester, Sir E. Ray, K.C.B., F.R.S., 29, *Thurloe Place, South Kensington, S.W.* £100

1884 The Rt. Hon. Lord Masham (the late) £100
1884 Moseley, Prof. H. N., F.R.S. (the late) £100
†1884 The Rt. Hon. Lord Avebury, F.R.S., *High Elms, Bromley, Kent* £100
1884 Poulton, Prof. Edward B., M.A., F.R.S., *Wykeham House, Oxford* ... £100
1884 Romanes, G. J., LL.D., F.R.S. (the late) £100
1884 Worthington, James (the late) £100
1885 Derby, the late Earl of £100
1887 Weldon, Prof. W. F. R., F.R.S. (the late) £100
1888 Bury, Henry, M.A., *Mayfield House, Farnham, Surrey* £100
1888 The Worshipful Company of Drapers, *Drapers' Hall, E.C.* £315
1889 The Worshipful Company of Grocers, *Poultry, E.C.* £120
1889 Thompson, Sir Henry, Bart. (the late) £110
1889 Revelstoke, The late Lord £100
1890 Riches, T. H., B.A., *Kitwells, Shenley, Herts* £230
1902 Gurney, R., *Ingham Old Hall, Stalham, Norfolk* £100

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With Preface by

E. RAY LANKESTER, M.A., LL.D., F.R.S.,

PROFESSOR OF COMPARATIVE ANATOMY IN THE UNIVERSITY OF OXFORD.

OBJECTS

OF THE

Marine Biological Association

OF THE UNITED KINGDOM.

THE ASSOCIATION was founded at a Meeting called for the purpose in March, 1884, and held in the Rooms of the Royal Society of London.

The late Professor HUXLEY, at that time President of the Royal Society, took the chair, and amongst the speakers in support of the project were the late Duke of ARGYLL, the late Sir LYON PLAYFAIR, Lord AVEBURY, Sir JOSEPH HOOKER, the late Dr. CARPENTER, Dr. GÜNTHER, the late Lord DALHOUSIE, the late Professor MOSELEY, the late Mr. ROMANES, and Sir RAY LANKESTER.

The Association owes its existence and its present satisfactory condition to a combination of scientific naturalists, and of gentlemen who, from philanthropic or practical reasons, are specially interested in the great sea fisheries of the United Kingdom. It is universally admitted that our knowledge of the habits and conditions of life of sea fishes is very small, and insufficient to enable either the practical fisherman or the Legislature to take measures calculated to ensure to the country the greatest return from the "harvest of the sea." Naturalists are, on the other hand, anxious to push further our knowledge of marine life and its conditions. Hence the Association has erected at Plymouth a thoroughly efficient Laboratory, where naturalists may study the history of marine animals and plants in general, and where, in particular, researches on food-fishes and molluscs may be carried out with the best appliances.

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In the summer of 1902 the Association was commissioned by His Majesty's Government to carry out in the southern British area the scheme of International Fishery Investigations adopted by the Conference of European Powers which met at Christiania in 1901. In connection with this work a laboratory has been opened at Lowestoft.

The purpose of the Association is to aid at the same time both science and industry. It is national in character and constitution, and its affairs are conducted by a representative Council, by an Honorary Secretary and an Honorary Treasurer, without any charge upon its funds, so that the whole of the subscriptions and donations received are devoted absolutely to the support of the Laboratory and the prosecution of researches by aid of its appliances. The reader is referred to page 4 of the Cover for information as to membership of the Association.

CONTENTS OF NEW SERIES, Vol. VIII., No. 3.

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