MERA PUBLICATIONS.
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The Scientific and Economic Aspects of the Cornish Pilchard Fishery.

2.—The Plankton of the Inshore Waters in 1913 considered in relation to the Fishery.

By HAROLD SWITHINBANK,
Fellow of the Royal Society of Edinburgh,
and G. E. BULLEN.

ST. ALBANS PRESS.
1914.

FOREWORD.

In placing the following paper before the notice of those interested in Marine Biology the writers desire it to be understood that the present contribution forms the second of a series of pamphlets to appear at irregular intervals. The subjects to be dealt with relate largely to the scientific and economic aspect of certain fisheries, together with phases of Marine Bionomics having more or less connection therewith.

Applications for copies of the present paper may be addressed to G. E. Bullen, The Hertfordshire Museum, St. Albans.

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Methods and Data.

The observations upon which the following researches are founded were taken from the s.s. Mera, R.Y.S. during two cruises in the Summer of 1913. The original scheme of work was planned with a view to determining what contrasts existed in the plankton environment (*a*) between the principal fishing areas, *e.g.*, Mevagissey Bay, Mounts Bay and St. Ives Bay, and (*b*) before and after the inshore migration of pilchards took place.

The first of these cruises was undertaken from May 31st to June 3rd. Twelve stations were worked in Mevagissey and St. Austell's Bays (see Chart No. 1), eleven in Mounts Bay (see Chart No. 2), and six in St. Ives Bay (see Chart No. 3). Certain full speed tow-nettings were also taken between intermediate points. The positions of the several stations, together with surface temperature and other details, are shown in the following table (Table No. 1).

TABLE No. I.—TABLE SHOWING POSITIONS OF STATIONS, SOUNDINGS, SURFACE TEMPERATURES, SURFACE SALINITIES.

ABBREVIATIONS.—F.S.=Full Speed Net; ms =Metres; ftms.=Fathoms (Admiralty); sh c.=Coarse Shingle; sh f =Fine Shingle; sh.g =Shell Gravel; sd =Sand; rk.=Rock.

Station No.			Position.	Depth.	Bottom	1st Cruise. Temp.	1st Cruise. Salin	1st Cruise. Time.	1st Cruise. Date.	2nd Cruise. Temp.	2nd Cruise. Salin.	2nd Cruise. Time.	2nd Cruise. Date.
			° ′ ″ ° ′ ″			Cd.	‰				‰		
Mevagissey	1		50.18 30 N × 4.41.15 W.	11 ms.	sh c.	13 2	33 74	9.43 a m	June 1st	16·6 c	—	1.24 p.m.	Aug. 25th
	2		50.18.10 N. × 4.42.20 W.	21 ms.	sh.f	,,	33 31	10.2 ,,	,,				
	3		50.17.45 N. × 4.43.30 W.	22 ms	sd.	,,	34·26	10.30 ,,	,,	16 4	35·02	1.54 ,,	,,
	4		50.16 50 N × 4.45 40 W.	25 ms.	sd.	,,	60	11.10 ,,	,,				
	5		50.16.00 N. × 4.46 50 W.	20 5 ms	sd.	,,	·69	11 27 ,,	,,	16 6	35 03	2·10 ,,	,,
	6		50 15 50 N × 4 45.30 W	20 ms	sd.	,,	·76	11 40 ,,	,,				
	7		50.16.30 N. × 4 44 40 W.	30 ms.	sh.f.	,,	·78	11 57 ,,	,,	16 4	35 03	4 0 ,,	,,
	8		50.15.45 N. × 4 46.20 W.	19 ms.	sd	13 6	·69	12 18 p.m	,,				
	9		50.16.25 N. × 4 46 25 W	19 ms.	sd.	,,	·61	12 32 ,,	,,	16 5	35 02	4.22 ,,	,,
	10		50.17.25 N × 4 45.40 W	18 ms.	sd.	13·7	·55	12 50 ,,	,,				
	11		50.18.30 N. × 4 44 10 W.	18 ms.	rk.	,,	·22	1.15 ,,	,,	16·6	35·03	4.48 ,,	,,
	12		50.19 20 N. × 4 42.45 W.	10 ms.	rk.	,,	33 73	1.35 ,,	,,				
Lizard to Fowey	1	F S	50.0.20 N. × 5.3 10 W to								35·02	12 noon	Aug. 23rd
			50.3.75 N. × 4 57.00 W.										
,,	2	F.S	50.7.00 N × 4 51.75 W. to								35 02	1.20 p m.	,,
			50.11.40 N. × 4 45 60 W.										
Mounts Bay St. 10 to Lizard		F.S	See Chart.									10.40 a.m	,,
Mounts Bay	1		50.06.40 N. × 5 30 20 W	19 ms.	sd.	13 4	34·96	10 0 a m.	June 2nd				
	2		50.06 29 N × 5,28 08 W	20 ms	sd.	,,	35·05	10.20 ,,	,,	14 5	35 07	2.5 p.m.	Aug. 22nd
	3		50.05 18 N × 5 26.16 W.	22.5 ms.	rk.	,,	01	10 58 ,,	,,	14 6	35 07	2.35 ,,	,,
	4		50.05 10 N. × 5.30.10 W	18 ftms	sd.	13 2	06	1 55 p m.	,,				
	5		50.04.20 N × 5.27 55 W	19 ftms	b.g.	12·8	07	2 17 ,,	,,	15 6	35 05	9.30 a.m.	Aug 23rd
	6		50 03 00 N. × 5.25.00 W	14 ftms	rk.	,,	10	2 48 ,,	,,	15 7	35 06	10.30 ,,	,,
	7		50.04.22 N. × 5.24 10 W	14 ftms	rk.	,,	10	3 15 ,,	,,				
	8		50.03 54 N. × 5.21.00 W.	16 ftms	rk.	13 0	10	3 32 ,,	,,				
	9		50 01 00 N. × 5.17 40 W	24 ftms.	sd.	,,	·12	4 7 ,,	,,				
	10		49 59 55 N. × 5 24.50 W	30 ftms	sd.	12 7	·12	5 ,,	,,	15 7	35 05	11.0 ,,	,,
	11		50 01 30 N. × 5.32 52 W	32 ftms.	sd.	13 0	·10	5.55 ,,	,,				
Mounts Bay St. 1 to St.	5	F.S.	See Chart							15 7	35 05	8.55 ,,	,,
Mounts Bay to Scilly	1	F.S	49.59 00 N. × 5 46 50 W							16 5			Aug 21st
			to 50.1.75 N. × 5.27 20 W										

TABLE No. I.—*continued.*

Mounts Bay to Scilly	2	F.S	St. Marys Sound to 49 57 50 N. × 5.57.00 W.							16.6			Aug. 21st
Scilly	1		49.54.55 N. × 6 19.50 W.	10 ftms.	rk.					14·6	35·20		,,
	2		49.55 24 N. × 6 19 55 W.	4 ftms	rk.					,,			,,
	3		49.53.26 N. × 6.12.22 W	15 ftms.	rk.					,,	·21		,,
St. Ives.	1		50 12.50 N. × 5.26.08 W.	19 ms.	sd.	13·0	35·10	1.55 p.m.	June 3rd	15·6	·07		Aug. 20th
	2		50.13.40 N. × 5.25 15 W.	21 ms.	sd.	12·8	,,	2 15 ,,	,,	15·8	·07		,,
	3		50.14.14 N. × 5 24 50 W.	21 ms.	sd.	12·9	,,	2.31 ,,	,,	,,	·06		,,
	4		50.14.15 N. × 5.28 00 W.	25 ms.	sd.	11·9	35 18	3 8 ,,	,,	15·6	·08		,,
	5		50.13.30 N. × 5.27.10 W.	25 ms.	sd.	11·9	,,	3 25 ,,	,,	,,	·08		,,
	6		50.12.50 N. × 5.27.24 W.	20 ms.	sd.	12·8	35·12	3.45 ,,	,,	15·7	·08		,,
Polperro to St. Albans Head		F.S	50.17 00 N × 4.28 00 W.									12.30 p.m.	Aug. 26th
		F.S.	50 14.00 N. × 4.06.00 W.									2.30 ,,	,,
		F.S.	50 11.00 N. × 3.37 00 W.									4.30 ,,	,,
		F.S.	50 14.00 N. × 3 10.00 W.									6.30 ,,	,,
		F.S.	50.17.00 N. × 2.42 00 W.									8 30 ,,	,,
		F.S	50.21.00 N. × 2.15.00 W									10 30 ,,	,,
		F S	50 23.00 N. × 1.57 00 W.									12 mdngt.	,,

The second series of observations were obtained from August 20th—27th, but in view of the then existent condition of the fishery, certain material modifications were made upon the original scheme of work. The full number of stations was worked in St. Ives Bay; a detour was made to obtain observations at three positions in St. Mary's Sound, Scilly; the number of stations in Mounts Bay and Mevagissey Bay was reduced, but full speed tow-nettings were taken covering a large part of the unworked area; and a series of full speed tow-nettings were taken to a position 50° 23′ N. × 1° 57′ W. (roughly eleven miles S. of St. Albans Head).

At each of the stations, surface tow-nettings of five minutes' duration were taken with the fine and medium nets. The nets used were of the ordinary open type, constructed of Swiss bolting silk of two sizes of mesh, the fine (A) embodying 70 holes per 1 c.m., and the medium (C) 18 holes per 1 c.m., the average length of a hole being .056 c.m., and the average breadth .036 c.m. At several positions oblique hauls, from bottom to surface, were made, but as the analyses of these samples were not found to differ materially in composition to those taken at the surface, they have not been included in the tables. The contents of the net were filtered through a net-bag of fine silk and preserved immediately in 5 per cent. formalin.

In the determination of the samples, a general examination was first made under low magnification, the phytoplankton being subsequently submitted to critical treatment, under cover slip, with higher powers, i.e., ×600 to ×800. In view of the fact that many of the developmental forms of metazoa, and certain of the more minute crustaceans occur more frequently in the fine net, it has been deemed advisable to combine the analyses of both nets under a single column for each station. The comparative signs are those adopted in the International Plankton Investigations. But as it is impossible, by the examination of these symbols, to gain any exact idea of the actual bulk of a sample, the quantity of plankton taken was measured, after five minutes sedimentation, in a c.cm. glass, and the results are shown in the next table (Table No. 2).

Table No. II.

Table Showing Volume of Plankton Collected by Each Haul.

Station	No.	1st Cruise. Quantities. A Net. C.Cm.	1st Cruise. Quantities. C Net. C.Cm.	1st Cruise. Quantities. F. S. Net. C Cm.	1st Cruise. Duration of haul. A Net. Mins.	1st Cruise. Duration of haul. C Net. Mins.	1st Cruise. Duration of haul. F. S. Net. Mins.	2nd Cruise. Quantities. A Net. C. Cm.	2nd Cruise. Quantities. C Net. C.Cm.	2nd Cruise. Quantities. F. S. Net. C.Cm.	2nd Cruise. Duration of haul. A Net. Min.	2nd Cruise. Duration of haul. C Net. Mins	2nd Cruise. Duration of haul. F. S Net. Mins.
Mevagissey	1	4·0	3·5		5	5		8 0	3·5		5	5	
	2	3·0	3 0		..	..					..	..	
	3	6·0	2·0		..	..		5 0	3·5		..	..	
	4	4 5	1 5		..	..							
	5	8·0	2 0		..	..		12·5	12·0		..	..	
	6	13·5	3 5		..	..							
	7	10 5	2 5		..	..		4 0	2 5		..	..	
	8	6 0	7 0		..	..							
	9	5·5	4·5		..	..		6·0	2·0		..	..	
	10	8 0	5 0		..	..							
	11	4·5	1·0		..	..		10·5	1 0		..	..	
	12	9 0	0·5		..	..							
Lizard to Fowey	1									12 5			40
..	2									12 5			40
Mounts Bay St. 10 to Lizard										6·5			40
Mounts Bay	1	5·0	4·0		..	..							
	2	5·5	1 0		..	..		5 0	6 0		..	..	
	3	5·0	1·5		..	..		16 0	7·5		..	..	
	4	11 5	14·5		..	..							
	5	8·0	34 5		..	..		27 5	16·0		..	..	
	6	9·5	7 5		..	..							
	7	7·5	6 5		..	..							
	8	7·0	4·5		..	..							
	9	7·5	8 5		..	..							
	10	10 5	9·5		..	..		7 5	6 0		..	..	
	11	15·0	12·5		..	..							
Mounts Bay to Scilly	1									22·5			70
.. ..	2									23 0			70
Scilly	1							18·5	31·5		..	..	
	2							—	24·0		..	..	
	3							26·0	26·5		..	..	
S. Ives Bay	1	13 5	3·0		..	..		0·5	0 5		..	..	
	2	8 5	3 5		..	..		0 5	1·5		..	..	
	3	6·5	3 0		..	..		1 5	4·5		..	..	
	4	8·5	2·75		..	..		0·5	3·5		..	..	
	5	10·0	4 0		..	..		1 5	0 25		..	..	
	6	15·5	3 0		..	..		0 5	0·5		..	..	
Polperro to S. Albans Head	1									10·5			30
	2									1·5			..
	3									14 0			..
	4									16·5			..
	5									17 5			..
	6									5			..
	7									10 5			..

The writers do not desire to throw particular emphasis upon the value of this method of showing the extent of the product of each net for several reasons, the chief being the highly collapsible nature of certain organisms, notably *Phaeocystis*, when submitted to the action of a preservative, especially when it is stated that these determinations were made some weeks after the samples had been preserved.

Yet, with this method of treatment in view, the tow-nettings in every instance were accurately timed, and the samples are therefore to a certain extent comparable. When, as may be seen from the plankton tables, a general similarity in character exists between a series of samples, the simple process of adding together the figures for each net gives some indication of the sporadic distribution of the plankton generally, and a comparison of the two, taken in conjunction with a critical examination of the analyses, may enable the reader to gain some impression of the preponderance of phyto- over zooplankton, or vice versa.[1]

Further, it may be stated that, in order to render the results of the analyses as nearly comparable as possible, the survey of each area was carried out in daylight.

The surface temperatures were obtained with a Centigrade thermometer by Negretti and Zambra (Kew Tested) for hydrographical work; the water samples were collected in bottles fitted with rubber corks (4oz. capacity), and were tritrated at the Plymouth Marine Laboratory by Mr. C. W. Frost within one month of delivery. The soundings were partly taken with a Lucas sounding machine, whilst others (*i.e.*, those marked in fathoms) are from the Admiralty Charts.

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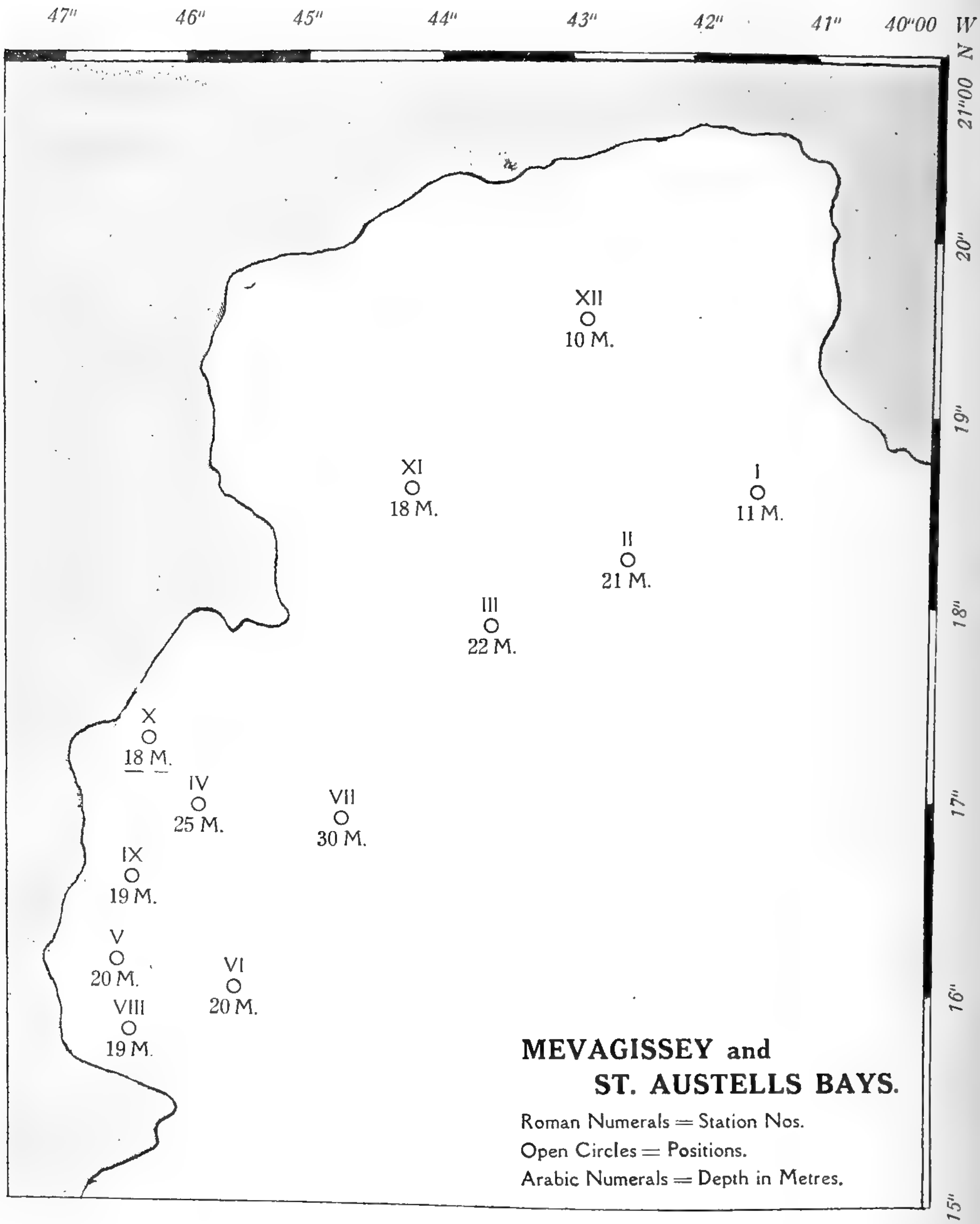
[1] The authors desire to emphasize their full appreciation of the general recommendations with regard to plankton work contained in Appendix iv. of the 1st Rep. of the Advisory Committee on Fishery Research, but more especially that clause regarding the estimation of plankton. The wording of this section is as follows:—"It is desirable that a special investigation should be at once set up by the Board (of Agriculture and Fisheries) in order to elaborate if possible a chemical or physical method for more rapidly estimating plankton or the organic matter of plankton in a given sample of water. Such a method, if evolved, would be of great value and would save much time, etc."

THE PLANKTON OF MEVAGISSEY AND ST. AUSTELL'S BAYS.

An examination of the plankton tables (Tables Nos. 3 and 4), so far as they relate to the Mevagissey area, does not show that any remarkable changes had taken place in the composition of the plankton during the period intervening between the two cruises. It is important to note, however, that the diatom flora has become materially reduced in variety, as might be expected, by the end of August. In June the bulk of the phytoplankton was composed of the diatoms *Rhizosolenia alata* and *R. semispina*, together with *Ceratium fusus*. In August both of these diatoms had become comparatively scarce, their place being taken by the allied species *R. Stolterfothi*. But it is worthy of note that this latter species occurred in very sporadic abundance, rising from "rare" to "very common," a fact which is further demonstrated by the volumetric measurements.

From the tables, however, it will be seen that the sporadic distribution of individual species of phytoplankton is not so generally marked as it is in the case of the zooplankton. Thus in the June cruise, it is not difficult to trace the occurrence of surface shoals of *Acartia Clausi* and *Temora longicornis*, together with others of greater frequency composed of Zoeas, which in the present series were observed chiefly in the Megalopa stage. The samples taken on the first cruise, moreover, gave some indication of the interest which was forthcoming throughout nearly all the series, from the presence of a large and interesting variety of Peridiniales. Thus at Stations 1, 5 and 12 examples of *Ceratium candelabrum* were observed; at Stations 1, 3 and 9 *C. horridum;* and at several positions *C. hexacanthum*.

Considered, however, from the food standpoint, the plankton did not appear to offer much attraction to drift fish. Reference to the volumetric measurements (Table No. 2) shows that throughout the entire area the product of the fine net was almost invariably greater than that of the medium, on both cruises; and in the light of our examinations it would appear that this disparity was attributable to a heavy preponderance of phyto- over zooplankton. By adding the products of both nets throughout the entire area we get 118.5 cc. of material


47"
46"
45"
44"
43"
42"
41"
40"00 W
21"00 N
20"
19"
18"
17"
16"
15"
XII
10 M.
XI
18 M.
I
11 M.
II
21 M.
III
22 M.
X
18 M.
IV
25 M.
VII
30 M.
IX
19 M.
V
20 M.
VI
20 M.
VIII
19 M.
MEVAGISSEY and
ST. AUSTELLS BAYS.
Roman Numerals = Station Nos.
Open Circles = Positions.
Arabic Numerals = Depth in Metres.

collected at 12 stations on the June cruise, and 70.0 cc. for six stations on the August cruise. Reducing these figures to common factors we find that the ratio is .84 for the July cruise to one for the August, a fact which may possibly indicate some increase in the general amount of plankton.

The Plankton of Mounts Bay.

As may be seen from the plankton tables, a somewhat marked contrast appears to exist in the conditions of this area, not only in relation to those of Mevagissey Bay in June, but also between the results shown for the two cruises. It will be noticed that there is a marked diminution in the variety of the protophyta generally in June to that occurring at Mevagissey. The bulk of the phytoplankton, however, is still composed of the two diatoms previously mentioned, both of which on certain positions are reduced to rare and very rare. There is certainly a general marked increase in the amount of zooplankton, and this is largely due to an abundance of Nauplii, together with *Evadne nordmanni* and *Podon intermedius*, all of which were chiefly the product of the fine net. The generally higher markings against certain Copepods, *e.g.*, *Acartia Clausi*, *Centropages typicus*, and *Oithona similis* are additional evidence of this fact. The most interesting feature, perhaps, in connection with the samples taken on the June cruise was the abundant occurrence of the copepod *Anomalocera Pattersoni*, at Stations 4, 5 and 6.

We have already, in a letter to the Editor of "Nature,"[2] described in general terms the visitation of this species to the area under consideration, but an examination of the plankton tables will show the restricted extent of the shoal, an idea of the density of which may be gained from the tables of volumetric measurement. It is to be regretted that the weather conditions were unfavourable for any exact visual observation, similar to that described by Mr. Matthias Dunn later in the year,[3] of the colour and appearance of the sea, in the tract of water supporting the shoal.

At the present stage of our investigations, we can

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2 "Nature" No. 2,279, Vol. 91, p. 451.

3 *Vide*, "Mera No. 1," p. 20.

TABLE NO. III.—FIRST CRUISE, MAY 31ST—JUNE 3RD, 1913. FOR POSITIONS OF ALL STATIONS SEE TABLE NO. I.

REMARKS.

* China Clay in Suspension.

† Zoeae as recorded chiefly in "Megalopa Stage."

‡ Fish Larvae as recorded chiefly *Ammodytes* sp. and *Motella* Sp.

	May 31st.	June 1st.													June 2nd.											June 3rd.					
	Rame Hd. to Dodman	Mevagissey and S. Austell's Bays.												Lizard to Newlyn	Mounts Bay.											S. Ives Bay.					
Stations Nos.		1	2	† 3	† 4	5	† 6	† 7	† 8	* † 9	† 10	† 11	12		1	2	3	‡ 4	‡ 5	6	7	8	9	10	11	1	2	3	4	5	6
Diatomaceae.																															
1. Asterionella japonica, Castr.	c	+	+	r	+	r	r	r	r	r	r	r	r	rr	r	rr	–	–	–	–	rr	–	–	rr	–	–	–	–	–	–	–
2. Biddulphia alternans, V.H.	r	rr	–	–	–	–	rr	–	–	rr	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
3. ,, mobiliensis, Bail	–	rr	rr	r	rr	rr	rr	rr	rr	rr	r	rr	–	r	rr	rr	–	–	rr	rr	rr	–	rr	–	–	rr	rr	rr	+	+	+
4. Ceratulina bergonii, Perag.	+	+	+	r	r	+	+	r	+	+	+	r	r	r	–	–	–	–	–	–	–	rr	–	–	–	–	–	–	–	–	–
5. Chaetoceras boreale, Bail.	rr	r	–	rr	r	–	–	–	–	–	rr	–	–	r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
6. ,, contortum, Schutt.	+	+	r	r	–	–	r	–	rr	rr	rr	rr	r	r	–	–	–	–	–	–	r	–	rr	–	–	–	–	–	–	–	–
7. ,, decipiens, Cleve.	+	rr	–	rr	–	–	r	–	–	rr	–	r	rr	rr	–	–	–	–	–	–	r	rr	rr	rr	–	–	–	–	rr	rr	–
8. ,, didymum, Cleve.	r	r	rr	rr	–	–	–	rr	rr	–	rr	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
9. ,, pelagica, Cleve.	+	+	rr	r	r	–	r	r	r	rr	r	+	+	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
10. ,, teres, Cleve.	rr	rr	–	+	r	–	–	rr	r	r	r	+	r	r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	rr	rr
11. Eucampia zoodiacus, Ehbg.	–	rr	–	–	–	rr	–	–	rr	–	–	–	rr	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	rr	–
12. Hyalodiscus stelliger, Bail.	r	rr	–	r	–	–	–	–	–	rr	–	–	rr	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	rr	–	–
13. Guinardia flaccida, Perag.	rr	r	+	r	+	+	+	+	+	+	+	r	+	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
14. Paralia sulcata, Cleve.	r	r	+	+	r	r	+	+	+	+	+	+	+	r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	rr	–	rr
15. Pleurosigma Sp?	–	rr	–	rr	–	rr	rr	rr	–	–	rr	–	–	rr	–	–	–	–	–	–	rr	–	–	–	–	–	–	–	rr	–	–
16. Lauderia borealis, Gran.	r	+	r	+	+	r	+	+	+	+	r	r	r	r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	rr	rr	–
17. Rhizosolenia alata, Brtw.	c	c	c	+	cc	cc	cc	cc	cc	cc	cc	cc	cc	+	+	c	c	r	r	+	c	c	c	c	r	r	+	+	c	c	c
18. ,, semispina, Hens.	c	c	c	+	c	c	c	c	c	c	c	c	c	+	+	c	c	r	r	+	c	c	c	c	rr	r	+	+	c	c	c
19. ,, Shrubsolei, Cleve	+	rr	+	rr	r	+	+	r	r	+	+	r	+	r	–	–	–	–	rr	rr	rr	rr	rr	rr	–	–	–	–	r	r	r
20. ,, Stolterfothi, Perag.	–	–	–	–	–	rr	rr	rr	–	–	r	r	rr	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
21 Thalassiothrix nitzschioides, Grun.	+	+	r	+	r	r	r	+	+	+	+	+	+	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Peridiniales.																															
22. Ceratium candelabrum, Cleve.	rr	rr	–	–	–	rr	–	–	–	–	–	–	rr	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
23. ,, hexacanthum, Gourret.	r	r	–	+	–	rr	rr	r	rr	–	rr	–	r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
24. ,, furca, Clap and Lach.	rr	rr	rr	r	rr	–	–	–	rr	–	rr	–	–	rr	–	–	rr	–	–	–	–	–	–	–	–	–	–	–	–	–	–
25. ,, fusus, Ehbg.	c	+	c	c	c	c	c	c	c	c	c	c	c	+	+	+	+	rr	r	r	+	+	+	+	rr	–	–	–	–	–	rr
26. ,, horridum, Cleve.	–	rr	–	r	–	–	–	–	–	rr	–	–	–	–	–	–	–	–	rr	–	–	–	–	–	–	–	–	–	–	–	–
27. ,, longipes, Bail.	rr	+	rr	r	–	–	rr	rr	rr	rr	rr	rr	–	–	–	–	–	–	–	–	–	rr	rr	–	rr	–	–	–	–	–	–
28. ,, tripos. O. F. Muller	+	+	r	rr	r	rr	rr	–	rr	rr	+	r	+	rr	rr	rr	r	–	–	r	rr	r	r	r	–	–	–	–	rr	rr	–

TABLE No. III.—*continued.*

29.	Diplopsalis lenticula, Bergh.	–	–	rr	–	–	–	–	rr	–	–	rr	rr	r	+	rr	rr	–	–	rr	rr	r	r	r	r	–	rr	–	–	–	–	–
30.	Dinophysis rotundata, Clap. and Lach.	–	–	–	–	–	–	–	rr	–	rr	–	–	rr	rr	–	–	rr	–	–	–	–	–	–	–	–	–	–	–	–	–	–
31.	,, acuta, Ehbg.	rr	rr	–	rr	–	–	–	–	–	–	rr	–	rr	–	–	–	–	–	–	rr	–	rr	–	–	–	–	–	–	–	–	–
32.	Peridineum conicum, Gran.	r	rr	rr	+	r	rr	r	r	r	r	r	+	+	+	–	–	rr	–	rr	rr	rr	r	+	+	rr	–	–	–	–	–	–
33.	,, depressum, Bail.	r	r	rr	rr	r	–	r	r	r	r	rr	r	r	+	rr	rr	rr	rr	r	r	+	+	+	+	rr	–	–	–	–	–	–
34.	,, globulus, Stein.	–	–	–	–	–	–	–	–	–	–	–	–	–	r	–	–	–	–	–	–	–	r	r	r	–	–	–	–	–	–	–
35.	,, pallidum, Ostf.	r	–	rr	+	r	rr	r	–	rr	–	r	+	+	+	–	rr	rr	–	r	r	+	+	+	+	rr	–	–	–	rr	–	–
36.	,, Steinii, Jorg.	+	r	rr	rr	r	–	r	rr	rr	rr	rr	rr	–	rr	–	–	–	–	–	–	–	rr	–	–	–	–	–	–	–	–	–
37.	Prorocentrum micans, Ehbg.	r	–	rr	–	rr	–	–	rr	–	–	–	rr	r	+	–	rr	–	–	–	–	rr	r	r	r	r	–	–	–		–	–
Protophyta cetera																																
38	Halosphaera viridis, Schmitz.	+	r	r	rr	+	+	+	+	+	+	+	r	+	r	r	+	+	r	rr	rr	+	+	+	r	r	–	rr	rr	rr	rr	rr
39.	Trochiscia Clevei, Lemm.	–	rr	–	rr	–	–	–	–	rr	rr	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
40.	Phaeocystis globosa, Scherfel	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	cc	cc	cc	cc	cc	cc
Protozoa et Metazoa varia.																																
41.	Tintinnopsis campanula Ehbg.	+	c	c	r	+	+	+	r	+	+	+	r	+	r	rr	rr	rr	–	–	–	–	–	–	rr	–	rr	rr	rr	rr	rr	rr
42.	Muggiaea atlantica, Cunningham	–	–	–	–	–	–	–	–	–	rr	–	rr	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
43.	Margellium octopunctatum, Sars.	–	r	+	–	–	–	–	rr	rr	rr	–	rr	–	–	–	–	–	–	–	rr	rr	–	–	rr	–	–	–	rr	rr	rr	–
44.	Obelia nigra, E. T. Browne	+	+	+	–	–	–	–	–	–	–	rr	rr	r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
45.	Echinopluteus.	r	rr	r	–	rr	rr	+	+	+	+	+	+	+	r	c	c	c	r	r	r	+	+	+	+	+	–	rr	–	–	–	–
46.	Annelida, larvae	rr	rr	r	–	–	–	rr	–	–	–	–	–	rr	–	–	r	r	r	rr	–	rr	rr	rr	rr	rr	–	–	–	–	–	–
47.	Sagitta bipunctata, Quoy and Gaim	r	rr	rr	–	–	–	rr	–	–	–	rr	rr	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	rr	–	rr
48.	Oikopleura dioica, Fol.	+	r	+	rr	rr	rr	r	r	r	r	r	r	r	rr	+	+	+	r	rr	rr	+	+	+	+	+	–	–	r	r	rr	rr
Crustacea—Copepoda.																																
49	Acartia Clausi, Giesbr.	+	c	c	cc	+	cc	c	c	c	+	+	+	+	r	+	+	cc	c	c	c	cc	c	c	c	+	+	+	+	+	+	+
50.	Anomalocera Pattersoni Temp.	rr	–	r	–	–	–	–	–	–	–	–	–	–	+	–	–	–	c	cc	c	r	rr	rr	–	r	–	–	–	–	–	–
51.	Calanus finmarchicus, Gunn.	+	rr	r	rr	rr	–	+	r	r	r	+	r	r	rr	+	+	r	r	r	+	+	+	+	+	c	rr	r	r	r	r	+
52.	Centropages typicus Kröyer	+	rr	rr	rr	r	–	r	–	–	–	–	–	–	rr	+	+	+	+	r	+	+	+	c	c	c	rr	r	r	rr	rr	rr
53.	Oithona similis, Claus.	r	rr	rr	–	rr	rr	r	rr	rr	rr	r	r	r	+	+	c	c	c	+	+	c	c	c	c	c	+	+	r	+	+	+
54.	Metridia lucens, Boeck	–	–	–	–	–	–	–	–	–	–	–	–	–	–	r	rr	–	r	–	rr	–	–	–	–	–	–	–	–	–	–	–
55.	Paracalanus parvus, Claus.	–	–	rr	–	–	–	–	rr	–	–	rr	rr	–	rr	–	–	r	r	rr	–	r	r	r	+	c	–	rr	r	+	+	+
56.	Pseudocalanus elongatus Boeck	+	+	+	rr	–	–	–	r	–	–	rr	–	rr	rr	–	–	r	r	–	–	–	–	rr	r	+	–	–	–	–	r	r
57.	Temora longicornis. O. F. Muller	r	r	c	rr	r	rr	r	rr	–	–	–	–	rr	rr	–	+	r	r	–	–	r	r	r	r	r	–	–	–	–	rr	rr
Crustacea cetera.																																
58	Anchialus agilis, G. O. Sars.	rr	–	rr	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–		–	–	–	–	–	–	–	–	–	–
59	Caradidae, larvae	+	+	r	rr	–	rr	rr	–	–	–	–	–	–	–	rr	–	–		–	–	–	–	–	–	–	–	–	–	–	–	–
60.	Cirripedia, larvae	rr	–	rr	–		rr	–	·	r	r	rr	–	r	r	r	r	–		r	–	r	r	–	–	–	–	r	r	r	r	r
61.	Evadne nordmanni, Loven.		–	rr	rr	–	rr	rr	rr	–	r	rr	r	–	–	cc	cc	c	c	+	cc	c	c	c	r	+	–	–	–	–	–	–
62	Nauplii	+	+	+	–	rr	rr	rr	r	–	r	r	r	r	+	c	c	c	cc	c	c	c	c	c	c	+	–	rr	r	r	r	+
63.	Podon intermedius, Lilljeb.	–	–	–	–	–	–	–	–	–	–	–	rr	rr	–	+	+	r	+	+	+	+	+	+	c	cc	–	–	–	–	rr	rr
64	Zoeae	+	+	r	cc	c	+	c	c	cc	cc	cc	c	rr	–	rr	r	rr	c	cc	c	c	r	r	r	r	+	r	r	r	c	c
Vertebrata—Pisces																																
65.	Fish ova and larvae.	rr	–	rr	r	+	+	+	r	r	r	r	r	–	–	r	+	r	c	c	+	+	+	r	r	r	–	rr	rr	rr	rr	rr

TABLE NO. IV.—2ND CRUISE, AUGUST 20TH-26TH, 1913.

For positions of all Stations see Table No. 1.

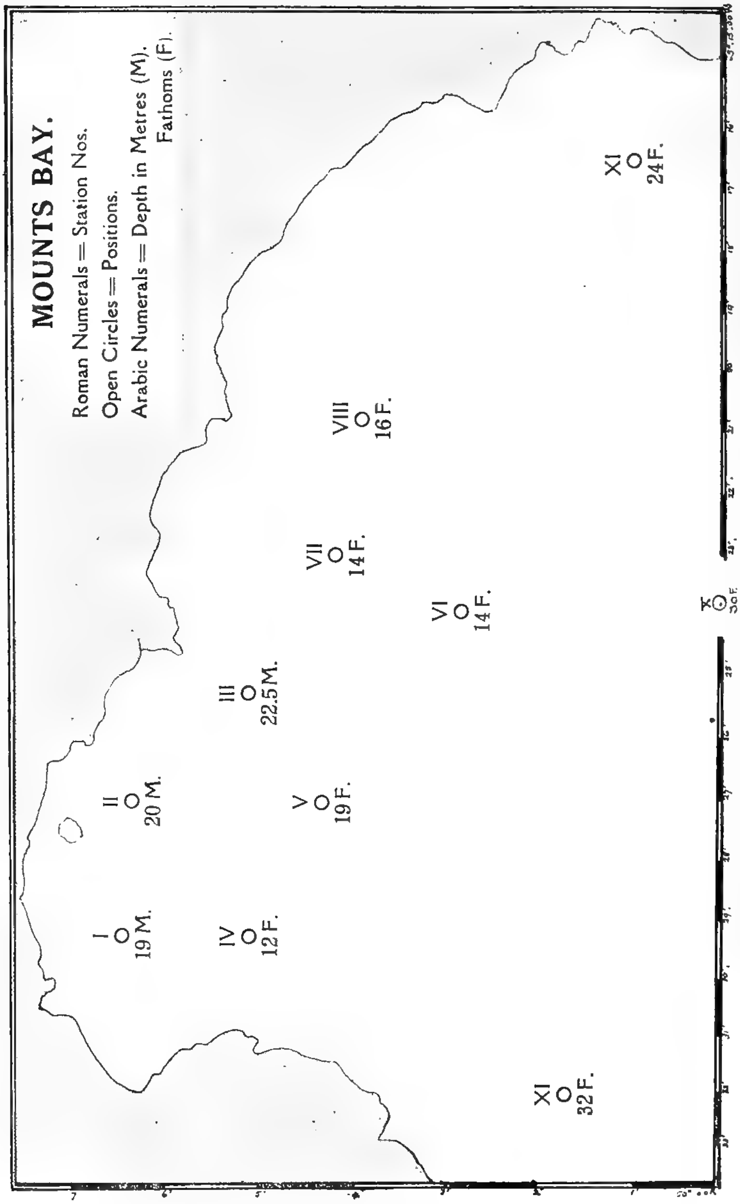
REMARKS.

* A Net burst, sample not determined or measured.
† No. 1 St. Ives taken in duplicate for purposes of comparison.
‡ "Caradidae larvae" as described chiefly larvae of *Squilla ? desmarestii*.

	Mevagissey and St. Austell's Bays						F.S. Lizard to Fowey 2.	Do. 1.	F.S. St 10M.B to Lizard	Mounts Bay.		F.S. St. 1 to 5.				F.S. Newlyn to Wolf.	F.S. Wolf to Scilly.	St. Mary's Sound, Scilly.			St. Ives Bay.						Off Polperro to St. Albans Head. F.S. 1.	F.S. 2.	F.S. 3.	F.S. 4	F.S. 5	F.S. 6	F.S. 7.
Station Nos.	1	3	5	7	9	11				2	3		5	6	10			1	2 *	3	1 †	2	3	4	5	6					‡	‡	‡
Diatomaceae.																																	
1. Bacillaria paradoxa, Gmel.	rr	–	–	rr	–	–	–	–	–	–	–	–	–	–	–	–	–	–		–	–	–	–	–	–	–	–	–	–	–	–	–	–
2. Chaetaceras boreale, Bail.	+	r	+	+	+	c	+	+	+	rr	r	r	rr	rr	rr	–	–	–		–	–	–	–	–	–	–	rr	rr	–	–	–	–	–
3 ,, densum, Cleve	+	rr	+	+	+	c	+	+	+	rr	r	r	rr	rr	rr	–	–	–		–	–	–	–	–	–	–	r	rr	–	–	–	–	–
4. Coscinodiscus radiatus, Ehbg.	–	–	–	–	–	–	–	–	–	rr	rr	–	rr	rr	rr	rr	rr	rr		rr	rr	rr	–	rr	rr	rr	–	–	–	–	–	–	–
5. Guinardia flaccida, Perag.	–	–	–	–	rr	rr	–	rr	–	–	rr	rr	rr	–	–	–	–	–		–	+	r	–	r	rr	rr	–	–	–	–	–	–	–
6. Rhizosolenia alata, Brtw.	r	rr	r	r	r	+	+	r	+	rr	+	+	+	r	rr	–	–	–		rr	r	rr	–	rr	–	rr	rr	rr	–	–	–	–	–
7. ,, semispina, Hens.	+	rr	+	+	+	c	c	+	r	rr	+	r	r	r	rr	–	–	rr		rr	rr	–	–	–	–	–	r	rr	–	–	–	–	–
8. ,, Shrubsolei, Cleve.	+	rr	+	+	+	c	+	r	r	–	r	+	r	–	r	rr	–	rr		rr	rr	rr	–	rr	rr	–	+	rr	–	–	–	–	–
9. ,, Stolterfothi, Perag.	c	r	cc	+	c	cc	c	+	cc	rr	cc	cc	c	r	+	rr	rr	–		–	+	rr	rr	rr	rr	rr	r	rr	–	–	–	–	–
Peridiniales.																																	
10. Ceratium furca, Clap and Lach.	–	–	–	–	–	–	–	–	rr	–	–	–	–	–	rr	r	r	rr		–	–	–	–	–	–	–	–	rr	–	–	–	–	–
11. ,, fusus, Ehbg	–	–	rr	r	r	+	cc	cc	c	r	c	+	+	r	+	cc	c	c		cc	+	+	+	+	+	+	+	c	+	r	r	+	+
12. ,, hexacanthum, Gourret	r	–	+	+	+	c	c	c	c	+	+	+	c	r	r	r	–	rr		+	–	–	–	–	–	–	+	–	–	–	–	–	–
13. ,, longipes, Bail.	+	r	+	+	+	c	c	c	c	r	+	+	+	rr	r	r	–	+		–	–	–	–	–	–	rr	r	r	rr	rr	r	r	rr
14. ,, tripos, O.F. Muller	+	r	+	+	+	c	cc	cc	c	+	c	c	c	+	c	cc	cc	c		c	+	+	+	+	+	+	cc	c	+	r	rr	r	r
15. Dinophysis acuta, Ehbg.	rr	–	rr	–	rr	rr	+	+	+	–	r	r	rr	–	–	r	–	–		–	–	–	–	–	–	rr	rr	rr	–	–	–	–	–
16. ,, rotundata, Clap and Lach.	–	–	rr	–	–	–	r	r	r	–	rr	rr	r	–	–	rr	–	rr		–	–	–	–	–	–	–	rr	–	–	–	–	–	–
17 ,, tripos, Gourret	–	–	–	–	–	–	rr	–	–	–	–	–	–	–	–	rr	rr	rr		–	–	–	–	–	–	–	–	–	–	–	–	–	–
18. Diplopsalis lenticula, Bergh.	r	rr	r	r	+	+	c	cc	c	+	c	+	+	+	+	+	c	c		+	rr	rr	rr	rr	rr	rr	c	cc	+	r	r	c	c
19. Peridinium conicum, Gran.	–	–	–	–	–	–	r	r	r	–	rr	rr	rr	rr	–	–	r	–		–	–	–	–	–	–	–	rr	–	–	–	–	–	–
20. ,, depressum, Bail.	r	rr	r	r	r	+	c	c	c	r	+	r	r	r	r	+	r	+		rr	rr	rr	–	–	rr	rr	r	+	rr	r	rr	r	rr
21. ,, divergens, Ostf.	–	–	–	–	–	–	–	–	–	–	–	rr	rr	–	–	rr	rr	rr		–	–	–	–	–	–	–	–	–	–	–	–	–	–
22. ,, pallidum, Ostf.	rr	–	rr	rr	rr	+	+	+	+	–	r	rr	rr	rr	rr	rr	–	r		–	–	–	–	–	–	–	–	–	–	–	–	–	–
23. Prorocentrum micans, Ehbg.	–	–	rr	rr	r	r	+	+	+	rr	rr	rr	rr	rr	rr	+	+	+		rr	–	–	–	rr	rr	rr	rr	–	–	–	–	–	–

TABLE No. IV.—*continued.*

Protophyta cetera.																																	
24. Halosphaera viridis, Schmitz.	rr	–	rr	–	rr	r	+	+	r	–	rr	rr	rr	r	–	r	r	r		rr	rr	rr	rr	rr	rr	rr	–	rr	–	–	–	–	–
25. Trochiscia Clevei, Lemm.	–	–	–	rr	–	–	rr	–	rr	–	–	–	rr	–	–	–	–	–	–	–	rr	–	rr	–	rr	rr	r	r	rr	rr	rr	–	–
Protozoa et Metazoa varia.																																	
26. Tintinnopsis campanula, Ehbg.	rr	r	rr	rr	rr	r	rr	rr	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	rr	–	–	–	–	–	–
27. Cyttarocylis denticulata, Fol.	rr	r	r	r	r	+	r	rr	–	–	rr	–	–	–	–	–	–	–	rr	–	–	–	–	–	–	–	cc	r	rr	–	–	rr	rr
28. Muggiaea atlantica, Cunn.	rr	rr	+	r	r	rr	rr	+	rr	+	rr	r	+	+	r	r	r	–	–	r	–	–	–	–	–	–	–	–	–	–	–	–	–
29. Pleurobrachia pileus, Mod.	–	–	–	–	–	–	–	–	–	–	rr	–	–	–	rr	–	–	–	rr	–	–	–	–	–	–	–	–	–	rr	–	rr	–	rr
30. Euphysa aurata, Forbes	–	–	–	–	rr	–	–	–	–	–	r	rr	rr	–	rr	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
31. Margellium octopunctatum, Sars.	rr	rr	–	rr	rr	rr	–	rr	rr	r	–	–	–	rr	–	–	–	–	–	–	–	rr	rr	rr	rr	rr	–	–	–	–	–	–	–
32. Obelia nigra, E. T. Browne	–	–	rr	rr	r	rr	rr	rr	rr	r	r	–	+	+	rr	+	r	–	–	–	–	rr	–	rr	–	rr	–	–	–	–	–	–	–
33. Phialidium cymbaloideum, E. T. Browne	–	rr	rr	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
34. Sarsia prolifera, M. Sars.	–	–	rr	rr	rr	–	–	–	–	rr	–	rr	rr	rr	rr	rr	rr	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
35. Echinodermata, larvae	rr	r	r	r	r	rr	rr	rr	r	r	r	r	r	r	r	r	r	–	–	–	–	–	–	rr	rr	–	rr	–	–	+	r	–	–
36. Annelida, larvae	–	–	–	rr	rr	–	rr	rr	–	rr	–	–	–	rr	rr	+	rr	–	–	rr	–	–	–	rr	rr	rr	–	–	–	rr	rr	–	r
37. Sagitta bipunctata Quoy and Gaim	rr	+	r	rr	rr	rr	rr	+	r	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	r	r	–	–	r	+	c	–	c
38. Limacina, retroversa, Flem.	rr	–	rr	rr	rr	r	–	rr	–	–	rr	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	rr	r	rr	r	+	rr	rr
39. Oikopleura dioica, Fol.	r	rr	r	r	r	rr	r	+	+	r	rr	rr	r	r	r	r	r	rr	–	–	–	–	–	–	–	–	r	–	r	r	r	–	r
Crustacea—Copepoda.																																	
40. Acartia Clausi, Giesbr.	c	c	c	c	c	c	+	c	+	+	+	+	+	c	+	r	r	rr	rr	rr	r	rr	rr	rr	rr	rr	cc	r	r	r	r	–	+
41. Anomalocera Pattersoni, R. Temp.	–	–	–	–	rr	–	–	rr	–	rr	r	r	rr	–	rr	rr	r	rr	r	rr	–	rr	+	+	+	r	–	–	rr	–	–	–	–
42. Calanus finmarchicus, Gunn.	rr	r	+	rr	r	rr	rr	r	+	+	+	r	+	+	+	+	+	+	+	c	+	+	r	r	+	+	r	rr	+	c	c	r	c
43. Centropages typicus, Kröyer	+	c	cc	+	+	+	+	+	+	c	c	c	c	c	c	cc	cc	cc	cc	cc	c	+	+	+	+	+	c	r	c	c	c	r	cc
44. Corycaeus anglicus, Lubb.	r	rr	r	r	r	r	rr	r	r	r	+	r	r	+	r	–	–	–	–	rr	–	–	–	rr	rr	rr	r	rr	+	+	+	rr	+
45. Euterpe acutifrons, Dana	+	+	c	c	c	c	+	c	c	+	+	+	r	+	r	r	rr	–	–	–	–	–	–	rr	rr	rr	+	rr	r	–	–	r	r
46. Metridia lucens, Boeck.	–	–	–	–	rr	–	rr	–	–	–	rr	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
47. Microsetella atlantica, Brady	–	–	–		–	–	–	–	rr	–	–	–	rr	–	–	rr	rr	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
48. Oithona similis, Claus.	r	r	+	+	+	+	c	c	c	c	c	+	+	c	c	c	cc	c	+	c	r	rr	rr	r	r	r	c	rr	c	c	c	r	c
49. ,, plumifera, Baird	–	–	–	–	–	–	–	–	rr	–	–	–	rr	rr	–	rr	r	rr	rr	rr	–	–	–	–	–	–	–	–	–	–	–	–	–
50. Paracalanus parvus, Claus.	+	+	+	+	+	r	+	+	+	c	+	c	c	c	c	c	cc	r	r	r	+	r	–	+	r	r	+	rr	cc	cc	cc	r	cc
51. Pseudocalanus elongatus, Boeck	–	rr	rr	–	rr	–	rr	–	r	+	+	+	+	+	+	+	+	rr	r	r	+	r	rr	+	r	r	–	–	+	c	c	r	c
52. Temora longicornis, O. F. Muller.	+	c	+	+	+	+	r	+	+	c	cc	c	c	cc	cc	c	c	c	c	cc	+	r	rr	r	rr	r	+	+	cc	c	c	r	c
Crustacea cetera.																																	
53. Caradidae, larvae	rr	r	rr	–	rr	rr	–	–	–	rr	rr	rr	–	r	rr	–	–	r	r	+	–	–	–	+	rr	–	–	–	–	–	c	rr	c
54. Cirripedia, larvae		rr	+	+	+	r	r	r	r	r	r	r	r	r	r	rr	rr	rr	rr	r	–	rr	–	rr	rr	–	r	rr	rr	r	r	–	+
55. Nauplii	+	+	+	+	+	+	+	c	c	+	c	+	+	c	c	+	c	cc	cc	cc	c	c	c	c	c	c	+	c	cc	cc	cc	c	cc
56. Evadne Nordmanni, Loven	c	c	c	+	c	c	+	r	r	+	+	+	+	c	+	+	+	rr	rr	r	–	–	rr	rr	rr	rr	cc	c	+	+	+	rr	+
57. Podon intermedius, Lilljeb.	rr	–		–	rr	–	–	rr	–	rr	r	r	r	+	r	r	r	–	r	r	–	–	rr	rr	–	rr	–	–	–	–	–	–	–
58. Zoeae	r	r	r	–	rr	rr	–	rr	rr	r	rr	rr	rr	r	rr	r	r	rr	r	r	–	–	rr	r	r	rr	–	–	–	r	+	–	+
Pisces																																	
59. Ova and Larvae	rr	rr	rr	–	rr	rr	rr	–	rr	r	–	r	r	r	rr	rr	rr	rr	rr	r	–	–	rr	rr	rr	–	rr	–	–	–	r	rr	rr


MOUNTS BAY.
Roman Numerals = Station Nos.
Open Circles = Positions.
Arabic Numerals = Depth in Metres (M).
Fathoms (F).
I 19 M.
II 20 M.
III 22.5 M.
IV 12 F.
V 19 F.
VI 14 F.
VII 14 F.
VIII 16 F.
X 30 F.
XI 24 F.
XI 32 F.

hardly think that this copepod plays any important part in the diet of the pilchard in English waters, but we take into consideration the statement of the late Mr. Matthias Dunn[4] to the effect that he had observed the stomachs of fish, *presumably* arriving from deep water, containing large numbers of *Anomalocera*. The following remarks upon the occurrence of the species by Prof. G. O. Sars,[5] moreover, would seem to indicate that an occasional abundant occurrence of the species in inshore waters would afford ideal food conditions for drift fishes. This author states :—" I have met with this form in several places, both off the south and west coasts of Norway, generally congregated in great shoals. The true habitat of this form, however, is undoubtedly the open ocean, and it is only after heavy gales, and by the accompanying strong sea currents, that it is occasionally brought close to the shores and into the fjords. . . . Off the west coast of Norway, where it is known to the fishermen as 'Blaaaate' (blue bait), its presence in the fjords is a very good sign of the approach of the summer herring."

So far as the area under consideration is concerned, we can find no previous record of an inshore visitation of the species in large numbers, and an examination of the plankton tables published in the International Bulletins shows that the species has hitherto been generally recorded in comparative frequency only at the extreme western stations (Nos. E4, E5).

It is perhaps worthy of record that a fair number of young fish were taken with the coarse tow-net on the same positions at which *Anomalocera* was very abundant, and these upon examination proved to be *Motella* sp. ranging in length from 7 m.m. to 19.5 m.m., *Ammodytes* sp. from 8.5 m.m. to 19 m.m., and *Clupea ? harengus* 18 m.m. (one only). We dissected out the stomach contents of several of the rocklings, and found that they consisted chiefly of *Acartia Clausi*, *Calanus finmarchicus*, *Centropages typicus*, *Nauplii*, etc., in many cases in an intact condition, but in no instance were we enabled to detect the remains of *Anomalocera*.

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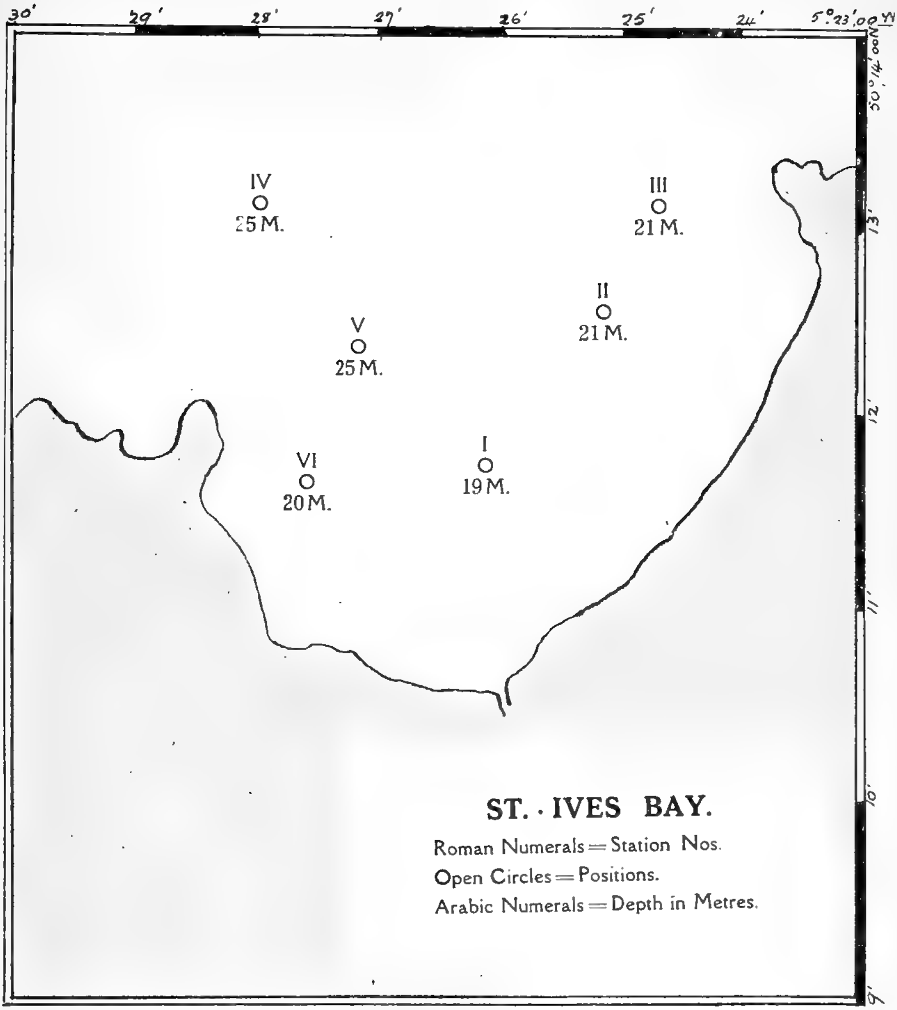
4 Dunn, M., "Migrations and Habits of the Pilchards," Lectures on Fishes, etc., County Fisheries Exhibition, Truro, 1893, p. 159, etc.

5 Sars, G. O., "An account of the Crustacea of Norway," Vol. iv., "Copepoda," p. 140.

Passing now to a consideration of the plankton taken on the August cruise, we observe a similar change in the diatom flora to that already noted in the case of the Mevagissey area, namely, the general decadence of the two species, *Rhizosolenia alata* and *R. semispina*, and an increase in the growth of *Rhizosolenia Stolterfothi*. The condition of this last named species, moreover, is somewhat remarkable, occurring as it did in very sporadic abundance. Thus, at Stations 3 and 5, and in the full speed netting between Stations 1 and 5, it was met with in such profusion that the nets became choked after a short immersion in the water, the product appearing as a dense glairy mass, whilst at Stations 2 and 6 the species occurred in an almost negligible quantity, and at the outer Station (No. 10) there was a considerable diminution. In the samples taken to the west of Mounts Bay and in St. Mary's Sound, Scilly, the species was practically non-existent.

With regard to the Peridiniales, an examination of the tables shows a general increase in certain species, notably *Ceratium fusus*, *hexacanthum*, and *tripos*, *Diplopsalis lenticula*, etc., though it will be noticed that the heavier gatherings of *C. fusus* and *tripos* were taken by the full speed net to the east and west of Mounts Bay, and at the Scillies. With *Ceratium hexacanthum* and *longipes*, reference to the tables will show that their distribution was not so marked in the extreme western area as it was in Mevagissey Bay and the adjacent waters. The comparatively close inshore occurrence of *Dinophysis tripos* between the Lizard and Fowey, west of Mounts Bay, and at the Scillies, is also a matter deserving of comment.

In the case of the zooplankton generally, the tables of volumetric measurement show more clearly than do the plankton tables the contrast existing between the samples taken in Mounts Bay and those from the Scillies. In both areas it will be seen that the predominant species are the Copepods *Centropages typicus*, *Oithona similis* and *Temora longicornis*, but that in St. Mary's Sound, Scilly, the samples were of a much richer character; an important feature when the contemporary condition of the fishery is considered.



The Plankton of St. Ives Bay.

But few features of interest appear to exist between the composition of the plankton observed at the several stations in St. Ives Bay on both cruises, but generally speaking the contrast between the samples taken on the first cruise and those of the second is somewhat remarkable. In June, as it may be seen from the plankton tables, the whole of St. Ives Bay was literally choked with *Phaeocystis globosa*, to such an extent in fact that the contents of a bottle filled over the ship's side appeared to be composed entirely of the species, amongst which a few zoeas seemed to struggle for existence. We do not maintain that the analyses of the samples can give the reader a just appreciation of the actual composition of the plankton, in view of the fact that both the fine and coarse nets undoubtedly ceased to filter after a very short immersion. The chief point of interest which we have to consider, therefore, lies solely in the fact of the profusion of this flagellate in St. Ives Bay, whilst it appears to have been entirely absent from Mounts Bay. It is well known that *Phaeocystis globosa* is a neritic species, belonging to the so-called "periodic plankton," and as its term of vegetation is comparatively short, it was a matter of no remark to find that, on our second visit to St. Ives Bay in August, it had entirely disappeared. Yet an examination of the volumetric measurements of the samples taken in August shows that the quantity of plankton generally existent in this area, after the passing of the *Phaeocystis*, was very slight indeed. A discussion upon the causes of this phenomenon: as to whether *Phaeocystis* crowds other forms of the plankton out of existence by its rapid propagation, or in its decay renders the water insupportable for a time to other organisms, etc., is beyond the province of this paper.

Apart from *Phaeocystis*, the general composition of the rest of the plankton, so far as it was possible to judge under the deterrent influence to which we have already referred, *i.e.*, the clogging of the nets, appeared in June to present several features in common with those observed in Mounts Bay. For example, the two diatoms, *Rhizosolenia alata* and *R. semispina*, again make their appearance in varying abundance at the several stations, and the two Copepods, *Acartia Clausi* and *Oithona similis*, are also fairly well represented. In the August cruise, however, the substitution of *Rhizosolenia Stolterfothi* for the two allied species already mentioned was not observed. The only point of some interest in connection with the zooplankton was the occurrence of *Anomalocera Pattersoni* at five of the stations. This copepod was represented, however, solely by *unadult* individuals of the species.

General Considerations upon the Plankton of the Cornish Inshore Waters.

In considering the condition of the plankton observed as occurring throughout the several areas studied, together with certain other facts, we find that there is some evidence to show that an abnormal influence was at work during 1913. As to whether this condition had existed to any extent in 1912 it is impossible to determine; but, if we associate possible cause with now well known effect, and attribute the extreme eastern migratory movement of pilchards in 1913 to such abnormal influence, we have also to take into consideration the statements of fishermen at Brighton to the effect that pilchards were taken there regularly, in small numbers, during 1912. Thus, if one might be permitted to speculate upon these facts, it would seem possible to suggest that in 1913 these conditions had become sufficiently pronounced to bring about an effect so marked as to engage attention.

But we have now to consider in detail such evidence as we hold lending support to our theory so far as it affects the year 1913. Unfortunately the only previous observations which have a more or less direct bearing upon the area under consideration are those taken in connection with an investigation upon the mackerel[6] in 1906-7, together with others taken throughout a greater number of years upon the International Plankton Cruises at Station E.7,[7] which, it is to be regretted, is situated at some distance outside Mounts Bay.

With such slender evidence of the planktonic conditions existent in former years it is impossible to do very much in the way of comparison, but certain facts are too obviously of importance to be overlooked.

We have already remarked upon the abundance and variety of the Peridiniales occurring in the plankton samples. With regard to *Ceratium hexacanthum*, we can find no observation of its abundant occurrence in the Channel, other than that of

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6 *Vide* Bullen, G. E., "Plankton Studies in relation to the Western Mackerel Fishery."

7 *Vide* Plankton Tables, "Bulletins de Conseil International pour l'Exploration de la Mer."

Gough[8] in 1903, who recorded it for the south-western area alone and only in February and November. From the plankton tables it will be seen that this species occurred in comparative scarcity at Mevagissey in June, increasing somewhat in abundance and extending its distribution to the Scillies in August. In view of the fact that the species appears to be an oceanic one, its greater abundance in the full speed nettings which were taken on the run of the ship's course well out to sea, would suggest that it occurred in some profusion outside the close inshore waters of Mounts Bay and the adjacent area.

It is important, moreover, to note the sporadic abundance of *Diplopsalis lenticula* in August, and the occurrence of *Peridineum divergens*, *Dinophysis tripos*, *Microsetella atlantica*, *Oithona plumifera*, and *Limacina ? retroversa*, to understand that in the coastal waters we have observed certain forms which have generally hitherto been associated with the plankton of the extreme western area of the English Channel. In this connection, moreover, it may be mentioned that Gough[9] states that *Anomalocera Pattersoni* may be regarded as a species generally occurring in the Great West Bay. We thus have some evidence to show that the plankton of the areas under consideration was of an abnormal character, and in the nature of its composition lending support to a theory that extreme western biological conditions were existent further to the east than in certain former years. Certain other facts are before us, which might possibly lend some support to a still wider view of the matter than that which we have already indicated. We refer more particularly to the occasional visitations of shoals of *Physalia*, which extended to our personal knowledge as far east as Studland toward the end of May.

Salinities of Water Samples.

The analyses of the water samples taken within the area under consideration, and the absence of similar observations derived from Mid Channel and elsewhere however lend no

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[8] Gough, L. H., "Rep. of the Plankton of the English Channel in 1903," p. 333 Int. Inv. Mar. Biolog. Ass. Rep. I.

[9] Op. cit., p. 335.

useful evidence in support of the above theory. For it will be seen, on reference to the salinity table (Table No. 1), that no remarkably high salinities occur at any position. On the May cruise the highest figures are 35.12 for the extreme southern and eastern stations (Stations Nos. 9, 10) in Mounts Bay, and 35.18 for two positions in St. Ives Bay. In Mevagissey and St. Austell's Bays there is a drop to 33.31, rising to 33.74 in the three extreme eastern stations (Stations Nos. 1, 2, 12), a moderate constancy ranging from 34.6 to 34.7 obtaining farther to the west.

On the second cruise in August the salinities recorded throughout the entire coastal area vary only in the second place of decimals, from 35.02 to 35.08. The samples taken in St. Ives Bay are very nearly similar *inter se*, but generally very slightly higher than those of Mounts Bay and the Mevagissey area. A contrast certainly does exist between these samples generally and those taken in St. Mary's Sound, which show an increase to 35.2; a fact which, when it is remembered that the samples were taken in enclosed coastal waters. may possibly indicate the presence of water of higher salinity in the comparatively near vicinity. From the above observations, it is obviously impossible to draw any definite conclusions; but, when considered in the light of what is already known regarding the physical conditions of the Channel,[10] some importance has necessarily to be given to such a material increase within a radius of 50′.

THE PLANKTON OF THE EASTERN AREA.

It is to be regretted that circumstances precluded a more thorough investigation of the planktonic conditions existent to the east of what hitherto has been regarded as the pilchard fishery area, and that the observations, such as they are, consisting solely of full speed tow-nettings, were not continued up to the Straits of Dover. For, lacking as they do the full value of samples taken by the ordinary tow-net at regular stations, the gatherings of plankton taken between Polperro

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10 *Vide* Matthews, D. J., "Rep. on the Physical of the English Channel in 1913," and other subsequent papers.

and St. Albans Head afford many points of interest, and lend much valuable support to the general considerations upon food conditions. We have to consider the bathymetrical rise and fall of certain species, the long distance covered by each haul (about five miles), in which it was possible to run through one or more shoals of various organisms, together with several other important points, in making any comparison between these samples and others taken in the western area. But the examination of the analyses shows at least one very important point, namely, that phytoplankton gradually decreases to a minimum from west to east of the course covered, and that what we may justly regard as desirable food species increase in abundance. The seven hauls comprising the present series are comparable *inter se* solely in length of duration (thirty minutes each), and for the reasons previously stated it is obviously impossible to draw any exact deductions. Yet from the evidence afforded by the volumetric measurements of samples Nos. 2 and 6 taken almost at the extreme western and eastern points, it would seem possible to suggest that throughout the area covered the distribution of the plankton generally was very sporadic. The appearance in comparative abundance of that most important food species, *Calanus finmarchicus*, in the eastern area, hitherto noted in comparative scarcity in the coastal waters of the west, is another matter of some importance. But, in comparing roughly the last five samples with the two full speed nettings taken from Scilly to Mounts Bay earlier in the cruise, we find that the actual volume of material is somewhat higher for the former;[11] and in view of the fact that this plankton consisted almost entirely of animal matter, we have some evidence to show that the richer feeding grounds lay to the east of Plymouth.

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[11] Note.—Our method of comparison has consisted in adding together the total volume of (a) the five last samples of the eastern series and (b) the two western (Scilly-Mounts Bay), dividing each product by the total number of minutes occupied in the collection of each. The comparable figures gained in this way are 325 western, 383 eastern. When it is noticed that one sample of the latter series consisted only of 0.5 c.cm. of material it will be seen that the contrast is not without some significance.

The Condition of the Pilchard Fishery considered in relation to the Plankton.

In a previous paper[12] it has been shown that an intimate correlation appears to exist between the plankton environment of inshore waters and the extent of migration. It was naturally to be expected that the quantity and suitability of the food supply should constitute what, in the present state of our knowledge, certainly appears to be the predominant factor in a profitable fishery. For it has never been suggested that the pilchard moves into inshore waters for any other purpose than that of seeking suitable feeding grounds.

Cunningham[13] has described the pilchard as being the most truly marine clupeoid frequenting the coastal waters of Great Britain; and it is a well-known fact that the species, unlike certain of its congeners, habitually spawns at some distance from land.

That the family trait of seeking brackish, or even fresh water, occasionally manifests itself, however, is evidenced by the now well-established fact that pilchards may often be taken in the Fowey river as far inland as Lostwithiel.[14] Yet upon occasional instances of this character we can adduce no useful evidence to show that the pilchard seeks the coastal waters *from necessity*. It is well known that the fish forming the subject of the Cornish fishery are for the greater part in either unripe or "shotten" condition (shirmers), and in this respect the pilchard may be compared with the small immature mackerel which move into coastal waters, after the advent of the spring shoals. In considering the migrations of pilchard, therefore, we are *probably* discussing movements which are undertaken for no other reason than that of feeding. Yet in making this statement we do not desire to be too definite, since in dealing with a species whose near allies seek fresh water for the important purpose of spawning—a species, moreover, which occasionally seeks similar habitat itself—it is impossible to say whether an atavistic tendency may not be in evidence.

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12 "Mera No. 1."

13 Cunningham, J. P., "Mark. Mar. Fishes."

14 *Teste* Mr. Moses Dunn, of Fowey, and several other local observers.

On the coast of France, Portugal and elsewhere, where the sardine industry is prosecuted, the success of the fishery is well known to depend largely upon what may be termed the caprice of the fish in appearing at certain stations at more or less regular seasons. The uncertainty of this fishery alone appears to afford some evidence in support of a theory that inshore migration is determined largely by the attraction afforded by the coastal waters from the food standpoint. Yet, bearing in mind the normal delimitation of range of the species, we have also to place important consideration upon sea temperature and salinity.

It is not hard to believe that if physical conditions approximating to those existent in the normal habitat of the pilchard were to extend beyond their usual limits, and that the fish in migration found no suitable food supply awaiting them in their usual summer haunts, that migration might be extended farther afield within the area exhibiting suitability of habitat from the phenological aspect.

We have already summarized the somewhat scanty direct evidence at our disposal, showing that certain planktonic conditions, usually associated with the extreme western area of the Channel, were existent in the coastal waters of Cornwall during the summer of 1913. The meteorological observations[15] for the south coast of England in the same season show air temperatures generally above the mean for July, August and September, and our own observations tend to show a general surface water temperature distinctly above the normal. The visitations of *Physalia* and certain other forms of Mediterranean fauna had also been noted. So much for the evidence supporting a theory of the extension of suitability of habitat.

With regard to the unsuitability of the food supply existent in the coastal waters of Cornwall, we may refer briefly to the high proportion of phytoplankton over zooplankton in Mevagissey Bay, St. Austell's Bay and Mounts Bay, the literally choked condition of St. Ives Bay in June, due to *Phaeocystis*, and the extreme poverty of the plankton remaining there in August. And when we compare these conditions

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[15] *Vide* Appendices to the "Daily Weather Reports" of the Meteorological Office.

with those existing farther to the east, and in the Scillies, we find that suitable food conditions certainly did not exist in the usual summer fishery area.

Summarizing briefly the condition of the fishery, we find in the effect some remarkable evidence in support of the probable cause upon the lines which we have already indicated. It is now a well-known fact that the migratory movements of pilchards extended as far east as Deal. From information derived from fishermen at Brighton, it appeared that regular catches of some thousands had been made a few miles off the coast in the adjacent waters and up to the Straits of Dover, throughout the latter half of July, in August, and well into September. It may be mentioned that we examined the stomach contents of fish taken off Brighton in September, and found that they consisted largely of zoeas and certain Calanoid Copepods, notably *Calanus finmarchicus*, *Centropages typicus*, etc.—food of a character which we have often met with in fish from the western area in former years. During the months when pilchards, the catches of but a few drifters, were being marketed regularly at Brighton and elsewhere under the fictitious name of "herring," and one firm at Deal[16] were accumulating as a "by-product" over five hundred barrels of fish cured as "bloaters," the Mevagissey and Mounts Bay fishermen were securing slender catches of but a few hundreds per night. In the Scillies, however, where something in the nature of an experimental fishery was being carried on, chiefly by men who had little previous experience of drifting, the fish appeared to be present on the ground in sufficient quantity.

It was not until the beginning of October,[17] that the Mounts Bay fishery became in any way productive; and it is a significant fact that this change was practically contemporaneous with an observed inshore visitation of a large shoal of the two Copepods *Anomalocera Pattersoni* and *Calanus finmarchicus*.[18]

In an important paper on the mackerel, Dr. E. J. Allen[19]

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16 *Teste* Mr. Matthias Dunn, of Newlyn.

17 *Vide* "Mera No. 1," p. 20.

18 *Vide* "Mera No. 1," *id. loc.*

19 *Vide* Allen, E. J., "Mackerel and Sunshine."

has tentatively shown that some correlation may be found to exist between the productiveness of the fishery, and the extent of bright sunshine occurring in the early spring months, prior to the fishing season. This author states, " Experiments on the cultivation of marine plankton diatoms in the laboratory, upon which I had been engaged, had drawn my attention to the great importance to be attached to the intensity of light to which the diatoms were exposed. It therefore occurred to me that a special abundance of Copepods during the month of May might be due to a special amount of sunshine during the earlier months of the year, which would increase the amount of phytoplankton, the Copepod food. An attempt was therefore made to correlate the average quantity of mackerel per boat taken in May with the number of hours of bright sunshine recorded during the first quarter of the year."

The observations upon which this paper is founded appear to leave little doubt in the mind of the reader that, under what we may term ideal conditions, such a correlation probably does invariably exist, but under the present inadequate system of fishing by the majority within a comparatively confined area, the official statistics of landings, as the author justly points out, lend but little support to such a theory. For as one of the present authors has already shown,[20] a superabundance of phytoplankton in coastal waters appears to correlate with a poor mackerel fishery, and to a large extent the findings in this and a previous paper (Mera No. 1) indicate that the same may hold good in the case of the pilchard. It follows that we have to go beyond the limits of the area affected by the majority of the fishermen, in those years when phytoplankton is abundant in the coastal waters, to find evidence of the more exact working of this cycle of events. For as it now stands, a superabundance of phytoplankton in coastal waters, food of a character unsuitable to the fish themselves, appears to form a powerful factor in the delimitation of the extent of inshore migration. It follows that it is necessary that this vegetable plankton be consumed largely by the zooplankton before the fish are induced to approach in appreciable numbers to the

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[20] Bullen, G. E., "Plankton Studies," p. 281.

inshore waters. A productive fishery, carried on within the comparatively narrow limits of the coastal waters, as is usual, appears to be based on a very finely adjusted cycle of physical and biological conditions, in which an extremely narrow margin is allowed for any abnormal condition, arising from the preponderence or paucity of one or other of the given elements.

The general results of the present season's work, therefore, tend in every way to support the deductions advanced in a previous paper;[21] but, although at this early stage of our investigations it is obviously impossible to define with any degree of certainty the probable causes governing the extent of migration of pilchard to the coastal waters of Great Britain, a consideration of the abnormal conditions of 1913 afford a basis of argument, such as might not have been forthcoming from a study of a succession of normal seasons.

Briefly to summarise these considerations, therefore, we find:—

(1) That certain biological conditions, which may usually be associated with the extreme south-western area of the English Channel, were observed in the coastal waters of the Cornish fishery area; a fact which might lend support to a theory of an extension of suitable habitat for pilchards.

(2) That in the same region phytoplankton, *i.e.*, food of a character undesirable to the fish, preponderated over zooplankton throughout the greater part of the season.

(3) That in Scilly, and to the east of Plymouth, food of an eminently desirable character was largely in evidence.

Passing now to the facts concerning the fishery, we find:—

(4) That the migration of pilchards extended as far east as Deal, and that a profitable fishery was carried on within the near vicinity.

(5) That the fishery was also of a productive character in Scilly.

(6) And that it was not until an observed coastal visitation of shoals of Calanoid copepods to the waters of Mounts Bay early in October that the Cornish fishery became productive.

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21 "Mera No. 1."

The above facts, considered conjointly, obviously lend some support to a theory that the pilchard seeking coastal waters, prompted thereto possibly by some obscure atavistic tendency, may, if suitable feeding grounds be not afforded by the waters in the immediate vicinity to its winter habitat, and providing that suitable conditions of sea temperature, salinity and density exist elsewhere, extend its migration beyond normal limits until a desirable feeding ground is encountered.

APPENDIX I.

The Occurrence of Sexually Mature Pilchards in Inshore Waters.

As previously stated in the foregoing paper, the pilchard habitually spawns at a considerable distance from land, the fish forming the object of the Cornish drift fishery are therefore either in unripe condition, or of the type known as "shirmers," *i.e.*, spent fish of somewhat emaciated appearance and above the usual size. Cunningham[22] remarks upon the fact that ripe pilchards are generally taken accidentally in mackerel nets shot twenty to forty miles from land, the catch seldom exceeding fifty. The period of time over which such fish are taken extends from the beginning of June to the end of October; they are commonest in July and August. The same author comments upon the comparative scarcity of ripe males caught in this manner, but omits to mention any exact data as to the usual area from which such examples were derived, beyond detailing one specific instance of the collection of eggs on September 5th, 1893, ten miles south of the Eddystone.

All of our records prior to 1913 of the capture of spawning pilchards in mackerel nets lie on positions twenty to thirty miles south to south-west of the Wolf, and they are not numerous.

From information derived from a fish curer at Newlyn, it appeared that a catch of five hundred ripe pilchards was made by a drifter shooting for mackerel about ten miles south of the Lizard early in June (1913). The same observer mentioned that he had dealt with a catch of about two thousand in July, and that fish of this character had been very frequently through his hands prior to the end of August. These facts appeared to have impressed themselves on his memory more particularly owing to the difficulty he had experienced in getting the fish to cure satisfactorily by the usual method of salting. Replying to our further enquiry, he stated that, to the best of his belief, the ripe males were in almost even proportion to the females.

APPENDIX II.

Net Curing by Creosote.

In the "Fish Trades Gazette," Vol. xxxi., No. 1606, p. 36, appears an interesting article dealing with the curing of herring and pilchard gear by means of "green oil," *i.e.*, crude creosote, a practice which has been recently in vogue amongst the West Country fishermen. It appears that the majority of observers interested in the fishing industry, if not from the scientific from the enlightened standpoint, have regarded the innovation with considerable misgiving throughout the past season. As to how well founded these fears certainly were, is proved by the results of a series of experiments performed at the Plymouth Marine Laboratory by Dr. E. J. Allen. It appears that in a first experiment one part of the oil added to 100,000 parts of sea-water, and well shaken up, proved fatal to thirty healthy swimming prawns (Hemimysis) within an hour. In a further experiment one part of the oil was added in a similar manner to 10,000,000 parts of sea-water, and twenty-five specimens of the same crustacean were put in. One-half were dead in twenty-four hours, three -quarters were dead in two days; all were dead in five days. In both experiments sufficient aëration of the water was provided for, and in a control experiment carried out in ordinary sea-water under similar conditions of aëration, etc., no deaths occurred.

[22] Cunningham, J. P., "Mark. Mar. Fishes," p. 170.

It may perhaps be mentioned that medicinal creosote is soluble about one in four hundred of water, but the solubility of "green oil," in which guiacol probably predominates over creosol, may be considerably less. When, as we have heard it described by Mr. Matthias Dunn, a freshly cured net is shot and one can see an emanation of creosote floating on the surface of the water, it is not hard to understand the natural result upon both plankton and fish situated in the near vicinity. For even if we do not admit that a toxic effect could be produced upon plankton in the open sea by such means, it is not hard to believe that the pilchard possesses sufficient intelligence to prevent it from driving headlong into contaminated water.

APPENDIX III.

Pilchard with Reduplicated Rays to Caudal Fin.

On August 20th (1913) we examined at Newlyn a pilchard 252 m.m. in length, a male, caught two miles S.W. × S. of St. Michael's Mount, which exhibited a malformation of a type approximating to another which we once before met with in a specimen now preserved in the Museum of the Plymouth Marine Biological Laboratory. Unfortunately the present example was inadvertently destroyed, but referring to our notes upon the subject taken at the time, it appears that the specimen had a double complement of rays to the caudal fin. This characteristic had the effect of broadening the base of the tail to about one-half again its normal extent. The fin itself was nearly double the width of that of an ordinary example at its widest part, but appeared naturally to slightly overlap upon itself in the centre. The individual rays appeared to be generally thicker throughout their entire length than is usual. A fisherman, questioned upon the subject, stated that he had, very infrequently, met with similar examples before.