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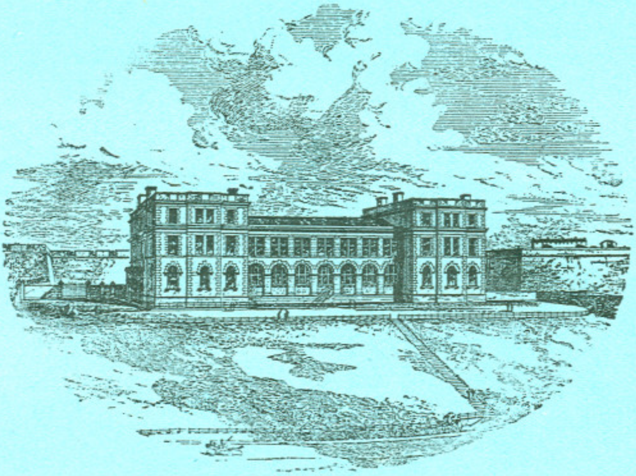

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Notes on a Fishing Voyage to the Barents Sea in August, 1907.

By

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Assistant at the Lowestoft Laboratory.

With Plate IV and three figures in the Text.

CONTENTS.

CHIEFLY with the object of obtaining material from which comparisons of an intact plaice population with that at present existing in the North Sea might be made, I undertook, in August, 1907, a voyage in a commercial steam trawler to the new fishing grounds in the "White Sea."*

As this area was only exploited commercially by trawlers for the first time in 1905, an exceptional opportunity was afforded for the study of an accumulated stock of plaice unaffected by the influence of man.

To Mr. F. O. Hellyer, who kindly arranged the voyage for me in the s.s. *Roman*, of the Imperial Steam Fishing Company, Hull, and to Captain W. Leighton, through whose co-operation I was enabled to measure and examine over four thousand plaice, my heartiest thanks

* Generally so mis-named. Very little trawling has taken place within the White Sea proper, nor has it proved profitable.

are due. I am also indebted to my friend, Mr. A. E. Jones, who accompanied me and recorded the various measurements. During the collation of my material and the preparation of this memoir, I have received much valuable assistance and advice from my colleagues at Lowestoft, particularly from Drs. Wallace, Garstang, and Allen.

Owing to the keen struggle to make and keep the "White Sea" fishing a commercial success, it was naturally stipulated that the actual position of the fishing grounds should not be revealed. This from the immediate scientific point of view is immaterial, nor was it the object of the investigation.

Depths, however, are of importance in the distribution of plaice, and their insertion entails no breach of trust, as the latest Admiralty charts afford no clue to the position of the fishing bank visited. Doubtless in the course of time the fishing in the area will be generally understood, but by that time the pioneer fishermen of Hull will have reaped the rich reward of their discoveries, and the knowledge gained will continue to stand them in good stead.

I propose here to deal with the notes made on the various fishes met with during the voyage, but before doing so will recall briefly the general conditions which are found throughout the year in the Barents Sea as far as they are at present known.*

The sea is at its coldest in June. From this time an inflow of Atlantic water commences, and continues till November, bestowing a considerable increase of temperature on the whole area. After November the influence of the Arctic water gradually predominates. It has been pointed out by Knipowitsch that the fisheries of the Barents Sea are dependent on this annual flood of warm Atlantic water.

The coming of the most important fishes with this flood, and their subsequent departure when Arctic conditions again prevail, have been studied by the Russian investigators by means of fishing experiments. By these means it has been found that quantities of fish can be obtained in the neighbourhood of the different branches of the North Cape Current at the times when there is no fishery worthy of mention on the usual fishing grounds along the Murman coast. To cite one example†: from May 15–17th, 1898, quantities of haddock, catfish, halibut, black halibut, cod, Norway haddocks, tusk, and other fish were

* L. Breitfuss. *Ozeanographische Studien über das Barents Meer. Petermanns Mitteilungen*, II, 1904.

N. Knipowitsch. *Expedition für wissenschaftlich-praktische Untersuchungen an der Murman-Küste*, I. Cf. *Rapports et Procès-verbaux.* Appendix A, Vol. iii, 1905.

† N. Knipowitsch. *Expedition für wissenschaftlich-praktische Untersuchungen an der Murman-Küste*, I, p. 594.

caught by means of long-lines in Lat. 71° 14′ N., Long. 32° 46′ E., a position in the southernmost branch of the constant North Cape Current.

At this time the fishing on the Murman coast was of no importance, and the conviction of the fishermen was that no fish would be found out in the open sea.

Knipowitsch records that in March and April the Murman coast is very deficient in fish, though quantities can be met with as a rule more to the west (north of Finmark, etc.). Then the eastward migration commences, the chief shoals still being found in the neighbourhood of the well-marked warm stream. As summer approaches, they draw near the coast, and the population of the open sea decreases.

Late in summer the fish still press on to the east, towards the neighbourhood of Cape Kanin. Late in autumn the return migration from the coast commences, though many fish can remain till midwinter* off the Murman coast.

Marked differences have been observed in the fauna as the bottom temperature rises above the freezing point; it is very rare to find the valuable food-fishes present in water with a temperature below freezing point. Bearing this in mind, it is probable that the use of a satisfactory deep sea thermometer would greatly assist the efforts of our own fishermen in these regions. As they first work in this sea in June and July,† when the influence of the Atlantic flood is commencing to extend, a thermometer might prove as useful a guide as the lead. Though it cannot be claimed that such an instrument would show where fish are to be caught, futile trawling in the unproductive, ice-cold Arctic water, which undoubtedly has taken place, might be avoided.

By means of a simple reversing thermometer of his own design, to be worked on the ordinary leadline, kindly supplied me by Mr. D. J. Matthews, of the Plymouth Laboratory, I was able to determine on several occasions that the bottom temperature on the bank where the plaice were chiefly taken was 34° F., or two degrees above freezing point. The surface temperature at the the same times varied from 45°–48° F. In similar depths (34–36 fathoms) in the North Sea the difference in top and bottom temperatures would only be slight.

An English trawler in June, working in suitable depths some distance to the eastward of the fishing ground now under consideration, found an almost entire absence of plaice, and the icy coldness of

* The winter in respect of the land, not sea.—G. T. A.

† The tendency has been to make an earlier start each year. In 1907 the first trawler left Hull on May 1st.

the water was remarked on; the region had then eventually to be abandoned, and the fishing voyage concluded at Iceland. In my notes on the plaice the influence of temperature on the movements of this species in other regions will be further indicated.

The Plaice (*Pleuronectes platessa*).

This was by far the most abundant species met with, and is of course the special object of the trawlers' exploitation of the region.

Throughout the greater part of this voyage on the *Roman*, samples of the catch were measured and examined.

Methods of Obtaining and Measuring Samples.

The method of obtaining and working through the samples was as follows: As the contents of the trawl lay upon the deck, the crew proceeded to gut the plaice and throw them one by one into the "pound" on the side of the deck opposite to which the trawl had been hauled, where they were eventually washed before being put below.

Thus, by getting one or more of the men to put their gutted fish as they picked them unselected from the deck into baskets, and by taking as many baskets as it was possible to dispose of without interfering with the regular routine of the ship, good samples could be obtained.

The gutting process consists of making an incision into the body cavity, through which the viscera, with the exception of the reproductive organs, are extracted. Thus it was comparatively easy to make an examination of the maturity of each individual fish.

The international method of measurement was adopted (e.g. 39–39·9 cm., recorded as 39 cm.), and the operation was carried out on a portable measuring board, on the open deck in fine weather and under the "whaleback," or roofed-in bow deck, when it was rough.

On six occasions the whole catch of plaice was measured and examined. The close agreement of the average sizes (p. 76) then obtained, with those of smaller samples at other stations in the vicinity, confirms the confidence in the value of the smaller samples.

As each measurement was made and recorded the sex of the fish was noted, together with the maturity. From these records (Table I) it will be seen that the lengths of the smallest mature fishes were 24 and 35 cm. for male and female respectively, and the corresponding largest immature 41 and 45 cm. The average size of the mature males is 40·9 cm., and of the mature females 48·3 cm.

The lengths of 113 fish (65 ♂, 48 ♀) have been excluded from all consideration, as in each of these cases the tail had been more or less damaged, sometimes half, and even the whole, of it being missing, and the record was only kept to show the great frequency with which this damaged condition occurred. I am strongly inclined to agree with the fishermen, who noticed this feature in the previous year, and to attribute it to the depredations of the Greenland shark (*Laemargus microcephalus*), which without a doubt includes the plaice in its diet (see p. 97). If this is the case, the fact that nearly $2\frac{1}{2}$ per cent of the fish in my samples were in this condition is significant, and shows that

TABLE I.—*Showing the actual length frequencies of plaice measured on board the s.s. "Roman" in the Barents Sea, August,* 1907 *; classified according to maturity :—*

MALES.

Length cm.	Maturity. Immature.	Mature.	?	Total.
24	–	1	–	1
25	–	1	–	1
26	1	–	1	2
27	1	1	–	2
28	–	1	–	1
29	–	2	3	5
30	1	2	3	6
31	4	4	3	11
32	2	12	3	17
33	3	11	5	19
34	4	18	4	26
35	2	30	7	39
36	–	79	–	79
37	3	129	3	135
38	1	176	1	178
39	–	202	1	203
40	–	235	1	236
41	1	294	1	296
42	–	254	1	255
43	–	195	–	195
44	–	159	–	159
45	–	116	–	116
46	–	72	1	73
47	–	41	1	42
48	–	19	1	20
49	–	13	1	14
50	–	4	–	4
51	–	2	2	4
52	–	1	–	1
53	–	2	1	3
54	–	–	–	–
55	–	1	–	1
56	–	–	–	–
57	–	1	1	2
Totals	23	2078	45	2146

FEMALES.

Length. cm.	Maturity. Immature.	Mature.	?	Total.
24	1	–	–	1
25	–	–	–	–
26	1	–	–	1
27	3	–	–	3
28	2	–	–	2
29	1	–	–	1
30	5	–	–	5
31	9	–	1	10
32	8	–	–	8
33	12	–	1	13
34	15	–	2	17
35	18	1	2	21
36	16	–	5	21
37	18	1	14	33
38	11	4	17	32
39	19	12	19	50
40	13	26	28	67
41	16	51	37	104
42	5	77	31	113
43	7	87	23	117
44	1	109	16	126
45	3	168	18	189
46	–	168	10	178
47	–	186	3	189
48	–	178	5	183
49	–	175	4	179
50	–	140	1	141
51	–	132	2	134
52	–	104	1	105
53	–	86	–	86
54	–	60	–	60
55	–	62	–	62
56	–	32	–	32
57	–	28	–	28
58	–	19	–	19
59	–	7	–	7
60	–	7	–	7
61	–	5	–	5
62	–	6	–	6
63	–	3	–	3
64	–	2	–	2
65	–	4	–	4
73	–	1	–	1
Totals	184	1941	240	2365

in this region at least the plaice lives in the presence of a serious natural enemy (or enemies, for though the food of the seals in the Barents Sea has not yet been sufficiently studied, the possibility of their preying upon plaice is by no means precluded).

It may perhaps seem possible that, owing to the novelty of this phenomenon, the fishermen would be inclined specially to select these damaged fish for my benefit, thus exaggerating their occurrence. I am confident that this is not the case, as the men were not even aware that these fish were being in any way regarded.

The Composition of the Catch.

The length frequencies of 2146 females and 2365 males, representing over three tons of fish, are shown in Table I above, each sex being subdivided, according to maturity. The measurements, arranged in 2 cm. groups, are further displayed in diagrams (pages 78 and 79).

Care was taken to secure as fair a sample as possible of each catch dealt with. That this object was attained appears evident from the slight variations in the average sizes at the twenty-nine stations. For the males, of which the averages vary between the narrow limits of 40·4 cm. and 41·9 cm., a total average size of 40·7 cm. is obtained; in the case of the females, as might be expected, a greater range in the average sizes occurs: 45·3 cm.–48·9 c.m., with one exception, 50·5 cm. (in the smallest sample taken). The total average size of 2365 female fish is 46·7 cm.

The population consisted almost entirely of large mature fish, the total range of size being for males 24 cm. to 57 cm, and for females 24 cm. to 73 cm.

In Table II below the measurements for each sex are summarized in 5 cm. groups, the percentage of males in each being also presented.

Table II.—*Showing the measurements of Barents Sea plaice summarized in 5 cm. groups, the percentage of males in each group being presented below:—*

Cm.	<30	30–34	35–39	40–44	45–49	50–54	55–59	60+	Total.
♂ . . .	12	79	634	1141	265	12	3	–	2146
♀ . . .	8	53	157	527	918	526	148	28	2365
Totals	20	132	791	1668	1183	538	151	28	4511
% of Males .	60	60	80	68	22	2	2	0	47

The striking feature of this table is the great proportion of males in each group up to 40–44 cm., and the subsequent rapid decrease.

The male plaice is generally recognised as being a constitutionally smaller fish than the female, and would not be expected to attain to the same length, but at the same time the rapid decrease after 44 cm., and virtual disappearance after 49 cm., is surprising.

In this recently spawned shoal the usual earlier maturity of the sex* would account for the great numbers of males in the smaller groups; for instance, in the 35–39 cm. group 96 per cent of the males were mature, in contrast to only 11 per cent of the females. To only a small extent would this account for the high percentage of males being maintained in the next group, as only 8 per cent of the females now remain immature. We must look for some other explanation, which seems to me to lie in the probable infinitesimal annual growth which the males now undergo. The fishes of this sex are now some 10 or more centimetres above the size I have estimated for first maturity, after which stage in life considerable retardation of growth takes place.† It is probable, therefore, that in these slow growing plaice (see p. 84) of the Barents Sea many year groups are comprised in this arbitrary 40–44 cm. group.

It is probable, too, that the rapid diminution in numbers and final disappearance of males in the succeeding groups is accentuated by an earlier mortality of the sex here, as in the North Sea.‡ Looking at the curves of length frequencies it will be seen that the curve for the males does fall more rapidly from its mode or maximum height (at 41 cm.) than does that for the females from its mode (at 47 cm.).

The variation in the proportion of the sexes at individual stations and groups of stations, as possibly giving a clue to migrations, is dealt with later (p. 87).

The curves of length frequencies (Figs. 1 and 2) in the case of both sexes, display remarkable regularity, representing an absolutely intact stock of *mature* plaice, such as is to be found in no other region of the world at present fished. A series of annual observations, tracing the inevitable reduction of this stock by the influence of man, and a contemporary study of this fishery's statistics in their modern improved form, will throw interesting and valuable light on the changing aspects of a plaice fishery. Icelandic waters cannot now afford similar opportunities, for in the comparatively few years this region has been exploited for plaice a marked reduction of the original stock is observed by the fishermen to have occurred.

* FULTON. *Twentieth Annual Report Fishery Board for Scotland*, Part III, pp. 354–60 (1902).

WALLACE. *Preliminary Investigations on the Age and Growth-Rate of Plaice.* North Sea Investigation Committee, Report 2. Southern Area, 1902–3. Cd. 2670 (1905), pp. 218, etc.

† WALLACE. *Report on the Age and Growth-Rate of Plaice in the Southern North Sea.* North Sea Investigation Committee. Second Report (Southern Area), 1904–5, Part I, p. 33.

‡ WALLACE. *Loc. cit.*, p. 34.

MALES.

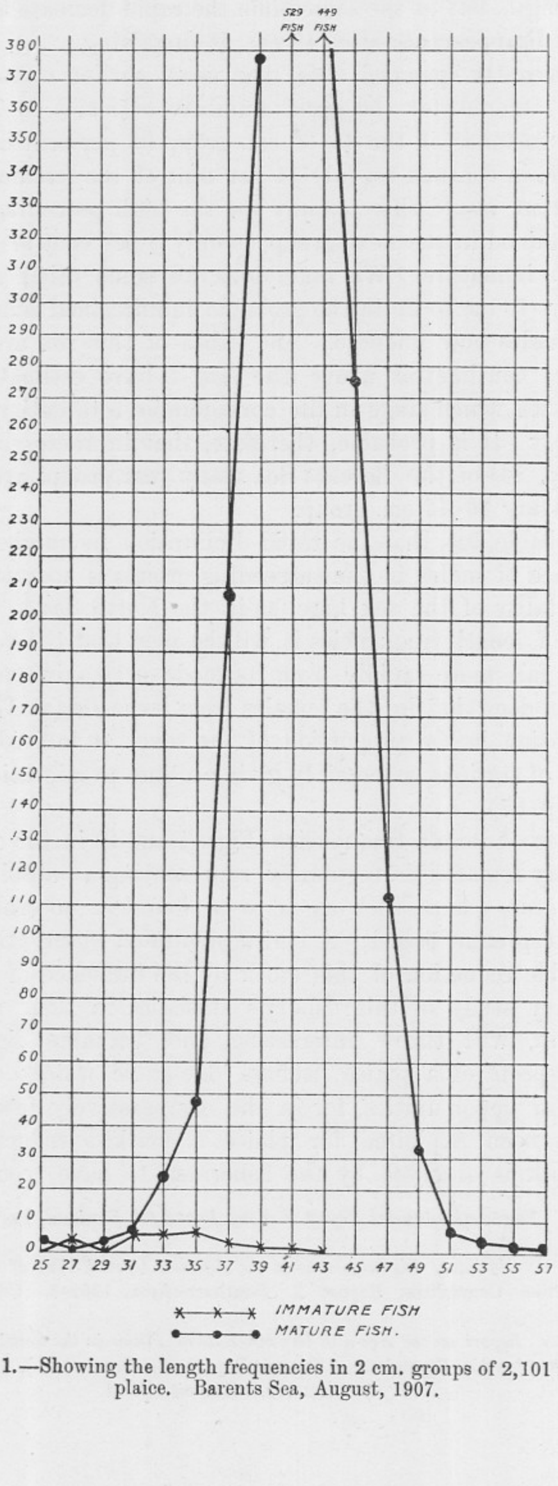


FIG. 1.—Showing the length frequencies in 2 cm. groups of 2,101 male plaice. Barents Sea, August, 1907.

FEMALES.

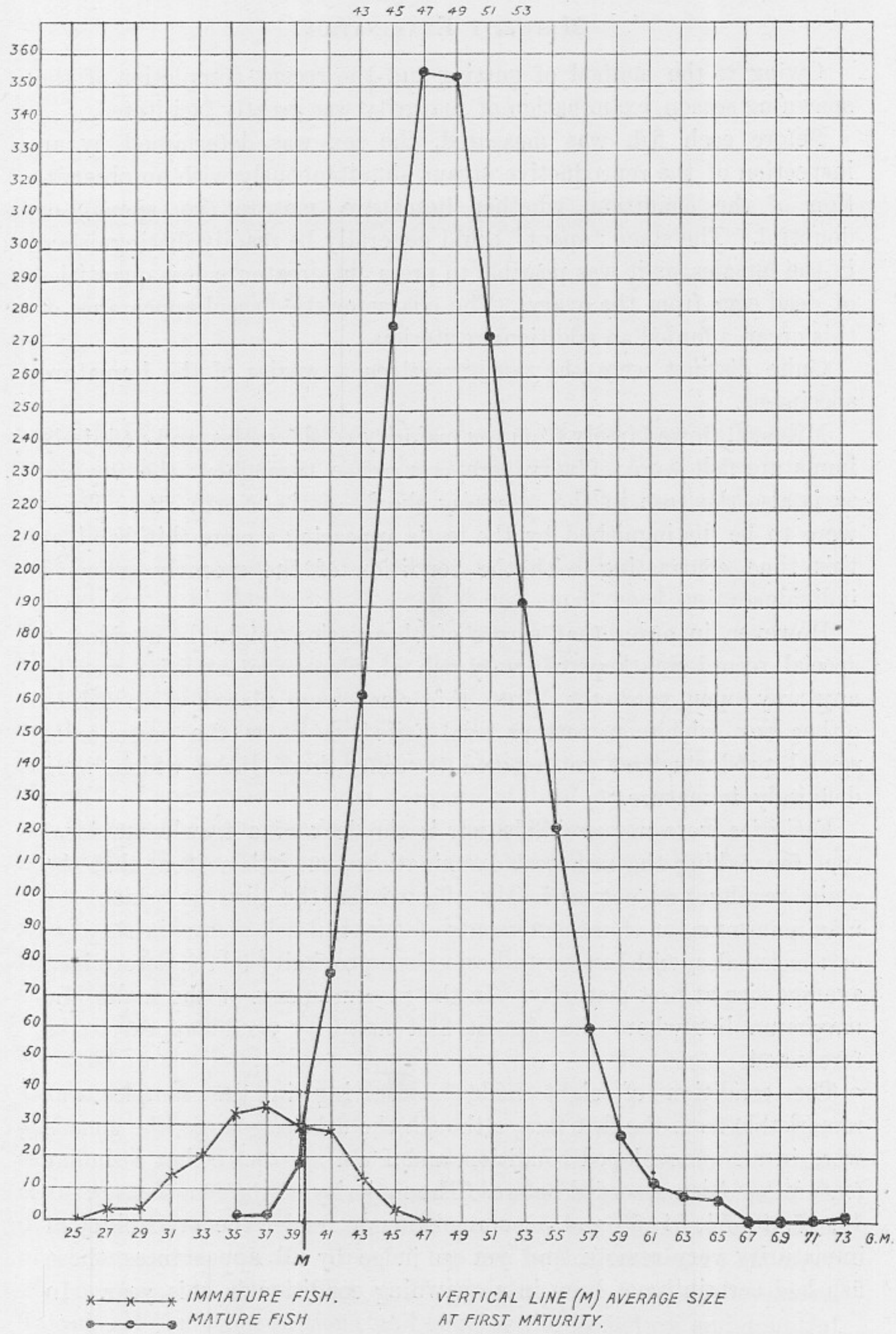


FIG. 2.—Showing the length frequencies in 2 cm. groups of 2,125 female plaice. Barents Sea, August, 1907.

The length of the smallest mature male was 24 cm., and of the smallest mature female, 35 cm. The largest immature female was 45 cm. The largest immature male was recorded as 41 cm., but this record is rendered open to doubt by the curious condition of the eight males recorded above. The average size of the mature males is 40·9 cm., and of the mature females, 48·3 cm.

MATURITY EXAMINATION.

Owing to the method of gutting and the recent completion of the spawning season, examination of maturity was greatly facilitated.

Before each fish was measured, the sex was determined by an inspection of the reproductive organs simultaneously with an observation of the condition, whether immature, mature (i.e. spent), or doubtful. The stage "spent" could generally be readily distinguished in the females, as it was possible to press out greater or less quantities of dead eggs from the ovary. The characteristic flaccid appearance of this organ afforded an additional criterion.

Quite distinct were the taut, translucent ovaries of the immature specimens.

Milt still flowed freely from the majority of the males, and definitely immature fish were of very rare occurrence throughout the voyage, as is also the case in the *spawning* shoals of the North Sea. These were to be distinguished by the testis appearing a mere thin band, at this time contrasting with the condition of the recently spawned individuals.

However, in order that errors of observation might be avoided, a special record was kept of every fish of which the condition was in any way open to doubt. Into this class were placed those fish of either sex which on further trial failed to show the presence of sexual products, and yet seemed to differ from those which were definitely immature.

Facilities were not available, nor is the deck of a trawler an ideal spot for making the minutest examinations, but it is evident that the main results are not seriously affected, as the size at which the maximum number of measurements of doubtful fish occurs, in the case of the females, will be seen to lie in close proximity to the determined average size at first maturity. In the measurements of the males, the maximum lies where the size at first maturity would appear to be forecasted.

The condition of eight males* occurring in the samples was remarkable from the fact that, although the fish were large, the gonads were in an undeveloped condition, and I am not aware that a similar feature has been recorded before. The majority of the lengths, viz. 40, 41, 47, 48, 51, 51, 53 and 57 cm., obviously render the probability of immaturity very remote, and yet to judge by all appearances, these fish had certainly not been in a spawning condition in this year. In

* Two more occurred in the earliest samples, but I rejected them, thinking that the apparent absence of reproductive organs was due to accidental removal in gutting.

one fish, 57 cm., the testis, about 2 mm. wide, was such as is found in the immature condition, but the measurement is the largest in the records for the sex. As regards the other seven fishes, no definite testis could be traced.

Whether this phenomenon was due to the lifelong sterility of the individuals, or to the fact that sterility had supervened on account of the great age to which they must have survived, is an interesting biological question which must for the present remain open.

Having made an extensive examination of spawning plaice in the southern parts of the North Sea in the spawning season (January–February) this year (1907), I received the distinct impression that the quantity of spermatic fluid and unextruded dead ova was far greater in the Barents Sea fish than in those of the southern region. It would be interesting if investigation should prove this to be actually the case.

No females actually spawning or about to spawn were found, and it will be seen from the summary of measurements that the number of immature fish of both sexes was very small, particularly in the case of the males.

It is interesting to find that the greatest number of immature occurred in the haul across the shoalest part of the bank (26 fms.) at the end of the first day's fishing. The catch then consisted of eighteen baskets of plaice, of which four were measured. These contained 183 fish (73 males, 110 females). Of the males, 7, or 9½ per cent, were definitely immature; and 11, or 15 per cent, recorded as doubtful. Of the females, 24, or 22 per cent, were immature; and 5, or 4½ per cent, doubtful. Thus, of the fish in this sample, 18 males, or 25 per cent, and 29 females, or 26 per cent were possibly immature. Taking all the other stations, and classing the immature and doubtful fish together in the same way as "possibly immature," I find only about 3 per cent of the males, and 16 per cent of the females would fall into that category.

As a result of the international investigations in progress, we know that the same phenomenon, viz. an excess in the proportions of immature females compared with that of immature males, also obtains on the central grounds of the North Sea at a similar period.

The length of the smallest mature male was 24 cm., and of the smallest mature female, 35 cm. The largest immature female was 45 cm. The largest immature male was recorded as 41 cm., but this record is rendered open to doubt by the curious condition of the eight males recorded above. The average size of the mature males is 40·9 cm., and of the mature females, 48·3 cm.

The Average Size at First Maturity.

The average size at first maturity, that is to say, the size at which equal numbers of mature and immature fish occur, I find to be about 40 cm. (see diagram, page 79), in the case of the females.

In regard to the males, owing to the virtual absence of immature individuals, this size cannot be determined. The indications, however, from the material available, point to this size being not far remote from 31 cm.

These sizes correspond closely with those Dr. Wallace kindly informs me he has determined from 895 females and 561 males for the central grounds of the North Sea (Dogger, Flamborough Off Grounds, Clay Deep, etc.), viz., 40 cm. for females and 31 cm. for males. The correspondence is remarkable, and would hardly seem a mere coincidence. It is evident, however, that the plaice of the Barents Sea mature at a much later age (p. 85).

Age.

The age investigation presents many difficulties. It is evident that the rate of growth is extremely slow, and this not only renders the distinction of year groups impossible by a study of the length frequencies (Petersen method), but it is also reflected in the otoliths, on which the annual rings are so narrow and crowded together that only in the case of the smallest fishes found has it been possible to estimate the age with a degree of certainty.

I made a small collection of otoliths on board the *Roman*, and although this material is quite insufficient for obtaining an estimate of the rate of growth, it can be seen that this is exceedingly slow, even during the years before maturity is attained.

A noticeable feature of these otoliths is the contrast of the comparative width of the white and dark rings, the latter being exceedingly narrow.

The physical conditions which apparently regulate the deposition of these respective rings have been studied in the case of plaice from the Baltic and North Seas.

Various investigators* have found that the white ring first shows itself in spring, when the temperature of the water commences to rise and the fish to feed. In late summer and into the autumn (the period

* Reibisch. *Ueber die Eizahl bei Pleuronectes platessa und die Altersbestimmung dieser Form aus den Otolithen.* Wiss. Meeres. Abt., Kiel, N. F. Bd. 4, 1899.

Maier. *Beiträge zur Altersbestimmung der Fische;* Arb. d. wissen. Komm. f.d. Intern. Meeres. No. 5. Bd. viii., 1907.

Wallace. *Loc. cit.*

of warmest water and most rapid growth in the North Sea) the dark ring is formed. In winter the growth of the otolith, as of the fish, ceases.

Immermann* has shown that these rings on the otoliths of the plaice are purely optical effects, explicable by the regular changes in the life conditions of the fish.

Avoiding technicalities, the reason for the occurrence of apparent white and dark rings is as follows: The whole otolith is composed of layers of chalk substance deposited regularly as the growth of the fish is in progress. Restrained growth, as when cold water conditions prevail, has the effect of crowding together these layers. As the temperature rises, and the growth rate of the fish increases, so must that of the otolith, and thus is effected a wider expansion of the layers of chalk substance. The optical effect of this is that the crowded rings, not permitting the passage of light, appear white, whilst the expanded translucent layers appear dark by contrast.

The reason for the narrowness of the dark ring, and the comparative great width of the white ring in the otolith of the Barents Sea plaice, is thus afforded. For the greater part of their annual growth-period these fish are subjected to very low temperature (at the time of my visit the bottom temperature was only two degrees Fahrenheit above the freezing point), so that for only a short period would rapid growth appear to take place, and it is not unlikely that this period coincides with the culmination of the Atlantic flood.

As has been pointed out before (p. 72), this expansion of Atlantic water is in progress in the month of August; in other words, biological spring has commenced. Correlated with this physical phenomenon the otoliths of the plaice *show the commencement of a white ring at the edge.* In the North Sea by this time, according to investigations (Wallace, Maier, etc.), the dark ring has commenced. Thus in the two regions of the ocean, many hundreds of miles apart, it can be seen on the otoliths of the plaice that biological spring in the one region coincides with midsummer in the other, as we know to be the case from hydrographic observations referred to above.

For suggestions and help in the investigation of the small collection of otoliths, I am greatly indebted to Dr. Wallace, who also kindly undertook an independent investigation of a number. Our two results were in close agreement, the chief discrepancies being in the case of otoliths on which certain of the rings appeared to split in a doubtful manner.

* *Beiträge zur Altersbestimmung der Fische II. Die innere Struktur der Schollen Otolithen.* Arb. d. wissen. Kom. f.d. Intern. Meeres. No. 6. Bd. vi., 1907.

In Table III are shown the ages of certain individual fishes, reckoning that, as in the North Sea, one white ring is deposited annually, and that each fish had recently completed the number of years specified. In the case of the larger (older) fishes, the outer rings are so crowded together that accurate counting would seem impossible.

I have, however, included a few examples of these, estimating the age at *not less than a* certain number of years, as shown by the number of distinct white rings.

If fishes of either sex are not less than ten years old when 40 cm. in length, to what age must a male of 57 cm. or a female 73 cm. in

TABLE III.—*Showing the age of certain individual plaice from the Barents Sea, August*, 1907, *estimated according to the number of white rings shown on the otoliths :—*

	MALES.			FEMALES.	
	Number of White Rings.			Number of White Rings.	
Length cm.	Immature.	Mature.	Maturity Doubtful.	Immature.	Mature.
24 . .	–	–	–	6	–
26 . .	–	–	6	–	–
27 . .	5	9	–	6	–
	–	–	–	5	–
	–	–	–	6	–
28 . .	–	–	–	10	–
	–	–	–	6	–
29 . .	6	9	–	6	–
	–	–	–	6	–
30 . .	–	–	10[1]	9	–
	–	–	–	9	–
	–	–	–	10	–
31 . .	8	–	–	7	–
	7	–	–	8	–
	–	–	–	8	–
	–	–	–	9	–
32 . .	9	8	–	9	–
	–	–	–	9	–
	–	–	–	9	–
33 . .	–	8	–	10	–
34 . .	–	–	–	not ∠ 9	–
35 . .	–	–	–	9	–
37 . .	–	not ∠ 11	–	–	–
39 . .	–	not ∠ 11	–	–	–
	–	not ∠ 15	–	–	–
	–	11	–	–	–
40 . .	–	not ∠ 11	–	–	–
	–	not ∠ 10	–	–	–
41 . .	–	11	–	not ∠ 12	not ∠ 12
	–	not ∠ 13	–	–	–
	–	11	–	–	–
	–	not ∠ 10	–	–	–
42 . .	–	not ∠ 11	not ∠ 11	–	–
43 . .	–	not ∠ 15	–	–	–
44 . .	–	–	–	–	not ∠ 12
45 . .	–	not ∠ 12	–	–	–
	–	not ∠ 12	–	–	–
46 . .	–	not ∠ 16[2]	–	–	not ∠ 20
50 . .	–	–	–	–	not ∠ 21
54 . .	–	–	–	–	not ∠ 18

[1] Probably 10. [2] Probably 17.

length have survived, considering that each year the growth becomes less and less!

Although the material in Table III cannot be regarded as satisfactory, it shows plainly how slow the rate of growth must be, and would seem indicative of the direction future plaice investigations should take in this inhospitable region.

In connection with the majority of these specimens (Table III), the possibility presents itself that they may be actually amongst the best grown fishes of their respective year groups. That plaice in the North Sea are larger for their age the further they are caught from the coastal grounds has been very clearly shown by Wallace in a recent paper (*op. cit*), so it seems possible, if not probable, that a similar state of things obtains in the off-shore grounds of the Barents Sea.

The youngest plaice of either sex amongst those examined had apparently already completed five years, but this would seem quite exceptional. In addition to the slow rate of growth, the evident late age at which maturity is attained is striking.

Amongst these few fish examined for age, no male less than eight years (32 cm.), and no female less than twelve years old (41 cm.) was found to be mature, though younger mature specimens must have *occasionally* been present in the catch (see Table I). In the North Sea few males are found to survive to eight years.

If the plaice in the Barents Sea have really to live through some eight or nine years before they attain the size at which they reproduce their species, the question occurs to us, "How long will the present stock, accumulated through many years, hold out in sufficient abundance to make this long, expensive voyage of three to four thousand miles down to the Arctic Ocean profitable to our trawlers?"

Migrations.

Speaking in a general way, the migrations of mature fish seem to be determined by the search for food, or to be in connection with the reproduction of the species. Currents, temperature, and such local factors as a general exodus from shoal to deeper water in stormy weather, are amongst other causes of fish movements, but all have more or less direct bearing on one of the main stimuli.

Although conclusions as to migrations in the Barents Sea would be impossible from the material collected on the voyage of the *Roman*, nevertheless every fact in my possession points to a general movement of this mature plaice population from deeper and here probably warmer water, after spawning has taken place, on to the banks to the eastward, apparently in search of food.

That rich supplies of molluscs were available, was evident from the frequent occurrence of living specimens in the trawl; the masses of crushed shells in the stomachs of the plaice and catfish; and, perhaps most important of all, the fine, plump condition of the plaice when first caught. This is a striking contrast to the condition met with a few years ago at Iceland, and reported of the earliest trawling times on the Dogger Bank.

How sensitive some fishes are to external conditions, when about to spawn, has been pointed out by Schmidt.* The same investigator has found more recently† that plaice marked on the north and east coasts of Iceland, migrate from their cold surroundings towards the warm Atlantic water, when preparing for reproduction.

As further contributing to our knowledge on this problem, I find that among the Lowestoft fishermen, whose fishing in January and February is almost entirely confined to the spawning plaice of the southermost North Sea, it is common knowledge that in a severe, cold winter, plaice always set in more abundantly, and remain longer, in the deep channels of this region, than is the case when the winter is mild. Hydrographic observations have shown that the water here is of Channel origin, and has a higher temperature at this period than any other part of the southern North Sea.

From the evidence I shall present below, it will be seen that the spawning plaice of the Barents Sea probably seek to the west the more congenial surroundings which their condition demands.

The Russian hydrographers‡ have pointed out how the ramifications of the North Cape current follow well-defined channels along the sea bottom towards the east, and we may perhaps justifiably surmise that the influence extends to the deep water west of the bank on which the present investigations were carried out.

At any rate, it is the experience of our fishermen that the plaice are found further to the west, and in denser shoals, when they first visit these grounds in June and July, than later in the season. I should estimate, from the condition of the fish taken by the *Roman* in August, that this year the spawning season terminated in July.

An analysis of the *Roman's* hauls of the first two days, relative to their respective positions and depths, reveals features which bear comparison with North Sea grounds at a similar period, viz., just after

* Johs Schmidt. "Contributions to the Life History of the Eel," (Anguilla vulgaris. Turt.), *Rapports et Procès-Verbaux*, V, p. 234, *et seq.*, 1906.

† *Marking Experiments on Plaice and Cod in Icelandic Waters.* Meddel. fra Komm. f. Havunders., Serie Fiskeri. Bind ii, No. 6, 1907.

‡ *Rapports et Procès-Verbaux*, Vol. iii, 1905. Appendix A, pp. 3 and 4.

spawning has taken place. This is in regard to the proportions of the sexes.

Recent investigations* have shown that a high percentage of males is characteristic of the catches in areas where plaice are spawning, or have recently spawned. To gain additional knowledge on this point, I made, in the first days of February this year (1907), a voyage in the Lowestoft smack *Rosebud*, and measured all the plaice caught, 2631 fish, of these no fewer than 85 per cent being males. The spawning season had then about half expired.

TABLE IV.—*Showing analysis of the total catch of plaice made by the Lowestoft sailing-trawler "Rosebud," January 31st to February 5th*, 1907. *Eastern Deep Water*:—

Cm.	<20	20–24	25–29	30–34	35–39	40–44	45–49	50–54	>55	Total.
♂	202	648	555	505	257	50	9	–	–	2226
♀	1	38	148	108	48	33	23	4	2	405
Totals	203	686	703	613	305	83	32	4	2	2631
Percentage of Males	99·5	95	79	82	84	60	28	0	0	85
Spent Females .	–	7	18	26	24	18	7	2	1	103
Immature Females .	1	26	115	64	6	–	–	–	–	212

The early hauls of the *Roman*, referred to just above, were, roughly speaking, in a series—starting from the deep water to the west of the bank, extending over the same, and dropping again into deep water to the east of it.

Three hauls were made up the western slope at depths of 55, 40, and 38 fathoms. The complete catch of two of these hauls, and a greater part of the third, was measured, and the condition of the reproductive organs examined, the numbers showing that males greatly predominated here.

Out of the 294 fish comprising these samples, 179, or 61 per cent, were males; the first haul, indeed, in 55 fathoms, resulted in a catch of 42 fish, of which 33, or 79 per cent, were males.

Crossing the bank with water as shallow as 26 fathoms, measurements of two hauls were made, these samples amounting to 288 fish. The males now only numbered 123, or 43 per cent.

In three hauls down the eastern slope, the water deepening to 49 fathoms and shoaling again to 40, and eventually to 37 fathoms, an eighth, nearly half, and, on the third occasion, the whole of the catch was measured.

A complete reversal in the proportion of the sexes, as compared with the west side, had now taken place. Out of 319 fish dealt with, only 115, or 36 per cent, were males.

After the last haul of this batch, the vessel steamed westward on to

* *Rapports et Procès-Verbaux.* Vol. vii, 1907. Comm. B., p. 20.

the body of the bank, and fish were eventually found in satisfactory quantities. The remaining 21 hauls, from which fish were measured, give 48 per cent of males.

It is evident that this unmistakeable change in the proportions of the sexes from west to east is not without significance, and when we consider that a great preponderance of males is characteristic of spawning areas in the North Sea during, and immediately after the spawning season, it would seem that we have a clue to where these plaice had spawned in the Barents Sea.

Evidence of a probable abundance of plaice some little time previously in the deep water to the west of the bank, was accidentally afforded in the following manner: When first approaching the intended fishing grounds, a trawler's fishing buoy was found anchored in 55 fathoms. No vessel was in sight, and it had been in the water some little time, evidently having been lost sight of in one of the frequent fogs. A trial haul of nearly two hours gave the result previously mentioned, viz., 42 plaice, 33 of which were males.

Now the experienced skippers who make this long voyage to the Arctic Ocean would only be likely to employ a buoy for one of two purposes—to mark either a rough ground, or a shoal of fish. In the latter case plaice would be the species, for in the present limited scope of the fishery this is the only species specially sought after in this region.

No rough ground was encountered in the haul taken, so the probability is that when the buoy was put down quantities of plaice were to be had in the vicinity. It was not until nearly two days later, after searching to the eastward and then returning to the body of the bank, that the *Roman* fell in with sufficient quantities of plaice to warrant the use of a fishing buoy.*

The rapidity with which an accumulation of plaice can under certain conditions disappear from a given spot, is a phenomenon well known amongst fishermen.

Thus we have evidence, indirect and admittedly not conclusive, yet from various aspects corroborative of a distinct eastward movement of these plaice subsequent to spawning. Conversely it would appear as if the westward migration, from this bank at least, into deeper water for the purpose of spawning, might be assumed.

* Since the above was written, information has been obtained on this point, which corroborates in each respect the surmises mentioned in the text. From distinguishing marks on the buoy, and through the courtesy of Captain Leighton, it has been possible to discover the Hull skipper who lost it. He states that it was actually on a bank with 52 fathoms, and was lost in a fog of two days' duration towards the end of June. At that time he was catching sixty baskets of plaice for a two hours' haul.

G. T. A., 27.12.07.

Whither the eggs drift, where the larval forms reach the coastal shallows necessary for the development of young plaice, the life history of these, and where they spend the long years before they reach the outer grounds as mature fish, all afford highly interesting subjects for future investigation.

The pioneering trawlers have found that the plaice are smaller near Cape Kanin, as would be expected, but neither here nor in the entrance to the White Sea, has any great quantity of small fish been found. A study of the Admiralty chart reveals the fact that west of Long. 45° E., the water deepens from the coast comparatively rapidly; indeed, no extensive tracts of shallow water overlying a fine sandy bottom such as characterize the small plaice nurseries in the North Sea, are indicated until Long. 53° E. is passed.

Thereafter to the eastward a long, broad area of fine sandy ground extends across the wide mouth of the Pechora River. It is perhaps significant that the glass balls which Norwegian fishermen employ in connection with their fishing gear, have been found at the mouth of this river.* This reminds us of the drift of derelict fish trunks from our fishing fleets in the North Sea, which with other flotsam, find their way on to the beaches of Holland, Germany, and Denmark, as do also the early developing stages of the plaice.

That this class of evidence is not without significance is shown by the results of later scientific experiments with drift bottles,† by which the trend of the surface currents in the North Sea has been determined.

How the Investigation of the Plaice Fishery in the Barents Sea may throw Light upon the Condition of that Fishery in the North Sea.

It is now desirable to see if from this mass of material from a virgin fishing ground, we can gain any light upon the condition of the plaice fishery in any comparable area of the North Sea.

It must at the outset be recognized that many conditions of life must differ vastly, and yet we have aspects from which this fishing bank in the Barents Sea and the central grounds of the North Sea are comparable as regards the plaice populations at present found on each.

We have the sea bottom in both cases deepening from the coast, whence we may take it the small plaice originate. Far out to sea the

* Nansen. *Oceanography of the North Polar Basin*, Part II, p. 263.

† Fulton. "The Currents of the North Sea and their Relation to Fisheries"; Fifteenth Annual Report Fishery Board for Scotland, Part III, 1897.

Garstang. "Report on the Surface Drift of the English Channel and Neighbouring Seas during 1897," *Journ. M. B. A.*, Vol. v.

bottom rises, forming a bank or banks, rich in the food of plaice: in one case the Dogger Bank, in the other, this uncharted bank discovered by the fishermen from Hull, and on which my investigations were made.

Further seawards in both areas, depths are eventually attained which cease to interest the plaice. In this regard, the Barents Sea is more comparable with the North Sea than is Iceland, where the plaice are restricted by the configuration of the sea bottom to a comparatively narrow coastal zone, throughout their lives. Biologically,

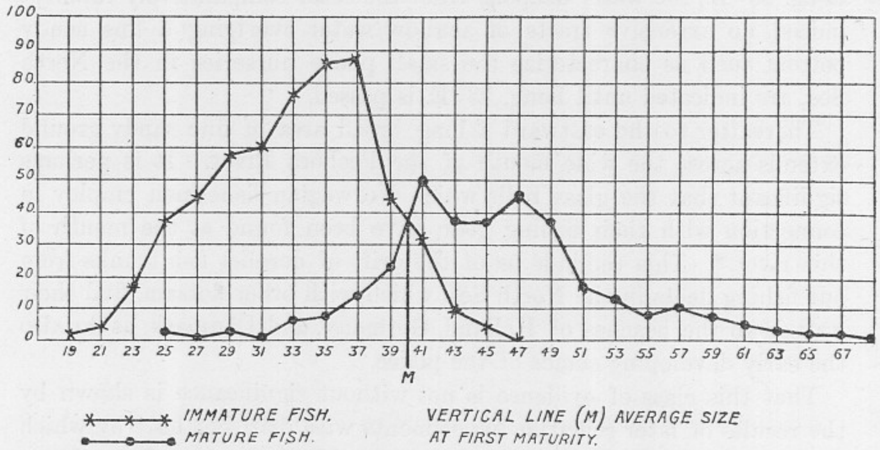


FIG. 3.—Showing the length frequencies of 895 female plaice from the central grounds of the North Sea (Dogger Bank, Clay Deep, etc.).

The ordinates at 19, 21, 23, etc., represent the frequencies in 2 cm. size groups 18–19, 20–21, 22–23 cm. etc.

for both regions, we have this important standpoint from which a comparison can be obtained.

The average size of the females at first maturity was found to be 40 cm. (*approximately*), the same as in the central part of the North Sea.*

Moreover, it is remarkable that out of 2365 and 895 fish from the Barents Sea and the central part of the North Sea respectively, the size of the largest fishes definitely determined as immature should be 45 cm. (Cf. Wallace, Fig. 3).

In order to compare the populations from this standpoint, I have constructed curves of the actual length frequencies of mature and immature female fishes in the two regions (Figs. 2 and 3, pp. 79, 90).

For the rich material from which that for the central North Sea is

* FULTON. 20th, 22nd, and 24th Ann. Report. Fishery Board for Scotland.
HOLT. *Journ. M. B. A.*, Vol. ii.
KYLE. 18th Ann. Report. Fishery Board for Scotland.
WALLACE, *op. cit.*

constructed, I am indebted to Dr. Wallace, who has made the determination of the maturity of 895 female fish on the fishing grounds of the Dogger Bank, Clay Deep, and off Flamborough Head.

In this curve for the central North Sea we find that the immature females, commencing at 18–19 cm., attain their greatest frequency at 36–37 cm., and ultimately disappear after 45 cm. The smallest mature female occurs at 25 cm., with the actual greatest frequency at 40–41 cm. This curve, however, representing the mature fish, rises again at 46–47 cm., so that it seems that its real mode lies between these groups. The largest fish in this collection was 66 cm. long.

In the curve for the Barents Sea (Fig. 2), the smallest immature female was at 24 cm., and then, as in the central part of the North Sea, the greatest frequency occurs at 36–37 cm., and the largest immature specimen at 45 cm. The smallest mature female was found to be 35 cm. in length, and the greatest frequency occurs at 46–47 cm. (thus coinciding with the second mode in the curve for the mature North Sea females, Fig. 3). The largest specimen had a length of 73 cm.

The size at which the numbers of immature and mature are equal (the average size at first maturity), represented by the line M, is for each curve in the vicinity of 40 cm.

Thus in the Barents Sea with its intact stock of plaice, the mode of the length frequency curve (Fig. 2), viz., 46–47 cm,, is some 7 cm. *higher* than the average size at first maturity, viz., 39–40 cm. On the other hand, in the diagram (Fig. 3) representing the stock in the central parts of the North Sea, we should naturally not expect to find any such great accumulation of mature fish; but it is somewhat alarming to find that the mode here (36–37 cm.) fails by 3 cm. to reach the average size at first maturity (39–40 cm.). That is to say, some factor is at work which keeps down the plaice population to such an extent that *the greater proportion are not, at the present time, once permitted to reproduce their kind.* If we compare this with Dr. Petersen's previous discussion of these points in his paper, "What is over-fishing?" (*Journ. M. B. A.*, Vol. vi., 1903, pp. 587–94), it would appear as though the chief theoretical effects of over-fishing in the North Sea, suggested in that paper, were now being substantiated.*

It may be that this enormous contrast is partly due to the fact that

* KYLE (*Journ. M. B. A.*, Vol. vi, p. 496) suggests that one effect of fishing a plaice population is to reduce the average size at first maturity. The Barents Sea will afford the opportunity of testing this; meanwhile, if we were to accept the suggestion that such a reduction has taken place to the extent of, say, 5 cm. in home waters, the deterioration of the stock would be still more evident, and even a greater proportion of North Sea plaice than my curves tend to show would be prevented from attaining maturity.

the fish dealt with in the Barents Sea were possibly selected naturally by the function of spawning, and that immature fish had not migrated so far seawards to an appreciable extent. I think this is in part probable, and that in the North Sea a similar state of affairs may have once obtained, but has now undergone the following change :—

Formerly the plaice population was dense on suitable areas, from the nursery grounds out to such a central ground as the Dogger Bank, and the food supply was everywhere restricted. The early influence of man's fishing was to reduce the numbers of the largest fish at proportionally the greatest rate, and thus reduce the density of the population on the central grounds.

Better feeding conditions would now be afforded on the central grounds, and to these the younger plaice would tend to move more and more, as the reduction in the numbers of the older individuals became more appreciable. At the present time there seems no doubt that density of population is restricted to the nursery grounds, so it is to the advantage of the individuals to radiate rapidly to the more favourable surroundings offshore. Thus it may be that the larger of the immature plaice extend further seawards than was formerly the case, i.e., emigrate at an earlier age, in consequence of the reduced competition within the species on the offshore grounds.

At any rate, whether it was the case or not in former times, there is now to be found everywhere, and at all times in the North Sea, a proportion of immature fish many times greater than I found this year in the Barents Sea. Even amongst the spawning shoals in the North Sea it is quite usual to find as many immature female fish as mature.

On the other hand, it may possibly be that we have on this bank in the Barents Sea an accumulated stock of plaice such as the Norwegian investigators* have shown to have existed in suitable areas on their coast, on a much smaller scale. When these spots were first fished, quantities of large plaice were to be obtained. After a few years, however, the population appeared to have been almost entirely fished out, the explanation being that the currents, setting out of the fiords, carry the majority of the floating eggs and young fish to water in which they cannot develop. The capture of the stock is thus out of all proportion to its renewal by natural means, and the decay of the fishery in these particular spots is inevitable.

From this it would seem to be of the greatest importance for the future welfare of the plaice fishery in the Barents Sea, that steps should be taken to ascertain definitely whether extensive nursery

* *Report on Norwegian Fishery and Marine Investigations.* Vol. i., 1900, pp. 138–52.

grounds actually exist, from which the stock of the outer grounds may be renewed.

If the majority of the eggs and larvæ are carried by currents to regions in which they must naturally perish, as Hjort and Dahl (*loc. cit.*) have shown to be the case on parts of the Norwegian coast, it is evident that the fishery can only flourish so long as the present stock, accumulated through a great number of years, continues to be sufficiently abundant to pay for its capture.

It is not difficult to imagine that there may have been a period when the central grounds of the North Sea were inhabited by a plaice population, of which at least the majority of the individuals were mature; and, had we a curve of measurements of that period, the mode would conceivably have exceeded the average size at which the fish were first mature, by an amount as great as may now be found in the virgin waters of Northern Europe.

One of the earliest effects of fishing on any ground is to reduce the number of the large fish, and consequently lower the average size; that is to say, representing this effect on a diagram to compare with Figs. 2 and 3, the mode will recede to the left, and approach the size at which the species becomes mature.

If it is allowed that an accumulation of mature plaice once preponderated in the central North Sea, it will be obvious that the retrogression of this modal size to its present position (36–37 cm.) *below* the average size at first maturity (39–40 cm.) must have been effected gradually by the influence of man, for no serious natural enemy of large plaice in the North Sea is recognised, whilst the intensity of fishing is known to be very great.

Hence it is conceivable that if intense fishing continues, the modal size of the plaice will imperceptibly recede to even lower limits, and a period must arrive, if it is not already with us, when the supply of eggs, and consequently young fish, seriously suffers.

SUMMARY.

In this preliminary investigation of the plaice on a bank in the Barents Sea the following were among the chief features noted:—

1. The population consisted almost entirely of mature fish, thus presenting a marked contrast to the conditions prevailing at the present day in the central parts of the North Sea (Dogger Bank, etc.).

2. The "average size at first maturity" for the females appears to be approximately the same (39–40 cm.) in the Barents Sea as in the central parts of the North Sea: but, whereas in the Barents Sea the

predominant size is several centimetres *above*, in the central parts of the North Sea it is several centimetres *below* that standard.

In other words, whereas on the virgin grounds of the Barents Sea the female plaice live to spawn many times, in the southern much-fished region the majority at the present time do not live to spawn once.

3. The number of rings on the otoliths indicate a remarkably slow rate of growth and great age attained in this region as compared with the North Sea. It also appears from these investigations that "biological spring," and also the spawning season, is some three to five months later than in the North Sea, viz. in mid summer.

4. On this voyage the differences in the proportions of the sexes at different sizes was striking. Up to a certain size (40–44 cm.) males were in great excess; after this, rapid diminution in their numbers took place.

In the North Sea the same two features have been found to occur, and are connected respectively with the spawning habits of the species and with earlier mortality of the male fish and its slower rate of growth.

5. Various evidence points to the existence of a spawning ground somewhat to the westward of the bank where the fishing took place.

OTHER SPECIES.

The few other species which occurred during this voyage were as follows:—

Dab (*Pleuronectes limanda*).
Long Rough Dab (*Hippoglossoides platessoides*).
Halibut (*Hippoglossus vulgaris*).
Cod (*Gadus morrhua*).
Haddock (*Gadus aeglefinus*).
Catfish (*Anarrichas* (*minor* ?)).
Greenland Shark (*Laemargus microcephalus*).
Starry Ray (*Raia radiata*).
Lump-fish (*Cyclopterus lumpus*).
and *Cyclopterus* (*Eumicrotremus*) *spinosus, Müll.*
A Cottoid (*Gymnacanthus tricuspis*).

Dab (*Pleuronectes limanda*).

This species was of very rare occurrence in the area visited. Only four were observed, all being large; two of these measured 35 and 36 cm. respectively. On an otolith from the latter fish seventeen white rings appear very clearly, tending to show that the rate of growth of this species, like that of the plaice, is exceeding slow in these waters.

Long Rough Dab (*Hippoglossoides platessoides*).

This fish occurred in small numbers every haul. It appears to attain a much larger size here than in the North Sea, where the majority recorded by Fulton* are below 15 cm., and only an occasional specimen over 25 cm. A sample of 42 measured from one haul on the *Roman* ranged from 19–39 cm., the majority being between 25 and 29 cm. Slightly larger and smaller fish probably occurred, but no very small specimens were observed. The species is not brought to market at present.

Halibut (*Hippoglossus vulgaris*).

Four only were caught. Two measured 66 and 78 cm., the other two being a little larger and a little smaller than the lengths recorded. Examination of the otoliths of the fish 78 cm., a male, shows it to be apparently either seven or eight years old.

The species has but rarely been met with in the region, though from the Russian records it would appear to be more abundant further west. The specimens found on this occasion were probably all immature.

Cod (*Gadus morrhua*).

Small individuals occurred in practically every haul, and on one or two occasions in abundance.

A sample basket (52 fish) out of about three was measured from a haul on the second day, and the whole catch (51 fish) eight days later. The features presented by the tabulation of these measurements, if not accidental, are interesting.

In the first sample the sizes range 30–49 cm., with an exceptional fish 58 cm., the maximum number of measurements grouping about 40–42 cm.

The fish in the second lot had a range of size, 27–52 cm., with a very exceptional specimen 82 cm. The maximum of length frequencies occurs some 8 cm. lower, 32–34 cm., with a smaller maximum at 42 cm.

The possibility presents itself that two year groups are chiefly represented, the younger sparsely at the former station, and predominating at the latter, which would be further east than the early haul.

The above-mentioned specimen (82 cm.) was much the largest noted, other exceptionally large fish measuring 60, 69, 70, 77 cm., but never

* "Rate of Growth of Sea Fishes." Twentieth Annual Report, S. F. B.

more than one or two such large fish could be found in any haul. Mature cod at this time were thus practically absent from the area visited. Small codling have been found in quantities by the trawlers towards Bear Island.

Haddock (*Gadus aeglefinus*).

In the first haul (55 fms.) thirty fish were caught ranging from 24–34 cm.

Throughout the remainder of the voyage such small specimens were only rarely to be found. Very large fish up to 81 cm. were caught in quantities varying from one or two fish in a haul up to, on one occasion, 143 fish. These fish had evidently spawned some time previously.

An increase in the catch was noticeable in the few hours the sun was below the horizon.

In 1906* Dr. Hjort procured some large haddock from the catch of a Hull trawler which had been fishing in this region. His specimens were from 55–80 cm. in length, and their ages determined by investigation of the scales ranged between nine and fourteen years.

Catfish (*Anarrichas* (*minor ?*)).

I have records of this fish occurring regularly throughout the voyage in number from one to about a score a haul. With one exception (49 cm.) all the specimens were very large.

Two catches, 10 and 11 fish respectively, were measured, the range of size being 88–120 and 102–125 cm. These ranges and the quantity were typical of most of the hauls in the region at this time.

On various occasions stomachs of seven fish were examined. Crustacea (*Hyas*) and Mollusca appeared to be the staple food, though in one stomach I found three codling.

Greenland Shark (*Laemargus microcephalus*).

Called by the fishermen "oakettle."

Fourteen were recorded, but one or two more occurred. Of these fourteen, eight were measured, viz., 14 ft. (427 cm.), 12 ft. (366 cm.), 11 ft. 4 ins. (346 cm.), 10 ft. 6 ins. (320 cm.), two specimens 7 ft. (213 cm.), 6 ft. 10 ins. (208 cm.), and 5 ft. 6 in. (168 cm.). No very small specimens were found.

Difficulty was experienced in examining the stomach contents of

* Johan Hjort. "Nogle Resultater af den Internationale Havforskning," Saertryk af Aarsberetning vedk. Norges fiskerier, 1907.

these cumbersome creatures. Steam power was necessary to remove them from the remainder of the trawl contents, so that this and hoisting over the ship's side was made one operation. Before cutting the monsters adrift a lateral incision was made through which the liver was extracted.

To have opened the stomach as the fish lay upon the heap would not have improved the remainder of the catch. In two instances, however, I was able to examine the stomach contents.

In the first instance the food consisted of three codlings, about 40 cm., and a plaice of the same length. On the second occasion I found in a fish 6 ft. 10 ins. (208 cm.) in length two round fish (one probably a codling, about 60 cm. in length), one long rough dab, and a piece some twelve inches long from the mid-lateral region of one of the salmon species (*Salmo salar ?*) evidently a large fish.

Quantities of plaice could be observed at times pouring from the mouth of these sharks when suspended by the tail and lowered over the ship's side. That their depredations amongst the plaice are great, I feel convinced. I do not think the missing and damaged tails, so frequent as to be commonly noted by the fishermen, can be otherwise accounted for.

I have observed in the North Sea that when the dogfish (*Acanthias vulgaris*) feeds on small plaice, these are devoured from the tail first, in contrast to round fishes, such as herring, which are taken head first.

In my samples, the significant number of 113 fish, or nearly $2\frac{1}{2}$ per cent of the total, I found with tails more or less damaged, and subsequently healed; in some instances the whole tail had disappeared. The possibility of this phenomenon being the result of disease, such as is sometimes found to be destroying the tails and fins of fresh-water fish, would seem excluded, as the damaged extremities were clean and healthy. In the only exception the extremities of the tail rays were raw and bleeding.

All these facts, in conjunction with the concave shape of the majority of the assumed bites, seemed to me to point to the successful escape of the individual plaice from the jaws of a Greenland shark, though, as previously suggested, the possibility of depredations by seals must not be overlooked.

Starry Ray (*Raia radiata*).

This was the only ray species which occurred, and only occasional, full grown specimens were to be seen. Two female fish in one haul measured 35 and 37 cm. between the extremities of the pectoral fins. In the stomach of each of these was found two large specimens of the Arctic shrimp (*Sclerocrangon boreas*), identified by Mr. R. A. Todd.

Lump-fish (*Cyclopterus lumpus*).

One medium-sized specimen was found.

Lump-fish (*Cyclopterus* (*Eumicrotremus*) *spinosus, Müll*).

Two or three individuals of this lump-fish occurred during the first day or two of the voyage, but it was not observed afterwards.

A Cottoid (*Gymnacanthus tricuspis, Reinh.*)

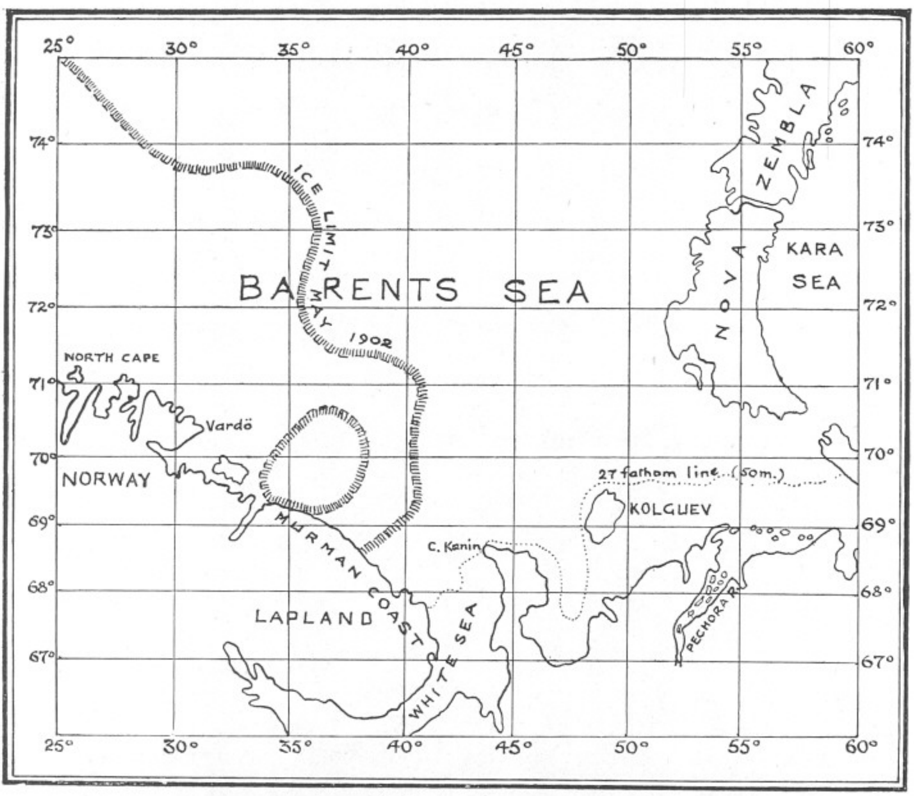
This was represented on the voyage of the *Roman* by one specimen. For the identification of this and the preceding species, my thanks are due to Mr. L. W. Byrne.

EXPLANATION OF PLATE IV.

Photograph of a three hours' catch of plaice in the Barents Sea (about 40 baskets), s.t. *Roman*, H 948, Aug., 1907.

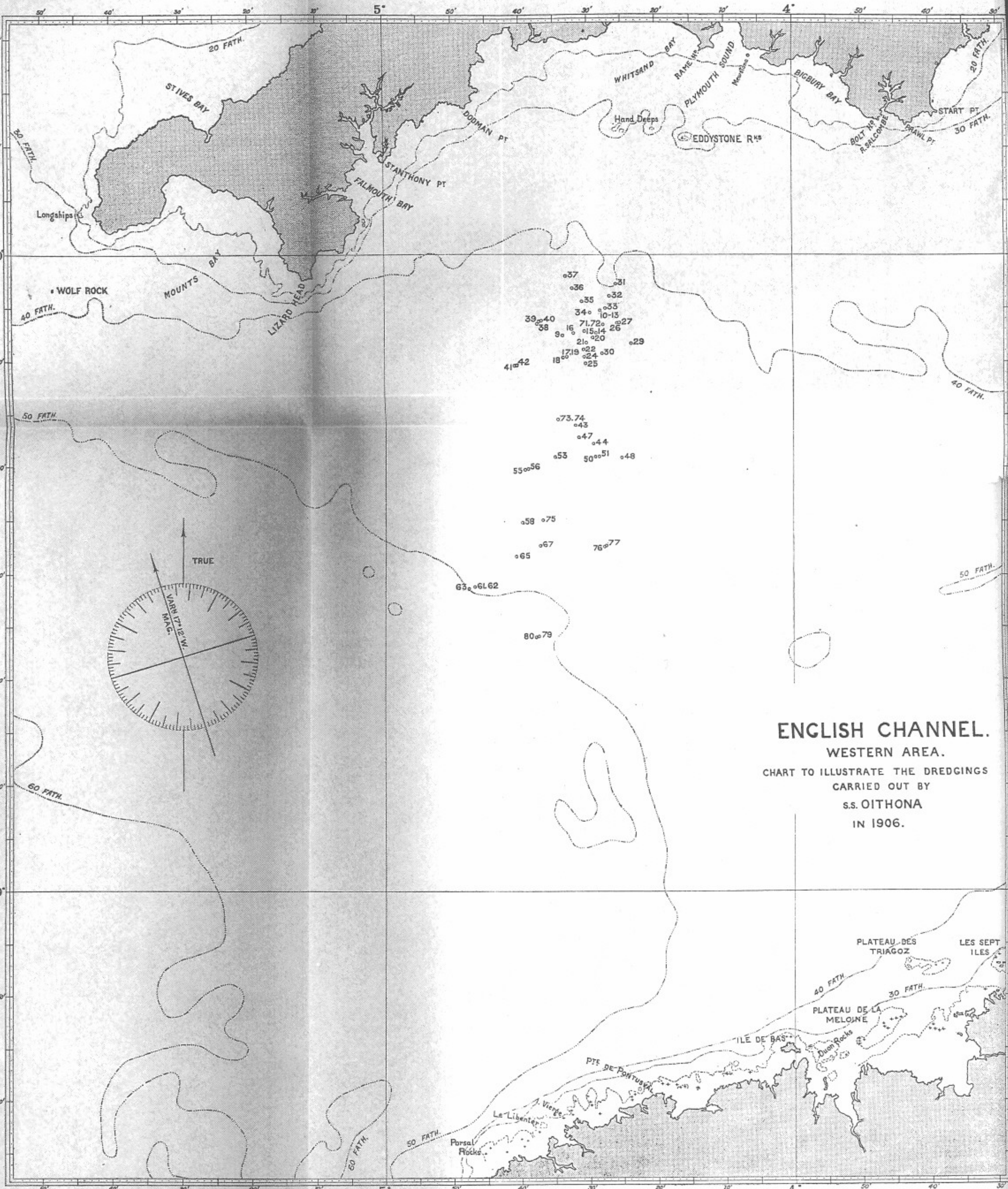
General Chart of Barents Sea.

Photograph of a three hours' catch of plaice in the Barents Sea (about 40 baskets), s.t. *Roman*, H 948, Aug., 1907.



General Chart of Barents Sea.

To face p. 98.



Adapted by L. R. Crawshay from the Chart of the English Channel published by Imray, Laurie, Norie, and Wilson, 1906.

To face p. 99.

On Rock Remains in the Bed of the English Channel.

An Account of the Dredgings carried out by ss. "Oithona" in 1906.

By

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With one Chart (Plate V) and two Figures in the Text.

In the programme of work for the summer of 1906, it was decided by the Director that a series of cruises should be carried out by the Association's steamer *Oithona* to investigate the fauna of the deeper waters of the English Channel. The bearing S.W. ½ S., Magnetic, = S. 23° W., True,* from the Eddystone Lighthouse was chosen as a base-line, and the work was to be carried out with special reference to points at 10-mile intervals along this bearing. The fauna was to be investigated as fully as possible, and bottom-deposits, particularly stones, were at the same time to be carefully recorded and collected. In all, eight cruises were made, the work being extended nearly as far as the 50-mile point.

Pending the completion of the report on the fauna collected, it has been decided to issue in a separate form an account of the geological collections that were made, which afford valuable evidence in the light they throw on the history of the Channel.

The stones, with which Mr. Worth's report deals copiously in a subsequent paper, were first found on June 11th at the close of the second cruise at Position (9), bearing S. 31° W. from the Eddystone, 22 miles, and at a depth of about 40 fathoms. The 3′ 0″ dredge was cast to try the nature of the bottom. After an unsatisfactory

* Except where otherwise stated, all bearings here given are true, a variation of 16° 45′ W. (say 17° W.) having been allowed throughout.

haul the arrangement of the gear was modified,* and as the result of a third attempt the dredge came up three parts full of stones. The contents of this haul were of so great interest that it was decided to investigate the subject further, and so far as was possible without unduly interfering with the faunistic work, the most careful attention was given during the subsequent cruises to tracing the extent of these stones and estimating the conditions associated with their occurrence.

In the third cruise, commencing on June 14th, the course was accordingly set to the position where they had been encountered. The stones were found again without difficulty, and were followed at close intervals during this cruise over a considerable area. Subsequently their inner limit was observed at points adjacent to the base-line of the work at some 15 miles outside the Eddystone. Beyond this their extent was still unknown, and much time was therefore occupied at first by short runs about the 20-mile point, which will explain the large number of positions shown on the chart in this region. Finally, from Position (37), S. 41° W., 17 miles, a test run of 12 miles was made in a south-westerly direction. The casting of the dredge at 6 and 12 miles showed rough ground at both points, one of the dredges being so bent out of shape as to be rendered temporarily useless. After this the work was extended on broader lines to the southward.

Some general points in connection with the stones will now be considered from evidence afforded in the course of the work. The extent of the area covered by the cruises is shown in the accompanying chart (Plate V), where the positions plotted are all of them directly concerned with the stones collected. All bearings and distances are reduced to the Eddystone Lighthouse. The work was done entirely by log and compass, no sextant observations being taken. At the same time much care was taken throughout with a view to securing as close a degree of accuracy as by dead reckoning was possible, and the positions given may be regarded as nearly accurate.

(1) *Extent of Exposure.*—The inner limit of the stones, as previously mentioned, was traced by two or three samples at about 15 miles outside the Eddystone. Here only a very few small stones were found, mingled with the sand and shell deposit which covers the sea-bottom. Inside this point, that is to say, between 8 and 15 miles

* That is to say, by attaching a heavy sounding-lead to the hemp warp employed, a few feet in front of the dredge. From this point the hemp warp was dispensed with, and a wire rope substituted for it in all dredgings.

outside the Eddystone, the dredges revealed nothing but clean shell-sand. Outside it, however, from the time when the gear was suitably adjusted to the work, there was no single point among the forty-five positions in which either of the larger dredges was used where stones were not found in greater or lesser degree. It may therefore be said that outside this 15-mile point a stony area was traced without interruption for a distance of 34 miles S.S.W. and for some miles to the eastward and westward of this line, covering a total area of some 300 square miles. At Position (80), the outermost point reached, bearing S. 16° W., 49 miles, which is slightly beyond the middle of the Channel, both the average size and the average weight of the stones collected were, with one exception, higher than anywhere observed, and there is every reason to suppose that beyond this point similar conditions prevail to within close proximity to the French coast.

(2) *Intensity.*—Of the distribution of the stones exposed in point of intensity it is more difficult to speak with assurance, so many are the factors which must enter into consideration: the character and possibilities of the gear employed, the variation of local conditions, and the tendency of the dredge to become quickly filled with animal débris in a particular spot, the general success of a haul dependent on tidal and weather conditions; all these tend to complicate the result as shown by the stones actually taken; so that it is difficult to form a just quantitative estimate without a more complete and systematic method of investigation than was possible in the circumstances. From the available data, however, there is little doubt that the stones lie scattered about the surface, with very little interruption over the whole area. In a table appended below (Table I, p. 114) detailed particulars are given of every sample obtained, including the estimated area covered by the dredge used. This estimate assumes an average rate of towing of one sea-mile per hour throughout. This cannot be regarded as more than a rough approximation, but it is sufficiently near for the general purpose. Excluding three hauls where no definite result was obtained owing to the dredge being fouled on obviously rough ground, the total area actually covered by the remaining 53 hauls amounts on this estimate to 11,950 square yards. The total number of stones of 4 cm. and over that were collected being 5808, an average ratio of distribution is obtained for the whole area of 0·5 per square yard.

Probably this estimate is somewhat short of the true state of things, for it does not take into consideration those stones which are too large to enter the opening of the dredge, nor does it make allowance for the limited capacity of the dredge in regard to those positions where the stones are exceptionally numerous. But as a general estimate I do not think it is very far short of the truth, having reference, of course, only to stones exposed at the surface or very little covered. The most reliable test is probably to be found in the result of hauls with the conical dredge and the 1′ 6″ dredge. The former of these instruments is so constituted as to dig deeply with its heavy frame into the sea-bottom, and is therefore allowed to work only for a fraction of a minute, during which time the canvas bag with which it is fitted is rapidly filled with a complete sample of the bottom from a very small area, about 4 to 8 square yards. The 1′ 6″ dredge was also fitted with a canvas bag, and though not digging so deeply was used for a very similar purpose. Of five hauls with the conical dredge, from 19 to 49 miles, two produced no stones at all; of six hauls with the 1′ 6″ dredge, from 30 to 46 miles, three produced no stones at all; but if these 11 hauls be summarised, and the number of stones of 4 cm. and over be distributed over the sum of the estimated areas covered, a ratio of distribution is obtained for these short hauls very nearly equivalent to that for the whole area of the work, namely, 0·6 per square yard.

With reference to this absence of stones in five hauls with these small dredges, there is no doubt that the stones lie exposed on the sea-bottom very much more thickly in some places than in others, owing to the varying degree of sedimentary deposit in different areas dependent on tidal action and the physical conditions influencing animal settlement, and so regulating the local deposition of shell and other débris of animal origin. In the "Distribution" column of the table it will be seen that the ratio varies as widely as from 0·4 to 28·0 square yards per stone. An interesting case in point occurs in the Positions (10) to (13), S. 26° W., 18 miles. These four samples were taken in quick succession in a westerly direction over a distance of about 1 mile, and lying thus close together, are shown on the chart as coincident. It seems evident that here the dredgings passed through the middle of a stony patch which was almost covered by finer deposits at either limit.

At (10)	6 stones were obtained with an average distribution				of 1 stone to	28	sq. yds.
,, (11)	166	,,	,,	,,	,,	2	,,
,, (12)	187	,,	,,	,,	,,	1·8	,,
,, (13)	21	,,	,,	,,	,,	27·3	,,

To quote another instance, at Position (17), S. 28° W., 23·3 miles, a haul of 11 minutes with the 3′ 0″ dredge produced only 15 stones, with the small mean dimension of 4·8 cm., and a distribution of 1 stone to 24·7 square yards. The dredge had here passed through a large and flourishing settlement of *Pallasia murata*, Allen, and a vast number of the tubes, together with several living specimens of this valuable Polychæte, were brought up in it with little else. As it was evident from the next haul, (18), that we had passed outside the limit of the *Pallasia* settlement, we steamed back to the ground of Position (17) in the hope of securing some more specimens, setting this run at half a mile. But the *Pallasia* ground was missed, and a very heavy haul of 34 stones was brought up at (19) with a mean greatest dimension of 10 cm., which was one of the highest averages obtained during the work. These two positions, (17) and (19), cannot have been separated by very many yards from one another, though the results obtained were totally different.

Again, the two blank hauls with the conical dredge previously referred to, (71) and (73), at 19 and 29 miles respectively, were followed in each case immediately afterwards by a haul with the 3′ 6″ dredge at (72) and (74). The first of these latter gave 213 stones with a mean distribution of 0·8 per square yard. In the second, the safety-stop of the dredge was broken, owing to the roughness of the ground passed, and no more definite conclusion was therefore obtainable than that very heavy stones had been encountered within about a quarter-mile of (73), where the conical dredge revealed only coarse shell-sand.

(3) *Size and Weight.*—A single greatest measurement of each of the stones was taken. Ultimately all stones of less than 4 cm. were left out of consideration, and a mean was obtained for each haul, derived from the products of dimension × number in each case, at intervals of 1 cm. Similarly, the samples were weighed, and a mean was worked out in pounds per stone, for each haul.

A cursory glance at Table I (p. 114) does not convey any very definite impression as to the relation between size or weight and distance of position from the Eddystone. A certain rate of increase occurs with distance, but it is very irregular. This is evidently due to the fact that the main bearing of the work does not lead directly out towards mid-Channel, but nearly four points to the westward. If a line be drawn due E. and W., Mag., through the Eddystone, a distinct increase is obtained, both in size and weight, in a direction perpendicular to this line, *i.e.* due S., Mag. Parallel lines being accordingly drawn E. and W., Mag., at 5-mile intervals outwards, and a mean being taken for all the samples falling within these several intervals, a fairly regular curve is obtained for both size and weight (pp. 105, 106).

The disposition of the samples is as follows:—

5–10 miles S., Magnetic	1 sample .	. .	43 stones
10–15 „ „	18 samples	. .	2924 „
15–20 „ „	13 „	. .	1765 „
20–25 „ „	3 „	. .	334 „
25–30 „ „	7 „	. .	424 „
30–35 „ „	7 „	. .	455 „
35–40 „ „	2 „	. .	22 „

The area between 20 and 25 miles, represented by three samples, should properly include the sample (74) previously referred to, where the stop of the dredge being broken, owing to the roughness of the ground, no numerical results were obtainable, and the position had therefore to be left out of consideration. There is little doubt therefore that it is owing to an insufficient number of samples that a drop occurs over this area in both curves.

In point of size and weight, then, there is a steady increase correlated with distance in a mid-Channel direction. For the location of the samples, the bearing and distance of all the positions has been reduced to the Eddystone; but the main bearing of the work being S. 23° W. from this point, that is, almost directly on Ushant, their location must be regarded from a different standpoint, where questions are involved relating to their distance from the English coast. Treating the Eddystone as an outlying point on the coast-line, a line running through it E. and W., Mag. will be roughly parallel to the mid-Channel line, and less than one point off the main direction of Hurd Deep. Outside it the positions fall naturally into the groups from which the curves (Figs. 1 and 2) are obtained at 5-mile intervals, as follows:—

5–10 miles.	37.
10–15 „	36, 31, 32, 35, 33, 34, 10, 11, 12, 13, 39, 40, 9, 16, 15, 72, 26, 27.
15–20 „	14, 20, 21, 22, 29, 30, 34, 25, 17, 19, 18, 42, 41.
20–25 „	73, 74, 43, 47, 44.
25–30 „	55, 56, 53, 44, 50, 51, 58.
30–35 „	58, 75, 67, 76, 77, 63, 62.
35–40 „	79, 80.

In connection with the foregoing deductions, two points may here be considered: (1) the size of the stones in relation to that of the opening of the dredge frame; (2) the position in which they lie.

In regard to the first point, the 3′ 6″ dredge, the largest used, with a frame of 3′ 6″ × 1′ 0″, offered an opening of about 100 × 30 cm. Similarly the 3′ 0″ and triangular dredges allowed of stones at least

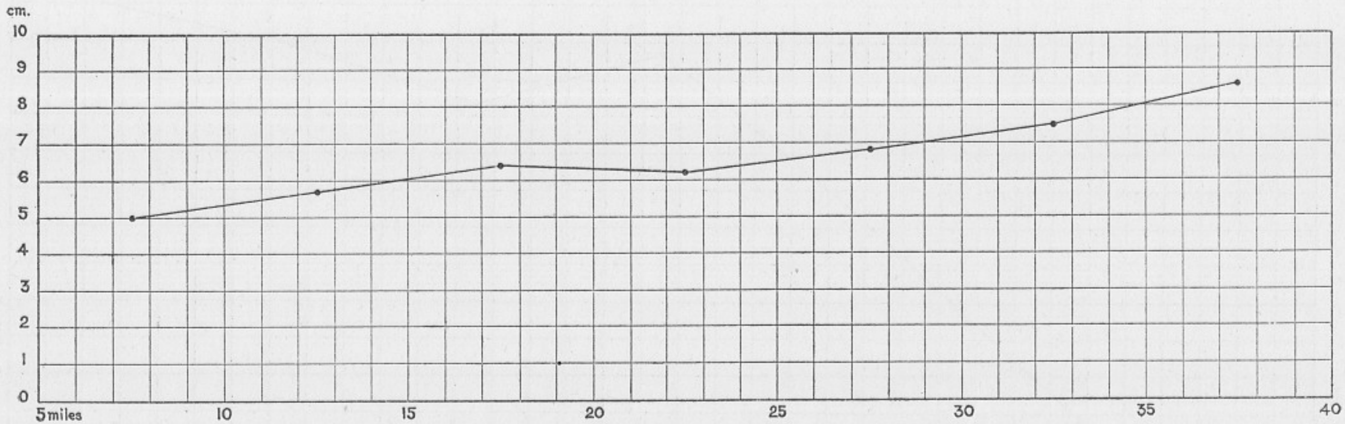


FIG. 1.—Average greatest dimension of stones for 5-mile intervals S. 17° E. from Eddystone.

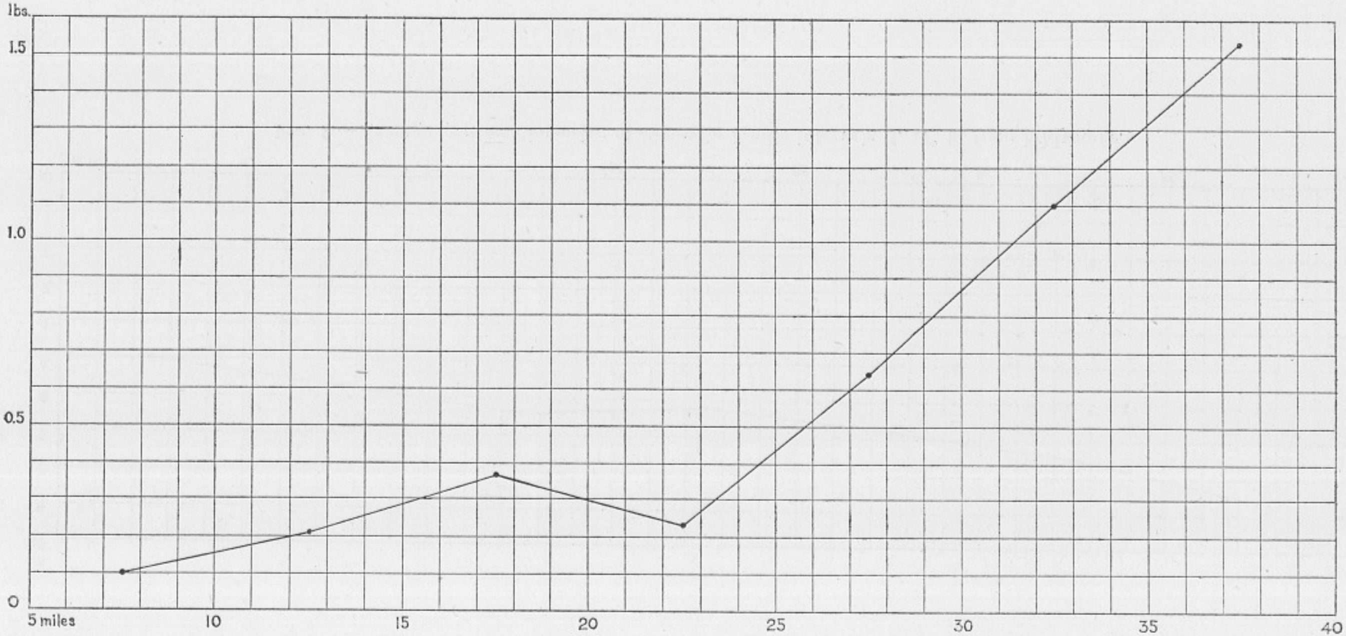


FIG. 2.—Average weight of stones for 5-mile intervals S. 17° E. from Eddystone.

as large as 90 cm. and 50 cm. being taken. But it is significant that in forty-five hauls with these three dredges, no stones with any approach to such a size, even in their greatest dimension, were obtained. Among the largest were—

four of 20 cm. on (19), (77), and (58)
five of 21 „ „ (19), (58), and (62)
four of 22 „ „ (19), (53), and (67)
one of 26 „ „ (58)
two of 27 „ „ (53) and (80)
one of 30 „ „ (77)

It may therefore be concluded that, except, of course, in so far as they are largely or wholly covered up, very large stones are not very numerous in this area, and the dimensions and weights shown on the curves may be taken as a fair approximation to the true average. There is no doubt, however, that very large stones and even boulders do occur with considerable frequency, as on the trawling-grounds off Start Point. The heavy working of the dredge communicated through the warp, the breaking of the safety-stop, and the bending or even breaking of the ironwork of the dredge afforded frequent evidence of this. A broken stop occurred at the following points:—

(38), S. 38½° W., 22·2 miles
(39), S. 38° W., 22·2 „
(18), S. 29° W., 23·4 „
(62), S. 25° W., 46·4 „

At (21), S. 25° W., 21·2 miles, the 3′ 0″ dredge employed was brought up fast and lost, only a portion of one arm being recovered.

To break the safety stop, a strain is required of some 600–700 lbs. To sharply open out the wrought-iron frame of the dredges used, in the manner that too often occurred, involves a strain of several hundredweight; while in the total loss of the dredge at (21), the parting of the remaining arm would only be caused by a strain of about twelve tons. At some of these points, then, and at (21) in particular, heavy boulders must have been encountered, the size of which can only be estimated at a rough minimum.

As regards the second point, the position of the stones as they lay when dredged up, there is ample evidence to show that, with very few exceptions, they were well exposed at the surface of the sea-bottom, and that they have probably so lain for a considerable time past. Almost without exception, they supported living animal growth or its remains—Porifera, Hydrozoa, Polychæta, Polyzoa, Mollusca, etc. Scarcely any of the stones were without investing Polyzoa, which often covered the greater part, sometimes the whole, of the surface.

A large majority supported living Hydrozoa, in addition. The animal growth often showed well-marked limits above an underlying bare portion on which the stone had rested in its bed, evidently undisturbed for a long period of time. Such a position, with the greater part of the stone exposed, was the commonest; but in places, especially near mid-Channel, on (80), S. $16\frac{1}{2}°$ W., 48·9 miles, evidence pointed to the stones resting more openly on one another, with very little fine deposit associated with them. Under the more ordinary conditions, with the exposed stones lying scattered about at intervals of a yard or two, in an even shelly or sandy bed, it is not surprising that the bottom of the Channel has been so widely charted as sand and shell, the lead rarely happening to strike these stones except in places where they are exposed to an abnormal degree. There is much reason to believe that the intervening deposit of shell and sand forms for the most part only a thin covering, and that if this could be penetrated to a depth of not many inches, the true bottom of the Channel over the whole of this area would be revealed as an uninterrupted stony bed.

(4) *General Form.*—The stones exhibited every gradation of form, between that of perfectly rounded outline and sharp angulation; the fact that numerous examples of these two extremes repeatedly occurred in the same sample is sufficient to show that little or no wearing action has taken place in recent times. Frequent instances occur of a sequence of events: (1) complete rounding; (2) sharp fracture; (3) secondary rounding; but the ultimate investment of animal growth afforded constant evidence in such cases of the secondary rounding not being recent.

(5) *Bottom-Deposits.*—Thirteen hauls were taken with the conical and 1′ 6″ dredges, two of them being from positions at eight to nine miles outside the Eddystone, and therefore well inside the point where the stones first appear. I am indebted to Mr. R. A. Todd for his assistance in grading the whole of these samples. The results are given in Table II (p. 117), where the samples are arranged in order of their distance on a S.W., Mag. bearing from the Eddystone. The method of grading is that adopted at the Lowestoft Laboratory for estimating the texture of bottom-deposits in connection with the International Fishery Investigations. The material is separated into eight grades by washing it successively through a series of sieves with circular perforations of 15 mm., 10 mm., 5 mm., 2·5 mm., 1·5 mm., 1·0 mm., and 0·5 mm., the residue which passes through the 0·5 mm. sieve forming the eighth grade. The exceptionally high proportion of "shell" contained in these samples, that is to say, fragments of the shells of Mollusca, fragments of plates and spines of Echinodermata,

and fragments of Polyzoa, especially *Cellaria* and *Cellepora*, rendered the accurate grading of them a difficult matter, owing to the repeated breaking of the more delicate fragments in the sifting process, so that some small excess error must be allowed for throughout in the direction of the finer grades. The percentage of Carbonate of Lime present in the material above and below the dimension of 0·5 mm. has been determined as shown in Table II. The proportion of this due to inorganic matter is so slight that the percentage may be treated as representing entirely organic remains. For convenient comparison of the samples an "average grade" is added in each case. This method of averaging the samples, which was used by Mr. Worth in estimating the texture of bottom-deposits of the Start to Eddystone Grounds,* consists in multiplying each grade-percentage by its conventional number (15 mm. + = I, . . . $\angle$ 0·5 mm. = VIII,) and then dividing the sum of the products by 100, the quotient being the average grade of the sample. It is an interesting point to observe that in these samples, as is shown in Table II, there is a distinct tendency for the average grade to decrease, *i.e.* for the texture to become coarser, with the increase of distance outwards, as far as (75) at 38 miles, beyond which an increase occurs up to (79) at 48 miles. If these few samples be grouped together on broad lines of 10-mile intervals on a S.W., Mag. bearing, the combined averages appear as follows:—

5–10 miles .	. 2, 69 ,	. Average Grade,	7·576
10–20 „ .	. 71 .	. „	6·524
20–30 „ .	. 73, 48, 50	. „	6·480
30–40 „ .	. 50, 75, 76	. „	5·255
40–50 „ .	. 65, 61, 79	. „	5·033

Sample (50), falling on the 30-mile point, is included in both intervals between 20 and 40 miles.

While this method of averaging is useful as indicating the comparative texture of the samples, it is open to the objection that the inclusion of the coarser grades may unduly influence the result in the way of obscuring the finer ones. If the coarser grades be disregarded, and only those below and including 1 mm. + be considered, the average percentage of material within this range for the samples grouped in the same manner as before works out as follows:—

5–10 miles	95·0 per cent.
10–20 „	77·1 „
20–30 „	76·2 „
30–40 „	52·1 „
40–50 „	41·6 „

* *Journal of the Marine Biological Association*, Vol. V, p. 381.

In most of the samples the smaller particles, both organic and inorganic, show a good deal of rounding and often a high polish, and in all of them there is almost or entirely an absence of silt.*

Few as these samples are and irregularly disposed over so great a distance, the fragmentary evidence afforded by them is important in its bearing on the final question to be dealt with.

(6) *Conclusion.*—One point remains to be considered in conclusion. How is the exposure of these stones at the present time to be accounted for? The Channel bottom is probably disturbed to a considerable depth by wave action in stormy weather, though to what degree is a matter yet to be investigated. Fine particles of sand and other matter have often been taken in the tow-net at a considerable distance from the bottom, and even at the surface, in water as deep as in any part of the Channel. It would be difficult not to attribute this, in some degree, to wave action. It is commonly asserted by fishermen that on the trawling-grounds off the Start, in 35 to 40 fathoms, they are much more liable to have their trawls fouled by large stones immediately after stormy weather than at other times, the belief prevailing that at such times the boulders become more exposed owing to the disturbance of the fine deposit. A case in point occurred quite recently (December 15th, 1907), after an exceptionally rough spell of weather, when some of them encountered heavy stones on these grounds, and by one of them, the Brixham trawler *Love and Unity*, a block of granite was brought into Plymouth weighing 833 lbs.† Probably there is much truth in this impression, and the influence of wave action should be considered as partly contributing to the continued exposure of the stones far out in the Channel. But the direct agent must be sought for in the tides, and I think it will be found that the tidal conditions in this region are sufficient to explain the cause at work.

As far at least as about the 40-mile point referred to in these cruises, there appears to be a constant gain on every complete tide in a north-easterly direction. The meridian of the Eddystone is roughly the western limit of the conflicting tidal conditions caused by the Dover Stream, involving at intervals an opposite direction of the current in the easterly and westerly portions of the Channel. When in this westerly part of the Channel the tide turns to flow, it has to encounter, to the southward of the Eddystone, a still strongly ebbing stream from Dover. Aided by the northerly set from the Bay of Biscay, it is forced against this in such a way as to be deflected to the

* *i.e.* matter which remains in suspension in water at the end of one minute.

† This stone is referred to by Mr. Worth on p. 122.

northward and north-eastward, and it is only when the Dover ebb has slackened, some time afterwards, that the direct up-Channel flood can be resumed. On the turn to the ebb the case is different. The two streams simply flow away from one another, and there is very little or no appreciable deflection through the south. While there cannot perhaps be much doubt as to the existence of this north-easterly gain, nearly as far, at least, as mid-Channel, the existing data available are too incomplete to admit of its being definitely estimated with confidence as to the result. I have made reference to the surface current measurements as shown in the *English and Irish Channel Tidal Streams,* compiled for the Admiralty by Commander Simpson, R.N., and in order to form some estimate on this basis the measurements of the mean current between neaps and springs for each hour were combined, and a mean resultant worked out for one complete tide at 10-mile intervals S. 23° W. from the Eddystone. The values thus obtained are as follows:—

Eddystone	N. 23° E.,	10 miles	. .	N. 24° E., 2·2 miles
„	„	20 „	. .	N. 21° E., 1·3 „
„	„	30 „	. .	N. 26° E., 1·1 „
„	„	40 „	. .	N. 39° E., 1·2 „

These results must, of course, be treated with reserve. In the first place, they are derived from measurements in which, admittedly, too great reliance must not be placed on detail; and in the second place, they are surface measurements, and, however accurate as such, do not necessarily represent the condition of things at the bottom. But they show a remarkable degree of regularity in the general result, which seems to justify their being given here. The most doubtful point is that at 50 miles, where different conditions arise with the commencing approach to the French coast, and there is more southerly drift than at the other points. Owing to the difficulty of estimating closely from the tidal charts the force and direction of the current here at some intervals of the tide, the position has been left out of consideration. Close to this point, Mr. D. J. Matthews has made, from time to time, a number of measurements with the Ekman-Nansen current meter. In August, 1905,* he was able to carry these observations through one complete tide at different depths. From his 22 measurements at the surface on this occasion I have derived a resultant of S. 4° W., 0·96 mile. At 70 metres, however, his 18 measurements give a resultant of S. 21° E., 0·40 mile. The gain at this point would therefore seem to be a southerly to easterly one. The most important

* *Conseil Perm. Internat. pour l'Expl. de la Mer. Bulletin Trimestr.* August, 1905. Part B., p. 25.

point in Mr. Matthews's observations in the present connection is the fact that he has found a stronger current at 70 metres than at the surface. On this occasion, which was about the time of three-quarter Springs, it amounted to as much as 1·3 miles per hour. In the preceding May,* he made, on the same station, a series of measurements at 90 metres *i.e.* close to the bottom, extending through almost one complete tide, but not, unfortunately, in quite sufficient detail to admit of a resultant being taken. The force of current then measured rose to as much as 0·5 mile per hour, and as it was only one day subsequent to the date of the Moon's first quarter, one may fairly safely assume at high Springs a bottom velocity, at this point, reaching 1·5 knots or more.

It is on this latter point that the main question turns concerning the exposure of the stones. If it should be true, as evidence seems to point, that there exists a constant tidal gain on the English side of mid-Channel in a north-easterly direction, and in the more central waters, as would seem from Mr. Matthews's observations towards the south-east and south, this fact, combined with the presence of a bottom current reaching as much as $1\frac{1}{2}$ knots, would be sufficient to explain the exposure of stones. No fine deposit could accumulate with this gradual shifting process constantly at work in the outer waters of the Channel. It must be passed on elsewhere, perhaps to come to rest ultimately off the English coast-line, or, on the other hand, it may be, to be carried through the south towards the Atlantic. The evidence afforded by the bottom-samples that were taken with the conical and 1′ 6″ dredges tends to support this conclusion. Outside about ten miles from the Eddystone no instance was found of what could, strictly speaking, be called a fine deposit. Beyond this point the deposits obtained might be described in general terms as coarse shell-sand mingled with fine or coarse gravel and usually stones, with a very small proportion of quartz grains. Except in sample (50), S. 16° W., 30·9 miles, the material above 1 mm. in grade comprehended within the range of Table II, amounted in all cases to more than 30 per cent of the sample. In most of them it exceeded 50 per cent. Sample (50), moreover, cannot by any means be regarded as of a fine grade, since it also contained in addition to the finer deposit indicated in Table II, several stones with an average greatest dimension of 6 cm.† Further, it has already been pointed out (p. 109) that this coarser texture of

* Id. May, 1905. Part B., p. 94.

† The same point applies to several of these bottom-samples, in which the inclusion of stones would have been too cumbersome for the purposes of Table II; cp. especially sample 79 (Table I, p. 116), where the larger stones averaged 0·67 lb. per stone.

the bottom deposit increases with distance outwards, or conversely, the percentage of the finer deposit increases as the coast-line is approached, till at some eight to ten miles outside the Eddystone there is found, in 40 fathoms, a deep accumulation of fine sand, 92 to 95 per cent of which is less than 1 mm. in grade.*

It would be difficult to account for these facts except on the assumption that there is a constant tendency for the finer material to be drifted, by combined tidal and wave action, from the outer waters of the Channel towards the coast-line, the direction of the drift being apparently, so far as the English side of the Channel is concerned, north-easterly. On such an assumption, with the continuous transportation of the finer material from the more distant positions, the greater degree of exposure of the stones in like proportion would be accounted for. Without the presence of a constant process of the kind no explanation would seem adequate to account for the fact that in the midst of shifting deposits brought from other regions and continuously augmented by the local growth and decay of numerous lime-secreting organisms, even small pebbles of no more than a centimetre or two in height are found again and again, affording an undisturbed base for delicate animal growth, evidently for a long period.

Whether the present conditions are undergoing any change, or whether they represent a state of equilibrium maintained between the factors of deposition and tidal action it would be of deep interest to know. In either case there is very little doubt that at the present time, over almost the whole of this area, the true stony bed of the Channel is but barely obscured by a very thin, superficial covering.

* It must, however, be expressly stated that it is not intended here to assign to this last formation, represented by the samples (2) and (69), an *origin* in the outer waters of the Channel. The inference is rather that somewhere between it and the region of sample (71) the outer Channel drift encounters an opposing action of coastal currents, to which latter it would seem that this distinct deposit is properly to be ascribed, thus preventing its further distribution seawards and deflecting the outer Channel drift itself from the actual coast-line.—L. R. C.

Table I.

DETAILS OF HAULS, WITH AVERAGES OF SIZE AND WEIGHT AND ESTIMATED INTENSITY OF THE STONES, AS EXPOSED.

Sample.	True bearing from Eddystone.	Distance. Miles.	Depth. Fathoms.	Gear used.	Length of haul. M nutes.	Estimated area covered. Sq. yds.	Weight of total sample. lbs.	Stones of 4 cm. and over.				General character of bottom-deposit.	Remarks.
								Number.	Arithmetic mean c.m.	Ratio of distribution. 1 : sq. yds.	Average weight. lbs.		
31	S. 25° W.	15·0	40	3 6″ dredge	10	395	8·5	65	5·1	6·0	0·13	[Shell]	
32	S. 25° W.	16·3		,, ,,	7	276	3·0	16	4·6	17·2	0·19		
37	S. 41° W.	17·1		,, ,,	9	355	4·5	43	5·0	8·3	0·10	[Shell-sand and some gravel]	
36	S. 37° W.	17·5	43	,, ,,	8	316	43·0	190	5·9	1·7	0·23		
33	S. 25° W.	17·5		,, ,,	7	276	56·0	289	5·5	1·0	0·19		
10	S. 26° W.	17·8	42½	3′ 0″ dredge	5	169	0·5	6	5·6	28·0	0·08	[Shell]	
11	,,	,,	,,	,, ,,	10	338	59·0	166	6·4	2·0	0·35	[Shell]	
12	,,	,,	,,	,, ,,	10	338	39·0	187	5·9	1·8	0·21	[Shell]	
13	,,	,,	,,	,, ,,	17	574	6·0	21	6·0	27·3	0·28	[Shell]	
35	S. 32° W.	18·0		3′ 6″ dredge	8	316	50·0	227	5·9	1·4	0·22		
27	S. 19° W.	18·3	44	Triangular dredge	8	173	27·5	147	5·6	1·2	0·19	[Shell and gravel]	
26	S. 20° W.	18·4	44	,, ,,	8	173	27·5	156	5·5	1·1	0·18		
34	S. 28° W.	18·5		3′ 6″ dredge	8	316	61·0	298	5·9	1·1	0·20		
71	S. 23° W.	19·0		Conical dredge	¼	4	—	—	—	—		Shell-sand and gravel	
72	S. 23° W.	19·0		3′ 6″ dredge	7	276	57·0	213	6·3	1·3	0·27	[Shell and gravel]	
29	S. 14° W.	19·8	44	Triangular dredge	7	151	74·0	295	5·9	0·5	0·25	[Coarse gravel and shell]	
14	S. 24° W.	20·0		3′ 0″ dredge	15	506	174·0	711	6·0	0·7	0·24	[Gravel]	
15	S. 27° W.	20·3		,, ,,	10	338	34·0	144	6·2	2·3	0·24		
20	S. 25° W.	20·5	44	,, ,,	10	338	44·0	162	6·2	2·1	0·27		
16	S. 29° W.	20·9	44	,, ,,	10	338	24·0	105	6·0	3·2	0·23	[Shell and gravel]	
21	S. 25° W.	21·2		Triangular dredge	9	194	49·5	162	6·2	1·2	0·31	[Shell and gravel]	After having brought up with & lost 3′ 0″ dredge.
30	S. 21° W.	21·5	43½	,, ,,	10	216	8·0	22	6·4	9·8	0·37	[Shell]	
9	S. 31° W.	21·7		3′ 0″ dredge	20	675	101·0	435	5·9	1·5	0·23		
40	S. 38° W.	21·7	44	Triangular dredge	5	108	38·0	256	5·6	0·4	0·15	[Broken shell and gravel]	

Sample.	True bearing from Eddystone.	Distance. Miles.	Depth. Fathoms.	Gear used.	Length of haul. Minutes.	Estimated area covered. Sq. yds.	Weight of total sample. lbs.	Stones of 4 cm. and over.				General character of bottom-deposit.	Remarks.
								Number.	Arithmetic mean. c.m.	Ratio of distribution. 1: sq. yds.	Average weight. lbs.		
22	S. 25° W.	21·9	44	Triangular dredge	4	86	4·5	26	4·8	3·3	0·17	[Shell-sand and gravel]	
39	S. 38° W.	21·9	44	3′ 6″ dredge	4	158	—	—	—	—	—		Stop broke. Arm bent. Rough ground. 3 stones with mean of 5·3 cm.
38	S. 38½° W.	22·2	44	3′ 6″ dredge	7	276	—	—	—	—	—		Stop broke. Frame bent. Very rough ground.
24	S. 24° W.	22·5		Triangular dredge	5	108	41·0	152	6·0	0·7	0·27	[Shell-sand and gravel]	
25	,,	23·0	46	,, ,,	8	173	13·0	86	5·3	2·0	0·15	[Shell and small gravel]	
17	S. 28° W.	23·3	45	3′ 0″ dredge	11	371	2·5	15	4·8	24·7	0·17	[Shell and *Pallasia* tubes]	*Pallasia murata* ground.
19	,,	,,	45	,, ,,	10	338	34·5	34	10·0	9·9	1·01	[Shell]	Having steamed back ½ mile with intention of striking same ground as (17).
18	S. 29° W.	23·4	45	,, ,,	10	338	6·5	32	6·1	10·6	0·20		Stop broke.
42	S. 36° W.	26·4	44	Triangular dredge	6	130	6·5	53	4·4	2·4	0·12		
41	S. 36½° W.	26·6	44	,, ,,	7	151	20·5	15	10·7	10·0	1·37	[Stones]	
43	S. 21° W.	28·8	45	,, ,,	10	216	51·5	179	6·8	1·2	0·29		
73	S. 24° W.	28·8		Conical dredge	(a few seconds)		—	—	—	—	—	Coarse shell-sand	
74	,,	,,		3′ 6″ dredge	4	158	—	—	—	—	—		Stop broke. Rough ground. A few stones of 4–5 cm. brought up.
47	S. 19° W.	29·7		1′ 6″ dredge with canvas bag	½	8	4·5	20	6·3	0·4	0·22		
44	S. 17° W.	29·8	46½	Triangular dredge	10	216	23·0	135	5·6	1·6	0·17		
48	S. 11° W.	30·5		1′ 6″ dredge with canvas bag	½	8	—	—	—	—	—	Shell-sand	
51	S. 15° W.	30·8	43	{ Triangular dredge { 3′ 6″ ,,	5 10	108 { 395 { 503	9·5	46	5·1	10·9	0·21		Two consecutive samples were numbered "51" in error and are therefore combined.
50	S. 16° W.	30·9	43	1′ 6″ dredge with canvas bag	2	34	3·5	7	6·0	4·8	0·50	Shell-sand	
53	S. 22° W.	32·2	46	3′ 6″ dredge	10	395	7·5	52	6·7	7·6	0·14	[Shell and gravel]	
56	S. 25° W.	34·3	49	Triangular dredge	4	86	27.5	124	5·1	0·7	0·22	[Broken shell and gravel]	

TABLE I.—*continued.*

Sample.	True bearing from Eddystone.	Distance. Miles.	Depth. Fathoms.	Gear used.	Length of haul. Minutes.	Estimated area covered. Sq. yds.	Weight of total sample. lbs.	Stones of 4 cm. and over. Number.	Arithmetic mean. c.m.	Ratio of distribution. 1: sq. yds.	Average weight. lbs.	General character of bottom-deposit.	Remarks.
55	S. 25½° W.	34·4	49	1′ 6″ dredge with canvas bag	1	17	8·5	39	5·8	0·4	0·22		
75	S. 20° W.	38·1	49	Conical dredge	⅓	6	8·0	9	6·8	0·7	0·90	Stones, gravel, and broken shell	Very rough ground.
77	S. 11° W.	38·8	49	3′ 6″ dredge	7	276	103·0	57	10·6	4·8	1·80	[Shell and stones]	
76	S. 9° W.	38·9	49	Conical dredge	½	8	—	3	5·0	2·7	—	Coarse shell-sand	
58	S. 22° W.	39·0	49	3′ 6″ dredge	10	395	62·0	21	13·0	18·8	3·00	[Broken shell and gravel]	
67	S. 19° W.	40·5		Triangular dredge	10	216	22·0	48	6·4	4·5	0·46	[Shell]	
65	S. 22° W.	42·2	52	1′ 6″ dredge with canvas bag	1	17	—	—	—	—	—	Coarse shell-sand	
	S. 25° W.	46·4	50	1′ 6″ dredge with canvas bag	1	17	—	—	—	—	—	Coarse shell-sand and gravel	
62	S. 25° W.	46·4	50	3′ 6″ dredge	7	276	88·5	268	5·3	1·0	0·33		Stop broken after very heavy work.
63	S. 25½° W.	46·8	50	Triangular dredge	7	151	6·0	49	5.4	3·1	0·12	[Shell and gravel]	
79	S. 16° W.	48·7	51	Conical dredge	¼	4	2·0	3	7·6	1·3	0·67	Coarse shell-sand and gravel	
80	S. 16½° W.	48·9	51	3′ 6″ dredge	7	276	46·5	19	9·6	14·5	2·44	[Stones]	

NOTE.—In the last column but one of the above table the term "gravel" is employed to designate inorganic material ranging in greatest dimension from about 1·5 to 20 mm.

In the same column the entries enclosed in square brackets have reference only to such fine material as was retained with the general contents of the haul, in dredges with a more or less open mesh. They have not, therefore, the same completeness as the others.

TABLE II.

TEXTURE OF BOTTOM DEPOSITS, AS SHOWN BY SAMPLES TAKEN WITH CONICAL DREDGE AND 1′ 6″ DREDGE.

Sample.	Distance on S.W. Bearing (mag.). Miles.	Weight treated. Grs.	Percentage of Grades (Grades in mm.).								Percentage of $CaCO_3$.		Average Grade.
			15·0+	10·0+	5·0+	2·5+	1·5+	1·0+	0·5+	<0·5	>0·5	<0·5	
2	8	798·0	1·4	0·5	0·5	0·2	0·4	1·3	9·7	86·0	73·4	20·5	7·704
69	9	1204·0	3·7	1·2	0·7	0·4	0·7	1·6	10·0	81·5	75·4	19·5	7·449
71	19	1032·0	2·6	1·3	2·2	6·8	10·1	8·6	36·7	31·8	77·6	32·3	6·524
73	29	1012·0	0·2	0·1	1·0	10·7	18·7	24·0	37·1	8·3	69·4	32·5	6·098
48	29	849·0	—	0·2	1·8	8·8	14·1	19·7	29·5	25·8	87·5	28·8	6·426
50	30	874·0	—	0·1	0·7	5·8	8·9	12·2	28·3	43·8	92·8	36·5	6.917
76	37	1116·0	7·4	8·9	12·8	11·2	7·0	4·2	14·4	33·9	63·9	66·3	5·406
75	38	872·0	19·1	21·2	21·8	12·2	5·9	4·7	7·5	7·3	41·6	68·7	3·443
65	42	1052·0	8·1	10·4	15·3	21·1	6·7	4·3	15·4	18·7	69·7	49·8	4·759
61	46	855·0	0·2	1·0	8·9	34·3	22·6	13·2	16·4	3·4	91·2	41·0	5·003
79	48	917·0	6·2	6·2	9·5	15·2	9·5	11·9	25·9	15·7	82·8	47·8	5·337

Samples (47) at 29 miles and (58) at 39 miles contained no fine deposit, only stones being brought up.
Stones of 4 cm. and over are left out of reckoning in this table.

The Dredgings of the Marine Biological Association (1895-1906), as a Contribution to the Knowledge of the Geology of the English Channel.

By

R. Hansford Worth, F.G.S.

With Plates VI–XVII (including five charts) and four figures in the Text.

INTRODUCTION.

INVESTIGATION of the geologic problems connected with the English Channel is no new matter. Setting aside all speculations deriving from the study of its coast-line, the first serious examination of the bed of the Channel was made by R. A. C. AUSTEN, and his results published in the *Proceedings of the Geological Society*, 13 June, 1849. Although, as he states, he had examined the sea-bed with dredge and sounding-lead he has little to say as to its lithology. But none the less his work is a notable contribution to our knowledge, and his conclusions bear well the test of subsequent discoveries. Following AUSTEN, in 1871, DELESSE published his *Lithologie des Mers de France*, in which considerable attention is given to the Channel; and the lithology of its coastal deposits, and to some extent of the sea-bed, is considered in detail. But, valuable as this work is, its chief interest lies in the information given as to the nature of the sea-bottom, the grade and extent of the varying deposits. AUSTEN and DELESSE alike, and in agreement, point out the large areas of the Channel bed which are occupied by stones, boulders, and pebbles of some size, and argue on much the same lines as to the conditions which have formerly existed there.

In 1879 the petrology of the English Channel was first seriously attacked. MR. A. R. HUNT then published in the *Transactions of the Devonshire Association* a paper "On a Block of Granite from the Salcombe Fishing Grounds." This was followed in 1880, 1881, 1883, 1885, and 1889 by five papers entitled, "Notes on the Submarine Geology of the English Channel off the South Coast of Devon." And, in 1896, the same author added later information in his paper on

"West Country Geological Problems," published in the same Transactions. It is noteworthy that MR. HUNT was on the track of a shore problem when his attention was thereby directed to the large boulders occasionally trawled by the fishermen off the south coast of Devon, and it is to these boulders that he confines his work. None the less he stands the first to really approach the matter from the point of modern petrology.

Meanwhile, in 1886, the late R. N. WORTH had taken up the question on very similar lines, and in the *Quarterly Journal of the Geological Society*, in August of that year, he reported the existence of a submarine Triassic outlier off the Lizard; in a subsequent paper, in the *Transactions of the Royal Cornwall Geological Society*, he dealt with a similar discovery off the Dodman.

Here the matter rested until, in 1895, DR. ALLEN commenced an investigation into the fauna and bottom-deposits near the thirty-fathom line from the Eddystone grounds to Start Point. In the course of this work numerous samples of the bottom-deposits were taken, and in vol. v, no. 4, of this journal will be found, incorporated in Dr. Allen's paper, some notes on these. The geologic results were subsequently dealt with at greater length by the present writer in the *Transactions of the Devonshire Association*, 1899, xxxi. pp. 356–75 ("The Bottom-Deposits of the English Channel from the Eddystone to Start Point, near the Thirty-Fathom Line"). Since 1899 the inshore grounds nearer Plymouth have also been subjected to an examination on similar lines, and additional geological information obtained which has not hitherto been published.

In the present paper it is intended to incorporate the whole of the previous results with the work done in 1906, of which latter an account is given by Mr. Crawshay in the preceding pages. By Mr. A. R. Hunt's kind consent an abstract of his petrographic work is added by way of an appendix, which, with other short appendices, will bring together the whole of our present knowledge of the geology and petrology of the western part of the English Channel.

Mr. Crawshay's long line of dredgings, extending to a point near 50 miles S. 16½° W. from the Eddystone, and Mr. Hunt's specimens, which reach 43 miles E. of the Eddystone, between them cover a large area; while to the westward for a distance of 36 miles we have the records of the late R. N. Worth. The difficulties which exist where no field work is possible are naturally considerable, but, as the writer has endeavoured to show elsewhere, very definite results, within certain limits, may be obtained by an inquiry of this kind. Other usual observations being barred, lithology becomes of the utmost importance, and the microscope invaluable, since much of the minuter evidence afforded by a rock is as direct and positive as that on a large scale. It has been impossible to microscopically examine every variety found, but one hundred sections in all have been prepared, and it is hoped that most of the rocks may safely be grouped around those thus represented.

Before entering upon detail, it may be well to pass in review the manner in which the problem has been attacked by the various investigators. AUSTEN used both sounding-lead and dredge, he differentiated the textures of the deposits, giving such statements as that the gravel was of the size of almonds, beans, olives, walnuts, or the ground was stony, or large angular and rounded blocks occurred; he mentions flint, granite, black granite, tin-stone, serpentine, etc., but with no clearer lithological definition, and he records any shells of littoral species found in the deeps. His observations covered the whole Channel bed, but not closely, and extended from the Nymph Bank to near Dover.

DELESSE, with greater attempt at detailed location, but with less information as to the size of the constituents of gravels, maps out the Channel, discriminating between areas covered by 'argile,' 'craie,' 'sable,' 'sable riche en coquilles,' 'sable sur les roches pierreuses,' 'roches pierreuses,' 'roches en pierres désagregées,' and 'roches en pierres pourries ou décomposées.' He trusted to the sounding-lead for his samples, and none is recorded as coarser than gravel, while none which came from a greater depth than 28 metres is lithologically examined in detail; most were obtained very near the French coast.

HUNT chiefly derived his material from the occasional boulders captured in fishermen's trawls off the south coast of Devon; the more part of these were decidedly heavy, ranging from about 3 to about 12 cwt. All were examined microscopically by modern methods.

R. N. WORTH was supplied with blocks and stones of some size which had become entangled in long lines or bolters; he, too, examined the rocks microscopically.

THE ASSOCIATION has conducted systematic dredgings and endeavoured to obtain fair samples of the bottom-deposits, including sands, gravels, pebbles, and small boulders. Its gear has not permitted the capture of the larger blocks which undoubtedly occur, but three of these have been traced which have been obtained by fishermen, and hand specimens taken. Where pebbles have been dredged, in the later work at least, these have been entirely depended on for information as to the lithology of the station; in the earlier work, where pebbles were scarce, the sand was examined in detail also. The superior facilities which the Association enjoys advantages it greatly, but our debt to the earlier workers remains undiminished, and in many instances they have preserved evidence of great importance, which must otherwise have been lost.

PETROLOGY.

To avoid the confusion which might arise from the system of numbering the dredgings, whereby three distinct sets of samples have all been numbered from 1 onward, the following method has been adopted. Actual hand specimens from Dr. Allen's first dredgings are referred to by the reference which the slides bear in the writer's collection, similarly specimens from the second set of dredgings further inshore, this will always be found to be a double number, such as "356/1", with sometimes a letter added also. In those cases where sands only have been examined, all of which occur in Dr. Allen's dredgings alone, the station number already published in the Journal is used, prefixed by the letter "A." The most recent stations, of last year's work, have the letter "M" set before the number; and Mr. Hunt's own figures are used with the letter "H" prefixed. Mr. R. N. Worth's specimens bear a number prefixed to which is the letter "W."

Where more than one rock is described from a station small letters are added after the number, by which the various specimens are discriminated.

With reference to the dredgings taken last year, the rule has been adopted that if several varieties or specimens of one class rock have to be described, those are set first which are nearest the Eddystone, and of those at equal distance precedence is given to the more western.

Throughout, the abbreviation "Edd." represents the word Eddystone.

GRANITES AND ALLIED ROCKS.

A large number of specimens, generally distributed over the area examined, fall within the popular acceptation of the term '*Granite,*' but the greater part of these when submitted to microscopic examination must be transferred to the Quartz-diorites in consequence of the distinct preponderance of plagioclase felspars. Since it is impossible to be certain in which class to place many of the specimens on mere inspection, and it has been out of the question to section all, those as to which any doubt exists are hereafter collected under the head of '*Granitoid Rocks.*'

GRANITES.

Boulder. S.S.W. Start, 15 miles. Weight about 8 cwt.

A fine-grained white granite, with very uniformly disseminated black mica. The little felspars are bright and fresh, and the simple twinning of orthoclase shows in almost every one. Some of the felspars are slightly tinted yellow by powdery decomposition products. The mica inclines to a reddish bronze lustre. The general structure of the rock is very uniform.

In the section a portion of the felspars is seen to be slightly clouded. The more part are orthoclase, but the orthoclase at places encloses small crystals of triclinic felspars, of which larger areas also occur. There is a tendency to zonal structure in some of the felspars, and there are a few very small areas of graphic structure. The quartz contains fairly numerous fluid inclusions with bubbles, some apparently empty or gas-filled cavities, and frequent hair-like microlites, probably apatite. Almost all the mica is brown and intensely pleochroic, but associated with this is a little which is colourless and shows no pleochroism. Apatite is present.

Boulder. S.W. by S. ½ S. Bolt Head, 19 miles. Weight 833 lbs.

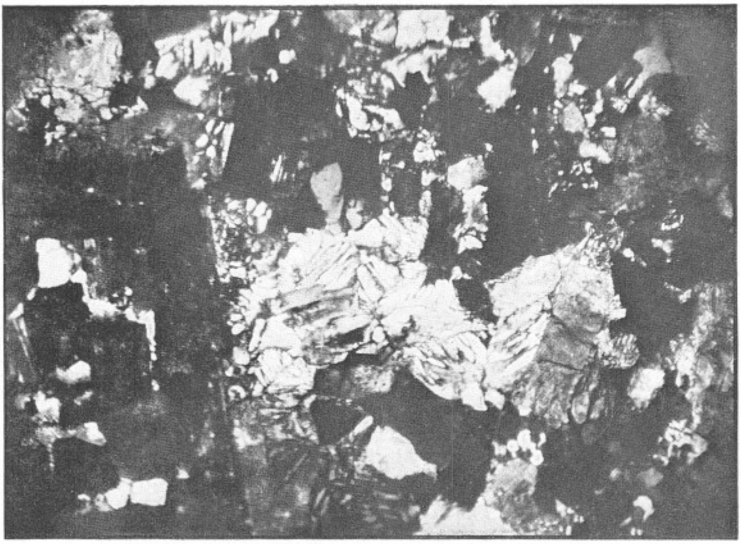
A coarse rock of granitic texture. The felspar gives bright cleavage surfaces, but is largely yellow-stained by dusty decomposition products; there are no good crystal outlines. Black mica occurs in patches of granular texture.

The large orthoclase areas are seen in section to be intergrown with plagioclase, narrow irregular and only approximately parallel strips of which penetrate the orthoclase; all the strips in each crystal extinguish together and in a different position to the main crystal, and all show lamellar twinning, the direction of which is constant throughout the crystal; thus the intergrowth gives rise to micro-perthite. Those felspars, the less numerous, which are clouded with decomposition products, all appear to be triclinic. The quartz presents numerous fluid inclusions, and in places is crowded with other inclusions which appear as a fine black dust; there are also small acicular microlites. The mica passes from olive-brown to dark green on rotation, but there is a little that is almost colourless.

M. 58b. S. 22° W. Edd., 39 miles.

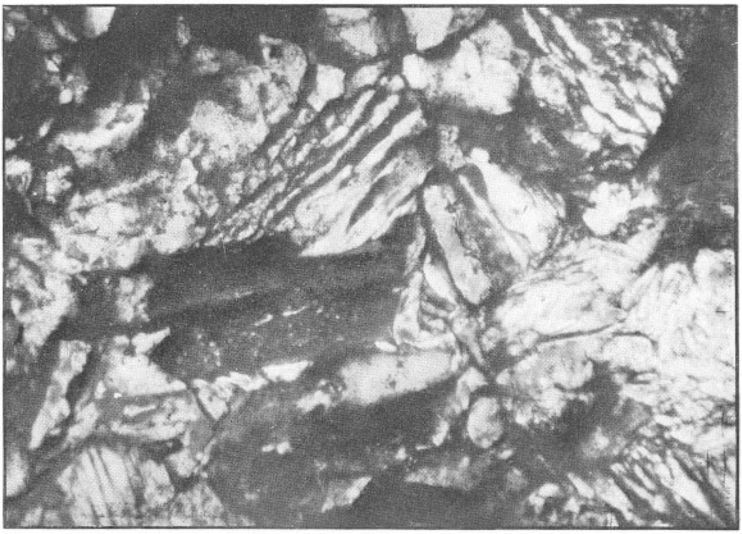
Medium textured granitic rock, pale flesh-coloured felspar, dark and light mica. Structure granitic. Felspars clouded brown. There are small patches of very well defined graphic structure, here the felspar is clearer. Multiple twinning can still be detected in places. Nearly half the felspar is still almost clear; none of this shows plagioclase twins. Much colourless widely biaxial mica. Quartz plentiful, crowded and lined by fluid inclusions, all with bubbles; many of these inclusions are of comparatively large size. There is a little apatite, and in one part of the slide a chloritic mineral fills the cracks in a felspar.

FIG. 1.



M. 11a. S. 26° W. Edd., 17·8 miles.
Micro-pegmatite.
Crossed nicols. × 29.

FIG. 2.



M. 11a. S. 26° W. Edd., 17·8 miles.
Micro-pegmatite.
Crossed nicols. × $97\frac{1}{2}$.

To face p. 123.

MICRO-PEGMATITE.

M. 11a. S. 26° W. Edd., 17·8 miles.

Red granitoid rock of fine grain, black mica.

Many felspars clouded entirely with red-brown decomposition products. Others, but fewer, almost clear. Some crystals are practically opaque in the centre, clear outside, with successive narrow zones of brown. Graphic structure is well developed; often where it has invaded a felspar crystal there will be included in it small perfect crystals free from this structure. Repeated twinning is rather rare. The fluid inclusions in the quartz are very small, most have bubbles, and extremely rarely a cubic crystal occurs. There is a little dark green biotite and some ilmenite. The graphic structure is the great feature of the slide. (Plate VI, figs. 1 and 2.)

APLITE.

M. 11c. S. 26° W. Edd., 17·8 miles.

A fine grained red granular rock with nests of schorl visible in the hand specimen.

An aplite consisting of quartz and felspar only, except for the tourmaline above mentioned. Structure microgranitic. Felspar red, and somewhat clouded in parts, mainly orthoclase, but plagioclase present. The quartz contains numerous and rather large fluid inclusions, nearly all with bubbles, many with crystal inclusions. Most of the tourmaline is indigo in colour, but some small crystals give brown to blue pleochroism.

This might be a type rock from Dartmoor. It can be matched *in situ* in the valley of the Tavy toward and below the lower end of Tavy Cleave, and a precisely similar rock was found as a small boulder resting on the rock bed some hundred feet below the surface of the mud at Keyham Extension Works.

M. 27x. S. 19° W. Edd., 18·3 miles.

A schorlaceous aplite very similar to **M. 11c.**, but which has not been microscopically examined.

M. 24g. S. 24° W. Edd., 22·5 miles.

Granular felsite of rich red colour.

The section exhibits microgranitic structure. All the felspars are more or less clouded, a few considerably, and in some cases the ordinary optical properties are destroyed. Orthoclase distinctly predominates, but plagioclase twinning is not rare. The felspars show rounded outlines, marked in some instances by a narrow line of iron oxide, and flakes of hematite occur in some of the crystals. The quartz shows fairly numerous fluid inclusions of very small size. No other mineral is present. The rock must be classed as an aplite.

Similar rocks to **24g** are **34e, S. 28° W. Edd., 18·5 miles** and **14e, S. 24° W. Edd., 20 miles.**

FELSITES.

Under this heading are placed a number of rocks which fall readily into three groups, the first of which consists of two specimens, almost identical in character, and very familiar in appearance to any one who has an acquaintance with the Permian and Triassic rocks of Devon.

M. 27c. S. 19° W. Edd., 18·3 miles.

Compact red-purple felsite, with light porphyritic felspars and black mica. Fracture trachytic. Has all the appearance of one of the new red felsites.

M. 41a. S. 36½° W. Edd., 26·6 miles.

Felsite, texture trachytic, colour red-brown, small dull white porphyritic felspars, and a little black mica. Cryptocrystalline ground-mass. A few idiomorphic felspars. A few porphyritic quartz crystals with corroded outlines. Well developed, highly pleochroic brown mica. The ground-mass contains numerous microlites, also many small felspars outlined in or largely replaced by hematite. Flakes of hematite are very numerous. A typical red-rock felsite.

The specimens placed in the second group form a series, commencing at the Hand Deeps and terminating M. 62, 46·4 miles S. 25° W. from the Eddystone. Of these the northernmost example has been subject to considerable mineral alteration; the southernmost is the most fresh, and in the latter the porphyritic constituents are more prominent than in any other. The northernmost is probably alone in that it contains mica. All are strongly reminiscent of rocks elsewhere associated with the Permian and Trias.

354/3d. Slopes of Hand Deeps.

A grey rock, with a slight shade of green and small purple spots. Small felspars appear, colour buff, all somewhat decomposed. At places the tint of this rock varies to yellow and to purple. There are minute black specks of a hard mineral, and calcite is developed on joint faces.

Microscopically the ground-mass is seen to be crypto-crystalline with much minute calcite, areas of which mineral also occur. Small felspars are scattered through this mass, and are about uniformly divided between orthoclase and plagioclase. Quartz occurs in small patches of interlocked granules. Mica is now almost entirely replaced by pseudomorphs in limonite and magnetite.

M. 36e. S. 37° W. Edd., 17·5 miles.

Sub-conchoidal fracture. A dull purple rock, with parts more drab in colour, flesh-tinted felspars in a horny matrix.

M. 35d. S. 32° W. Edd., 18 miles.

Grey, with warm tinge, purple mottling, sub-conchoidal fracture, minute flesh-tinted felspars, mostly much decomposed.

M. 20a. S. 25° W. Edd., 20·5 miles.

Compact rock, very like 354/3d. in general appearance, but without the small black grains and the calcite. Rather harder than that rock. Grey in colour with warm tinge. Small flesh-coloured felspars, many of which are decomposed.

M. 21b. S. 25° W. Edd., 21·2 miles.

Compact light grey-drab felsite, red mottling, porphyritic quartz.

Crypto-crystalline felsitic ground-mass, in which porphyritic quartz is freely developed; the crystals, although rounded at the angles and at places invaded by the felsitic matter, are largely bounded by straight lines. Minute fluid inclusions are not uncommon, but comparatively the quartz is clear. The felspars are almost formless and ill differentiated from the ground-mass; micro-perthite is indicated in some individuals. There is a small yellow patch of some granular mineral showing brilliant colours between crossed nicols. This same mineral is also sometimes associated with the dusty, somewhat dendritic red oxide of iron which gives the rock its mottling.

M. 62c. S. 25° W. Edd., 46·4 miles.

A green-grey compact rock, with much quartz and felspar irregularly distributed. The felspar is pink. The porphyritic constituents more prominent than in any of the preceding. Calcite is freely developed on joint faces.

The third group would appear to bear a close relation to the granites which form a prominent feature of the lithology of parts of this area. In this respect they probably stand much as the very hard India-red felsite so freely found on the Hallsands Beach does to the granites of Dartmoor. All are horny in texture and have a sub-conchoidal fracture.

M. 12f. S. 26° W. Edd., 17·8 miles.

No detailed notes taken of this rock.

M. 72d. S. 23° W. Edd., 19 miles.

India-red, compact felsite, occasional small red felspars.

M. 9a. S. 31° W. Edd., 21·7 miles.

Red felsite. Green porphyritic felspars, compact texture.

Ground-mass crypto-crystalline. Felspars much decomposed, the green shade being due to a secondary mineral. This traverses the crystals along irregular cracks, and sometimes extends from them a short way into the ground-mass, continuing the line of the crack; it is also generally distributed in the crystal. The less altered felspar is pale red in colour. The green mineral is often fibrous and sometimes granular, it has a high double refraction; apparently we are dealing with epidote. Quartz crystals, somewhat corroded, are rather common, and show a fair number of very minute fluid inclusions with bubbles.

Titanic iron ore is scattered in small grains throughout the slide, but much more freely developed and in larger forms at some places where associated with the green decomposition product above referred to. All the ilmenite is much altered and the smaller crystals are now entirely leucoxene. Apatite occurs, and two much altered areas were once apparently mica.

QUARTZ-DIORITES, DIORITES, DOLERITES, AND DIABASE.

It is possible that exception may be taken to the manner in which some specimens have been placed in the subdivisions of this group. But the erection and maintenance of hard and fast boundaries, where none such exist in nature, invariably brings the element of personal judgment into play, and in most cases it will be found that ample detail is given to enable the reader to reclassify the specimens to his individual preferences.

No pretence can be made that any more than a few, and those the most representative, of the rocks in this group are here given.

QUARTZ-DIORITE.

M. 11, l. S. 26° W. Edd., 17·8 miles.

Brownish granitoid rock of medium grain. Texture granitic. Felspars clouded light brown, but wherever the structure is not masked by this show very closely repeated twinning. Outside the better defined crystals there is some clearer and probably secondary felspar. Quartz plentiful, traversed by streams of fluid inclusions in two or more directions. The cracks in quartz and felspars alike are iron-stained. Hornblende in short, well-marked, prism forms, pleochroism light brown to rich green, two twinned crystals. Ilmenite occurs both in hornblende and in felspars. A few minute crystals of apatite. Quartz hornblende diorite.

M. 72e. S. 23° W. Edd., 19 miles.

Pale green rock, with close texture and fine grain, black or very dark green spots of small size.

Micro-granitic structure. The minerals are felspar, quartz, hornblende, magnetite, mica, and augite. The felspars are clear in patches, but otherwise much clouded, and all are plagioclases. The quartz contains small and moderately numerous fluid inclusions. Hornblende occurs in two forms; some of it is almost certainly an original mineral, and shows good basal sections, with inclusions, however, of other minerals. Elsewhere the hornblende is more fibrous. The mica has suffered considerable change, if I am right in so identifying a very doubtful mineral, and very little unaltered augite remains. Might almost equally well be classed as a quartz aphanite.

M. 9e. S. 31° W. Edd., 21·7 miles.

Dark grey crystalline rock of rather fine texture. Small felspars of irregular shape and slightly greenish tint, small quartz granules, very clear and bright.

The felspars are plagioclase, much clouded in the centre, quite clear around the margins when crystal outline is shown. Some have obviously been broken. In the felspars occur very numerous small prisms and acicular forms of a clear mineral which may be zoisite. Some felspars show an irregular zone of decomposition products a little within the margin. Most of the quartz areas break down in some part to a mosaic of interlocked granules. The quartz contains fluid inclusions. Strain shadows show in both quartz and felspar. Hornblende, chiefly of an olive shade, is freely developed, much is markedly uralitic. A little chlorite occurs. There is some apatite, and a little ilmenite.

M. 9r. (Same location as last.)

Fine-grained grey rock, felspar and hornblende visible.

Plagioclase felspar, somewhat clouded, occasionally achieving good crystal boundaries, and with a marked tendency to zoning from secondary growth, clearer from decomposition than the centres. Repeated twins somewhat frequent. Minute epidote has been freely developed in many of the felspars, and granules of a mineral which is apparently epidote. Fibrous hornblende is a prominent constituent, occurring in large patches, spreading and extending between the felspar areas; principally it is of a green colour with a tendency to blue; here and there brown and olive shades occur, especially in the interior of some of the larger patches. Quartz is fairly plentiful, with numerous small fluid inclusions, most with bubbles, and a few apparently include very small cubic crystals. Some apatite.

M. 19a. S. 28° W. Edd., 23·3 miles.

Dark greenish grey, granular crystalline. Felspars small and slightly green in tint. Fine grain. Texture micro-granitic. The felspars a good deal clouded with pale brown decomposition products, but with frequent clear patches. Some crystals with characteristic microcline twinning. By far the greater part is probably, however, oligoclase. Quartz abundant, in large areas of compound structure. The quartz is traversed by narrow streams of fluid inclusions, and contains small rod-shaped crystals, apparently of apatite. Both massive and actinolitic hornblende occur. The pleochroism of the former is pale yellow-brown, dark olive-green. At places a vivid chlorite replaces some of the hornblende. The quartz is slightly iron-stained in some of the cracks. Quartz hornblende diorite.

Four rocks apparently similar to the group **M. 9e., M. 9r.,** and **M. 19a.,** are—

(1) **M. 11b. S. 26° W. Edd., 17·8 miles.**
Dark grey granitoid rock of fine grain.

(2) **M. 11k.**
A finer texture of M. 11b.

(3) **M. 9q.**
Dark grey, fine grained, felspars greenish.

(4) **M. 50a. S. 16° W. Edd., 30·9 miles.**
Grey crystalline rock, minutely granular fracture, rather small white felspars somewhat widely scattered.

M. 18a. S. 29° W. Edd., 23·4 miles.

Structure granitic, medium texture, colour grey.

Somewhat clouded felspar, apparently plagioclase. Graphic structure in many crystals. Quartz traversed by broad streams of fluid inclusions, some with bubbles; hair-like microlites also occur, and some larger, recognizable, apatite. There are two micas, the one colourless, the other brown and intensely pleochroic, the extreme tint being a very dark bronze green. Quartz mica diorite.

M. 58a. S. 22° W. Edd., 39 miles.

Black and grey granitoid rock, medium grain.

Granitic texture. Felspars in the main clear, but here and there clouded with decomposition products. All apparently plagioclase and probably oligoclase. The quartz clear, with small fluid inclusions and, at places, hair-like microliths. Brown and olive-brown mica, strongly pleochroic. Green and olive hornblende, always associated with mica, but on the whole in less quantity. The hornblende and mica interpenetrate. A fair amount of apatite is present.

The rock must be classed as a quartz-diorite, with hornblende as well as mica present.

M. 80d. S. 16½° W. Edd., 48·9 miles.

Fine-grained brown granitoid rock, with black mica, texture granitic.

Felspar much altered and crowded with brown decomposition products. A few crystals appear zoned, some still show repeated twinning. Much quartz, in which fluid inclusions are common; a majority of these inclusions have bubbles. Brown mica. Apatite. Some iron-staining. Quartz mica diorite.

DIORITE

M. 12d. S. 26° W. Edd., 17·8 miles.

A striking looking rock by reason of the lustre of its constituent minerals. Very dark in colour, consisting as it does of a black mineral in prismatic form, and a clear felspar. Some of the little prisms of the black mineral are as much as 3 mm. in length.

The rock consists of a clear labradorite, in which, however, calcite granules are developed here and there along cracks; and a green monoclinic pyroxene, ægirine, in which a very marked schiller structure has been set up, the microlites being of a dark brown. Minute crystals of pyroxene appear in the felspars. Irregular patches of an iron oxide, apparently magnetite, are common.

M. 35b. S. 32° W. Edd., 18 miles.

A fine grained, dark grey, granular rock with much mica. Besides the dark mica there is obviously a lighter mineral, and the two are very uniformly admixed.

The section shows this rock to be a mica-diorite. Rich brown mica occurs freely in irregular plates, and felspar in mosaic. A minority of the felspar granules are striated, a very few show decomposition products. An occasional crystal of apatite is present and a fair amount of titanic iron ore in small grains. The general appearance of the rock is very fresh.

A similar rock to **M 35b.** is

M. 79a. S. 16° W. Edd., 48·7 miles.

Dark grey, close textured, much mica in small form.

M. 9s. S. 31° W. Edd., 21·7 miles.

A dark coloured rock, the exterior of which shows large lustrous black hornblende and dark drab and brown felspar. Fracture very uneven and texture coarse.

The felspars in this rock are now almost indistinguishable as such, an occasional very small patch showing repeated twinning being all that remains unaltered; for the rest they have given place to a granular and fibrous mineral of high refraction and double refraction, and apparently colourless, although the larger grains may have a palest shade of green. The rest of the slide is occupied by fibrous pale green hornblende. Ilmenite is common. The structure ophitic.

DOLERITE.

M. 14e. S. 27° W. Edd., 20·3 miles.

A fine-grained even-textured rock of a distinct green colour. Some iron pyrites show in the hand specimen. Numerous lath-shaped felspar microlites with irregular terminations, all quite fresh and clear. Pale bluish-green fibrous hornblende is quite the most prominent constituent of the rock; there is no general direction pursued by its fibres. Scattered closely throughout the section are very irregular grains of a minutely granular pale brown mineral of strong double refraction when examined with high powers and strong light. Dirty white by reflected light, this is probably leucoxene.

Curious little streams of (?) magnetite occur rather frequently, in forms suggesting that they are reminiscent of some original prismatic mineral.

M. 16b. S. 29° W. Edd., 20·9 miles.

Pale green minutely granular rock.

A slide of confused texture. Fibrous green hornblende. Felspar with a tendency to lath-shaped sections. Apparently no quartz. Grain very fine.

M. 21e. S. 25. W. Edd., 21·7 miles.

A close-textured grey rock, looks much like a grit.

The most prominent feature in the section is the abundance of pale yellowish-green acicular or fibrous mineral in diverging bundles, which often have the appearance of having been drawn together at the middle. Here and there almost colourless, at other places this mineral takes a blue-green tint, and it is almost certainly actinolite. These bundles are largely set in a crypto-crystalline ground-mass, which is freely invaded by shorter prisms of actinolite. There are also felspar crystals of irregular outline, some certainly plagioclase, some possibly orthoclase, and micro-porphyritic quartz is about as frequent as the felspar. There is a considerable sprinkling of grains of titanic iron ore.

M. 80c. S. 16½° W. Edd., 48·9 miles.

Clouded white felspars, lath-shaped in part, in part conforming to the interspaces between the augites which constitute the more part of the rock. Portions of the felspars are still quite clear. The augite is in the main quite fresh, but traces of chloritic products occur. Characteristic patches of ilmenite.

DIABASE.

M. 27a. S. 19° W. Edd., 18·3 miles.

Compact dark grey rock, green felspar and hornblende. Augite, hornblende, chlorite, plagioclase, leucoxene, quartz. The augite, pale brown, apparently existed in ophitic form; it is now almost entirely replaced by hornblende. The hornblende is chiefly pale green, with a slight blue shade and orange-brown tints along cracks and cleavages. The titanic iron ore is entirely associated with the hornblende, and is present in large forms and branching growths. Chlorite occurs in fairly large areas, and exhibits marked pleochroism from pale brown pink to pale bluish green. The felspars are pale pink, rather fresh in appearance, but sometimes traversed along cleavages by chlorite; they have a tendency to elongated parallelogram section. Quartz shows good crystal outline.

M. 14v. S. 24° W. Edd., 20 miles.

A small hard pebble, distinctly green in colour, and having small somewhat vesicular looking cavities on the surface.

In section, seen to be a network of small lath-shaped felspars set in a grey and green ground-mass. Chlorite is disseminated throughout the slide, and the larger patches, which are not infrequent, are evidently after augite, as they are associated with unaltered remnants of the latter mineral. Calcite occurs, not only mingled with the ground-mass, but also in larger patches; the solution of these has probably left the cavities on the surface of the pebble. There are two or three recognizable crystals of ilmenite and scattered black grains that are either this mineral or magnetite.

M. 15c. S. 27° W. Edd., 20·3 miles.

Greenish hornblendic rock.

Large patches of very pale hornblende. Between these a fibro-granular ground-mass of low double refraction, prismatic and basal sections of zoisite of sufficient size for discrimination occur rather freely. Some iron ore. What other minerals may be present in minute forms cannot be determined.

Zoisite-amphibolite.

M. 22c. S. 25° W. Edd., 21·9 miles.

Dark green rock, massive hornblende.

Shows a very little felspar, and a few patches of augite. In the rest it consists of reedy hornblende of very varying tint, from almost colourless to olive-brown and blue-green, all in light shades.

GRANITOID ROCKS

M. 31. S. 25° W. Edd., 15 miles.

Granitic texture. Brown and black, ditto brown.

Felsitic. Brown, fine-grained, granular.

M. 36. S. 37° W. Edd., 17·5 miles.

Granitic texture. **f.** Medium grain, white felspar, black mica.

g. Fine grain, pink, black specks.

Felsitic texture. **b.** Brown, granular.

M. 33. S. 25° W. Edd., 17·5 miles.

Diorite.

M. 11, M. 12, M. 13. S. 26° W. Edd., 17·8 miles.

M. 11. *Granitic texture.* **g.** Fine-grained brown, black mica.

M. 12. Hornblende Diorite.

Granitic texture. Red with abundance of mica. Brown of fine grain. Brown of medium grain. Grey.

M. 35. S. 32° W. Edd., 18 miles.

Granitic texture. **f.** Brown.

M. 27. S. 19° W. Edd., 18·3 miles.

Granitic texture. Pale grey.

M. 26. S. 20° W., 18·4 miles.

Two quartz-hornblende-diorite pebbles.

M. 34. S. 28° W. Edd., 18·5 miles.

Felsitic texture. **g.** Brown, fine granular.

M. 72. S. 23° W. Edd., 19·0 miles.

Granitic texture. Medium grain, grey and brown, brown mica. Brown. Red with black mica.

Felsitic texture. **c.** Porcellanous cream-coloured.

M. 14. S. 24° W. Edd., 20 miles.

Granitic texture. **k.** Red medium grain, and several other varieties.

Felsitic texture. **t.** Close-grained buff.

M. 15. S. 27° W. Edd., 20·3 miles.

Granitic texture. Coarse-grained, white felspar, yellow-stained, black mica, much like boulder from S.W. by S. ½ S. Bolt Head, 19 miles.

Fine-grained grey, brown and silvery mica.

Brown with white mica.

M. 20. S. 25° W. Edd., 20·5 miles.

Granitic texture. **f.** Black and white, rather coarse, some hornblende.

e. Black and buff, fine grained, (?) some hornblende.

M. 16. S. 29° W. Edd., 20·9 miles.

Granitic texture. Distinctly granitic in appearance, flesh-coloured felspars, orthoclase twins, quartz.

Grey and brown, fine grained.

M. 21. S. 25° W. Edd., 21·2 miles.

A few grey granitic rocks.

M. 30. S. 21° W. Edd., 21·5 miles.

Granitic texture. **d.** Coarse, pale cream-coloured, dark mica.

M. 9. S. 31° W. Edd., 21·7 miles.

Granitic texture. **l.** Medium grain, red felspars.

m. Medium grain, buff felspars.

r. Fine-grained grey.

Medium grain, brown and black.

M. 40. S. 38° W. Edd., 21·7 miles.

Granitic texture. Brown, medium grain.

Felsitic texture. Brown, granular.

Greenish grey.

M. 22. S. 25° W. Edd., 21·9 miles.

Granitic texture. **b.** Buff and brown felspar, black hornblende, medium texture.

M. 24. S. 24° W. Edd., 22·5 miles.

Felsitic texture. **c.** Pale grey, compact, white mica. Red.

M. 25. S. 24° W. Edd., 23 miles.

Granitic texture. **b.** Brownish, fine grained, (?) hornblende.

M. 19. S. 28° W. Edd., 23·3 miles.

Granitic texture. **b.** Dark grey, fine grained, much dark mica.

M. 18. S. 29° W. Edd., 23·4 miles.

Granitic texture. Brown and grey, medium grain, pale grey felspars.

M. 43. S. 21° W. Edd., 28·8 miles.

Felsitic texture. Brown-grey, granular.

M. 77. S. 11° W. Edd., 38·8 miles.

Granitic texture. Brown, very fine grain.

Light brown, fine grain, black mica.

M. 58. S. 22° W. Edd., 39 miles.

Granitic texture. The granitoid rocks occur in rather large pebbles, almost small boulders.

Grey, rather coarse, clear felspars, black mica.

Grey, rather fine, clear felspars, black mica.

M. 62. S. 25° W. Edd., 46·4 miles.

Felsitic texture. **c.** Compact, greenish grey, with pink felspars and porphyritic quartz.

d. A somewhat similar rock, more granular, felspars white, some hornblende.

Also, pink, saccharine texture.

M. 80. S. 16½° W. Edd., 48·9 miles.

Granitic texture. Brown-grey, fine-grained, black mica.

Felsitic texture. Light brown-grey, black mica, apparently a variant of above.

All the above granitoid rocks are described from megascopic examination only, and the list is inserted chiefly in order to point out the localities in which this class of material has been found. To adequately deal with all the varieties a great number of sections would have been required, but probably those which have been microscopically examined give a fair general idea of the whole.

SCHORL ROCK.

Rocks consisting of tourmaline and quartz; placed here, although undoubtedly in a sense metamorphic, on account of their usual association with granite.

356/4a. W. ¼ S. Bolt Head, 4¾ miles.

A rather small pebble.

This rock consists of quartz and tourmaline. Much of the quartz is secondary; in part it forms a mosaic, in parts it extends from original crystals with which its crystal axis corresponds. The primary quartz contains fluid inclusions with bubbles, the bubble in many instances occupying more space than the fluid; these inclusions are very numerous and rather large. The secondary quartz contains few and very small fluid inclusions. Acicular schorl is scattered throughout the slide, sometimes in almost fibrous radial bunches, at others in slender, well-defined prisms, radially or otherwise arranged; there is also some more massive schorl. The colour is chiefly light blue to rich blue, but blue-green occurs, and occasionally olive-brown.

M. 31a. S. 25° W. Edd., 15 miles.

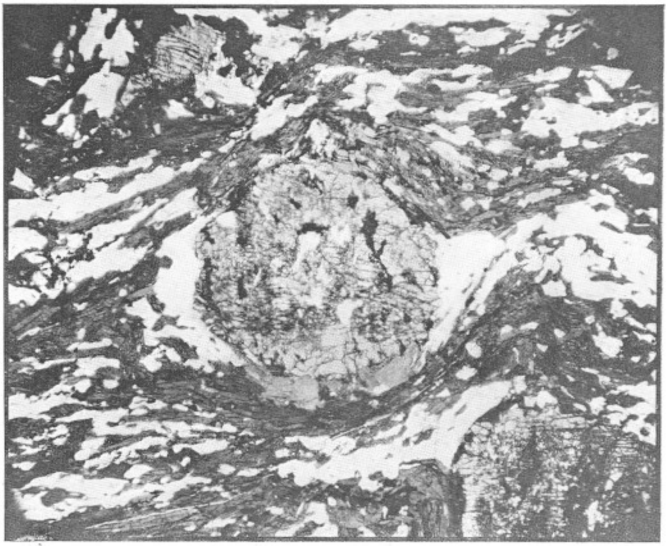
A schorl rock of Dartmoor type.

Ground-mass a quartz mosaic. The quartz contains many fluid inclusions, some of which, in addition to a bubble, have also cubic crystals in the fluid. These cubic crystals are, in fact, very common. The slide is crowded with granular tourmaline, chiefly a very dark brown colour, almost opaque, but a few grains are blue-green.

M. 31g.

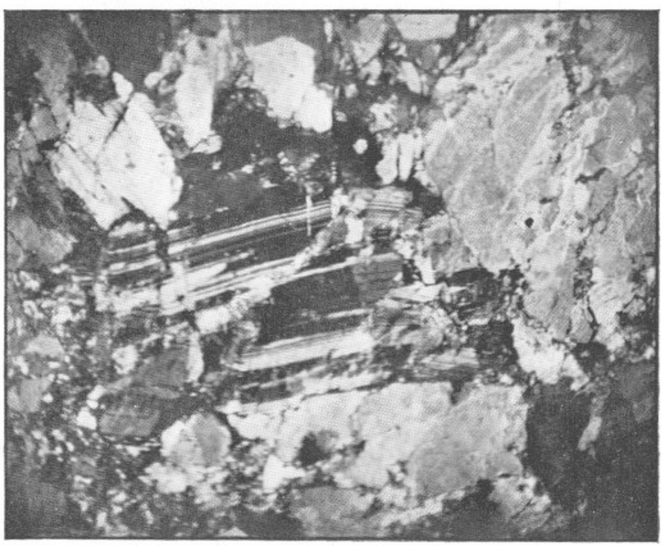
Schorl rock. The general ground of a brown shade, an intimate mixture of rather pale brown tourmaline and quartz. Frequent areas of quartz partially invaded by acicular tourmaline. Some cracks are also filled by quartz. The quartz areas all present a mosaic, in which some grains contain many more fluid inclusions with bubbles

Fig. 1.



354/1. N.W. by N. (mag.) Edd., $\frac{1}{2}$ mile.
Hornblende gneiss, with garnets.
Ordinary light. $\times 14\frac{1}{2}$.

Fig. 2.



M. 62a. S. 25° W. Edd., 46·4 miles.
Crushed plagioclase felspar in chlorite schist.
Crossed nicols. $\times 29$.

To face p. 135.

than do others. Small cubic crystals are not infrequent in these inclusions.

Schorl rock also occurs at **36a, S. 54° W. Edd., 17·5 miles ; 72, S. 23° W. Edd., 19 miles ; 14f, S. 41° W. Edd., 20 miles.**

ANDESITES.

354/4b. 6½ miles W. from Rame Head.

Strictly speaking a felsite. Red-brown felsitic ground-mass, with porphyritic orthoclase, quartz, and dark mica. One of several pieces here dredged, with every indication of being practically *in situ.* Is much like the andesitic felsite of Withnoe, but lacks the flow structure sometimes present in the latter. The similarity of the specimens to many, however, which have been collected at Withnoe practically amounts to identity. Thus to the Cawsand mass and the two near Withnoe we have to add another, and a submarine, patch of igneous rock of the New Red Sandstone period. Apparently this exposure is of some considerable area. A conglomerate containing large fragments of this rock was taken in the same dredging.

M. 15a. S. 27° W. Edd., 20·3 miles.

Brownish-grey trachytic rock.

Well-marked flow structure. Ground-mass a devitrified glass (palagonite). Some augite developed in rare crystals and crystalline areas. Flakes of very dark brown mica rather frequent. Lines and microdendritic growths of iron ore (?) hematite. Occasional patches of calcite.

M. 15. Also yielded a more red variety of the above.

GNEISS.

Some latitude must be allowed in any classification which attempts to discriminate Gneiss from Schist in this area. If anything, the writer leans toward identification as the former in doubtful cases.

354/1. N.W. by N. Edd., ½ mile.

A large stone or small boulder, angular with freshly fractured surface. A grey-green foliated rock with plates of brown mica and numerous garnets up to 1·75 mm. in diameter. Quartz fills thin joints at right angles to the planes of foliation. The mica is so developed as to give to the rock an easy cleavage.

The pale-pink garnets are a characteristic feature; these are much cracked, and around them bend the less resisting minerals. There is much blue-green actinolitic hornblende, the blades of which all approximately conform to one direction. Mica is in much less quantity than would appear from the hand specimen; it is intensely pleochroic, from pale straw-colour to dark cinnamon-brown; its occurrence is practically limited to the neighbourhood of the garnets.

Touching and partially enveloping the garnets is a certain amount of chlorite. Water-clear felspar in mosaic form fills all interspaces; it appears to be albite, and inclusions of apatite are frequent. There seem to be some rare fragments of pale brown-augite. (Plate VII, fig. 1.)

354/3f. Hand Deeps.

A schistose or foliated rock, dark steel-grey in colour, and highly lustrous from the abundance of pale mica. Rare eyes of red felspar occur.

The section does not pass through any of the felspar eyes. There is a distinct banded structure: bands in which hornblende predominates, bands consisting almost entirely of white mica, bands of felspar mosaic. But in every layer there is some slight admixture of the other minerals. The hornblende is both uralitic and actinolitic with very distinct indigo tint here and there. It is not entirely free from chlorite. The mica appears perfectly fresh and shows no trace of pleochroism. Both hornblende and mica exhibit a parallelism of arrangement. The felspar is apparently albite, quite clear, with apparently a casual grain of quartz. Grains of sphene are not uncommon.

355/1. West side of East Rutts.

A brown stained schistose or gneissic rock, exhibiting much contortion.

No part of the slide is entirely free from iron stain. Contorted bands of limonite traverse it, and these appear to have been developed at the expense of mica, bleached residual blades of which are associated with it. All the mica is much bent. Parallel with, and touching the limonite, are narrow interrupted bands of calcite. The general ground-mass is a mosaic of slightly stained clear minerals, and apparently consists of albite (?) and quartz in about equal proportions, the quartz showing fluid inclusions with bubbles, and the albite being rather frequently twinned.

M. 36p. S. 37° W. Edd., 17·5 miles.

A mica schist or gneiss, shows clear felspar, some in moderate-sized crystals, and mica which is in general rather silvery but in small patches dark bronze.

There are two orders of felspar, the one represented by slightly clouded crystals of irregular outline and exhibiting signs of crush, the other present in mosaic form. The repeated twinning of plagioclase appears almost constantly in the former, but not at all in the latter. And some few of the larger crystals extinguish differently in different zones, although there is no appearance of zonal structure except between crossed nicols. The mosaic in places is of larger and irregular granules, in places of small granules of lenticular form the longer axes of which lie parallel to each other and form lines flowing round the crystals of the first order. The mica conforms in general direction to these same lines, it shows moderately strong pleochroism, and its face colours range from rich cinnamon-brown in basal planes to a rather pale olive-brown in sections perpendicular to these planes. A very little apatite is present.

M. 16a. S. 29° W. Edd., 20·9 miles.

Schistose rock. Dark grey and pale brown, lamination very clearly defined; fissile. Much dark grey mica on joint faces.

Structure schistose. Irregularly bounded felspar areas occasionally associated with quartz form "eyes," around which the other minerals are bent. These felspars are all much clouded; some are thickly set with microlites, but polysynthetic structure is clearly discernible in many instances. Most of the felspars are curiously isolated from their surroundings and have a rounded form, as though due to friction. White mica is abundantly developed, forming streams in which the felspars appear as islands. Mingling with the mica is dull green hornblende in short blades and in grains. There are numerous long patches and irregular areas of quartz mosaic, the quartz containing some apparently fluid inclusions, prismatic microlites, the larger of which are seen to be hornblende, and rather frequent blades of the latter mineral. The mica does not appear to invade the quartz areas. Apatite is fairly plentiful. There is occasional staining by iron oxide, especially between the quartz grains and the blades of mica.

This rock is a gneiss, and has evidently been subjected to extreme pressure.

M. 9k. S. 31° W. Edd., 21·7 miles.

A grey gneiss.

Schistose structure well marked. Somewhat clouded felspars appear to form the only remaining original mineral. These show plagioclase twinning; some have been broken across with the development of a felspar mosaic along the line of fracture. There are two orders of mosaic structure, the one coarser and composed of a very clear mineral, the other much finer and containing minute hornblende and apparently zoisite. For the more part the large felspars are surrounded by this finer material, into which they have the appearance of having been driven. Ilmenite, hornblende, and zoisite mark out the planes of schistosity. The hornblende is almost entirely in minute blades and needles of a bright blue-green. Prisms of apatite are frequent in the mosaic. Of this mosaic, which is probably almost all felspar, it should be noted that the coarser part is formed of entirely irregular interlocking granules; in the finer part the granules all appear lenticular, and their longer axes conform to the planes of schistosity.

From **M. 9** a coarse gneiss was also noted, and **M. 36q** is but a slight variant of **M. 36p.**

M. 25c. S. 24° W. Edd., 23 miles is a coarse gneiss with white opaque felspar and grey-green chlorite.

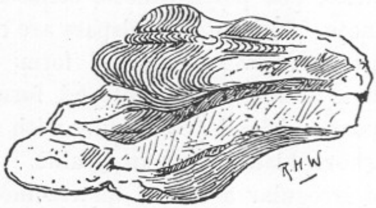
SCHISTS.

MICA SCHIST.

354/3/e. Hand Deeps.

A mica schist in which micaceous layers greatly contorted and convoluted alternate with granular layers of quartz and garnet. This rock has not been microscopically examined.

FIG. 1. Mica Schist from Hand Deeps.



M. 31f. S. 25° W. Edd., 15 miles.

A grey schist of very fine grain, traversed by rather broad lighter-coloured bands.

The section shows a distinctly foliated rock, the lighter parts are a clear quartz mosaic; I can detect no felspar; the quartz shows numerous fluid inclusions, some with very small bubbles. The darker parts appear to consist of a scaly mica of a yellow tint, associated with which is a little limonite and black granular matter which may be carbonaceous.

M. 11x. S. 26° W. Edd., 17·8 miles.

Micaceous schist, the planes of schistosity well marked by lustrous bronze mica, cleaves very perfectly.

The section shows, in addition to mica, a granular mosaic, which certainly in the main consists of quartz but also contains felspar, which latter can only be detected by its biaxial figure in convergent light. The quartz has, in the larger grains, fluid inclusions with bubbles. The mica is of a rich brown colour, but some few rather well-developed crystals are colourless. The basal sections show numerous acicular microlites, and also very dark brown patches, almost opaque, surrounding small crystals which are apparently zircon.

M. 9c. S. 31° W. Edd., 21·7 miles.

A schistose rock of light brownish-grey colour and rather pearly lustre; small darker spots mark an "eye" structure.

The general body of the rock is crypto-crystalline, polarizing in low tints. Streams of mica in minutest scales are developed in this ground-mass, especially near the "eyes," which largely consist of this mineral associated with a felspar mosaic in which some granules are large enough for identification. The basal planes of the mica follow one general direction throughout the slide. The dark colour of the "eyes" arises from irregular plates, aggregates of an olive-brown substance with moderate double refraction, but this may be somewhat masked by the colour.

M. 43a. S. 21° W. Edd., 28·8 miles.

A thin pebble of dark grey schist.

A minutely granular rock, consisting of quartz, felspar probably all plagioclase, white mica (sericite), epidote (?), chlorite, and traversed by a vein of calcite. Apatite is present in some quantity. The felspar granules freely exhibit the repeated twinning of plagioclase.

M. 20g. S. 25° W. Edd., 20·5 miles.

Closely resembles **M. 11x**, but the mica has a more decidedly bronze lustre. In both these rocks there are stray features of resemblance to the series from the immediate locality of the Eddystone.

M. 31c. S. 25° W. Edd., 15 miles.

Rather like a fine-grained granitoid rock, now stained brown by exposure, but fissile from the development of silvery mica along definite planes.

M. 36c. S. 37° W. Edd., 17·5 miles.

Largely quartz, but with possibly some felspar, silvery mica chiefly confined to the cleavage planes, which are stained pink with iron oxide. A very fissile rock.

CHLORITE SCHIST.

Off Stoke Point.

A silvery-green schist, consisting of vivid blue-green chlorite changed here and there to a dull orange, at which places it exhibits a moderate double refraction, and water-clear felspar in which no repeated twins are observable (the section is small). There is also apatite, and much of a granular dusty brown mineral, buff coloured by reflected light, leucoxene.

356/1. 4 to 5 miles S. ½ E. from Prawle Point.

A chlorite schist with bands of quartz one-eighth of an inch in width.

356/2. 3 miles S.S.E. ½ E. from Prawle Point.

A silvery grey chlorite schist with minutely wrinkled surfaces of chlorite precisely like the shore rocks. Much chlorite.

These last three specimens are practically identical with rocks to be found *in situ* on shore in the Start Point to Bolt Tail district. None of the specimens show signs of travel or wear.

M. 62a. S. 25° W. Edd., 46·4 miles.

A mixture of felspar and quartz, largely the former. Micro-mylonitic structure well developed and some of the felspars greatly deformed. One in especial, with well-marked plagioclase twinning, is much bent in reverse directions, is cracked, and finally at each end passes into mylonite. The slide is full of similar evidence of deformation. As a whole the felspar has a reddish tinge; some portions are crowded with microlites of high double refraction, probably calcite. Calcite is rather freely developed, filling interspaces and cracks. Chlorite plays a similar part, and the two are associated. In places the chlorite is thickly strewn with minute grains and blades of a feebly translucent brown mineral.

If the presence of original felspars is to be the criterion this rock should have been included among the gneisses. (Plate VII, fig. 2.)

HORNBLENDE SCHISTS WITH AUGITE.

356/4/b. W. ¼ S. Bolt Head, 4¾ miles.

A very compact dark greenish-grey schist with occasional small specks of pyrites.

The slide looks distinctly patchy, augite areas of brown tint, and granular augite. Much uralitic hornblende, blue in ordinary light, with a faint tinge of green, pleochroism brownish grey to blue-green. This mineral dominates the section. Much calcite, with a tendency to form broad bands. And, filling irregular interspaces, a mosaic of water-clear granules, containing both felspar and quartz. Calcite mingles with this mosaic. A little leucoxene occurs.

M. 80b. S. 16½° W. Edd., 48·9 miles.

Fine-grained dark grey rock; some pyrites.

Structure schistose. Marked in part by veins of secondary quartz in mosaic. The felspar is entirely clouded with decomposition products; it lies irregularly mingled with very pale green fibrous hornblende. The latter has apparently developed at the expense of a pale pink augite, of which a fair quantity remains; in turn the hornblende has here and there given place to chlorite. Irregular grains of a feebly translucent mineral, probably leucoxene, are plentiful, and have a distinct tendency to linear arrangement.

CALC SCHIST.

M. 14r. S. 24° W. Edd., 20 miles.

A compact rock with well-marked cleavage, the planes of which are not, however, closely set. Broken across the cleavage, the colour is a warm grey and the texture close and uniform. The cleavage planes show a somewhat pearly lustre and are stained in parts with red oxide of iron. The rock gives distinct effervescence with cold acid, with warm acid effervesces freely; fragments retain their form, however, but from the surface a few small quartz grains are set free.

The section shows numerous clear grains set in granular cement, with which, in places, is much red oxide of iron. Colourless mica (sericite) is rather sparingly developed, being more prominent on the cleavage planes. The clear grains are quartz, with the very rare exception of a felspar, and many show boundaries imposed upon them by the adjacent calcite and dolomite, which freely exhibits the rhombus form of larger or smaller dimensions. The granular cement consists, in fact, almost entirely of minutely crystalline dolomite and calcite, a high power being required to detect the crystal forms. A very large proportion of the quartz grains show secondary enlargement, the secondary quartz having the same crystal axes as the original grain. The boundary between the original and secondary is just such a dark line as occurs when a mineral of greater refractive index is enclosed in a mineral of less. Hair-like microlites are not uncommon in the primary quartz, but none pass over into the marginal secondary growth. In the loose powder obtained by treating this rock in hot acid I found one small crystal of tourmaline.

The fact that the rock retains its form after treatment with hot acid shows that neither the iron nor the dolomite are necessary cements, the secondary quartz being in itself sufficient.

Presumedly it is best to call the specimen a calcschist.

SERPENTINE.

M. 24h.

A small jet-black pebble with very smooth surface.

The section shows yellowish-green serpentine with "lattice" structure, traversed by roughly parallel streams of dense black material, which also occurs irregularly in cracks of varying direction, and more or less densely diffused in certain parts of the slide over areas which appear reminiscent of the original structure of the rock. The serpentine varies considerably in its depth of shade. At one point it is blue-green around the margin of a clear mineral, which appears possibly to be a plagioclase felspar.

The serpentine, some of which is colourless, splits up under crossed nicols into doubly refracting bands and isotropic portions.

The association of felspar with a massive serpentine is rare, but Professor Bonney has recorded an instance from the Lizard district.

This specimen acquires some value, despite its small size, since in HUNT'S series there occurs a serpentine boulder, **H. 6,** of 5 cwt.

QUARTZITES.

A number of quartzites, very similar to some in the Budleigh pebble-bed, have been dredged from a great many stations. Up to the present no fossils have been found in them. These rocks vary in colour, being purple, red, light red, buff, grey and white, and are associated with very hard grits which have not been sufficiently examined.

M. 80. S. 16½° W. Edd., 48·9 miles.

Purple quartzite, very compact in structure. Quartz grains, subangular and of very uniform size, fluid enclosures common. The cementing material silica with much iron oxide; this cement appears to be minutely granular. An occasional quartz grain shows hair-like microlites.

This may be taken as a type. Other *Purple Quartzites* were dredged at Stations **M. 31, M. 36, M. 13, M. 35, M. 27, M. 26, M. 34, M. 29, M. 14, M. 20, M. 9, M. 40, M. 22, M. 25, M. 43, M. 50, M. 67, and M. 80.**

Red quartzites from **M. 11, M. 72.**

Light red quartzites from **M. 13., M. 30.**

Buff quartzites from **M. 34, M. 20, M. 22, M. 41, M. 43.**

White quartzite from **M. 21.**

M. 11f. S. 26° W. Edd., 17·8 miles.

A grey grit.

A little mica appears in the section. The rock is practically a quartzite.

SEDIMENTARY ROCKS.

Under the heading of *sedimentary rocks* have been included all altered varieties, except such as may possibly have been fully metamorphosed to schists and quartzites.

CARBONIFEROUS AND EARLIER.

SANDSTONES AND GRITS.

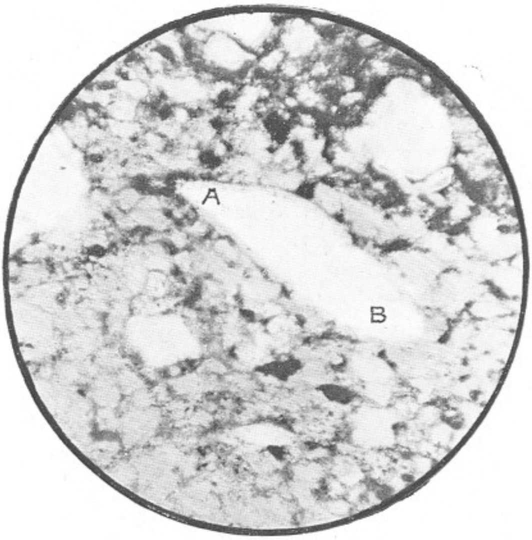
354/4k. 6½ miles W. from Rame Head.

A red micaceous grit, probably Devonian.

M. 9b. S. 31° W. Edd., 21·7 miles.

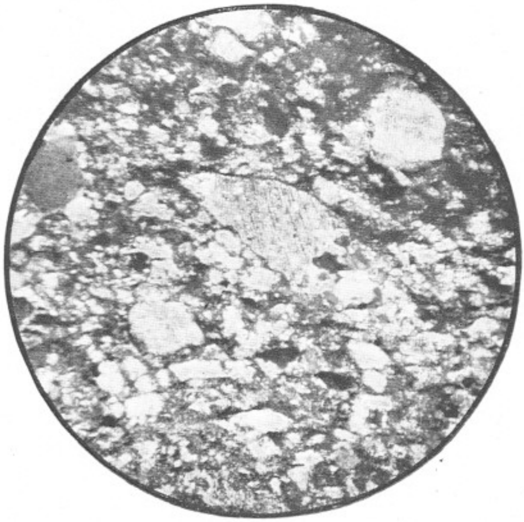
A light brown sandstone of flaggy structure, bedding marked by slight variations of tint. Possibly Devonian.

FIG. 1.



M. 9d. S. 31° W. Edd., 21·7 miles.
Grit, showing large grain, A–B.
Ordinary light. × 29.

FIG. 2.



M. 9d. S. 31° W. Edd., 21·7 miles.
Grit, showing compound structure of grain ; at end A striated felspar, at end B quartz mosaic.
Crossed nicols. × 29.

To face p. 143.

M. 9d.

A rather light grey rock, which appears to be a compact and very fine-grained grit; looks much like many grits of the Devonian age.

The microscope confirms preliminary examination; this rock is a grit of close texture. A considerable proportion of the granules are felspar, many showing repeated twins.

A number of the grains prove to be of compound structure, and are portions of quartz and felspar mosaics from some original schist or gneiss. Further than this, three of the larger grains are compounded of portions of felspars with bent striation and portions of quartz mosaic, being, in fact, derived microscopic specimens of gneiss. As bearing on the age of the rocks which have supplied the fragments. this slide is distinctly interesting. The interstitial matter largely consists of a rather pale chlorite in which occur rare blades of pale mica, There is some ilmenite, apparently detrital. (Plate VIII, figs. 1 and 2)

M. 11f. S. 26° W. Edd., 17·8 miles.

A fine grey grit slightly browned by exposure. Much like last in general appearance, and may well be of Devonian formation, already included as quartzite, the cement being apparently silica. The grains are sub-angular and include a few felspars. There are rather numerous grains of sphene, some irregular, some of the characteristic lozenge shape, all apparently derived.

Grits, not microscopically examined, were also taken at **M. 31, M. 27, M. 26, M. 14, M. 20, M. 16, M. 9, M. 40, M. 19, M. 41, M. 77,** and **M. 80.**

SLATES.

Unaltered slate was scarce, as might be expected from the fact that it would usually be associated with much harder material, and probably be soon destroyed.

M. 77a. S. 11° W. Edd., 38·8 miles.

Dark compact shale, a clay slate.

Under the microscope appears built up of minute grains of high double refraction. There are frequent traces of minute organisms, some possibly foraminifera. Some shell fragments still consist of carbonate of lime, and numerous forms of circular section are infilled with calcite.

M. 39. S. 38° W. Edd., 21·9 miles.

A decomposed slate.

ALTERED SLATES.

354/4j. 6½ miles W. from Rame Head.

A slate of Devonian type, evidently altered by the proximity of the andesite dyke which here occurs.

M. 14j. S. 24° W. Edd., 20 miles.

Almost black, a very compact rock with sub-conchoidal fracture, and lustre somewhat like a quartzite. The worn surface shows rather minute banded structure.

The same banded structure shows in section when examined by the unaided eye, but is less prominent under the microscope; this is a sedimentary rock altered by contact metamorphism. The general ground-mass is a crypto-crystalline substance, rising to a minute mosaic here and there, and probably having a complex mineral composition. Felspar almost certainly plays an important part. In this there occur small grey-clouded areas, presenting sections which are chiefly of somewhat ill-defined rhombus shape, and which in certain positions completely extinguish. One such area has a portion clear of dusty products, and this shows high double refraction in a bright and pure colour; other similar instances occur. The dusty material shows a tendency to arrange itself in zones and crosses, and from examination of a great number of these imperfect crystals there can be no doubt that the rock is crowded with andalusite in a condition bordering on the chiastolite form. For the rest, there is much small brown mica, and titanic iron ore, mostly in very small grains, is quite plentiful. Such a rock might easily arise from the metamorphism of a Devonian or Carboniferous slate by contact with a large boss of igneous material.

Altered slates, having the appearance of being baked by proximity to igneous rock, were also taken at the following stations, but have not been examined microscopically.

M. 11, M. 34, M. 72, M. 14, M. 15, M. 21 (common), **M. 24** (very common), **M. 17, M. 18.**

LIMESTONE.

M. 26b. S. 20° W. Edd., 18·4 miles.

A blue-grey limestone, veined and mottled with lighter calcite, much like some of the South Devon middle Devonian series. Consists almost entirely of irregular interosculating calcite patches, traversed by cracks filled with clear calcite. The calcite forms give indication of former organic remains, and at three places undoubted sections of madrepore occur. Around and between the boundaries of some of the calcite areas are very irregular and much folded lines of a granular black substance, apparently carbonaceous.

NEW RED SANDSTONE.

CONGLOMERATE.

354/3b. Hand Deeps.

A red conglomerate, certainly of the New Red Sandstone period.

Among the derived constituents are quartz grains of some size showing mosaic structure and containing fluid inclusions with bubbles. Other grains of felspar mosaic precisely similar to that occurring in the neighbouring schists and gneisses. Blades of mica that may have been similarly derived. Quartzites, and fragments of highly cleaved slates, or very fine-grained schists.

Calcite or dolomite, probably the latter, is very prominent, filling the interspaces.

354/4b. 6½ miles W. from Rame Head.
Conglomerate with fragments of andesite.

SANDSTONE.

354/3c. Hand Deeps.
A coarse, red, micaceous sandstone.

354/2a. S.W. Edd., 2 miles.
Variegated sandstone, fine texture, red and grey.

354/2b.
Buff sandstone, almost salmon coloured.

354/2c.
Fine-grained compact red marly sandstone, sub-jaspideous.

M. 31. S. 25° W. Edd., 15 miles.
Red sandstone and buff sandstone.

M. 32. S. 25° W. Edd., 16·3 miles.
Red sandstone and yellow sandstone.

M. 10. S. 26° W. Edd., 17·8 miles.
Red sandstone.

M. 33. S. 25° W. Edd., 17·5 miles.
Red sandstone.

M. 34. S. 28° W. Edd., 18·5 miles.
Variegated, red and grey.

M. 27. S. 19° W. Edd., 18·3 miles.
Red sandstone and buff sandstone.

M. 26. S. 20° W. Edd., 18·4 miles.
Red sandstone.

M. 40. S. 38° W. Edd., 21·7 miles.
Variegated, red and grey.

M. 17. S. 28° W. Edd., 23·3 miles.
Red sandstone.

M. 19. S. 28° W. Edd., 23·3 miles.
Red sandstone in large angular blocks.

M. 18. S. 29° W. Edd., 23·4 miles.
Red sandstone.

M. 21g. S. 25° W. Edd., 21·2 miles.

(Not inserted in the above series because structurally different; all the above are of ordinary type.)

A compact rock with granular fracture; the granules vary from buff to a light brown with a tinge of Indian red. The rock has been bored by molluscs.

A sandstone cemented by crystalline calcite, dolomite, or in the alternative a very sandy crystalline limestone. The quartz grains well rounded with numerous, and some large, fluid inclusions. One grain which proves to be part of a quartz mosaic contains a fragment of rich brown mica. Yet another grain contains brown mica, and many have acicular microlites, possibly apatite. Considerably less numerous than the quartzes are felspar grains, both orthoclase and plagioclase. There are numerous fragments of a brown rock, apparently a palagonite, containing some crystals, including mica. The rhombs of dolomite are clearly marked out by concentric bands of dark brown inclusions, grains, and microlites, which tend to form radial bunches. In some cases the centre of a rhomb is completely darkened.

MARLS.

Under this heading are included hard marly limestones, those more exceptional forms from the Trias which are calculated to resist abrasion; with them is a smaller percentage of the true friable marl.

M. 34b. S. 28° W. Edd., 18·5 miles.

A dark red pebble, with smooth surface, much bored by molluscs. A cut surface shows very compact rock, the red colour of which is slightly mottled by a lighter shade. In the section this mottling is much more prominent. The rock is minutely granular, the mineral being probably a mixture of calcite and dolomite. There are also small angular fragments of quartz, and apparently some fibres of gypsum. Some of the borings have been infilled with secondary sandstone having calcareous cement. The stone is a very hard marl.

M. 9f. S. 31° W. Edd., 21·7 miles.

A fine-grained red marl.

Much very fine sand, with some larger quartz grains. The colour not uniformly distributed but mottled with grey. Many of the grains appear to be crystalline calcite or dolomite.

M. 31. S. 25° W. Edd., 15 miles.

Soft variegated marl, red and green.

M. 36. S. 37° W. Edd., 17·5 miles.

Hard chocolate-coloured marl.

M. 11. S. 26° W. Edd., 17·8 miles.
Hard chocolate-coloured marl.

M. 12. S. 26° W. Edd., 17·8 miles.
Hard chocolate-coloured marl.

M. 35. S. 32° W. Edd., 18 miles.
Hard chocolate-coloured marl.

M. 34. S. 28° W. Edd., 18·5 miles.
Hard chocolate-coloured marl.

M. 14. S. 24° W. Edd., 20 miles.
Hard chocolate-coloured marl.

M. 15. S. 27° W. Edd., 20·3 miles.
Pale red, rather soft marl.

M. 20. S. 25° W. Edd., 20·5 miles.
Hard chocolate-coloured marl.

M. 24. S. 24° W. Edd., 22·5 miles
Hard chocolate-coloured marl.

LIMESTONES.

The following dolomitic limestones would appear to belong to the New Red Sandstone formation.

M. 34d. S. 28° W. Edd., 18·5 miles.

A rather small brown-grey pebble, much bored by saxicava. Freshly broken surface is pale brown, and shows somewhat granular, very uniform, texture.

The section, examined by the unaided eye, suggests a slightly marked banded structure. The matrix of the rock is a fairly pure crypto-crystalline calcite and dolomite, and minute zoned rhomboids of the latter mineral occur sparsely. But it is so closely set with small sand grains that it might almost be described as a sandstone with calcareous cement. Most of these clear grains are probably quartz, but some show the repeated twinning of plagioclase felspar. A little brown mica is to be found, and rather numerous rich brown and black specks, which may be rutile. There are also many pale olive patches, distinctly larger than the other granular constituents, somewhat ill defined in outline and apparently calcareous. The calcareous ground-mass has here and there a yellowish-brown tint.

M. 35e. S. 32° W. Edd., 18 miles.

A very similar rock to the last described.

M. 21a. S. 25° W. Edd., 21·2 miles.

A compact horny-textured rock distinctly hard, but bored by molluscs, etc. Colour of broken surface brown with a shade of purple, and buff. Weathered surface an uniform light brown.

A granular crystalline limestone, stained by iron in patches and lines. Apparently it has always contained some free spaces which are lined with larger crystal grains. Occasional almost complete rhombs of dolomite of small size occur. There are slight streams of a pale brown mineral of low double refraction; and scoriaceous looking inclusions of rich brown rock, containing small quartzes; these are the more aluminous parts of the rock.

PASSAGE BEDS—TRIAS TO RHAETIC.

M. 29a. S. 14° W. Edd., 19·8 miles.

A coarse, open-textured marl or marly limestone, drab coloured. The section shows widely varying colour and texture, giving at first sight the effect of a detrital rock with many derived fragments. That there are fragments of other marly limestones does indeed appear to be the fact; certain textures associated with definite colours, and with mineral forms not found generally distributed throughout the slide, are located in areas with well or less clearly defined boundaries. On the other hand, the same yellow iron stain which marks some of these areas runs irregularly across the section in a contorted and divided stream and is always associated with a finer ground-mass than the average.

In the general body of the rock, besides much granular crystalline calcite, occur small spheroids of a clear mineral, which consist of fibres radially arranged, and are also marked by a slight concentric zoning. One long vein shows the same structure, and its outline is botroidal. This mineral is soluble in HCl. There is a fair amount of dark material, which may be carbonaceous. Not infrequent quartz grains. And in the rather ill-defined orange-brown inclusions (if inclusions they are) a fibrous mineral in single blades showing a double refraction considerably less than that of mica; none of this is to be found in the residue after solution in acid, and it may be gypsum. One piece of certain mica is visible, with pleochroism from colourless to cinnamon-brown. The residue after solution in acid consists chiefly of a rich olive-brown isotropic matter in flocculent form.

M. 29b.

Compact, smooth, and fine-textured marl in thin slabs, can be marked by thumb-nail, drab coloured. The section shows very minute grains of calcite, and some brown fragments which may once have been mica.

M. 29c.

Angular fragment of stone-coloured marl, rather coarser than last, but still fine-grained and compact, just harder than the thumb-nail.

M. 29d.

Much like last, but has a greenish tinge.

M. 29e.

Like last, but harder and greener.

M. 29f.

Like last, but considerably softer, and greener still with patches of bright decided colour. Micaceous.

M. 29g.

Green marl and drab-brown marl as above in narrow alternate bands.

M. 29h.

A layer of coarse grey marl and one of fine-grained drab-brown marl.

The series **M. 29a.** to **M. 29h.** inclusive indicates a locality occupied by soft marls of varying texture and colour, associated in one and the same formation in layers of varying thickness, the alternations being frequent and repeated.

RHAETIC AND LIAS.

LIMESTONE AND SHALE.

Most of these limestones contain argillaceous matter; some, however, appear to resemble the White Lias; in the absence of field work it is not well to attempt to do other than group Rhaetic and Liassic together.

OFF LYME REGIS—*in situ.*

This type rock is frequently dredged off Lyme Regis. The specimen shows coral fragments, including *Gonioseris.* For the rest it is a rough, somewhat sandy limestone, inclined toward a marl. A great deal of brown and black matter occurs in granular form. Obviously a Lias Limestone.

M. 12a. S. 26° W. Edd., 17·8 miles.

Drab-coloured stone, fine in grain. The section shows crystalline granular structure with no visible organisms.

M. 30a. S. 21° W. Edd., 21·5 miles.

Darkish limestone, rather brown than buff. Minutely crystalline granular. Traces of organisms; grains and slight micro-dendritic growths of iron oxide.

M. 53a. S. 22° W. Edd., 32·2 miles.

A light brown slabby rock, bored by molluscs. A closely-cleaved, highly-calcareous shale. Corresponds to the "paper shales." Distinctly marly. The section shows occasional aggregates of crystalline calcite. The chief part of the rock is a minutely granular pale brown mixture, with mottling of rich orange-brown, less granular, substance, and grains and short irregular lines of an almost opaque dark brown. No undoubted organic remains.

M. 53b.

A light brown rock, a harder variety of the preceding, contains calcite veins, and one joint-face shows well-developed crystals. The laminæ of this rock are alternately of closer and of more open texture.

The section is made in one of the harder layers and corresponds with **53a**, except that it is lighter in general shade and the orange-brown portions are much less in proportion to the whole.

M. 53c.

Drab-coloured compact rock in slabs, one face of which is usually obviously a joint surface recently broken, and one face much bored, probably by annelids. The section shows a pale brown rock wholly but minutely granular, almost entirely calcite, with an occasional narrow vein of clear calcite, and small scattered brown and black granules. No trace of organisms. This forms the last of a series of which **53a** and **53b** are the first members.

M. 56a. S. 25° W. Edd., 34·3 miles.

A dull brown limestone of light shade.

Contains numerous fragments of shells and rather frequent echinoderm spines, but no foraminifera.

M. 44. S. 17° W. Edd., 29·8 miles.

Buff limestone, apparently liassic.

CRETACEOUS.

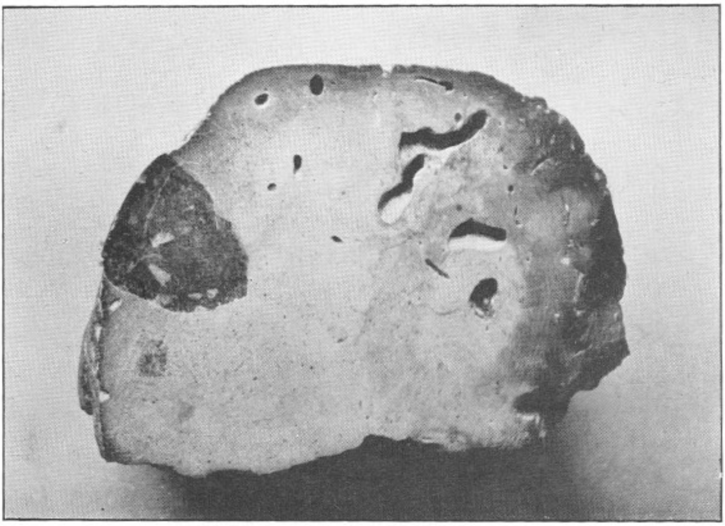
CHALK.

A very hard, yellow, or cream-coloured, chalk is of frequent occurrence; generally the exterior of the pebble is brown, and this colour extends some slight depth into the stone, getting less in intensity until it fades into the yellow or cream-colour. Unless the stone happens to be much bored it usually requires a considerable blow to break it.

M. 26a. S. 20° W. Edd., 18·4 miles.

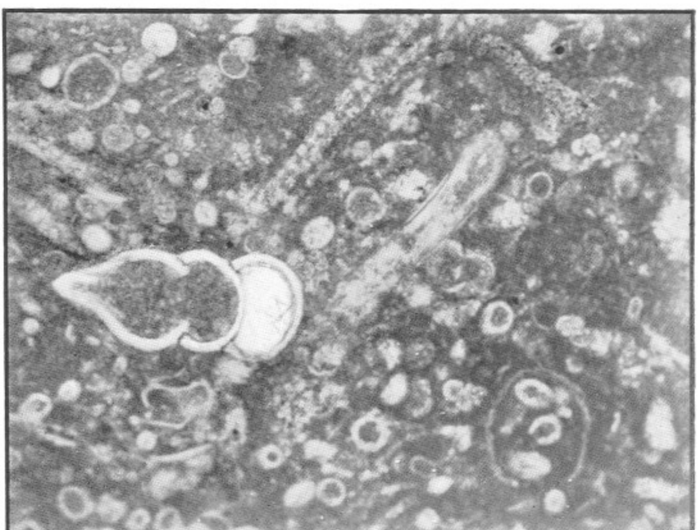
Hard, cream-coloured chalk. Minutely granular texture. Crowded with small organisms. Many good sections of small foraminifera. Fragments of larger shells frequent. Some of the foraminifera infilled with a yellow-orange substance. Several textularia. Fragments of nodosaria, and some rotaline forms and globigerina.

FIG. 1.



M. 14a. S. 24° W. Edd., 20¼ miles.
Hard yellow chalk, surface finely ground but not polished.
Derived inclusion on left.
$\times 1\frac{1}{2}$.

FIG. 2.



M. 14a. S. 24° W. Edd., 20 miles.
Hard yellow chalk.
Ordinary light. $\times 97\frac{1}{2}$.

To face p. 151.

M. 72a. S. 23° W. Edd., 19 miles.

Hard, cream-coloured chalk.

Texture minutely granular. Crowded with the remains of small organisms, and with shell fragments, etc.

M. 72b.

Hard yellow chalk. Shell fragments, small foraminifera, etc.

M. 21c. S. 25° W. Edd., 21·2 miles.

Hard yellow chalk. Crowded with foraminifera. There is a comparatively large circle of calcite ($\frac{1}{2}$ mm.) having radial structure, apparently the cross section of a cylinder, also shell fragments.

M. 14a. S. 24° W. Edd., 20 miles.

Should have preceded **M. 21c**, but placed last, because in some ways typical of the whole series.

A fair-sized pebble, some three inches in length, orange-brown on the outside, within distinctly yellow for an average depth of about 7 mm., then cream-coloured with small lighter patches. A somewhat irregularly bounded area on the surface is a darker brown and more compact than the rest, it is harder and stands slightly above the general level. Before the pebble was broken this measured over 30 mm. by 13 mm. On breaking the stone it was seen to be an inclusion extending 14 mm. inwards. This inclusion, viewed in cross-section, is green around the margin where it is in contact with the cream-coloured rock, and red in the interior and on its outside face. It has small curved cream-coloured markings, the largest 4 mm. by 1 mm., and in grinding down a section these markings were seen to all communicate with the original outer face of the inclusion; they are obviously borings made by some animal and have been infilled with chalk of the same character as the body of the pebble. This is the only specimen in which such a fragment has been observed, but perhaps closer inspection would discover more among the samples.

The section was cut through inclusion and general mass alike; it bears out in all respects the above description. There is a considerable similarity between the chalks forming the included fragment and the body of the pebble, but in the latter there are possibly more shell fragments; foraminifera are exceedingly numerous in both, and grains of glauconite are present in both. The cream-coloured rock has some considerable areas of calcite in interlocked crystalline grains; these are, however, infrequent. The whiter patches in the cream-coloured rock appear to be denser, to have fewer, although still very many, foraminifera, and smaller shell fragments, but there is no divisional line between the two. The foraminifera include Globigerina, Textularia, Bolivina, Cristellaria, and Lagena. There are occasional black and dark brown specks. In all except its hardness the rock is distinctly a chalk. (Plate IX, figs. 1 and 2.)

Mr. D. J. Matthews has kindly made an analysis of a portion of the specimen above described, and returns:—

Silica (SiO_2) 0·70 *per cent.*
Calcium Carbonate ($CaCO_3$) 94·05 *per cent.*
Magnesium Carbonate ($MgCO_3$) 1·56 „
Phosphorous pentoxide (P_2O_5) 0·66 „
A little Iron and Aluminia.

Alkalies not tested for.

From the above it will be seen that the rock is both phosphatic and dolomitic.

Hard Yellow Chalk was also taken at the following stations, among others. The list is not quite complete:—

M. 31, M. 36, M. 33, M. 35, M. 15, M. 25, M. 17, M. 41, M. 58, and M. 67.

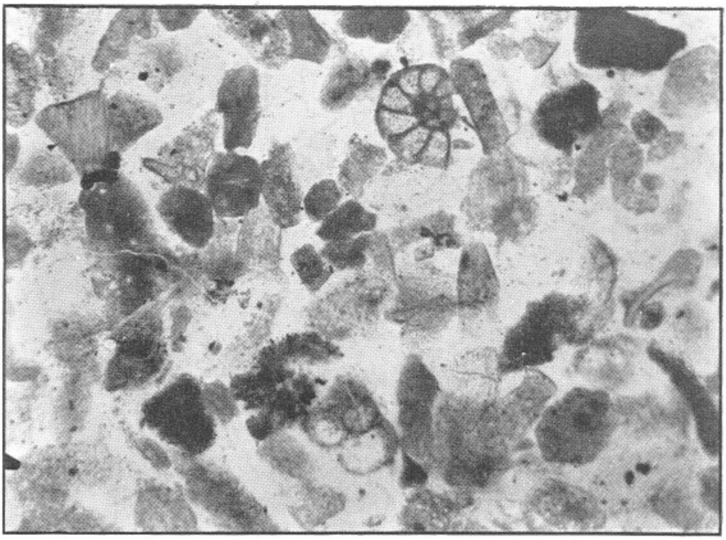
FLINT.

Flint is quite the commonest rock if the whole area covered by the dredgings is considered. It would be difficult to assert positively that it is anywhere entirely absent from the stony grounds. **A. 90**, about four miles toward Plymouth from the Eddystone, is all Devonian, but this was on a sandy ground.

Many of the flints are very unlike, in external appearance, any usually seen on land.[1] The unaltered mineral is very frequently black, but occurs only in the heart of the pebbles. A solvent action, not necessarily entirely marine, has removed a portion of the silica for some depth from the surface of the stone, and has left a white coherent gritty substance, which is sometimes soft enough to mark on a blackboard, sometimes quite hard. The progress of this alteration can frequently be traced in the section of a broken stone. Pebbles of some inches in thickness are often so far affected that a mere remnant, a patch of perhaps half an inch diameter, will be left in the centre to show what the former condition was. In some even of the large pebbles no unaltered flint remains. It seemed desirable to ascertain what proportion of the original mineral has been removed by this solution, and as an approximation the following method was adopted: **M. 15**. A piece of thoroughly altered flint, from a stone which showed some remnant of black flint

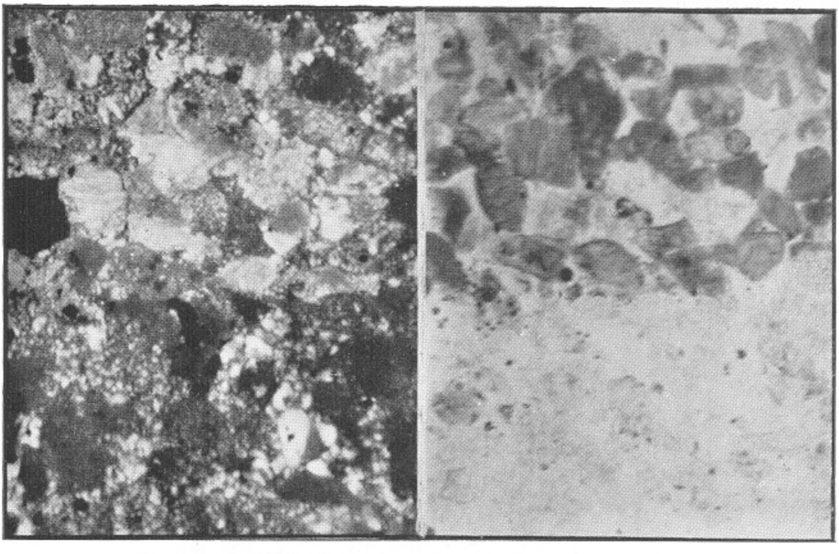
[1] Exceptionally, as, for instance, on Hardown Hill and Annis Knob, near Lyme Regis, chert and black Upper Chalk flint are found in much the condition here described, but the presence of carbonate of lime has not been reported, although probably existing much as in these specimens.

FIG. 1.



M. 62b. S. 25° W. Edd., 46·4 miles.
Decomposed black flint.
Ordinary light. $\times 97\frac{1}{2}$.

FIG. 2.



M. 62b. S. 25° W. Edd., 46·4 miles.
Decomposed black flint, the lower half of plate represents portion of slide treated with acid.

Crossed nicols. $\times 97\frac{1}{2}$.
Shell fragments dissolved away from lower half.

Ordinary light. $\times 97\frac{1}{2}$.
Shell fragments dissolved away from lower half.

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at the centre, when dried weighed 51 grains; it was boiled in water for twenty minutes, allowed to remain in the same water until cold, when it was taken out, wiped, and found to weigh 62½ grains. The specific gravity of the remaining mineral was ascertained to be about 2·56. If we assume that all the lost material was chalcedonic silica we have to multiply the weight of water absorbed, 11½ grains, by the specific gravity of chalcedony, say, 2·3, in order to ascertain the loss of the original rock by solution; this gives us about 26½ grains or somewhat over 33 % of the mass of the original flint. From the fact that the specific gravity of the residue is less than that of quartz, although some calcite also occurs in the rock, it may be assumed that not all the silica yet remaining is crystalline.

These porous altered flints effervesce, some more freely than others, on treatment with acid, but maintain their outward form. The same specimen on which the above determinations were made lost 3½ grains in weight after prolonged stay in dilute acid. (This loss includes a very small amount of silica and the merest trace of iron.) It would thus appear that the unaltered rock had contained at least 4 % of soluble carbonate. In some instances this is certainly exceeded.

M. 62b. S. 25° W. Edd., 46·4 miles.

This specimen was selected for especial microscopic examination; it is a somewhat chert-like black flint, the outer portion altered as above described. The first section was made from the black part of the pebble, and shows the flint to be nothing more than a silicified chalk. Foraminifera and shell fragments, all still carbonate of lime, crowd the slide, and there are occasional quartz grains and some of glauconite. The matrix is partly crypto-crystalline, and so intimately is the crystalline mixed with the isotropic that practically all the silica ground-mass gives some reaction with polarised light. A second slide, cut from the decomposed part of the rock, shows a crypto-crystalline ground-mass of silica crowded with forms in calcite after organic matter. Foraminifera quite numerous, the chamber walls well defined, but the original structure mainly, if not entirely, replaced by granular calcite. An occasional fragment of some larger shell (molluscan) appears to have retained pretty well its original structure. Glauconite grains occur freely, and some of the foraminifera are infilled with this material.

Finally, to remove any possible ambiguity as to the presence of carbonate of lime, a third section was prepared, also from the decomposed portion. After this had been ground down to the requisite transparency one-half of it was varnished with Canada balsam, and the whole section dipped in dilute acid; a brisk but brief effervescence followed. The slide now shows a clear-cut boundary; on the side which was varnished the foraminifera and shell fragments remain, on the other side they have vanished, leaving absolute vacancies. The crypto-crystalline silica is identical in character on either hand. The included quartz grains, which occupy the whole thickness of the slide, polarise in higher colours than the silica of the ground-mass, which is in too minute form to extend through the whole depth.

One interesting point is that the chalk thus converted into flint had not the same original structure as the yellow chalks described previously. (Plate X, figs. 1 and 2.)

The following further specimens were microscopically examined.

M. 15b. S. 27° W. Edd., 20·3 miles.

Decomposed flint. Lime not so common except in parts. There are instances of foraminiferal shell entirely replaced by silica. These are best seen by polarised light. In places the grain of the silica in the ground-mass becomes comparatively coarse.

M. 9h. S. 31° W. Edd., 21·7 miles.

Black cherty flint, with small light markings. The exterior reduced to a white loose-textured substance with minute brown spots. The varying resistance of the flint to decomposition is to be seen where the extreme outer surface has been chipped off, and small patches of almost unaltered rock are visible.

Shows the crypto-crystalline structure of the ground-mass very well. Much like other sections of the same material, except that the calcite fragments are larger, and there are iron-stained areas.

M. 18b. S. 29° W. Edd., 23·4 miles.

Decomposed flint. Hydrozoa and shell fragments, mainly in calcite, but some wholly replaced by silica of coarser texture than ground-mass. At one place slight dendritic growth of iron oxide.

Flint is present in greater or less quantity in every sample which yields pebbles or stones. Without actual count an approximate estimate of the proportion of flint to the whole sample has been made in most cases with the following results:—

A. 105. S.S.W. Bolt Head, 1 mile.

Flint in gravel 13 %.

A. 106. S. Bolt Head, 2 miles.

Flint in gravel 40 %.

M. 31. Flint two-thirds of whole.

M. 32. Thirty-seven pebbles, of which twenty are flint.

M. 36. Nine-tenths flint.

M. 10. Nine-tenths flint.

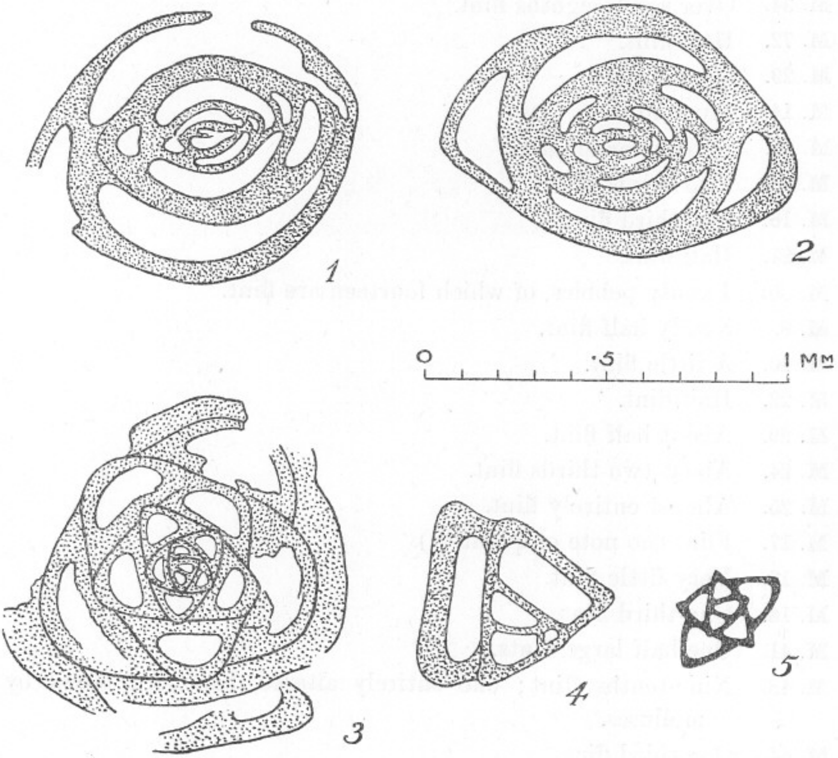
M. 33. Flint predominant.
M. 11. Nearly half flint.
M. 12. Three-quarters flint.
M. 13. About same as **M. 12**.
M. 35. Two-thirds flint.
M. 27. Much flint.
M. 26. Flint very plentiful.
M. 34. Over seven-eighths flint.
M. 72. Half flint.
M. 29. Some flints.
M. 14. Much flint.
M. 15. Three-quarters flint.
M. 20. Two-thirds flint.
M. 16. One-third flint.
M. 21. Half flint.
M. 30. Twenty pebbles, of which fourteen are flint.
M. 9. Nearly half flint.
M. 40. A little flint.
M. 22. Half flint.
M. 39. About half flint.
M. 24. About two-thirds flint.
M. 25. Almost entirely flint.
M. 17. Flint (no note of quantity).
M. 19. Very little flint.
M. 18. One-third flint.
M. 41. One-half large flints.
M. 43. Nine-tenths flint; one entirely altered, has been bored by molluscs.
M. 44. One-third flint.
M. 50. A little flint.
M. 53. One-third flint.
M. 56. One-third flint.
M. 77. Three-quarters flint, in large size, one about $6'' \times 6'' \times 4''$.
M. 58. Two-thirds flint, in large size, one about $10'' \times 6'' \times 4''$.
M. 67. Over nine-tenths flint, large and entirely unrolled, roughly cylindrical, with short branches, one 18 cm. × 13 cm. × 15 cm., one 21 cm. × 10 cm.
M. 62. One-half flint.
M. 79. Three stones, of which one is flint.
M. 80. A little flint.

EOCENE.

M. 77b. S. 11° W. Edd., 38·8 miles.

A rough-textured cream-coloured limestone, rather soft, and closely resembling the '*calcaire grossier*' of the Paris Basin.

Fine gravel or coarse sand is sparingly visible in the hand specimen. The microscope shows clear quartz grains, many of considerable size, and in the quartz fluid inclusions with bubbles. Fragments of



R.H.W.

FIG. 2. Sections of foraminifera from **M. 77b.**
1.2.3.5. *Miliolina* (*Quinqueloculina*) *seminulum.*
4. *Miliolina* (*Triloculina*) *angularis.*

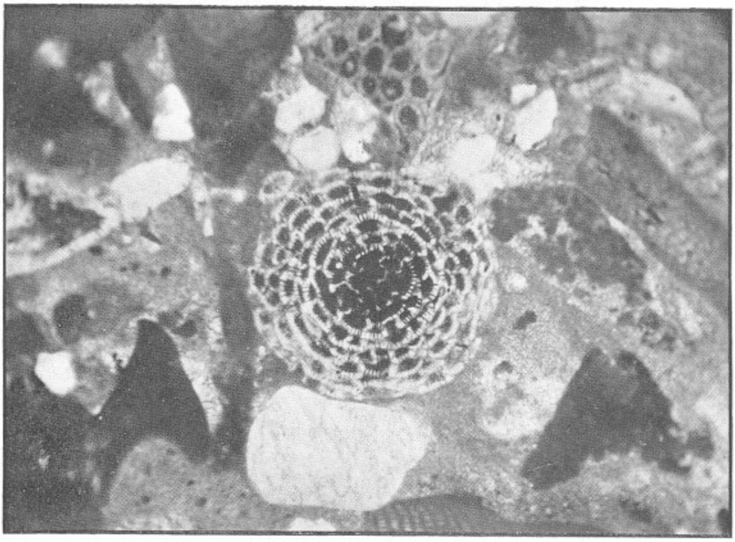
hydroids and of corals are clearly distinguishable. But the feature of the rock is its foraminiferal character. Various forms of *Miliolina* preponderate; these certainly include *Miliolina seminulum*, *Miliolina trigonula*, *Miliolina* (*Triloculina*) *angularis* (d'Orbigny), and possibly other varieties.

Of other foraminifera *Truncatulina refulgens* (Mont.) is identifiable, and there appear to be two species of *Discorbina;* one species of

M. 77b. S. 11° W. Edd., 38 miles.
Eocene limestone.
Ordinary light. $\times 33\frac{1}{2}$.

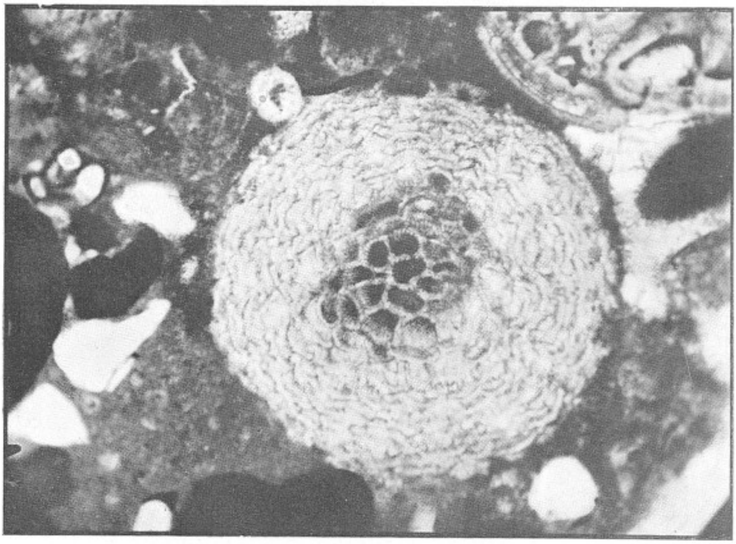
To face p. 156.

Fig. 1.



M. 77b. S. 11° W. Edd., 38·8 miles.
Section of *Planorbulina* (? *larvata*) in Eocene limestone.
Ordinary light. × 44.

Fig. 2.



M. 77b. S. 11° W. Edd., 38·8 miles.
Section of *Planorbulina* (? *larvata*) in Eocene limestone.
Ordinary light. × 44.

To face p. 157.

Verneuilina and one of *Textularia*, both the latter with arenaceous tests. *Biloculina ringens* is clearly present, and apparently a species of *Polymorphina* and one of *Spiroloculina*. There are several sections of a very beautiful foraminifera, all, however, in planes practically parallel to that of its spiral; still, cut at different parts of the thickness of the test, they give fairly clear information as to the form. It is certainly *Planorbulina*, and seems identical with *Planorbulina larvata*, Parker and Jones. This species is, however, only hitherto known as recent and of tropical habitat. The rock is too hard to admit the separation of the foraminifera as opaque objects, and sections must be relied upon wholly; so far three have been prepared, but many more will have to be cut before any certain identifications of the foraminifera can be made, except among the *Miliolinæ* and in a few chance instances where typical forms are fully displayed. Glauconite grains are common and of fair size, and the same mineral fills the chambers of many of the foraminifera. The foraminiferal shells have not been the subject of any mineral alteration. The groundmass of the rock has been a highly calcareous mud, with little aluminous matter. Comparatively shallow water conditions and a warm sea are indicated. (Plate XI and Plate XII, figs. 1 and 2.)

ROCKS OF UNDETERMINED AGE.

SANDSTONE.

M. 14d. S. 24° W. Edd., 20 miles.

A buff-coloured sandstone with calcite cement, appears rather open-textured on outer face of pebble, but is quite compact within.

By far the greater number of grains are quartz, but a few felspars show in the slide. There are also some shell fragments and other organic remains. Many quartz grains show acicular crystals of apatite, some few have zircon enclosures. Some are nearly free from fluid inclusions, but most show rather many, with bubbles in the majority of instances. Many of the grains are iron-stained yellow along cracks, obviously before inclusion in this rock.

This rock has all the appearance of a ragstone, and may very possibly belong to the *Neocomian* formation.

ARKOSE.

M. 62x. S. 42° W. Edd., 46·4 miles.

The fracture shows a pale pink rock; externally the worn surface looks rather like sandstone in which the cementing material is less hard than the sand grains, the fractured surface seems more like a granular felsite; felspar of a light flesh colour is clearly visible.

The section resembles a *breccia*, in which the individual grains are as well fitted to each other as the fragments in a tessellated pavement; thus there is a minimum of cementing matter. But, on the other hand, the normal constituents of granite, orthoclase, a little oligoclase, quartz, and some brown mica occur in much the proportions that would be found in a micro-granite, and very similarly distributed. Some of the felspar is micro-perthite. A great many felspars are cracked, some crushed, in each case the cementing material invades the crystal. Many of the quartz grains are similarly cracked, and the mica has been forced into curved forms to fit the surrounding grains, and in some cases has been structurally destroyed. The great majority of the grains of felspar and quartz show strain shadows in polarised light. The cementing material consists very largely of zoisite, with which is possibly a little felsitic matter. Small well-formed crystals of apatite and fluid inclusions with bubbles occur in the quartz. The felspar is fairly fresh and very little decomposed.

The rock has every appearance of a fine-grained granite, crushed, and then re-cemented by secondary minerals.

But for the appearance of the worn surface this would probably have passed in the hand specimen as a porphyritic felsite of the granitic class; it appears to agree precisely with the *Mimophyre quartzeux* of Brongniart, and the *Granite recomposé* of French petrographers.

A precisely similar rock is found at—

M. 13a. S. 26° W. Edd., 17·8 miles.

M. 30c. S. 21° W. Edd., 21·5 miles.

M. 44a. S. 17° W. Edd., 29·8 miles. Distinctly angular block.

Its range is, therefore, about 29 miles at least.

LIMESTONE.

M. 80e. S. 16½° W. Edd., 48·9 miles.

A large sub-angular stone, the surface distinctly polished. Very compact and hard. Brown with a vein of lighter buff or drab, dendritic markings on the lighter portion.

The section passes through both the mass of the specimen and a portion of the vein. Both consist of minutely granular crystalline material, largely calcite, but apparently dolomitic. The darker part gives indistinct evidence of organic remains, and shows clear rounded sand grains.

The rock is certainly puzzling, it may (doubtfully) have some affinity to the Cotham marble, but it would be a bold guess indeed to so identify it.

M. 51a. **S. 15° W. Edd., 30·8 miles.**

While this paper is in the press the writer has examined a rock from **M. 51**, which he had previously overlooked. This is a compact, dark brown limestone, with large shell fragments, now in calcite. The stone is angular. It is but little softer than **M. 80e**, and when sectioned shows dendritic markings similar to those in the lighter portion of that specimen. Undoubtedly liassic in type it in some sort forms a stepping stone from the more frequent forms to **M. 80e**, and the latter may now with fair certainty be identified as liassic. In mapping purposes this has been assumed.

GEOLOGY.

In the preceding section the various rocks have been assigned to their respective formations and their peculiarities noted. In Mr. Crawshay's paper their mode of occurrence, independently of their lithology, has been fully described. It remains to construct from the evidence thus called some coherent scheme of geology for this portion of the Channel.

With this end in view it is especially necessary to consider the probable date of these stony accumulations as such, and to find some reasonable explanation of their presence. Following which we must be assured that to some considerable extent the deposits are of local origin before we can proceed to any mapping of the various formations under the waters of the English Channel.

The one outstanding feature, as Mr. Crawshay has pointed out, is the general increase in average weight and size of the stones due south (magnetic), i.e. straight outwards into the Channel from the Eddystone. But although, as regards the dredged material, this fact is clear and important, against it or with it must be set the occurrence of large boulders on the Salcombe and Eddystone fishing grounds.

That the grade of the bottom deposit should grow coarser as the distance from land increases is against all probability and all experience, if the deposit is of recent formation under existing conditions. It should be expected that the detritus which enters the sea by the mouths of the rivers, derived from the denudation of the land, would so sort itself that the heavier and coarser particles deposit in the nearer and shallower waters, the lighter and finer particles coming to rest in the deeps; and, added to the river-borne detritus, the products of coast erosion and broken shells from the littoral zone should similarly distribute over the sea-bed with reference to the weight and size of their grains. No matter how small the rivers, how slight their supply of sands and clays, and without reference either to the rate of erosion and supply from the sea-cliffs, in time and in the absence of strong localised currents the bed of any sea will become covered with deposits, the average grade of which at any place will bear a relation to the depth and the distance from land. And the strength of the sea currents will in most instances accentuate this differentiation, being greatest in shallower water.

If, then, a contrary condition is found to exist, and the sands are replaced, even in parts, in the deeper water by coarse beds and blocks of stone, it becomes apparent that these latter belong in their origin to other conditions than those now prevalent. The present rivers, the cliffs which we see to-day have not supplied their material. Further, we may surmise that a sea which exhibits this anomalous feature, that the materials of its bed grow larger in individual constituent parts with distance from shore, cannot be, in its present form and depth, of very ancient origin. The time available has not sufficed to enable the shore-derived material to spread over the whole area.

Austen has discussed these points very fully and with great clearness; in fairness to his work and in recognition of his precedence the matter may be stated in his own words[1]:—

"The law of progressive change in the character of the sea-bed requires that the most remote deposits of the Channel should be the finest, and that no coarse materials should occur at any considerable distance from the coast; this law holds good for a given extent round all the shores of the Channel, but beyond the area of mud and ooze, fine and coarse sands, shingle and bare rock are again met with. . . ." And referring to the coarse deposits on the Sole Banks and Jones Bank, "the whole of these groups [of coarse material] are separated from the zones of coarse materials depending on the coast-line by a broad intervening area of the finest quality of sea-bed. We are precluded from supposing that the lines of coarse materials can have travelled over the mud zones, as their upper surface is soft and incoherent, into which the sounding-lead sinks some distance before the mass is tenacious enough to stop it, and in which the dredge buries; if therefore marginal or sub-marginal zone materials are found in places beyond well-defined areas of the low moving power of water, they become a clear indication that since their accumulation a great change in the position of such place, as to depth of water and distance from coast-line, has taken place." . . . "It may be objected to this, that these distant sand, gravel, and shingle beds may belong to any age, and not in any way be connected with the present seas. In tracing the remains of marine animals seawards, we may observe a like gradual comminution with that noticed with respect to mineral

[1] "Valley of the English Channel," *Q.J.G.S.*, Vol. VI, 1850, p. 83 *et seq.*

materials, long after the forms of the shells have ceased to be recognisable. The sea-bed, particularly on the French side of the Channel, is mainly composed of shell sand, or sand in which few particles of anything but such as show shell-structure occur. Areas of this character are laid down by the French surveyors, and occur in the interval between the Land's End of France, or Ushant, and the Little Sole Bank; yet on the sides of this bank, and more particularly on its western slopes, large, perfect, though decayed, shells again occur, and what is more remarkable, *Patella vulgata, Turbo littoreus*, etc. Taking the two phœnomena together, the occurrence of littoral shells and of marginal shingle, we may safely infer that we have at this place the indication of a coast-line of no very distant geological period, buried under a great depth of water, and removed to a great distance from the nearest present coast-line."

". . . In the very coarse beds which form the floor or lowest levels of the deeps in the upper part of the Channel, from the meridian of Cape la Hague eastward, and which have a depth of forty and fifty fathoms, we also seem to have the highest marginal zone of some former period, over which the drifting beds of the actual period are spreading; and, on the other hand, such masses as Jones Bank are to be considered as protruding portions of an older sea-bed isolated amidst the ooze deposits of the present sea."

"... The character of the greater part of the Channel area, if laid bare, would be that of extensive plains of sand, surrounded by great zones of gravel and shingle . . .; whilst along the opening of the Channel there is an obvious configuration of hill and valley, and an amount of inequality equal to that of the most mountainous part of Wales."

DELESSE attributes more to the action of currents in the deeper parts of the Channel than apparently would AUSTEN, but agrees that the coarser deposits are not of the present epoch, and argues that the settlement of the sands and silts of to-day has been prevented in certain areas by the strength of the currents, and hence these earlier deposits have been preserved from being covered. He writes[1]:—

"La Manche étant balayée par des courants énergiques, on doit s'attendre à ce que son fond ne reçoive pas partout des dépôts, mais soit au contraire formé très souvent par des roches pierreuses antérieures à l'époque actuelle; c'est, en effet, ce qu'apprennent les sondages, et proportionnellement ces dernières roches y occupent même une étendue beaucoup plus grande que dans les autres mers. D'abord, elles présentent des surfaces très vastes dans tout l'Ouest de la Manche; elles bordent la Bretagne et la Cotentin auquel elles

[1] *Lithologie des Mers de France*, p. 308 *et seq.*

réunissent Jersey ainsi que les autres îles anglo-normandes; de plus elles réunissent la Bretagne au Cornouailles et le Cotentin au Sud de l'Angleterre. Elles sont découpées suivant des écharpes très irregulières; non-seulement elle longent les côtes, mais elles traversent complétement la Manche, se poursuivant jusque dans les parties les plus basses de son bassin et même jusque dans son thalweg."

"Ces roches sont assurément très variées; cependant entre la Bretagne, le Cotentin, le Cornouailles, et le Devonshire, elles appartiennent au granite et au terrain de transition. Les sondages font connaitre qu'elles sont en partie formées de pierres désagrégées; qu'en outre les roches pourries sont fréquentes autour de 49° 5′ latitude et de 7° 10′ longitude, dans le thalweg de la Manche."

Finally, when we deal with the boulders from the Salcombe-Eddystone grounds we have MR. HUNT'S opinion.[1]

"My own contention being that they [the boulders] are to all intents and purposes *in situ*.

"The problem of origin is certainly a perplexing one. Those who maintain a distant derivation have to show where the blocks came from, and how they came.

"Those who contend for a local submarine origin have to explain how such solid blocks could have become detached from the parent beds.

"That trawls could detach the blocks from their beds is as possible as that 'Old Noll' fired them at the seagulls; but that trawlers could have dragged them about all over the Salcombe fishing grounds when detached is practically certain. Thus none of the detached blocks have any claim whatever to be considered *in situ* when caught, though they may fairly claim, I think, to represent rocks forming the bed of the Channel not far distant.

"However, it is clearly impossible to prove that some of them may not have been ice-borne. Let those who maintain that theory show cause for their belief."

We are somewhat more favourably situate now than when either of the above extracts left the hands of their authors. As regarding a definite line, from Plymouth Sound, past the Eddystone to a distance of nearly fifty miles from the latter, we have absolutely located and perfectly representative samples of the bottom deposit. From the 25-fathom line to the 35-fathom line these have been worked out in detail. Broadly speaking, the results are that we now know the Eddystone and, in part, the Hand Deeps to stand above the general

[1] "The Submarine Geology of the English Channel off the South Coast of Devon," *Trans. Dev. Assoc.*, 1889, p. 484 *et seq.*

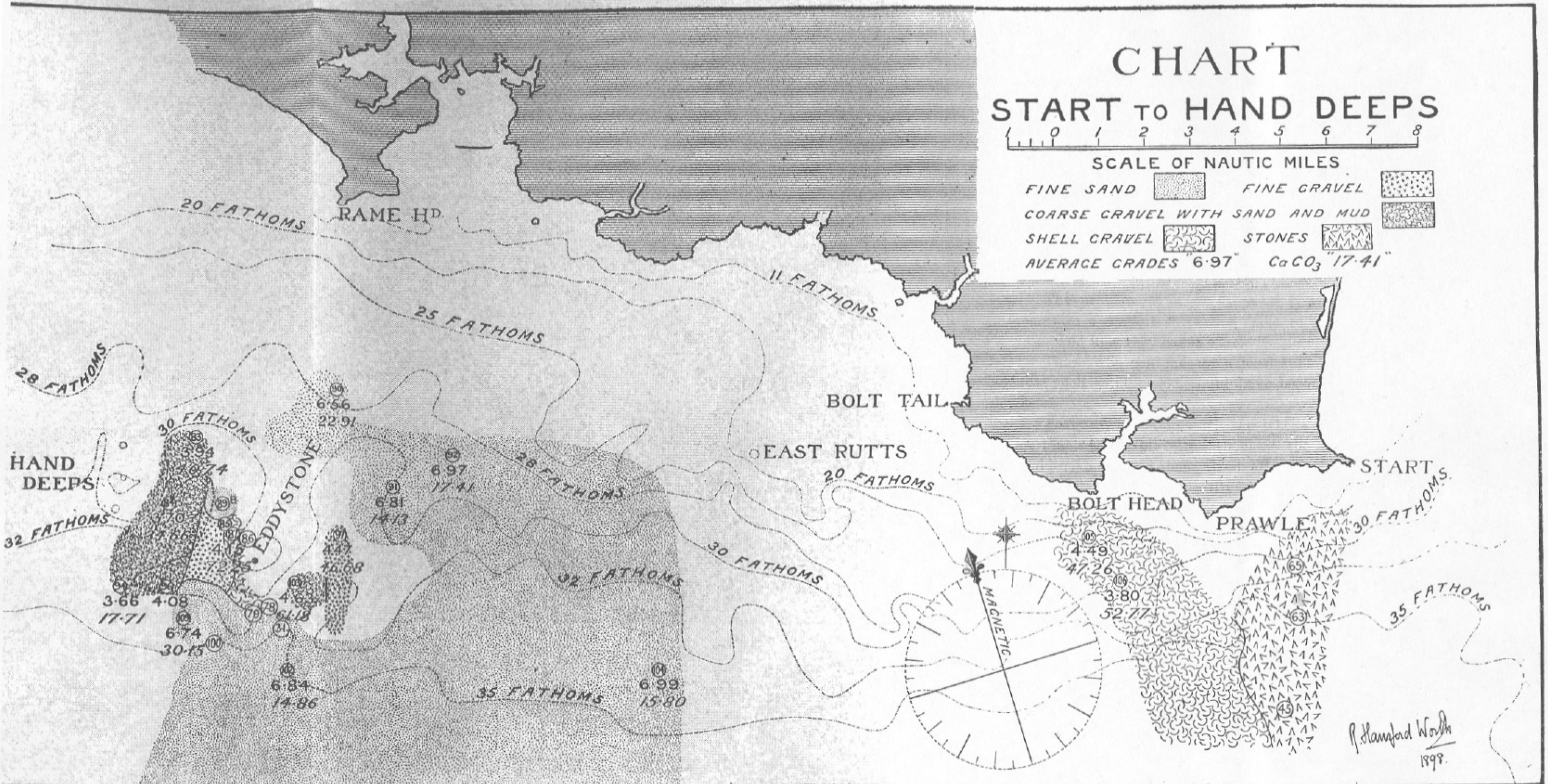


CHART
START TO HAND DEEPS
1 0 1 2 3 4 5 6 7 8
SCALE OF NAUTIC MILES
FINE SAND
FINE GRAVEL
COARSE GRAVEL WITH SAND AND MUD
SHELL GRAVEL
STONES
AVERAGE GRADES "6·97" CaCO3 "17·41"
RAME HD
20 FATHOMS
11 FATHOMS
25 FATHOMS
28 FATHOMS
30 FATHOMS
HAND DEEPS
32 FATHOMS
EDDYSTONE
BOLT TAIL
EAST RUTTS
20 FATHOMS
28 FATHOMS
30 FATHOMS
32 FATHOMS
35 FATHOMS
BOLT HEAD
PRAWLE
START
30 FATHOMS
35 FATHOMS
MAGNETIC
6·56
22·91
6·97
17·41
6·81
14·13
3·66
17·71
4·08
6·74
30·15
6·84
14·86
6·99
15·80
4·49
47·26
3·80
52·77
R. Hansford Worth
1898.

level of a sea-bed which consists of fine gravel and fine shelly gravel in patches; while south and east for some distance from the Eddystone are fine sands. South of the Prawle promontory, off the coast-line from Bolt Head to Prawle, is shell gravel, from Prawle to Start, stony ground.

The fine sands are quite unlike the silty sand of Plymouth Sound, are coarser as a whole and cleaner. A chart which the writer prepared in 1898, from Dr. Allen's details, is here reproduced; the undetermined areas have not yet been fully worked, and perhaps are better left blank until full information is available. There is a little stony ground at East Rutts, a stony patch off Stoke Point, and stones have been dredged north of the Eddystone, and on the margin of the Hand Deeps. (Plate XIII.)

All the stations on this chart are those to which I have elsewhere prefixed the letter A.

Station **A. 100**, south of the Eddystone, gave large stones as well as sand. Stations **A. 78** and **A. 31**, although near to and surrounded in part by sand, were actually on rock, and **A. 79** yielded Triassic sandstone. These three points are southward from the Eddystone, on the margin of the fine-sand area.

The first matter, the probable date of the stony deposits and their origin, may now be left for a time, to be resumed when the general geological mapping of the area has been attempted.

As to the second matter, the extent to which we may rely on the comparatively local origin of the various stones and pebbles, this, too, may be left in part to a later portion of the paper, but enough should be written here to justify the attempted location of the various formations *in situ*.

When a rock is obviously torn from its parent mass, as instanced by its form and freshly-broken surfaces, and when it comes from known rocky, as opposed to stony, ground, the inference as to its *in situ* origin is almost irresistible.

This is a matter of rare occurrence. HUNT'S **H. 19** appears to have been a clear instance. The trawler *Pelican* got fast in what was supposed to be a wreck, and remained thus fast for some hours. When the trawl came away, a fragment of granite showing a clean fracture was found in it. This fragment, No. 19, differs from HUNT'S other specimens in that it evidently formed part of a thin slab of rock, and not of a massive block. The stone proved to be a granite of coarse grain, with white and black micas, and a little triclinic felspar in addition to the orthoclase. The locality 20 miles S.W. of Eddystone. From practically the same spot, **M. 15**, the recent dredgings raised a fine-grained granite also with both brown and silvery mica.

There is evidence that the rock bottom at **A. 78, A. 79,** is Triassic. While the gneiss from **A. 86** (354/1), ½ mile N.W. of Eddystone, was a large angular slab, with one face of apparently clean fracture.

Thus on this class of evidence granite, gneiss, and trias have alike been found *in situ*.

Another feature that argues strongly for a rock being near its first home is the angular or sub-angular form occasionally presented; especially is this form of evidence of value when the stone is such as will readily suffer from transport.

A. 100 (354/2), 2 miles S.W. of Eddystone, gave large stones, a thin slab of variegated Triassic sandstone, a rather thin slab of buff Triassic sandstone, and a thin piece of red marl, all angular and practically unworn. Such rocks as these could not travel without great wear.

M. 19. S. 28° W. Edd., 23·3 miles, yielded large square blocks of Red Triassic Sandstone.

M. 14. S. 17° W. Edd., 29·8 miles, yielded thin sharp slabs of Liassic limestone.

There are other similar instances. Evidence of this type again demonstrates practically *in situ* exposures of Trias, and in this case of Lias as well.

A third clear indication of localisation is when the adjacent sea-bottom yields rocks of the same class and type as shore exposures. The sea-bed off the Bolt and around the Eddystone affords instances.

To some extent coupled with this is a fourth strong class of evidence —the restriction of the occurrence of a given type rock to areas with definite boundaries. Thus the Bolt and Prawle schists vary in type as we proceed southward along the sea-bed. The Eddystone and Hand-Deeps gneisses are restricted to the immediate neighbourhood of the reef; in **A. 102, S. Edd., 2½ miles,** the gravel contained no Eddystone reef material, although in **A. 87, N.W. by N. Edd., 1 mile,** 87 % of it is derived from the reef. It will presently be seen how, on a much larger scale, the New Red Sandstone series is definitely bounded. Thus at **M. 27, S. 19° W. Edd., 18·3 miles,** there is a representative series of Triassic rocks; at **M. 29, S. 14° W. Edd., 19·8 miles,** these are entirely replaced by the marls of the passage-beds to the Rhaetic. The distance is under two miles.

Another, the fifth, possible proof that a rock is near its point of origin applies in but a few cases. An example will best explain it. On all the preceding arguments we may decide that the gneiss of the Hand Deeps is practically *in situ*. **354/3b** is a red conglomerate of the

New Red series; it contains derived fragments of the Hand Deeps gneiss and schist; it is found side by side with them, and hence if they are *in situ* so, too, in all probability, is it.

The sixth line of argument for the demonstration of the local origin of the rocks and pebbles is as strong as any. There are some rocks so friable that they might not travel half a mile without being destroyed. Many of the marls of **M. 29** above referred to are of this class, the 'paper shale' of **M. 53a, S. 22° W. Edd., 32·2 miles,** is another rock which must be content to rest at home or be destroyed. From these which cannot be moved without destruction, through those which can only travel a little way without disintegration, on to others which may journey but must be considerably reduced in their progress and bear evidence of their wanderings, there is a complete succession. The extreme of the class may be taken to be flint, and if entirely unrolled flints are found, as at **M. 67, S. 19° W. Edd., 40·5 miles,** among other places, it may well be assumed that they are untravelled.

On some one or more of these six lines of argument every class of rock found in the dredgings may be shown to be practically *in situ* at one or more stations. Its associates are arguably almost equally near their points of origin, for it is impossible to attribute to any drift, arising from whatever cause, the selective and confounding ability to bring like to like, to transport from a distance and place among its kin any stone or stones. A little exchange of material between adjacent areas there must be, but we are not about to attempt any geological mapping within extreme narrow limits of error.

THE CRYSTALLINE ROCKS.

Granites, Diorites, Gneiss, Schist, etc.

Mr. A. R. Hunt quotes, in a paper above cited, a letter received by him from the late Mr. E. B. Tawney, as follows:—

"My views are rather Britannic; I look to Brittany for their origin [the origin of the Channel granites and gneisses, R.H.W.]. I consider Brittany reached to Plymouth Sound and then stopped short, but am inclined to give Start Point to it. If so, the granites are *not all* pre-Devonian, though pre-Carboniferous."

To much the same conclusion the writer has arrived, as at least a working hypothesis, with the correction that some at least of the Brittany granites are now commonly accepted as of Carboniferous age.

To one who has worked in a granite area such as Dartmoor there is nothing unexpected, nothing disappointing in finding, as in the present instance, such considerable variety among the plutonic rocks, a variety that by no means in all cases involves difference of origin.

For the moment all granites and associated rocks which may have had a Dartmoor origin are excluded from consideration; these are extremely few in number. The first part of this paper must be left to speak as to the variety of the plutonic rocks met in these dredgings. But here such slight evidence of relative age as can be adduced may well be considered. Gneiss is known to occur at the Eddystone *in situ;* it occurs also at the Hand Deeps and the East Rutts, and notwithstanding the doubt thrown upon the fact, I am inclined to consider that the 'Shovel Reef specimen' was, indeed, obtained near Plymouth Breakwater. This has been rendered the more probable by discoveries made since the time when Mr. A. R. Hunt, on evidence that warranted him in all fairness, challenged the fact.

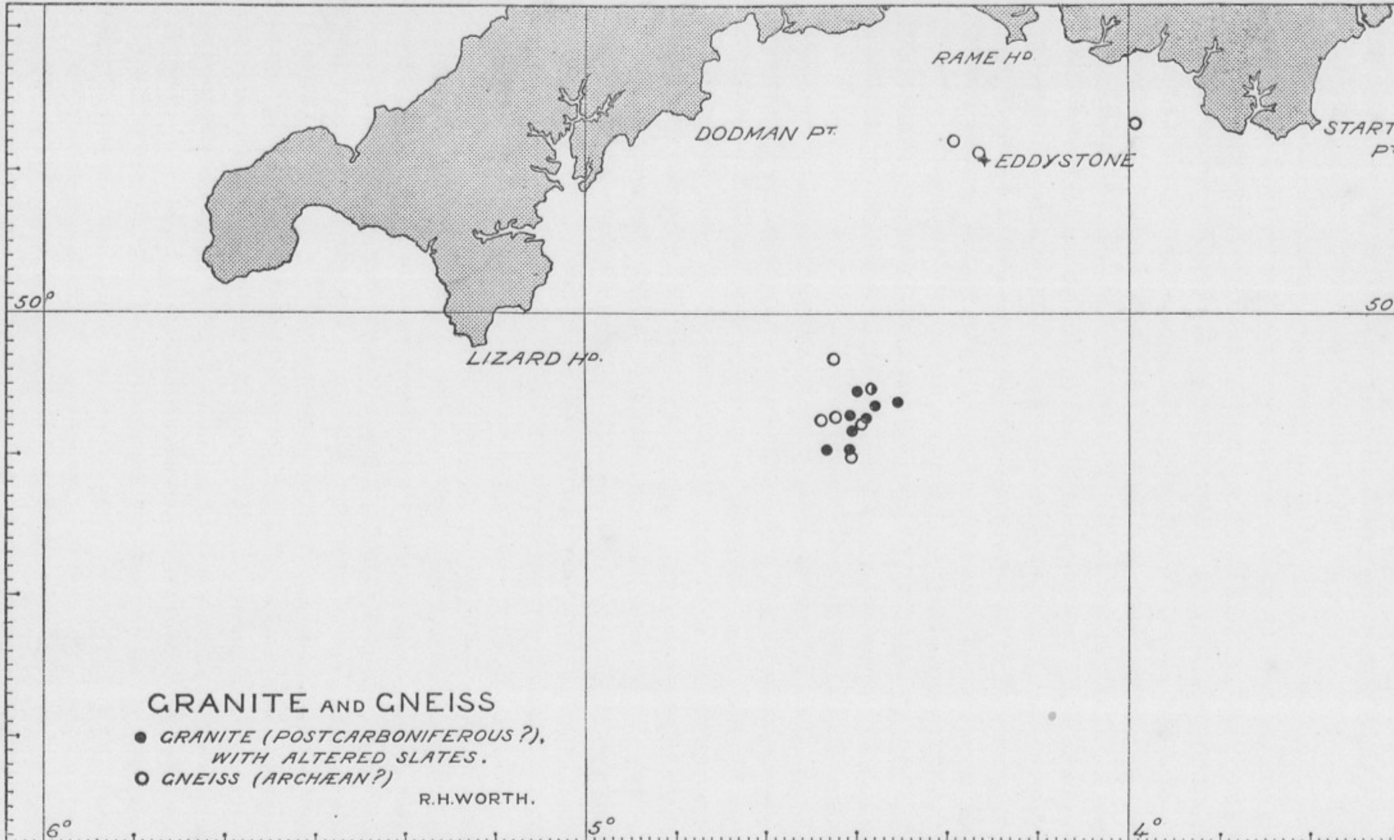
We now know, as we did not then, that gneiss occurs at the East Rutts, and chlorite schist off Stoke Point, in each case without any trace of their presence being visible on shore.

Gneiss also occurs at **M. 36, M. 9, M. 16,** and **M. 25** stations, which all lie in a narrow north and south strip, extending from 17·5 miles S. 37° W. from the Eddystone to 23 miles S. 24° W. from the Eddystone, a strip not quite three miles broad. **M. 11x** and **M. 20g** might also be classed as gneiss, and would somewhat broaden the patch referred to. In any event there is a certain localisation about these associated rocks. The writer has always hitherto leant to the hypothesis that the Eddystone gneiss was of Archæan age. From the features of similarity the gneiss from this area would presumedly be of the same formation. And there is an interesting piece of evidence which at least tends to indicate age. A number of grit stones have been dredged from various parts of the area examined (see p. 142). Among these is **M. 9d,** and that rock contains as derived fragments particles of just such gneisses as occur in the neighbourhood.

It is impossible to correctly date the grits, which may be either Carboniferous or earlier, perhaps more probably the latter.

Turning next to the schists. One of the most interesting finds was off Stoke Point, where chlorite schist is not uncommon (see p. 139). This brings the Bolt series many miles west. For the rest, the petrological notes give all the useful information.

As bearing on the age of some of the plutonic rocks we have to observe that there is an area over which slates are common which show evidence of contact metamorphism. The northernmost point of this area is **M. 11, S. 26° W. Edd., 17·8 miles,** the southernmost is **M. 24, S. 24° W. Edd., 22·5 miles,** about five miles long; the patch is from one to


RAME HD.
DODMAN PT.
EDDYSTONE
START PT.
50°
50°
LIZARD HD.
GRANITE AND GNEISS
GRANITE (POSTCARBONIFEROUS ?), WITH ALTERED SLATES.
GNEISS (ARCHÆAN ?)
R.H.WORTH.
6°
5°
4°

To face p. 166.

three miles in breadth (see p. 144); it is quite possible that similar rock in small quantity may occur outside this area and have been overlooked. **M. 14j** has been taken as the type. Possibly these slates are carboniferous; they more resemble the carboniferous series lithologically than the Devonian. It is to be noted that side by side with these slates occurs a red felsite, and red granites occur also. This distinctly looks like an area where the contact plane of the granite and the sedimentary rock is near to or reaches the surface. Felsites and red-coloured granites would be expected near the junction. If these slates are carboniferous, then the granite is post-carboniferous; if Devonian, the granite is post-Devonian, in any event not pre-Devonian. Some interesting features attend this area of altered rock. It is true that Hunt's **H. 19** granite *in situ* occurs 20 miles S.W. of Eddystone. Here, too, have been found the only specimens of schorlaceous granite or aplite **M. 11c, M. 27x**; hence come the other true aplites **M. 24g, M. 14e, M. 34e**; and hence we derive the micro-pegmatite, **M. 11a.**, all granitic, and not dioritic rocks. The only schorl rocks, except **M. 14f** and **M. 72**, come, however, from **M. 31** and **M. 36**, one to two miles north of this area, and possibly in the absence of **M. 11c.**, **M. 27x** would be regarded as strays. Such was the writer's first thought; but considering the nature of the adjacent rocks, he now inclines to believe that both schorl rock and schorlaceous granite truly belong to the area. The presence, in addition to the above-named, of diorite, quartz diorite, and some intermediate igneous rocks is not overlooked.

The areas of gneiss and altered slate lie side by side, but neither can claim exclusive occupation of its portion of the bed of the Channel. (Plate XIV.)

Since very little good can result, with the present materials, from any further attempt to deal with the plutonic and metamorphic rocks, we next turn to the New Red Sandstone, which overlaps and partially overlies the district just considered.

NEW RED SANDSTONE.

The westernmost shore exposures of New Red Sandstone are at Thurlestone in Bigbury Bay, and in Cawsand Bay on the Mount Edgcumbe shore. There is also on the beach at Drake's Island in Plymouth Sound an untravelled block of breccia of Triassic aspect, weighing about four or five tons.

The mica-andesite (felsite of the Geological Survey) at Withnoe in Whitsand Bay is an intrusive rock, evidently connected with the red trap in Cawsand Bay, and undoubtedly of New Red age. **354/4b** 6½ miles W. from Rame Head lies on another exposure of this same igneous series.

De la Beche, whose work stands as a model of careful discovery and accurate inference, with reference to the red trap of Cawsand writes: "Though unable to adduce direct proof, we are inclined to refer this porphyry, from its general character, to the date of the lower part of the red sandstone series, and to infer that it may be connected with a portion of that series beneath the sea in the direction of Bigbury Bay, on the coast of which, near Thurlestone, we find the patch above noticed."[1]

In 1867 Pengelly, and in 1886 Worth, supplied proof and confirmation as to the age of the 'porphyry.' And in 1898 the writer, as the result of Dr. Allen's dredgings, was able to assert that there was strong evidence that from the Hand Deeps to Bigbury Bay the New Red rocks were continuous. It may now be added that conglomerates dredged from off the *Mewstone Ledge* are distinctly of the New Red type. In the gravels and sands between the Eddystone and the Bolt New Red materials everywhere constitute a considerable percentage of the rock fragments.

In the vicinity of the Eddystone and the Hand Deeps New Red rocks are found *in situ* (wherever rock is exposed), through which protrude the reefs. The conglomerate at the Hand Deeps contains fragments of the local schists and gneisses.

The lithology of these rocks having been fully treated of in the first part of the paper, it is not proposed to make any repetition here, but pages 144 to 148 inclusive may be referred to. Although the variety of the rocks is considerable, all, or almost all, appear to be Triassic rather than Permian in character.

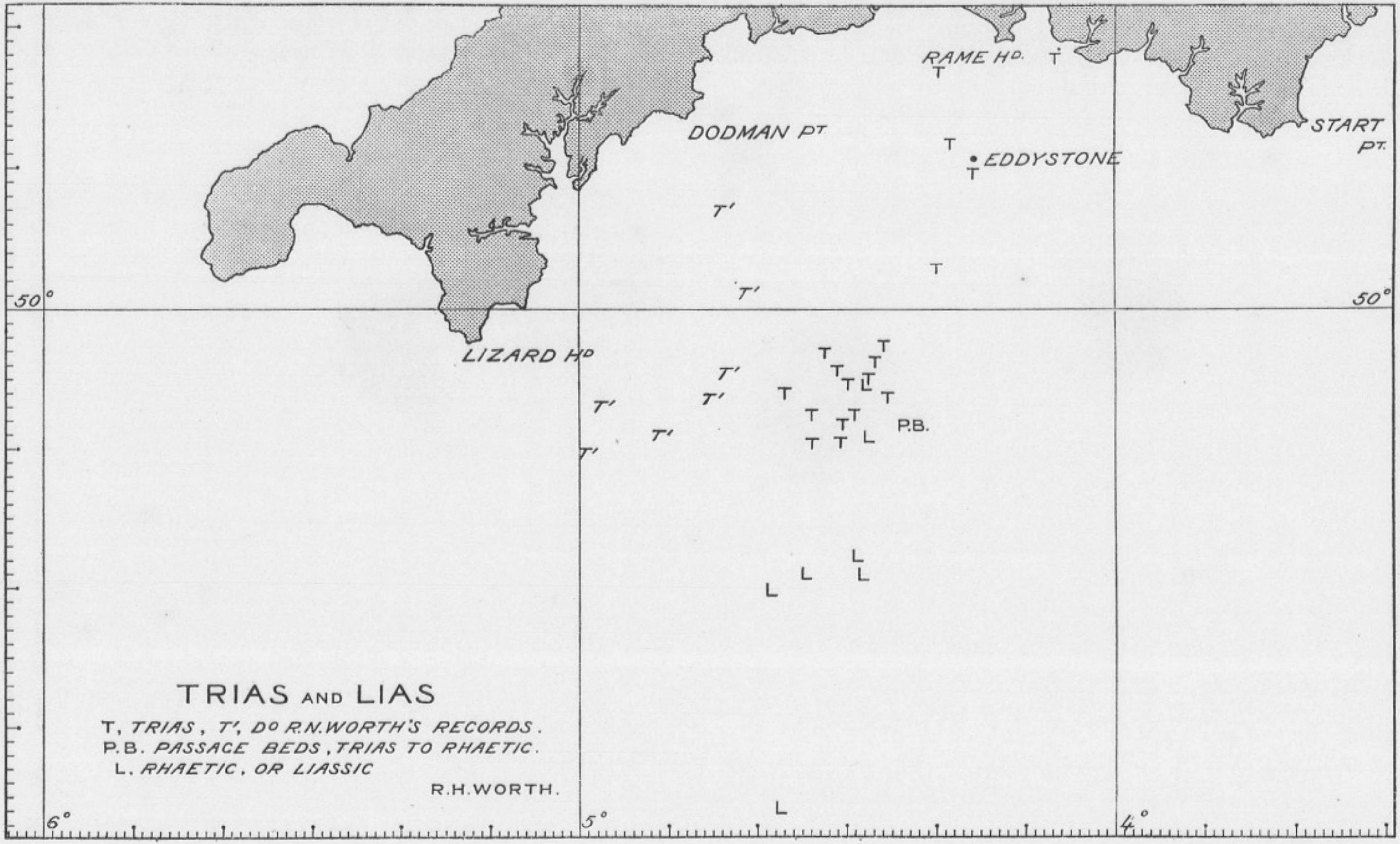
Only one of Hunt's specimens has any bearing on this formation, and that is **H. 10**, S. Edd., 20 miles—"Triassic Sandstone."

Worth's discoveries further westward, meeting and overlapping the Association's latest dredgings, are of especial importance; these carry the Trias to a point **W. 5**, S.W. by S. (mag.) Dodman, 25 miles, roughly 36 miles from the Eddystone.[2] He doubted the eastward extension of the outlier, on evidence which has interest as confirming the Association's results. In fact the Trias does so extend, but his two eastern-most points lay one on either side of the broad belt which it forms. His **W. 12**, S. by E. Dodman, 27 miles, lies about 3 miles north-east from **M. 29**, and at the latter point we now know that the Trias has given place to higher strata. **W. 12** yielded no Triassic rocks.

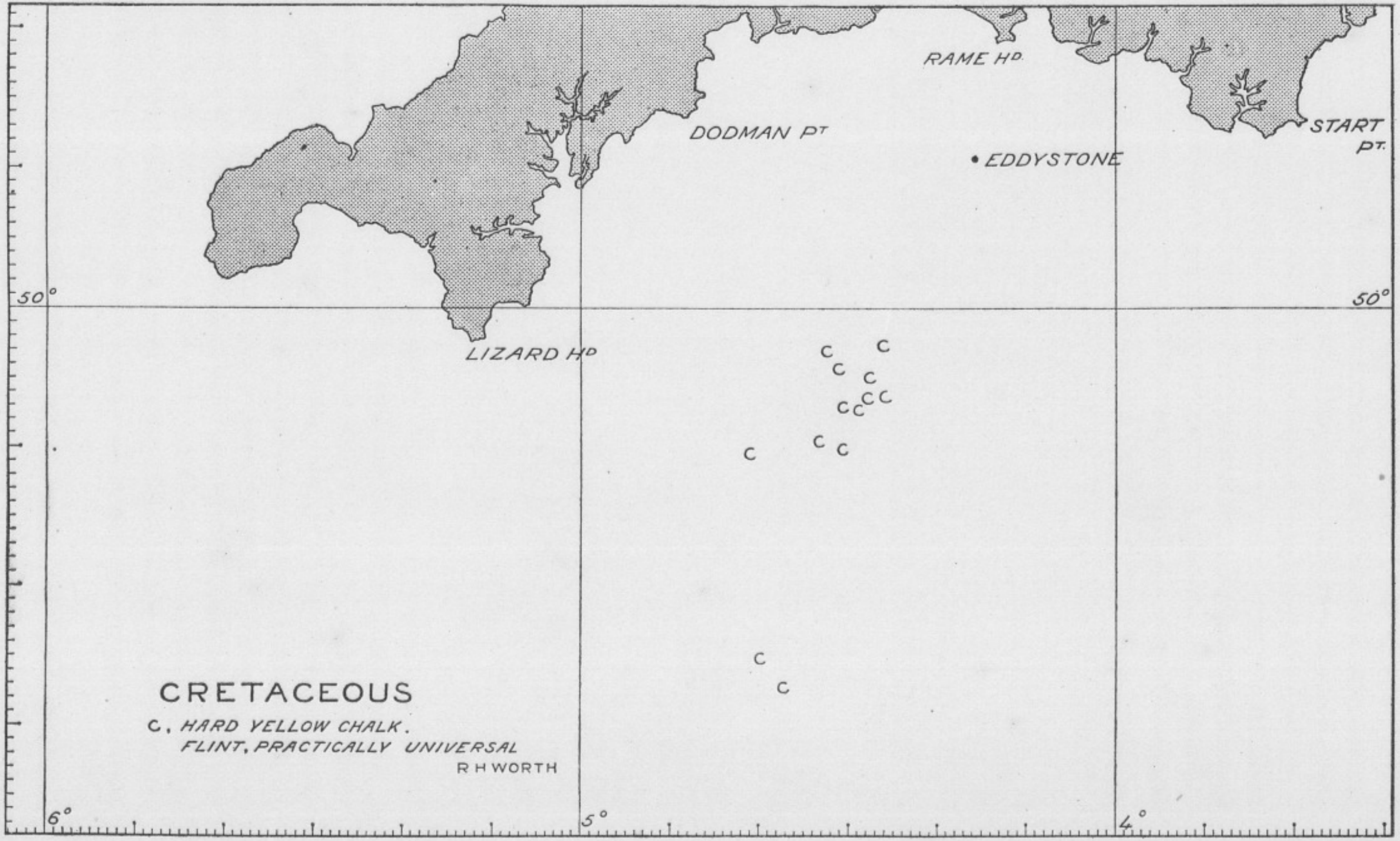
His **W. 6**, S. by W. Dodman, 20 miles, in addition to a salmon-tinted

[1] *Report on the Geology of Cornwall, Devon, and West Somerset*, p. 212, 1839.

[2] "On a Submarine Triassic Outlier in the English Channel," *Q.J.G.S.*, Vol. XLII, 1886, p. 313–15.


RAME HD.
DODMAN PT.
EDDYSTONE
START PT.
LIZARD HD.
50°
6°
5°
4°
P.B.
TRIAS AND LIAS
T, TRIAS, T', DO R.N.WORTH'S RECORDS.
P.B. PASSAGE BEDS, TRIAS TO RHAETIC.
L, RHAETIC, OR LIASSIC
R.H.WORTH.

To face p. 168.


RAME HD
DODMAN PT
EDDYSTONE
START PT.
50°
50°
LIZARD HD
CRETACEOUS
C, HARD YELLOW CHALK.
FLINT, PRACTICALLY UNIVERSAL
R H WORTH
6°
5°
4°

To face p. 169.

calcareous sandstone (Triassic), yielded pebbles of granitic, granitoid, and quartzite rocks, with flints, thus confirming **M. 40,** five miles westward.

On the chart here inserted the letter T indicates those dredgings made by the Association in which *New Red* rocks have been found; while WORTH's records are marked T'. (Plate XV.)

The point at which the *passage-beds* above the Trias were found is marked P.B., and L indicates limestones and marls of *Liassic* type.

CRETACEOUS.

Inasmuch as flints are recorded from practically every dredging, it is useless to place the localities on a special chart.

A chart has, however, been prepared showing the distribution of the hard yellow chalk. The northernmost location would appear to be HUNT'S **H. 13, S.W. Edd.,15 miles**; his record of "a small piece of buff-coloured limestone, riddled through and through by molluscs and other marine borers," probably refers to a piece of this chalk. From this point to **M. 41,** a distance of, say, 11 miles, records are frequent in the Association's dredgings. There is then a gap for about 14 miles, and following this two localities occur, **M. 58** and **M. 67**. (Plate XVI.)

The affinities of this yellow chalk appear to be with the 'Melbourn Rock,' described by Mr. A. J. Jukes-Browne, and later by the same author in collaboration with Mr. W. Hill.[1]

Whether lithological similarity in this case implies identity of age may be doubtful. But the writer is indebted to Mr. Jukes-Browne for the loan of some slides from his collection, and finds much in common between these and his own slides prepared from the dredged material. Unfortunately the latter contains no recognisable remains of any zonal fossils. If of the same age as the Melbourn Rock, the specimens indicate a formation lying at the base of the Middle Chalk.

EOCENE.

The one block of Eocene limestone is of great interest; it is large, over one foot in length, flat-bedded, and angular. From its nature it cannot have travelled far and preserved its present form; indeed, it must practically have been taken *in situ.*

The possibility of Eocene strata occupying some part of the western bed of the English Channel had been recognised before this specimen was taken, and the grounds for that recognition have been so well summarised by Mr. Jukes-Browne, that no apology is needed for inserting here an extract from his work, *The Building of the British Isles* (1892):—

"From the superposition of marine limestones upon the lignitic

[1] "The Melbourn Rock, etc.," *Q.J.G.S.*, Vol. XLII, 1886, p. 216 *et seq.*

series of the Paris Basin, and the sudden appearance in them and in their English equivalents of tropical forms of mollusca, it was formerly supposed that a subsidence took place which submerged part of the intervening land and allowed the waters of the great Eocene Mediterranean to occupy a portion of the low-lying tract on the northern side of the barrier. But the discovery by M. Vasseur of deposits with fossils of the Calcaire Grossier age near the mouth of the Loire, and the identity of their fauna with that of similar deposits in the little basin of Carentan in Normandy, makes it much more probable that the

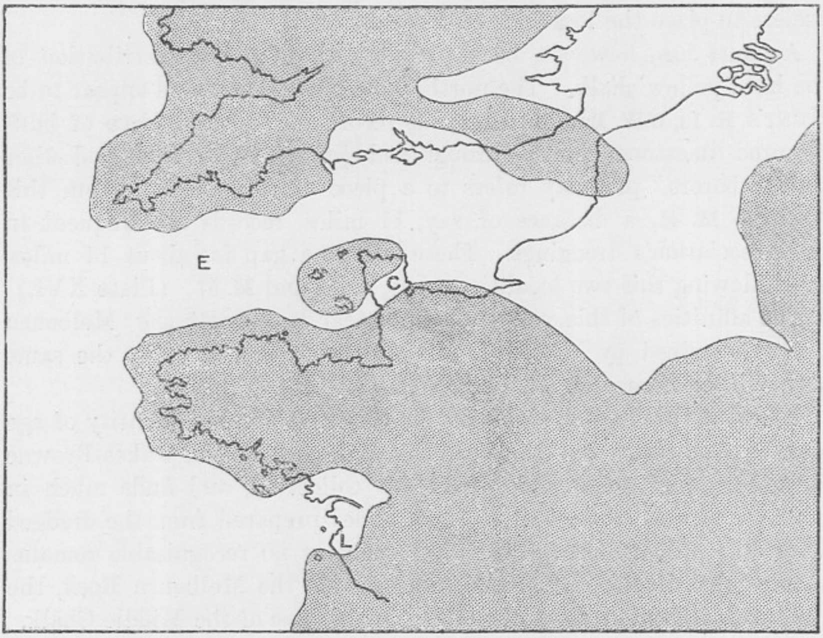


FIG. 3. The English Channel in the Middle Eocene Period. Land areas shaded. (After Jukes-Browne.)

incursion of warmer water came from the Atlantic. Professor Hébert remarks that the height of the ground between Carentan and Rennes makes it impossible to suppose that these two basins were directly united. Brittany must have formed a promontory between the inlet of the Loire and a channel which ran through what is now the opening of the English Channel. M. Dollfus is of the same opinion, and has recently proved by his researches along the south side of the Paris Basin that there was a continuous shore-line along that district throughout the whole of the Eocene period.

"It is fairly certain, therefore, that the opening was westward, and was nothing less than an incursion of the Atlantic into the North

European region. We may suppose that the Atlantic waves had long been thundering against the western land which united France to Ireland, and that at last only a narrow tract of rocky land between Cornwall and Brittany remained to separate the western ocean from the lowland of the Anglo-Parisian area. The final breaching of this was accomplished during the subsidence to which the Calcaire Grossier testifies; the waters of the Atlantic soon widened the straits, and established a sub-tropical fauna and flora on the southern shores of Britain."

Mr. Jukes-Browne gives a map showing the geography of the Anglo-Gallic area as so interpreted; this with some addition and curtailment is here reproduced (Text, fig. 3). The Eocene of Carentan has been marked 'C,' the similar strata near the mouth of the Loire have been marked 'L,' and the position of the dredging **M. 77**, from which came the Eocene limestone, is indicated by the letter 'E.' The confirmation afforded by this discovery to the views of French geologists, in a problem the key to which lies in their country, is a pleasant matter to record.

GENERAL CONCLUSIONS.

The affinities of the crystalline rocks in the area examined are strongly toward Brittany, and but slightly toward the mainland of Devon and Cornwall.

There is evidence, amounting at the least to a strong suspicion, that the granite which occurs at and around a point 20 miles south 26° west from the Eddystone is post-carboniferous; and this granite exhibits a tendency toward the Dartmoor type.

The Triassic outlier off the Lizard and Dodman discovered by the late R. N. Worth has proved to be connected eastward with an even larger area of New Red Sandstone rocks, which may very probably be continuous with the nearest shore exposures.

A clear indication of the eastern boundary of the Trias has been found at a point about 20 miles south 17° west of the Eddystone. There seems fair reason to suppose that the western boundary of the Jurassic formations may for a short distance approximate to a line drawn south-west from this point. It may, however, be noted that Lias limestone was found in a detrital deposit at Cattedown (Plymouth) by the late R. N. Worth.

The Cretaceous rocks dredged from the Channel are now for the first time recognised to include chalk as well as flint. There is some possibility that the rock found is from the base of the Middle Chalk.

Flints, in addition to occurring on modern beaches, are found also in the raised beaches of Devon and Cornwall; were very numerous, associated with Dartmoor rocks, in the detrital deposits lying on the limestone at Cattedown, and examined by R. N. Worth; have been found by the writer, again associated with Dartmoor rocks, on the floor of clay-filled fissures in the Plymouth Limestone 20 feet below low water, and have been found by him on the rock beds of the Plymouth estuaries, buried beneath the silt.

As a result of the dredgings a considerable westerly extension of the boundary lines of the Trias, the Lias, and the Cretaceous must be made on our maps, beyond the present usually accepted speculative bounds. And the theory of an Eocene drift, sometimes put forward to account for the flints, must be abandoned.

It appears that from distant geologic time a depression has existed, having the same trend as the western part of the English Channel, and occupying a part at least of the same area. The New Red Sandstone first distinctly shows the previous existence of this depression. From Torbay to Plymouth the northern verge of the New Red deposits touches the present shore-line here and there; always the derived fragments in the conglomerates and sandstones are largely from local rocks. From Plymouth to nine miles south-east of the Lizard it runs parallel to the coast without absolutely touching it, and how far further west it extends we do not at present know. An arm of the great inland sea of this period, probably of its later or Triassic years, had its northern shore much where the waters of the Channel now meet the cliffs of Devon and Cornwall. How wide the Trias lake was along this western extension cannot at present be known; its deposits are lost under those of the succeeding Liassic sea, perhaps to reappear nearer France, perhaps not.

During the later Jurassic period this depression would appear to have slowly risen free from the waters, and in part, if not in whole, to have become a subaerial valley.

The Cretaceous era witnessed its entire submergence, although the highest points of Devon, where Dartmoor and Exmoor now stand, may have appeared as islands above the surrounding waters.

This submergence was gradual. A problematic coast-line of the time of the Lower Chalk has been laid down by Mr. Jukes-Browne.[1] By that author's consent the map accompanying his paper in the *Transactions of the Devonshire Association* is here reproduced (Text, fig. 4).

It may be that the westerly extension of the Cenomanian sea has not been sufficiently prolonged; be that as it may, the sea of the Upper Chalk sent an arm westward to the Lizard parallel or probably beyond.

[1] "Devonshire in the Time of the Lower Chalk," *Trans. Dev. Assoc.*, Vol. XXXV, 1903, p. 787 *et seq.*

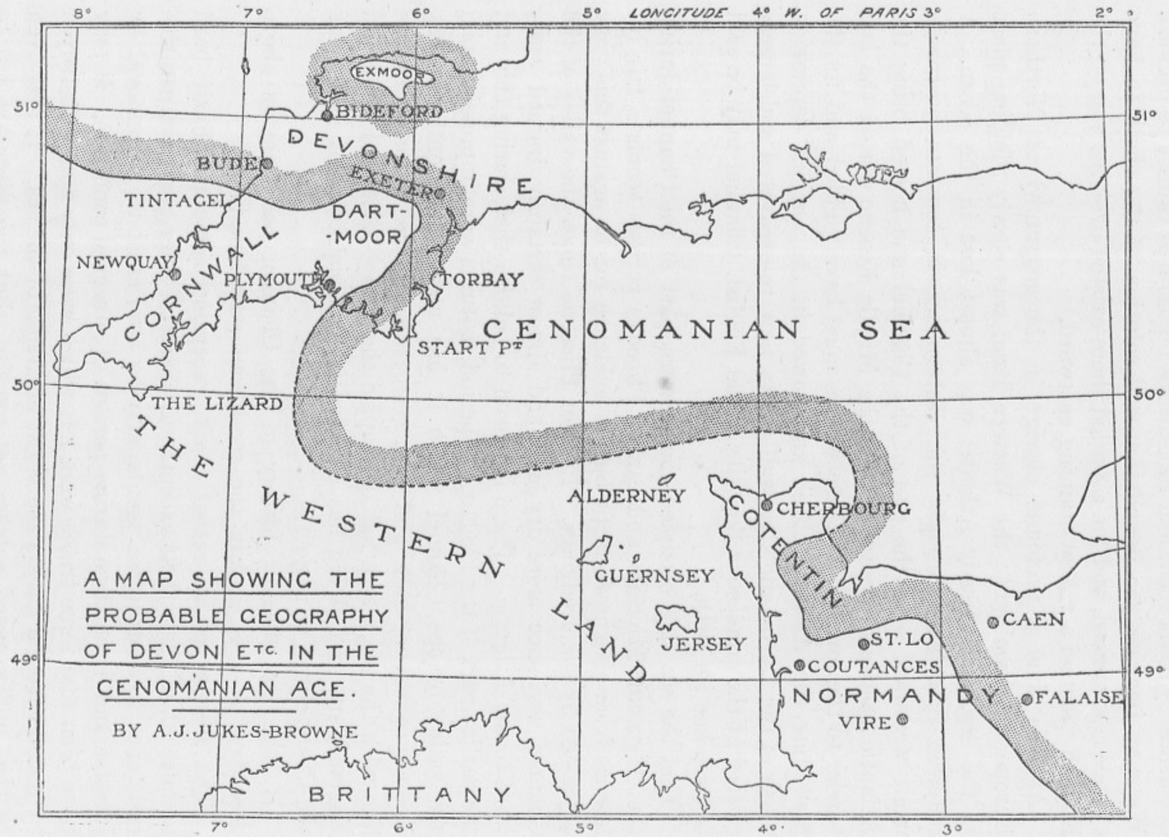


Fig. 4. Map showing the probable geography of Devon, etc., in the Cenomanian Age. (By Jukes-Browne.)

The next movement of the earth's surface involved an emergence of the land, and the depression which we are considering came into subaerial conditions once more; how far it had been filled in the meantime by chalk rocks and its features obliterated cannot be decided. We may imagine the denudation and solution of the chalk to have at once commenced, and for a period there existed over the site of the English Channel a valley draining eastward.

At this time a profound change in the geography of Northern Europe was imminent; the Western Land was slowly yielding place to the sea, and already Atlantis was almost lost in the ocean. A renewed subsidence brought the eastern sea in constant encroachment westward over the site of the Channel and helped bring the Atlantic eastward toward it. In the Middle Eocene period the last barrier to the junction of these waters must have yielded, and for the first time the Atlantic ebbed and flowed in the ancient depression south of the Devon and Cornwall coasts, now re-excavated and largely cleared of the cretaceous deposits. The English Channel may be said to have had its birth.

That the sea still occupied the western part of the Channel during the Oligocene, Miocene, and earlier Pliocene periods seems a fair inference from all known facts, but no evidence for or against this view is yielded by the dredgings. In later Pliocene times the valley of the Channel was once more dry land, and almost certainly drained westward to the Atlantic. There is reason to believe that, during this and the earlier part of the Pleistocene period, features were impressed upon the valley of the Channel which it has never since entirely lost. Despite occasional halts and even retrogressions, the victory has since lain with the sea, which has reoccupied the valley between France and England, and in so doing has modified its contour, bringing into being the Channel bed as it now is.

If the true physical history of the Channel has been as above described, does it explain the conditions now found?

The absence of all actual chalk, excepting some peculiarly hard nodules which from their exceptional character offer great comparative resistance to destructive agents, may be attributed to its removal by solution and denudation during periods of subaerial condition. It may have been that some traces were left which were only finally destroyed by marine erosion during the latest incursion of the sea. It may even be that undiscovered patches yet remain. But the flints are left to indicate where the chalk has been.

Bare patches of soft sandstone and softer marl present no difficulty of explanation. Assuming the last subsidence to have been even moderately rapid, the shore-line would never have presented any considerable height of cliff. Fringing the cliff in all bays and many creeks would be beaches of sand and shingle derived chiefly from the local rocks. Beyond the beach, where soft strata existed would be tidal plains of marine erosion, such level surfaces as now exist between tide-marks in Torbay. The constant advance of the sea, the constant depression of the land, would ever carry forward the line of shore, the sea-cliff for the time being existent, and the beach would follow; its material would always be largely derived from the actual cliff, but in part consist of older material driven forward by the waves. The rocky plain would sink beneath the sea, and be left as a rather uniform surface of slight gradient seaward. Little or no beach would be left behind, and the older constituents of the beaches, those derived from the outer previous shore-lines, would never long persist, the constant wear reducing and destroying them.

Boulders from harder rocks would not be driven on in the same manner as pebbles and shingle, but would remain near their points of origin. Until, however, some considerable depth of water flowed over them, such boulders would still be liable to wear from exceptional wave action; and, further, we may consider that, especially with the granitoid rocks, submarine weathering must produce, but in a greatly less degree, the familiar effects of subaerial exposure. The chief and important difference would arise from the more uniform temperature of the sea.

There is reason to believe that the first inlet of the sea was somewhat long and narrow, a comparatively sheltered area, where wave action would be slight. That large and relatively unworn stones might be left here would be no occasion for surprise. And as the land sank and the Channel widened, this first-formed portion of its bed would still receive some shelter, until it was covered with water too deep to permit destructive wave-action. Extending the argument, there seems here a reasonable explanation of the general increase in the size of the dredged stony material outward into the Channel. Other causes may have co-operated. That wave action beyond the forty-fathom line has little or no destructive effect upon the pebbles at present, may be judged by the existence of pieces of yellow chalk and of Lias limestone bored and riddled through and through and yet in pebble form.

But in a narrow sea, while the wave action would be slight the tidal currents would be swift, and sand would not readily deposit; hence the fact that these stones were not buried beneath finer deposits derived from the shores.

Even now, could the fine sands which float about in the Channel find a resting-place in its main water-way, a very short period would suffice to bury the stones and boulders. The surface tow-nets used on the cruises undertaken for the purposes of the International Sea Fisheries Investigations constantly catch considerable quantities of fine sand. But sand which by wave disturbance can be maintained at the surface over a depth of forty or fifty fathoms requires but a slight current to prevent it coming to rest on the bottom. It is not necessarily that the currents scour the inorganic sand from the sea-bed, but that they prevent its settlement there.

As regarding organic carbonate of lime, shell, and other material, which is forming even now in the deeper parts of the Channel, the currents must be credited with removing some of this mechanically, some by solution, as the particles become finer by disintegration, and the redeposit of such material must take place in quieter waters. Otherwise from the accumulation of this débris alone the stones would long since have been entirely covered.

Defective argument may be based on accurate observation, and if the hypotheses above put forward are found incapable of bearing the test of closer reasoning or of fresh discovery, the apology for their being must stand—that they are based in fact, and in fact the statement of which has been in no way influenced by them.

On two points further work is in hand: the examination of the flints for fossils, and the closer inspection of the baked shales from the neighbourhood of the presumedly Post-Carboniferous Granite.

AN ADDITIONAL NOTE.—THE SANDS AND GRAVELS.

Fine materials, sands and gravel, from eighteen dredgings have been examined, but not in such detail as might be desirable.

As a whole the mineralogical results confirm the conclusions derived from the stone samples; so closely are these in agreement that a very few points need be noted.

M. 29. S. 14° W. Edd., 19·8 miles, gives exactly the same results in the fine material as in the pebbles, small fragments of the passage-bed marls being fairly frequent, and no Triassic rocks present.

M. 71. S. 23 W. Edd., 19·0 miles, yields Triassic material, which **M. 72**, a coarse dredging from the same spot, did not; this is within the New Red Sandstone area.

M. 75. S. 20° W. Edd., 38·1 miles, yields a little Trias.

M. 65. S. 22° W. Edd., 42·2 miles, possibly contains a little Triassic material.

The southernmost find of New Red Sandstone rocks among the pebbles having been **M. 18, S. 29° W. Edd., 23.4 miles,** this trace of the same in the sands shows in all probability an outward and downward movement of small quantities of detritus, extending nearly twenty miles, certainly fifteen miles. This is the only evidence of any but very restricted movement among the mineral constituents of the sands, and it must be remembered that Triassic sandstones and marls are present in great quantity on their own area, and the amount of detritus would be proportionately large, some might well have trespassed on to other ground.

In all but this matter the inorganic sands agree so precisely with the closely adjacent coarse deposits, even in minute detail, and their constituents are so exactly parallel, that great strength is given to the previously urged view as to the value of the dredgings for approximate geological mapping.

In the gravels of some dredgings sharp chips of brown flints are rather common. Such angular flint flakes were taken at **M. 37, S. 41° W. Edd., 17·1 miles, M. 71, M. 40, M. 73, M. 56, M. 75, M. 76, M. 65,** and **M. 61, S. 25° W. Edd., 46·4 miles,** extending thus over a long range. For the more part the surfaces of the chips are practically undecomposed, and all are of brown flint. (It is black flint which chiefly shows the extreme alteration referred to in an earlier part of this paper.) These chips do not, however, look quite recent. They are such as would be formed by the mutual impact of subangular flints, possibly but rarely of broken flint pebbles. They could never last long on a beach or in any depth of water to which considerable wave action extended, although such wave action might constantly create a fresh supply. With a stationary shore-line a few such chips might be found a little below low-water mark, but only rarely. On the other hand, with an advancing shore-line and constantly deepening water it is quite easy to imagine that, formed on beaches or in shallow water, they might be placed in deeper water conditions soon enough to preserve many of them from destruction. Taking the deposit at Hallsands as an instance of a flint beach, long stationary, I may say that I have never dredged off that shore any such flint chips, although it must be imagined that some are at times formed. But probably one reason for their absence at Hallsands is the extent to which the shingle has been rounded, and a broken pebble is most rarely found; while with the sea advancing over a land surface covered with unrolled flints the process of rounding these into pebbles or commencing such rounding would give rise to very numerous chips. The fragments are therefore the supplement of the subangular blocks of flint still associated with them, and they persist—firstly, because the original supply was great; secondly, because for some time after their formation the sea was constantly deepening over them; and lastly, those only remain which have formed from material capable of resisting decomposition.

APPENDIX I.

M. Delesse on the English Channel. Translated extract.[1]

"*La Manche*, which washes the whole north-west of France, is a shallow sea, its mean depth being no more than 45 metres. Its basin shoals near the coasts of France and England, and also toward the *Pas-de-Calais*, while deepening toward the Atlantic.

"We would direct attention to the submarine terraces which border the coasts as among the principal features of the orography of *la Manche*. Outside these terraces somewhat numerous banks occur, especially toward the *Pas-de-Calais*, as, for instance, the *Bassure*, the *Vergoyer*, and the *Colbart*, which lie near and parallel with the French coast.

"Note should be made of the central deep which stretches from off the county of Sussex to *Finistère*. Near *cap de la Hague*, at the western extreme of *Cotentin*, it twists and presents irregular ramifications.

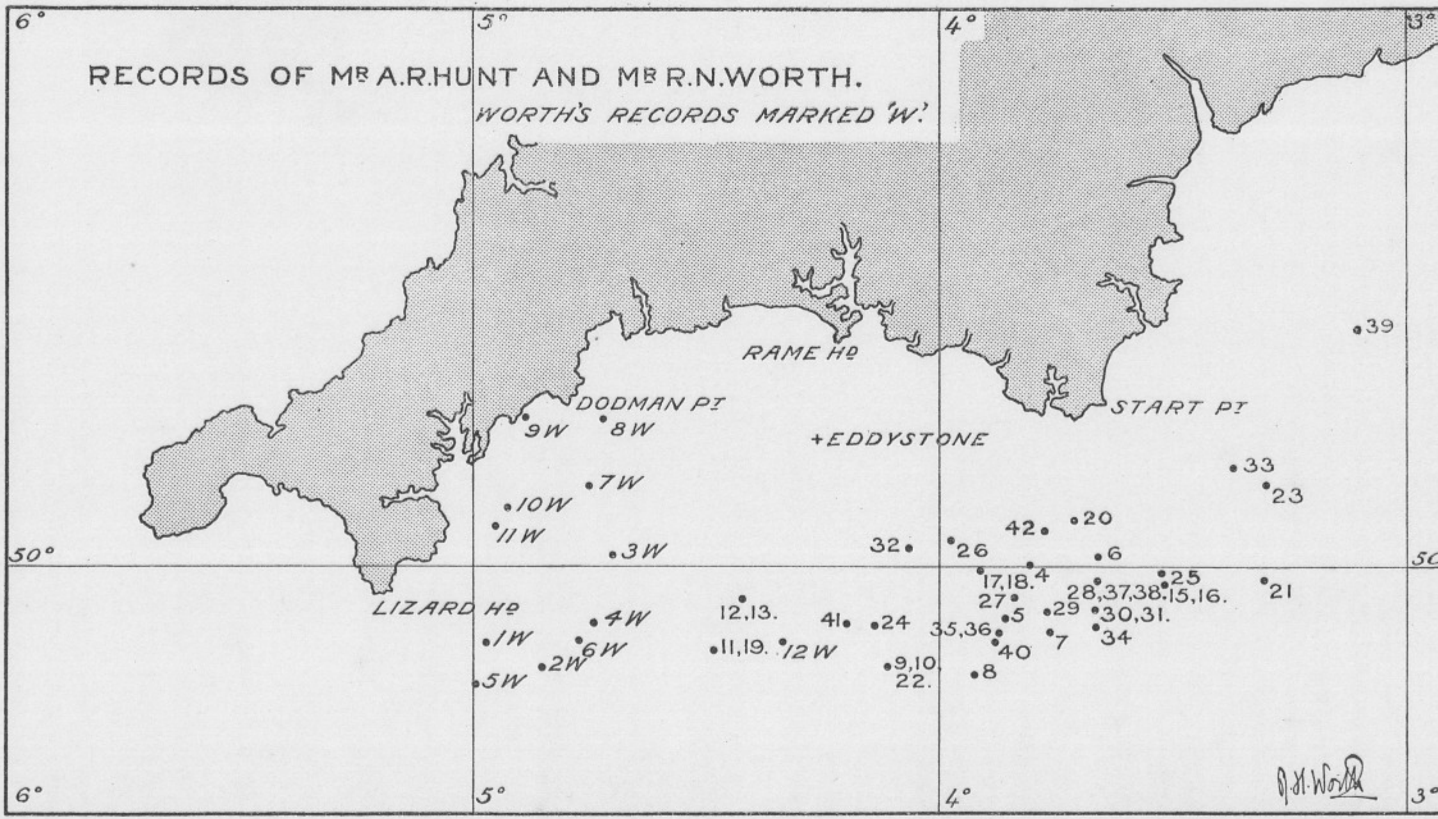
"In breadth but slight, in depth it much exceeds the rest of *la Manche*, reaching even, at the west of *cap de la Hague*, to over 160 metres. This central deep corresponds to a submarine valley, and that it has not been scoured out by the currents of *la Manche* its characteristics clearly show. It is formed, on the contrary, by a deep cleavage, having a general direction of E.N.E., and, although very narrow, not yet filled by recent deposits.

"Since *la Manche* is swept by strong currents, it should follow that deposits are not universally received on its bed, which, on the contrary, should frequently be formed of rocks (*roches pierreuses*) of earlier than the present period; and this, in fact, the soundings show, while these rocks occupy an even greater proportional area of the bed than in other seas.

"In the first place, they cover large areas in the western part of *la Manche*; they border Brittany and Cotentin, which they join to Jersey and the other Channel Islands; and further they unite Brittany to Cornwall, and Cotentin to the south of England. Cutting out on very irregular boundaries, not only do they spread along the coasts, but pass completely across *la Manche*, extending even to the deepest parts of its basin and the mid-course of its valley.

"These rocks are certainly very varied; between Brittany, Cotentin, and Cornwall and Devonshire, they are, however, either granites, or belong to the

[1] *Lithologie des Mers de France*, etc., p.p. 308–9.


RECORDS OF MR A.R.HUNT AND MR R.N.WORTH.
WORTH'S RECORDS MARKED 'W.'
6°
5°
4°
3°
50°
RAME HD
DODMAN PT
START PT
+EDDYSTONE
LIZARD HD
9W
8W
7W
10W
11W
3W
4W
1W
6W
2W
5W
12W
12,13.
11,19.
41
24
9,10,
22.
32
26
42
20
6
4
17,18.
27
5
29
28,37,38.
25
15,16.
30,31.
34
35,36
40
7
8
33
23
21
39
R.H. Worth

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transition formations. Soundings show that they consist in part of detached stones (*pierres désagrégées*); in addition to which rotten rocks (*roches pourries*) are frequent around latitude 49° 15′, longtitude 7° 10′ (W. of Paris), in the mld-course of the valley of *la Manche*.

"Further to the east the rocks should be submarine extensions of the secondary formations which build up the opposite coasts of France and England. Thus the coast rocks of *Calvados*, which are limestones of the lower Jurassic period, are continued far out under the sea. And, similarly, white chalk is found at a considerable distance from the chalk cliffs of *Fécamp*, of *Dieppe*, and of *Saint-Valery en Caux*, and is especially prominent on the bed of the *Pas-de-Calais*," etc.

APPENDIX II.

By the kind permission of Mr. A. R. Hunt, M.A., F.G.S., the following petrological notes, abstracted from his papers on the Submarine Geology of the English Channel[1] are here reproduced.

In his work, Mr. Hunt had the assistance of the late Mr. E. B. Tawney, M.A., F.G.S. (E. B. T.), Prof. T. G. Bonney, M.A., F.G.S. (T. G. B.), and Mr. A. Harker, M.A., F.G.S., (A. H.), and all the notes herein included are taken from the descriptions written by some one or other of these petrologists.

The initials of the authorities, as given above, follow each entry.

Although for present purposes the notes have been somewhat shortened, no variation has been made amounting in any way to more than the exclusion of minor detail.

All bearings are magnetic, and bearings and distances alike are given on the authority of the fishermen who trawled the blocks. Hence minute accuracy can not be expected, but, on the other hand, subsequent experience indicates that probably no very considerable error has been made. (Plate XVII.)

CRYSTALLINE ROCKS.

Eight Granite. Nos. 2, 19, 20, 27, 34, 35, 39, 42.

H. 2. Doorstep of Brixham Orphanage. A granite of moderately coarse grain and pinkish colour, with large pale flesh-coloured orthoclase twins.

Biotite and muscovite in about equal proportions. Orthoclase largely predominant, but some plagioclase present.

The quartz contains cavities, some with moving bubbles; also microlite needles, and hair-like delicate crystals of undetermined character. Some apatite is present.—E. B. T.

[1] *Transactions of the Devonshire Associations,* 1879, 1880, 1881, 1883, 1885, 1889.

H. 19. Broken off by trawl about 20 miles S.W. of Eddystone.

Granite of coarse grain. Both white and black micas present. A little triclinic felspar in addition to the orthoclase. The quartz contains large fluid inclusions with bubbles. Apatite is abundant in rather large crystals.—E. B. T.

H. 20. About 10 miles S.W. by S. of Start Point, weight about 15 to 16 cwt.

A coarse grey granite with silvery mica in addition to dark mica. Felspar chiefly orthoclase, but a little triclinic felspar, including microcline, is present. The quartz contains fluid cavities. An occasional tendency to micropegmatic structure.—E. B. T.

H. 27. Trawled 18 miles S.W. of the Start.

A rather fine-grained granite, reminding Prof. Bonney somewhat of granites from one or two localities in the Channel Isles.

It consists of quartz, felspar (orthoclase, oligoclase (?), and perhaps microcline), and two micas, black and white, the former occasionally somewhat altered.—T. G. B.

H. 34. Trawled 18 to 20 miles S.S.W. of Start Point. Weight 9 or 10 cwt.

A true granite, a good deal decomposed.—T. G. B.

H. 35. Trawled 21 miles S.W. of Start Point. Weight about 5 cwt.

A granite containing quartz, with the usual felspars, hornblende, and brown mica.—T. G. B.

H. 39. Trawled 15 miles S.E. by E. of Berry Head. Weight 4 to 5 cwt.

A rather fine-grained granite of a warm greyish colour. It consists of quartz,—containing fluid cavities, with bubbles and some acicular microliths (? rutile)—felspar, somewhat decomposed, both orthoclase and plagioclase (? oligoclase), brown mica, occasionally somewhat decomposed, a little white mica, and iron oxide.—T. G. B.

H. 42. Trawled 12 miles S.W. of Start Point. Weight 3 cwt.

A moderately finely crystalline rock, speckled lighter and darker grey, looking like a granite, with possibly a slight foliation. Consists of quartz, felspar (orthoclase and plagioclase), and a considerable quantity of brown mica, with a rich colour and strong dichroism. Now and then there is a little white mica.—T. G. B.

FOUR HORNBLENDIC GRANITE. Nos. 4, 21, 24, 25.

H. 4. Trawled 15 miles S.W. of Start Point. A rounded block measuring 3′ 6″ × 2′ 3″ × 1′ 8″.

A coarse-grained rock, exhibiting colourless felspar and quartz, black hornblende, and brown mica. Hornblende and biotite abundantly present. Of the felspars, orthoclase and plagioclase seem in almost equal proportions; both are much decomposed and kaolinised in patches. The quartz contains a quantity of hair-like crystals of undetermined nature; besides these are a few prismatic microlites, and enclosure of minute cavities. Apatite is well developed also.—E. B. T.

H. 24. Trawled 14 or 20 miles S.S.E. of Start Point. Weight about 4 cwt.

A rather coarse-grained hornblendic granite, of darkish tint; the felspars of slightly pinkish hue. Both hornblende and dark mica are present in abundance. The felspar is much decomposed, and is chiefly orthoclase. Apatite present.—E. B. T.

H. 21. Trawled 16 or 17 miles S. of Eddystone. Weight about 5 cwt.

A granite of medium grain, with faint pink-tinted felspars, and in which hornblende is abundantly visible; of biotite there is much less. Though the felspars are much decomposed, plagioclase can be detected in some quantity. Apatite seems nearly absent. Quartzes are clear, but moving bubbles are frequent in the liquid inclusions.—E. B. T.

H. 28. Trawled 15 miles S. of Start Point. Weight 3 to 4 cwt.

To the eye much like No. 24, but differs a little in shade. Biotite more abundant than hornblende; apatite very abundant.—E. B. T.

One Gneiss. No. 36.

H. 36. Trawled about 21 miles S.W. of Start Point. Weight 8 or 9 cwt.

Quartz, felspar (plagioclase predominating), brown mica and some white mica, apatite. Prof. Benney adds: "The rock, I think, is undoubtedly a gneiss, and it is of an Archæan type."—T. G. B.

Three Granitoid Gneiss. Nos. 3, 28, 61.

H. 3. Salcombe Block, buried at Brixham Orphanage.

A rather fine-grained granite-looking rock, in which a certain streaky arrangement of the mica is apparent, the felspars fresh and translucent.

The thin slice shows the micas distinctly set in one direction mainly; they wrap around the felspars or larger quartzes. The felspars show little or no kaolinisation; orthoclase more abundant than plagioclase. Both biotite and muscovite are present. The quartz contains numerous delicate, long capillary crystals, and cavities with bubbles. Apatite is present.—E. B. T.

No. 28. Trawled 15 miles S.S.W. of Start Point. Weight 12 cwt.

A very coarse gneiss rather than a granite. The quartz occurs both in larger grains, rather full of cavities, and in aggregates of small granules. The felspar is in parts more decomposed, and replaced by aggregates of secondary products (micaceous and other microliths), or by a dull greenish granular mineral, perhaps an impure epidote, but in parts is fairly well preserved, microcline being common. There are also flakes of an olive-brown older mica, and a few granules of iron peroxide. "This rock has the aspect of a very ancient Archæan gneiss."—T. G. B.

H. 61. Erratic on shore, S.E. of East Prawle.

A light grey rock with the appearance of a fine-grained granite or granitic gneiss. The foliation seen in the slice is not evident in the hand-specimen.

The rock consists mainly of felspar and quartz, with subordinate biotite, etc. The felspar is chiefly, if not wholly, of triclinic varieties. Much of it is microcline; there is also some oligoclase with carlsbad, and albite-twinning. Most is clear, but there are cloudy patches in places, which seem due to the development of white mica in minute scales. Quartz occurs in large and small grains, usually composite; strain-shadows are common. The biotite has a marked parallel orientation throughout the slice. It is a deep brown, intensely pleochroic mica, becoming green only by alteration. The other elements of the rock are rare magnetite and green hornblende, with some epidote and other secondary minerals.—A. H.

Two Hornblendic Gneiss. Nos. 33, 44.

H. 33. Trawled about 12 miles S.E. of Start Point.

Quartz abundant in irregular aggregated granules, felspar in occasional grains, with very irregular outline; orthoclase (probably) and plagioclase. Green hornblende, a strongly dichroic variety, in streak-like aggregates of long, slightly fibrous prisms, magnetite, a few films of brown mica, a little apatite, possibly zircon.—T. G. B.

H. 44. Trawled block, lying on Brixham Quay.

A medium-grained felspar-hornblende rock with well-marked banding, the white felspathic and black hornblendic bands being commonly from one-twentieth to one-eighth inch in width. There is no evident fissile structure, and the rock is perhaps to be styled a hornblende-gneiss rather than a hornblende-schist.

Felspar, the dominant mineral, is exclusively plagioclase, apparently a basic labradorite. Inconstant twinning is often seen to be clearly connected with a slight bending of the crystal, and must in great part be secondary and the consequence of strain. Most of the felspar is perfectly clear, but there are also cloudy opaque patches, white by reflected light. The abundant green pleochroic hornblende is in ragged or irregularly bounded crystals. Associated with it is a clear colourless augite. This is often embedded in the hornblende, but there is no clear indication of the latter mineral having originated at the expense of augite. No iron-ore appears in the slice.—A. H.

Three Hornblendic Granitoid Gneiss. Nos. 31, 32, 41.

H. 31. Trawled 18 miles S.S.W. of Start Point. Weight about 3 cwt.

Quartz, felspar, brown mica, a little hornblende, and a little green chloritic mineral, perhaps an alteration product after some of the mica, some apatite. The quartz has rather numerous minute cavities, some empty, some with small moving bubbles. The felspar (which is a little decomposed) is partly orthoclase, but there is a good deal of albite or oligoclase.—T. G. B.

H. 32. Trawled 12 miles S.S.E. of Eddystone. Weight about 7 cwt.

Minerals as in 31, but in rather different proportions. For instance, there is more hornblende. The state of preservation is not so good.—T. G. B.

H. 41. Trawled 16 miles S. by W. of Eddystone. Weight 5 to 6 cwt.

A pale-coloured coarse rock with a rather porphyritic structure, the felspar crystals occasionally about an inch long. Quartz containing rather numerous enclosures, chiefly little cavities with small bubbles; felspar, rather decomposed, one crystal in the section is a plagioclase, but the larger crystals resemble orthoclase; white mica; the section shows a good-sized grain of brownish hornblende; some dark granules or grains, probably hematite.—T. G. B.

One Microgranulite. No. 40.

H. 40. Trawled 22 miles S.W. of Start Point. Weight 2 or 3 cwt.

The ground-mass a very intimate mixture of quartz and felspar, exhibiting numerous varieties of micrographic structure. Rather rounded crystals of felspar, up to about quarter of an inch in diameter, generally in fair preservation, and in most cases orthoclase. Smaller and less distinct grains of quartz. Irregular patches of a dark mineral, seen in the section to be a green chloritic mineral, often rendered nearly opaque by the association of brown iron oxide.—T. G. B.

One Quartz Felsite. No. 43.

H. 43. Exact locality unknown. Weight about 12 cwt.

The microscope shows grains of quartz and felspar, and clusters of rather small flakes of biotite, scattered in a microgranular matrix of quartz and felspar, with occasional flakes of biotite or a greenish mineral, possibly a chlorite or a variety of hornblende, with sometimes a certain amount of ferrite staining. The felspar varies much in its state of preservation, some grains being very decomposed, others rather clear. Plagioclase is present.—T. G. B.

Two Syenite. Nos. 7, 9.

H. 7. Trawled about 20 miles S.W. by W. of Start Point. Weight about 4 cwt.

A dark green rock of coarse grain, felspars opaque, tinted with pale green and mixed with black hornblende in about equal proportions. Microscopic examination shows the felspars so much decomposed that they are not individually determinable; many are certainly plagioclase from indications of multiple twinning, whether plagioclase or orthoclase is predominant cannot be determined. There is a considerable amount of quartz present, of which much is certainly secondary; it is seen replacing felspar crystals and originating from their decomposition. The hornblende is green in colour; by decomposition it gives rise to chloritic matter, with which some epidote is mixed; epidote may also be seen in the decomposed felspars. Apatite crystals are large, and specially abundant near the hornblende. Ilmenite is also present.—E. B. T.

H. 9. Dredged 20 miles S. of Eddystone. Weight from $\frac{1}{4}$ to $\frac{1}{2}$ cwt.

The same minerals occur as in No. 7, but it differs by the abundance of quartz, the substitution mostly of chlorite for hornblende, and the obscure linear arrangement of the same.—E. B. T.

FOUR DIORITE. Nos. 1, 16, 22, 62.

H. 1. From Salcombe fishing grounds. Weight $9\frac{1}{4}$ cwt.

Macroscopically this rock shows a pale yellowish-white felspar and a very dark green hornblende, which appear to be rather closely set in a dull yellow-grey rather compact matrix. The slide shows felspar crystals, which have a tolerably regular outline, but are, as a rule, much decomposed, the mineral being often converted into an aggregate of earthly granules. In some of the crystals the polysynthetic twinning of plagioclase is still visible. The hornblende is a rich green colour, with fairly strong dichroism, and tolerably perfect crystal outlines. There are several grains of quartz, and a few clusters of small flakes of brownish mica, and a little magnetite.—T. G. B.

H. 16. Trawled 17 miles S. of Start Point. Measures 2′ 6″ × 1′ 10″ × 1′ 2″.

A sap-green coloured rock, in which the large actinolite crystals chiefly catch the eye; it is coarsely crystalline. The microscope shows the long actinolite crystals, green in colour, and at the borders often connected with diverging bundles and needles of pale green crystals, also actinolite, which penetrate the felspars.

The plagioclase still preserves its twinning for the most part, but much of it is attacked by decomposition, and it is everywhere permeated by long actinolitic fibres and particles. Apatite is present. Secondary quartz has been deposited in little veins and interstices.—E. B. T.

H. 22. Trawled 20 miles S. of Eddystone. Weight about 5 cwt.

Quartz is not so abundant as in granite, while the microscopic examination shows that the prevailing felspar is triclinic. Hornblende is abundant, and also dark mica; the latter occurs not so much as scattered crystals as in groups of diverging or matted prisms. Apatite is abundant; magnetite grains occur also mixed with the mica.—E. B. T.

H. 62. Erratic on shore near Gorah Run, E.S.E. of Prawle.

A moderately coarse granitic rock, in which black hornblende is conspicuous, set in white felspar and grey quartz. Lustrous flakes of dark mica are also seen.

Green hornblende and brown biotite are both well represented. The former often shows faces of the prism-zone, but never builds very perfect crystals. One section, three-eighths inch in diameter, is studded with little grains and rounded crystals of felspar, and some of quartz. The smaller crystals of hornblende are sometimes twinned on the usual law. Much of the biotite, which tends to build stout flakes, is bleached and partially decomposed. The felspar tends to form rectangular crystals, and is chiefly, if not wholly, oligoclase with rather close albite-lamellation. The crystals are often cloudy from alteration, especially in the interior. The clear quartz often shows strain-shadows. The only other original mineral is a little apatite.

Quartz is more abundant than in most ordinary quartz-diorites.—A. H.

TWO DIABASE. Nos. 17, 37.

H. 17. Trawled 17 to 18 miles S.W. by W. of Start Point. Weight 7 to 8 cwt.

A dark green rock of medium grain, with minute specks of pyrites. A diabase of ordinary type. The plagioclase is much decomposed, the twinning being often lost. Quartz has been secondarily deposited. The augite has also been partly attacked by decomposition, and chloritic matter has resulted thereby. A little apatite is present. Magnetite or black oxide is much more abundant than the pyrites.—E. B. T.

H. 37. Trawled 15 miles S.S.W. of Start Point. Weight 7 to 8 cwt.

A rather compact, dull, greenish-grey crystalline rock. Microscopic examination shows it has once been a fine-grained but holocrystalline rock, composed mainly of plagioclase felspar, augite, and some iron peroxide; but it is now composed of more or less altered felspars, associated with viridite and chloritic minerals, epidote and other secondary products, and perhaps some altered augite.—T. G. B.

THREE GABBRO. Nos. 8, 15, 38.

H. 8. Trawled about 25 miles S.W. of Start Point. Weight 5 to 6 cwt.

A coarse-grained rock consisting of white opaque felspar crystals and yellowish-grey diallage. Microscopic examination shows no other constituents; the felspar is almost entirely decomposed, scarcely showing original optical features. The diallage at borders sometimes undergoes a change into actinolite.—E. B. T.

H. 15. Trawled about 16 miles S. of Start Point. Measures 2′ 8″ × 1′ 8″ × 1′ 6″.

To this block some 'killas' was adherent, so that it was a junction specimen. The diallage scarcely retains its own physical properties; much of it has become altered to an aggregate of diverging fibrous, colourless or pale greenish crystals, which may probably belong to the actinolite group. The plagioclase is in places opaque from decomposition, and is everywhere much penetrated by the pale green actinolite microlites.—E. B. T.

H. 38. Trawled 15 miles S.S.W. of Start. Weight 10 cwt.

A moderately coarse-grained compound of a bluish-white felspar and a dull green mineral. Microscopic examination shows that it is a considerably altered gabbro. The plagioclastic felspar is to a very large extent replaced by micromineral products, such as occur in the so-called saussurite. The augite or diallage is replaced by hornblende, sometimes normal in aspect, sometimes rather actinolitic. An iron oxide and a little apatite are present, but no indication of former olivine.—T. G. B.

ONE SERPENTINE. No. 6.

H. 6. Trawled 13 miles S.S.W. of Start Point. Weight 5 cwt.

Mottled red and green colour, with steatite veins, and precisely like some of the Cornish varieties.

The microscope shows that none of the olivine is left unchanged in the meshes; in the serpentine are abundance of scattered hæmatite blotches. Veins of chrysolite, or steatite, have a central line of black iron oxide bordered often with red. Some of the enstatite is left unchanged, but only in fragments in the middle of bundles of talcose crystals and steatite, to which it seems to give rise by decomposition.—E. B. T.

One Trachyte. No. 29.

H. 29. Trawled 18 miles S.W. by S. of Start Point. Weight 3 or 4 cwt.

Under the microscope this rock exhibits a glassy base, in part but probably not wholly devitrified, with a fairly well-marked fluidal structure. It has undergone a certain amount of secondary change in the development of various microlithic minerals, showing bright colours between crossed nicols, and of specks of viridite. In this ground-mass occur numerous crystals of felspar, sometimes rather rounded or broken-looking, which contain microliths or glass inclusions, more or less altered. Some are plagioclase, probably oligoclase, others appear to be orthoclase. There is a filmy green mineral associated with streaks of opacite, which very probably replaces a mica, and there are some grains of iron peroxide. No quartz grains are to be seen in the slide; there may be some apatite.—T. G. B.

NON-CRYSTALLINE ROCKS.

Two Conglomeratic-grit. Nos. 5, 26.

H. 5. Trawled 20 miles S.W. of Start Point. Weight 10 cwt.

A coarse grit containing a few pebbles of rolled vein quartz, flesh-coloured felspar, and fragments of fine-grained felsite-like rock. The rock has much the appearance of an arkose.—E. B. T.

H. 26. Trawled 15 or 20 miles W.S.W. of Eddystone. Weight 3 or 4 cwt.

A moderately coarse grit composed wholly or almost wholly of rounded grains of whitish quartz, cemented by pyrite.—T. G. B.

One Killas. Attached to No. 15.

H. 15. Trawled 16 miles S. of Start Point.

One Triassic Sandstone. No. 10.

H. 10. Trawled 20 miles S. of Eddystone.

An unrolled fragment of a reddish-brown sandstone, similar in appearance to the Triassic sandstones abundant either in mass or as outliers on the coast of South Devon.

One Neocomian Sandstone. No. 23.

H. 23. Trawled 15 miles S.E. of Start Point. Weight 9 to 10 cwt.

A sandstone with green grains; it has all the appearance of Neocomian sandstone, as in Kent.—E. B. T.

FOUR (SETS) CHALK FLINTS. Nos. 11, 12, 14, 18.

H. 11. Trawled 20 miles S.W. of Eddystone.

Some twenty chalk flints; one weighs 6 lb., and is perfectly unrolled.

H. 12. Trawled 15 miles S.W. of Eddystone.

A small flint about 8 oz. in weight.

H. 14. Trawled 20 miles S.W. of Start Point. Weighs 3 lb. 2 oz. and 2 lb. 14 oz. respectively.

H. 18. Trawled 17 or 18 miles S.W. by W. of Start Point. One flint weighed 1 lb. 9½ oz.

ONE LIMESTONE. No. 13.

H. 13. Trawled 15 miles S.W. of Eddystone.

A small piece of buff-coloured limestone, riddled through and through by molluscs and other marine borers.

ONE GRIT. No. 30.

H. 30. Trawled 15 to 20 miles S.S.W. of Start Point.

This is a small stone, measuring about 8″ × 6″ × 4″, of fine grit, and may well have been used for ballast. Its evidence is accordingly valueless.

APPENDIX III.

THE observations of the late Mr. R. N. Worth,[1] F.G.S.

The bulk of the material was obtained for Mr. Worth by the late Mr. Matthias Dunn, of Mevagissey; it was all brought up entangled in the hooks of bolters or long-lines. All bearings are magnetic. (Plate XVII.)

"The evidence that the rocks were *in situ* when entangled (partly by the marine growths upon them, and partly by their irregularities and the holes bored by *Pholades*) is clear. With two exceptions only, the specimens retained the characteristics of the original bedding."

W. 1. S.E. Lizard, 10 miles.

Fine-grained, soft, red Triassic sandstone, in layers 1½ to 2 inches thick.

W. 2. S.E. Lizard, 15 miles.

Triassic sandstone of coarser grain, mottled red and grey.

W. 3. S.E. Manacles Rocks, 16 miles.

Fine-grained soft sandstone, grey with a passing tinge of red in places, in parts highly micaceous, containing both black and white micas.

W. 4. S.S.E. Falmouth Castle, 18 miles.

Fine-grained, compact, red, jaspideous sandstone, much bored. The specimen shows portions of two joint faces, at right angles to each other.

W. 5. S.W. by S. Deadman, 25 miles.

a. Chocolate marl, spotted white. The edges of this nodule were rounded, but it could hardly be called rolled.

[1] *Quarterly Journal of the Geological Society*, Vol. XLII, 1886, pp. 313–15.

b. A "Potato Stone," partially coated with marl and filled with pinkish calcite. The inside of the shell was studded with small brilliant pyramids of quartz.

c. Grey sandstone.

d. A nodule of Triassic Trap. A hard red rock, slightly micaceous; very closely resembles some varieties of the Triassic Trap of Thorverton, with affinities to those of Pocombe and Cawsand.

W. 6. S. by W. Deadman, 20 miles.

a. A light salmon-tinted drab calcareous sandstone, in a slab nearly two feet in longest diameter, the under surface intact and slightly pitted.

b. Granitic and granitoid pebbles.

c. Quartzite pebbles.

d. Flints.

W. 7. S. Deadman, 7 miles.[1]

Slabs of Triassic conglomerate, evidently torn from a submarine reef-point, sides, and upper and lower surfaces being intact in each instance, and the only broken surface that of fracture from the parent rock. Examined microscopically this conglomerate proves to contain pebbles of slate, grits, vein quartz, quartz-felsite, and andesite.

W. 8. S.E. Deadman, 3 miles.

W. 9. W. Deadman 4 miles.

W. 10. S.W. Deadman, 10 and 12 miles.

W. 11. S. by E. Deadman, 27 miles.

No Trias found at any of the last four positions.

W. 12. S.W. Falmouth, 10 miles.

Ochreous volcanic ash.

[1] "Additional Notes on the Cornish Trias," *Trans. Royal Cornwall Geological Society*, 1891.

EXPLANATION OF PLATES.

Plate VI. (Opp. p. 123). (1). Micro-pegmatite, with characteristic intergrowth of felspar and quartz. (2). Central portion of (1), more highly magnified.

,, VII. (Opp. p. 135). (1). Hornblende-gneiss. Showing 3 garnets; immediately beneath the central one a small, uniformly tinted area of chlorite. (2). Chlorite schist with crushed plagioclase felspar.

,, VIII. (Opp. p. 143). Grit, with derived fragment of older rock (A–B).

,, IX. (Opp. p. 151). (1). Hard yellow chalk, with derived inclusion of earlier chalk rock. (2). Section of same, showing foraminifera, shell fragments and other organic remains.

,, X. (Opp. p. 153). Decomposed black flint, with shell fragments and complete foraminifera in carbonate of lime. (2). Lower part with carbonate of lime removed.

,, XI. (Opp. p. 156). Eocene limestone.

,, XII. (Opp. p. 157). Eocene limestone, showing foraminifera.

,, XIII. (Opp. p. 163). Chart, Start to Hand Deeps. Illustrating Dr. Allen's Start-Eddystone dredgings.

,, XIV. (Opp. p. 166). Chart showing distribution of granite and gneiss.

,, XV. (Opp. p. 168). ,, ,, ,, trias, rhaetic, and lias.

,, XVI. (Opp. p. 169). ,, ,, ,, hard yellow chalk.

,, XVII. (Opp. p. 179). ,, ,, location of dredgings recorded by Mr. A. R. Hunt and Mr. R. N. Worth.

The Schizopoda and Isopoda collected by the "Huxley" from the north side of the Bay of Biscay, in August, 1906.

By

W. M. Tattersall, M.Sc.

I AM indebted to the courtesy of Dr. Allen for the opportunity of examining the collections of these two orders of Crustacea in the *Huxley's* material.

None of the species are new to science, and but few of them present any features worthy of remark. The chief interest of the collection lies in its bearing on the known geographical distribution of the species captured for, out of a total of twenty-eight, no fewer than sixteen are recorded for the first time from localities south of the British Islands, while only eight of the species have previously been recorded from the Bay of Biscay. The bathymetrical range of five of the species recorded has been considerably increased by this material.

A comparison of the following lists with those for the same orders collected by the *Caudan* expedition, reveals little that is common to the two, the explanation of which is probably that the *Caudan* was working in much deeper water and considerably south of the area explored by the *Huxley*. The results of the work done by the *Hirondelle* and the *Travailleur* and *Talisman* in the Bay of Biscay are not available for the orders now under consideration. The only other expedition which has worked in the Bay is the *Research*, but as that dealt entirely with plankton, the results are not strictly comparable with those of the *Huxley*.

List of Species and the stations at which they occurred.

	II	V	VII	VIII	IX	X	XI	XII	XIII
Station	II	V	VII	VIII	IX	X	XI	XII	XIII
Longitude, N.	48°24′	47°48′	47°36′	47°30′	48°7′	48°7′	48°10′	48°7′	48°7′
Longitude, W.	6°28′	7°46′	7°31′	7°31′	8°13′	8°13′	8°11′	8°13′	8°13′
Fathoms	75	109	111	Surface	240	Surface	146	246	412
SCHIZOPODA.									
Euphausia Mülleri	–	–	–	ca. 1000	–	28	–	–	–
Meganyctiphanes norvegica	–	–	–	5	–	ca. 300	–	22	–
Nyctiphanes Couchi	–	–	–	–	–	ca. 200	–	–	–
Nematoscelis megalops	–	–	–	2	–	32	–	–	–
Lophogaster typicus	–	2	–	–	2	83	1	–	–
Siriella norvegica	–	3	–	–	–	–	7	–	–
Haplostylus Normani	–	–	–	–	–	26	–	–	–
Anchialina agilis	–	–	–	–	–	38	–	–	–
Amblyops abbreviata	–	–	–	–	–	–	–	31	–
Paramblyops rostrata	–	–	–	–	1	–	–	–	–
Pseudomma affine	–	–	–	–	–	–	–	3	–
Mysideis insignis	–	–	–	–	1	–	–	36	–
Mysidopsis didelphys	–	1	–	–	–	–	–	–	–
Leptomysis gracilis	–	–	–	–	–	1	–	–	–
Leptomysis sp.	–	–	–	–	–	–	2	–	–
Mysidetes Farrani	–	–	–	–	–	–	–	4	–
Boreomysis arctica	–	–	–	–	–	–	–	3	–
Schistomysis ornata	–	10	–	–	–	–	3	–	–
ISOPODA.									
Aega Strömii	–	–	–	–	–	–	–	3	–
Rocinela damnoniensis	–	–	–	–	1	–	–	4	–
Cirolana borealis	1	1	–	–	4	–	–	12	–
Cirolana Hanseni	–	–	–	–	–	–	–	–	1
Eurydice truncata	–	–	–	–	–	53	–	–	–
Astacilla longicornis	1	–	–	–	–	–	–	16	1
Ianira maculosa	–	–	5	–	–	–	–	–	13
Munna Boecki	–	–	2	–	–	–	–	–	–
Eurycope longipes	–	–	–	–	–	–	–	3	–
Aspidophryxus peltatus	–	1	–	–	–	–	–	–	–

SCHIZOPODA.

Of the eighteen species of this order represented in the collection, none can be described as new, though two specimens of the genus *Leptomysis* cannot be referred satisfactorily to any described form. They are, however, very closely allied to *L. gracilis,* and I await further material before deciding the point. The depth at which they were found is unusual for the genus.

Only four of these species have been previously recorded from the Bay of Biscay, viz., *Euphausia Mülleri*, *Meganyctiphanes norvegica*, *Nematoscelis megalops*, and *Lophogaster typicus*.

Four other species, *Nyctiphanes Couchi*, *Haplostylus Normani*, *Anchialina agilis*, and *Boreomysis arctica* are, however, known from the Mediterranean, and their occurrence in the Bay of Biscay merely fills, in part, the gaps existing in their geographical distribution. The remaining species have not hitherto been recorded from localities south of the British and Irish area (*Leptomysis gracilis* is, however, known from the French side of the English Channel). The majority of them are deep water forms, which recent work has shown to be more or less abundant off the west coast of Ireland on the fringe of the Atlantic slope, and it was only natural, therefore, to expect that their known distribution would be considerably extended when the slope was further explored to the south.

Siriella norvegica and *Schistomysis ornata* are here recorded from depths greater than any at which they have up till now been taken, while the capture of no fewer than one thousand specimens of *Euphausia Mülleri* and eighty-three of *Lophogaster typicus* in surface hauls are features worthy of special note.

The records of *Paramblyops rostrata* and *Mysidetes Farrani* are of interest, since these two species have only lately been described from material collected in deep water off Ireland.

SCHIZOPODA.

Family EUPHAUSIIDAE.

Euphausia Mülleri, Claus.

Station VIII. *ca.* one thousand specimens, up to 22 mm.

Station X. Twenty-eight specimens, 5–11 mm.

The occurrence of no fewer than one thousand specimens of this species in a surface haul, Station X, is worthy of special note.

Meganyctiphanes norvegica (M Sars).

Station VIII. Five specimens, 14–28 mm.

Station X. *ca.* three hundred specimens, 11–33 mm.

Station XII. Twenty-two specimens, 17–34 mm.

Nyctiphanes Couchi (Bell).

Station X. *ca.* two hundred specimens, 7–17 mm.

Nematoscelis megalops, G. O. Sars.

Station VIII. Two specimens, 10 and 11 mm.

Station X. Thirty-two specimens, 10–18 mm.

Family **LOPHOGASTRIDÆ.**

Lophogaster typicus, G. O. Sars.

Station V. Two females, 20 and 22 mm.
Station IX. Two females, 21 mm.
Station X. Eighty-three specimens, 5–10 mm.
Station XI. One female, ovigerous, 21 mm.

The occurrence at Station X of no fewer than eighty-three specimens of this species in a surface haul is a feature of great interest. *L. typicus* is regarded as essentially a bottom living form, though Holt and Tattersall* have recently recorded a specimen from a haul made at 44 fathoms, over a depth of 136 fathoms. This latter specimen was a gravid female, in which the young were ready to be liberated from the brood pouch. The probable fact is that *L. typicus*, in its normal adult condition, is a true bottom haunting form, but that the female rises to the surface to liberate the young and thus to ensure a wide distribution. The haul at Station X above supports this view, since all the specimens are small, and only two or three of the very largest have assumed quite adult form.

Family **MYSIDÆ.**

Siriella norvegica, G. O. Sars.

Station V. One male, 19 mm.
Two females, 14 and 17 mm.
Station XI. Five males, 17–19 mm.
Two females, 15 and 19 mm.

Haplostylus Normani (G. O. Sars).

Gastrosaccus Normani, G. O. Sars; Middlehavet's Mysider, p. 65; Pls. XXIV, XXV, 1876.

Station X. Fifteen males, 6–8 mm.
Eleven females, 5–11 mm.

These specimens differ in one important respect from the description and figures given by Sars. Without exception, they have the hinder margin of the carapace furnished with two dorsal, upwardly and forwardly, directed lobes. The absence of lobes from the hinder margin of the carapace was one of the characters on which Kossmann separated the genus *Haplostylus* from *Gastrosaccus*. The present examples, however, agree exactly with *H. Normani* in the structure of the antennules, the length, form and armature of the telson, and

* Holt and Tattersall, "Fisheries, Ireland, Sci. Invest., 1904 V., [1906]."

especially in the rudimentary inner branch to the third pleopods of the male and the curiously twisted rami of the second pleopods of the same sex.

It is curious to note in this respect that Holt and Beaumont, writing of *Gastrosaccus sanctus* from the west of Ireland,* remark: "most of the specimens from Bofin have practically no trace of the upturned processes of the hind margin of the carapace, though agreeing in other respects with the type." From these observations it would seem that the presence or absence of lobes is a character which cannot be relied on either for generic or specific separation, but the point is obviously one that requires further investigation. In the meantime, the present specimens agree so well with *H. Normani* in other respects, that I provisionally record them here as that species.

Anchialina† **agilis** (G. O. Sars).

STATION X. Ten males, 6–9 mm.
Twenty-eight females, 6–9 mm., most of them ovigerous.

Amblyops abbrieviata, G. O. Sars.

STATION XII. Fifteen males, 12–16 mm.
Sixteen females, 12–16 mm.

Paramblyops rostrata, Holt and Tattersall.

STATION IX. One female, head and thorax only.

Pseudomma affine, G. O. Sars.

STATION XII. Two males, 11 mm.
One female, 11 mm.

Mysideis insignis, G. O. Sars.

STATION IX. One female, 25 mm.
STATION XII. Ten males, 14–20 mm.
Twenty-six females, 9–22 mm.

Mysidopsis didelphys (Norman).

STATION V. One male, 13 mm.

A specimen of the Isopod parasite, *Aspidophryxus peltatus*, G. O. Sars, was found attached to the basal joint of the left antennule.

Leptomysis gracilis, G. O. Sars.

STATION X. One female, 10 mm.

* HOLT and BEAUMONT, *Sci. Trans. Royal Dublin Soc.*, Series ii., Vol. vii., Pt. vii, 1900.

† *Anchialina*, Norman for *Anchialus*, G. O. Sars. See Norman and Scott, "Crustacea of Devon and Cornwall," London, 1906, p. 24.

Leptomysis sp.

STATION XI. One male, 11 mm.
One female, 11 mm.

These two specimens differed from *L. gracilis* (1) in having the dermis quite smooth instead of hispid; (2) the rostrum is quite short, and does not extend beyond the eyestalks, whereas in *L. gracilis* it is produced into a broadly triangular acutely pointed plate, which extends beyond the middle of the basal joint of the antennules. Otherwise they agree perfectly with normal specimens of *L. gracilis*, and it seems better to await further material before deciding whether they represent a hitherto undescribed form, or are merely abnormal specimens of *L. gracilis*.

Mysidetes Farrani (Holt and Tattersall).

STATION XII. Four females, 18 mm.

Boreomysis arctica (Kröyer).

STATION XII. Two males, 15 and 18 mm.
One female, 14 mm.

Schistomysis ornata (G. O. Sars).

STATION V. Two males, 14 mm.
Eight females, 12–15 mm.

STATION XI. Three females, 14 mm.

Both the stations at which these species occur are over 100 fathoms in depth. This depth is most unusual for the species, the greatest depth at which it has previously been captured being 50 fathoms. I cannot, however, at present find any substantial difference between these specimens and those from shallower water, and I am, therefore, obliged to consider them as belonging to the same species.

ISOPODA.

In all ten species of Isopoda are here recorded from the material collected by the *Huxley*. Of these only four have hitherto been found in the Bay of Biscay, viz., *Cirolana borealis*, *Cirolana Hanseni* (the type specimen of which was dredged by the *Caudan* expedition a little further south of the area explored by the *Huxley*), *Eurydice truncata*, and *Ianira maculosa*.

The remaining six species have not been recorded from localities south of the British and Irish marine area, so that the present records indicate the most southerly limit of their known geographical range.

With regard to the bathymetric range of the species, I am not aware that *Ianira maculosa, Munna Boecki*, and *Astacilla longicornis* have up till now been recorded from greater depths than 400 fathoms, so that the vertical distribution of all three has been extended as a result of the present material. *Ianira maculosa* was only found at Stations VIII and XIII, and from Professor Hickson's report on the *Alcyonaria* of the *Huxley's* cruise it was at both these stations that the majority of the *Alyconaria* were taken. In shallow water *Ianira maculosa* is very frequently found in considerable numbers crawling over colonies of *Alcyonium digitatum*, and in all probability the specimens in the present collection were clinging to the Alcyonarians found on the same grounds. *Eurycope longipes* is a species only recently described from specimens found off the west coast of Ireland on the edge of the Atlantic slope. Its occurrence further south on the same slope, while interesting, is only naturally to be expected.

Family ÆGIDÆ.

Æga Strömii, Lutken.

Station XII. Three specimens.

Rocinela damnoniensis, Leach.

Station IX. One specimen.
Station XII. Four specimens.

Family CIROLANIDÆ.

Cirolana borealis, Lilljeborg.

Station II. One specimen.
Station V. One specimen.
Station IX. Four specimens.
Station XII. Twelve specimens.

Cirolana Hanseni, Bonnier.

Station XIII. One specimen.

Stebbing, in his report on Professor Herdman's Ceylon Isopoda, suggests that this species should be referred to his genus *Hansenolana*, while Hansen, in his recent revision of the European members of the genus, still retains in it the genus *Cirolana*. The present specimen measures only 3 mm., and is therefore smaller than Hansen's largest specimens, which was 4·2 mm., and which Hansen thought to be still immature. As it is obvious that adult specimens are necessary before the correct genus for the species can be determined, I follow Hansen in retaining it in its original genus, *Cirolana*, for the present.

Eurydice truncata (Norman).

Station X. Fifty-three specimens.

Family **ARCTURIDÆ.**

Astacilla longicoris (Sowerby).

Station II. One specimen.
Station XII. Sixteen specimens.
Station XIII. One specimen.

Family **IANIRIDÆ.**

Ianira maculosa, Leach.

Station VII. Five specimens.
Station XIII. Thirteen specimens.

Family **MUNNIDÆ.**

Munna Boecki, Kröyer.

Station VII. Two specimens.

Family **MUNNOPSIDÆ.**

Eurycope longipes, Tattersall.

Station XII. Three specimens.

Family **DAJIDÆ.**

Aspidophryxus peltatus, G. O. Sars.

Station V. One specimen on the basal joint of the left antennule of *Mysidopsis didelphys* (Norman).

Both Sars and myself have recorded this parasite from the antennules of *Mysidopsis didelphys,* while I have also noted it on the same host from the more normal position for such parasites, viz., the dorsal surface of the thorax.

Notes on the littoral *Polychæta* of Torquay.

By

Major E. V. Elwes.

The following notes are confined to the species of Polychæta, which have been found by myself during the last four years, between tide-marks, on the coast comprised within the Borough of Torquay. Torquay is so well known as a hunting ground for the marine zoologist that it is unnecessary to describe the features of the shores. No special study of the Polychæta of Torquay appears to have been previously made, although the locality, Torbay, occurs somewhat frequently in the British Museum Catalogue of Worms.

Syllidæ.

Twenty species of Syllids have been found; of these eight have not apparently been previously recorded from the British area. They are, *Trypanosyllis cœliaca*, Clpd.; *Autolytus ehbiensis*, de St. Joseph; *A. longiferiens*, de St. Joseph; *A. macrophthalma*, Marenzeller; *Grubea clavatu*, Clpd.; *Eurysyllis paradoxa*, Clpd., and *Pionosyllis lamelligera*, de St. Joseph. The Syllids were nearly all obtained by bringing home the roots of Laminaria and placing them in glass vessels, when in a few hours the Annelids crawl out and can be picked out with a pipette.

Exogone gemmifera, Pagenstecher. *McIntosh, Mon. Brit. Ann.*, vol. ii., 1908, p. 151; *de St. Joseph, Ann. Sc. Nat. Zool.*, 1886, p. 209 (as *Pædophylax claviger*).

This species is by no means uncommon at Torquay amongst sea-weeds from half-tide mark downwards. When such weeds are placed in a glass jar, Exogone is one of the first species to leave the shelter of the weeds and crawl out on the glass sides; but unless observed within five or six hours from the time the weed is placed in the vessel, it probably will not be noticed, because it very quickly dies and falls down amongst the debris, where, owing to its small size, it is almost impossible to find it.

The appendages very easily fall off, hence it is not unusual to see individuals with only one or two tentacles.

Females with fully developed young ones, in the seventh stage of de St. Joseph, were found in the month of March.

The young are attached, as de St. Joseph states, to the ventral side by a pedicle; but this pedicle is sufficiently long to allow some movement of the young, so that when the mother crawls about, the young ones turn upwards and appear to be carried on the back.

GRUBEA CLAVATA, Clpd., *de St. Joseph, Ann. Sc. Nat. Zool.*, 1886, p. 200.

One example from Laminaria root, obtained at an unusally low spring tide, from rocks at Oddicombe Beach in the month of January.

PIONOSYLLIS DIVARICATA. Keferstein = *longocirrata*, de St. Joseph, *McIntosh, Mon. Brit. Ann.*, vol. ii., p. 164.

Three or four were obtained in the months of March and April from Corbyn's Head. They were extremely fragile, making it very difficult to prepare a satisfactory mount.

PIONOSYLLIS LAMELLIGERA, de St. Joseph. *Ann. Sc. Nat. Zool.*, 1886, p. 113.

This species is very common, one or more being found in nearly every root of Laminaria. Like P. *divaricata* it is very fragile breaking up into pieces of two or three segments. The Torquay specimens agree with the description given by St. Joseph, but some of them are rather longer, reaching 10 mm. in length and having about 67 segments.

A large proportion of the individuals found were females with ova of a conspicuous pink colour. They often violently vibrate the posterior portion of the body while the front remains fixed. It seems possible that one use of the so-called swimming bristles in the sexual forms of Syllids generally, is to break off a portion, or the bud, from the rest of the body at the proper time.

EUSYLLIS TUBIFEX, Gosse. *McIntosh, Mon. Brit. Ann.*, vol. ii., 1908 p. 173.

Fairly common in glass jars containing weeds covered with Polyzoa and Sertularia, just in the same way as it was first obtained by Gosse at Ilfracombe. Several females containing ova were obtained in the month of April, some of them showing well-developed swimming bristles, but in no case was there any sign of a stolon being formed.

It is curious that a species which is said to be common in the North, and is also found in Devon, should not yet have been reported from the other side of the Channel.

The dorsal cirri rapidly taper to a point, in which respect it appears to differ from *E. Blømstrandi*, which is apparently very near it.

ODONTOSYLLIS GIBBA, Clpd. *McIntosh, Mon. Brit. Annel.*, vol. ii. p. 183.

Several examples of this species were obtained from Corbyn's Head. They agreed in colour with the one from Plymouth figured in *Mon. Brit. Annel.* In one example two red eye-spots in front of the anterior pair of large eyes were distinctly observed. These additional spots apparently have only been previously observed in the *Umbellisyllis fasciata* of M. Sars which, according to McIntosh, is the same species.

ODONTOSYLLIS CTENOSTOMATA, Clpd. *McIntosh, Mon. Brit. Annel.*, vol. ii., p. 182.

The most abundant of all the species of Syllids at Torquay.

The colour is usually yellowish green. In glass vessels it creeps to the edge of the water. Although unripe individuals are so numerous, only one or two, females, were found with swimming bristles.

AMBLYOSYLLIS LINEATA, Grube. *McIntosh, Mon. Brit. Ann.*, vol. ii., p. 225.

Occasionally met with in weeds from the rocks between Oddicombe and Babbicombe beaches. One individual was marked with purple stripes, and appeared to belong to the variety *formosa*.

SYLLIS SPONGICOLA, Grube = *S. hamata*, Clpd. *McIntosh, Mon. Brit. Annel.*, vol. ii., p. 197.

Fairly abundant. The colour is rather a reddish brown than orange. Several females with ova showed no signs of swimming bristles or formation of a bud. Only one individual showed a distinct bud with ocular spots on each segment.

SYLLIS PROLIFERA, Krohn. *McIntosh, Mon. Brit. Annel.*, p. 161 (as *Pionosyllis prolifera*).

One of the most numerous of the Torquay Syllids. It appears to be a very variable species, both as regards the number of the articulations of the cirri and the colouring. Some have markings like those given in *Mon. Brit. Annel.*, fig. 53, others like the variety *variegata* as figured by Marenzeller, while some are uniformly coloured.

The articulations of the longer dorsal cirri, in some cases, are as many as fifty. Several with buds were found; one with a regenerated head, without proboscis or proventriculus, exactly like that described by de St. Joseph. *Ann. Sc. Nat.*, 1886, p. 147.

SYLLIS ALTERNOSETOSA, de St. Joseph. *Ann. Sc. Nat.*, 1886, p. 150.

The species found at Torquay is undoubtedly the one so fully described by de St. Joseph. Malaquin, in his *Recherches sur les Syllidiens*, considers *S. alternosetosa* as identical with *S. hyalina*, Grube. But this species, as described by McIntosh, *Mon. Brit. Annel.*, vol. ii., p. 167, differs from it, having all the terminal pieces of the compound bristles bidentate in all the regions of the body.

Giard, on the other hand, as stated on page 202 of *Mon. Brit. Ann.*, vol. ii., considers *S. alternosetosa* as a variety of *S. cornuta*, H. Rathke. The segments in the anterior part of the body are marked with a number of parallel transverse lines, about 20 in number. No buds were seen. Fairly common.

SYLLIS KROHNII, Ehlers. *McIntosh, Mon. Brit. Annelids*, vol. ii., p. 192. *Langerhans, Zeits. für Wiss. Zool.*, 1879, p. 529.

Five examples of this species were found amongst Corallina in a pool in the rocks which jut out from Corbyn's Head. They agreed better with the description and figures given by Langerhans than with those given by McIntosh.

The median tentacle is not shorter than the lateral one, but, as is generally the case with the Syllids, longer, The longer cirri, especially in the anterior part of the body, are also much thicker than the short ones, and somewhat club-shaped. The articulations are well marked. The colouring corresponds to that given in *Mon. Brit. Annel.*; the eyes on each side are very close together, almost touching. The bristles are exactly as described by Langerhans, the bulge just under the point of the stalk of the bristles being more pronounced than is shown in his drawing.

All the appendages are more or less speckled with opaque white spots.

TRYPANOSYLLIS ZEBRA, Grube. *McIntosh, Mon. Brit. Annel.*, vol. ii., p. 169.

This beautiful Syllid can be at once distinguished by the great proportionate breadth of the body and the markings, from which it derives its specific name.

It is fairly numerous, most of the specimens being obtained from Laminaria roots from the rocks between Babbicombe and Oddicombe beaches. No simple bristles were detected in the posterior region. It appears probable that these simple bristles in the Syllids generally only appear at certain periods, like the swimming pairs. Only one individual had a bud attached, but one free stolon was found. The number of spines varies from two to four. There are three different kinds of spines: one variety is pointed; another quite blunt at the point, looking as if it had been cut across at right angles to its length; the third variety is bent at right angles to its length at the point, forming a short hook. The segments are very short in proportion to their breadth, so that the large dorsal cirri almost touch each other.

TRYPANOSYLLIS CŒLIACA, Clpd. *de St. Joseph, Ann. des. Sci. Nat. Zool.*, 1886, p. 184.

This species, which has not been before recorded from this side of the Channel, is easily distinguished from the much larger T. zebra by the short tentacles, tentacular, and dorsal cirri. They have only six to ten articulations, and are all very nearly of the same length.

In life the cirri are of a most beautiful golden colour; the anterior eyes are situated on the ventral side of the head.

In most of the feet there is only one strong pointed spine, in others two. The proventriculus is very little longer than it is broad. Four or five specimens only were found; all from Oddicombe rocks.

EURYSYLLIS PARADOXA, Clpd. *de St. Joseph, Ann. Sc. Nat. Zool.*, 1886, p. 191.

Eurysyllis is easily distinguished from other Syllids by its spherical cirri; but the absence of comparatively long cirri, the sluggishness of its movements, and the fact that it is usually covered with mud, probably account for the fact that it has not before been recorded as British; de St. Joseph does not appear to have found it on the shore, but says it was common in the dredges. The Torquay specimens agreed with his description.

Examples were obtained from Oddicombe, Corbyn's Head, and Livermead, but none had buds.

AUTOLYTUS EHBIENSIS, de St. Joseph. *Ann. Sc. Nat.*, 1886, p. 228.

This is a very interesting addition to the British Fauna, on account of the excellent example it affords of the production of buds; de St. Joseph says he never found it without a bud, and I have only found two or three out of fifty or sixty examples without one.

Chains of five or six buds are common. In February, 1907, this species was found in great abundance on the Fucus, growing on the little breakwater at Babbacombe. The Fucus was covered with *Sertularia pumila.*

Two or three examples of the variety mentioned by de St. Joseph, with only twenty teeth in the proboscis, were also observed.

AUTOLYTUS PICTUS, Ehlers. *McIntosh, Mon. Brit. Annel.*, vol. ii., p. 211.

Rather common; the colour is similar to that of Pl. XLI., fig. 8, *Mon. Brit. Annel.;* but the tentacles are usually yellow instead of a madder-brown colour.

AUTOLYTUS MACROPHTHALMA, Marenzeller. *de St. Joseph, Ann. Sc. Nat. Zool.*, 1886, p. 226.

Two examples from Babbicombe. The teeth of the proboscis agreed exactly with the figure given by Marenzeller. *Zur Kenntniss der Adriatischen Anneliden*, 1875.

AUTOLYTUS LONGIFERIENS, de St. Joseph. *Ann. des Sci. Nat. Zool.*, 1886, p. 217.

Five or six of this species, so remarkable for the great length (2 mm.) of the proboscis, were found. Two red eye-spots, not mentioned by St. Joseph, are situated rather a long way in front of the anterior pair of large eyes. In the Torquay examples there are only two small teeth between the large ones, instead of three, as is the case with those from Dinard.

AUTOLYTIDES INERMIS, de St. Joseph. *Ann. des. Sci. Nat. Zool.*, 1886, p. 237.

One specimen was found. The proboscis was of full length, and there appears no reason to think that the absence of teeth is due to an accident.

KEY TO THE GENERA OF THE SYLLIDÆ FOUND ON THE FRENCH AND ENGLISH COASTS OF THE CHANNEL, ACCORDING TO THE CLASSIFICATION OF MALAQUIN (*Recherches sur les Syllidiens*).

VENTRAL CIRRUS PRESENT.

Palps united throughout.	One pair of tentacular cirri.	Tentacles and cirri very small, cylindrical . . .	*Exogone*, Œrsted.
		Tentacles and cirri swollen at the base and pointed . .	*Sphærosyllis*, Clpd.
	Two pairs of tentacular cirri.	Tentacles and cirri long, wide at base, tapering to a point .	*Grubea*, Quatrf.
Palps united at the base only. Tentacles and cirri not formed of distinct joints.	Proboscis straight.	Proboscis without any teeth	*Syllides*, Œrsted.
		Proboscis armed with one tooth in the anterior part . .	*Pionosyllis*, Malmgren (Langh. *emend.*)
		Proboscis armed with one large tooth and an incomplete crown of small teeth	*Eusyllis*, Malmgren.
		Proboscis armed with teeth pointing backwards . . .	*Odontosyllis*, Clpd.
	Proboscis much curved.	Proboscis armed with a crown of small teeth . . .	*Amblyosyllis*, Grube.
Palps free throughout their length.	Proboscis armed with one large tooth.	Tooth situated in anterior part of proboscis . . .	*Syllis*, Savigny.
	Proboscis armed with one large tooth and a crown of small teeth.	Cirri of several articulations	*Trypanosyllis*, Clpd.
		Cirri spherical of one articulation	*Eurysyllis*, Ehlers.

VENTRAL CIRRUS ABSENT.

Palps little developed, united.	Dorsal cirri cylindrical or threadlike.	Proboscis armed with a crown of teeth	*Autolytus*, Grube.
		Proboscis without teeth	*Autolytides*, Malaquin.
	Dorsal cirrus leaf-like.	Proboscis very long (4 mm.)	*Myrianida*, Milne Edwards.

NOTE.—*Syllis cornuta* is joined at the base of the palps according to McIntosh, and *Autolytus* (*Sylline*) *rubropunctatus* has a ventral cirrus.

KEY TO THE SPECIES OF SYLLIDS FOUND ON THE FRENCH AND ENGLISH COASTS OF THE CHANNEL.

EXOGONE.	No dorsal cirri on 2nd bristle-bearing segment			*gemmifera*, Pagenstecher = *Pædophylax claviger*, Clpd.
SPHŒROSYLLIS.	4 eyes. Proventriculus with 12 rows of points. Anal cirri swollen at base			*hystrix*, Clpd.
	6 eyes. Proventriculus with 17 rows of points. Anal cirri not swollen at base			**erinaceus*, Clpd.
GRUBEA.	Dorsal cirri tapering to a sharp point			*clavata*, Clpd.
	Dorsal cirri almost cylindrical, widest in the middle with a blunt point			**pusilla*, Dajardin.
SYLLIDES.	Dorsal cirri long, yellow			*longocirrata*, Œrst.
PIONOSYLLIS.	Dorsal cirri of anterior segments very long (2 mm.)			*divaricata*, Keferstein = *longocirrata*, de St. Joseph.
	First pair of ventral cirri leaf-like. Dorsal cirri not very long			*lamelligera*, de St. Joseph.
EUSYLLIS.	Two large glandular tubes, one on each side of proboscis.	First pair of ventral cirri leaf-like, different in shape to other ventral cirri		*lamelligera*, Mar. et Bob.
		First pair of ventral cirri not different to others		*intermedia*, de St. Joseph.
	No glandular tubes.	Terminal pieces of bristles not differing greatly in length and breadth.	Dorsal cirri tapering towards apex	*tubifex*, Gosse.
			Dorsal cirri cylindrical	*Blomstrandi*, Mgr.
		Terminal pieces differing. One kind short and stout, the other long and narrow		**monilicornis*, Mgr.
ODONTOSYLLIS.	Teeth of proboscis few and comparatively large.	Terminal pieces long and narrow. Length about nine times the breadth		*gibba*, Clpd.
		Terminal pieces short and broad. Length three times breadth.	Terminal pieces with a simple hook	*ctenostomata*, Clpd.
			Terminal pieces with a second tooth	*fulgurans*, Clpd.
	Teeth, numerous and small.	Terminal pieces bidentate		**polyodonta*, de St. Joseph.
AMBLYOSYLLIS.	13 pairs of feet. Appendages very long			*lineata*, Grube.

* Not yet recorded from British area.

KEY TO SPECIES—*continued.*

SYLLIS.

Simple bristles only present = sub-genus *Haflosyllus*, Langerhaus . . . . *spongicola*, Grube = *hamata*, Clpd.

Compound bristles present in anterior and posterior regions. Simple bristles only in median = genus *Syllis sensu strictu*, Langerhans . . . . *gracilis*, Grube.

Compound bristles present in all the feet.

- Terminal pieces of all the bristles distinctly bidentate = genus *Pionosyllis*, McIntosh.
  - Dorsal cirri with more than 25 articulations. One or more simple bristles with bidentate apex in posterior portion of the body . . . . . *prolifera*, Krohn.
  - None of the dorsal cirri with more than 25 articulations. A simple bristle not bifid at the apex present in posterior portion of body . . . . *hyalina*, Grube
- Terminal pieces of some at least of the bristles a simple hook, at the most with a minute secondary tooth.
  - Bristles differing distinctly in the length and breadth of the terminal pieces or in the size of the stalks = sub-genus *Ehlersia*, Langerhans.
    - Terminal pieces of anterior and posterior regions long and narrow, with a minute secondary tooth, of median region short and broad with a simple hook . . *alternosetosa*, de St. Joseph.
    - Long and short terminal pieces mixed in all the feet . . *cornuta*, H. Rathke.
    - On some of the feet one or two compound bristles with a simple hook a little larger than the other, and a stalk twice as thick as the others . . . . . *æsthetica*, de St. Joseph = *Cunninghami*, McIntosh?
  - Terminal pieces differing very little in size = sub-genus *Typosyllis*, Langerhans.
    - Tentacles and cirri with opaque white spots. Large and small cirri alternating . . . . . *Krohnii*, Ehlers.
    - Dorsal cirri equal, no opaque white spots.
      - Dorsal cirri with 24 or more articulations. Length $1\frac{1}{2}$ inches . . . *Buskii*, McIntosh.
      - Dorsal cirri with 10 to 12 articulations. Two lateral bars and a central bar of greyish brown on each segment . . *armillaris*, Müller.
      - Dorsal cirri with 9 articulations very stout . *brevicirrata*, McIntosh.
      - Dorsal cirri crenate rather than moniliform. Two spines with distinctly curved tips. *cucullata*, McIntosh.

KEY TO SPECIES—*continued.*

TRYPANOSYLLIS.	Dorsal cirri, alternating long and short, with about 40 and 20 articulations respectively		*zebra*, Grube.
	Tentacles and cirri, all nearly the same length, with 9 to 11 articulations		*cœliaca*, Clpd.
EURYSYLLIS.	Buccal segment distinctly visible from dorsal size.		*paradoxa*, Clpd.
AUTOLYTIDES.	Proboscis without teeth		*inermis*, de St. Joseph.
AUTOLYTUS.	Armature of proboscis 10 equal teeth of moderate size.	Dorsal cirri comparatively short. A simple bristle with a bent tip in each foot	*prolifer*, O. F. Müller.
	10 very large teeth, ·1 mm. long.	Proboscis, 2 mm. broad, 1 mm. long, almost straight	**megadon*, de St. Joseph.
	16 or 20 teeth not quite equal.	Appendages of head and first three segments massive. Eyes very large	*macrophthalma*, Marenz.
	16 small teeth equal in size.	Median tentacle and first pair of dorsal cirri very massive and opaque	**lugens*, de St. Joseph.
	24 unequal teeth.	Two transverse rows of glands on each segment	**punctatus*, de St. Joseph.
	24 equal teeth.	An orange coloured mark on each side of the back in front	**Edwardsi*, de St. Joseph.
	30 small equal teeth with short spurs at the base of the crown.	Colour dull grey	*ehbiensis*, de St. Joseph.
	30 or 34 equal teeth.	Four red or orange spots on each segment	*rubro-punctatus*, Grube = *ornatus*, Mar. et Bob.
	20 teeth, 10 large and 10 small.	Front part of the body marked with a regular pattern of brown spots	*pictus.*
	10 large teeth separated by 2 or 3 small ones.	Pharynx very long (18 to 20 mm.)	*longiferiens*, de St. Joseph.
	Number of teeth not known.	Dorsal cirri irregularly alternating long and short, the long about three times as long as the short	**paradoxus*, de St. Joseph.
MYRIANIDA.	Red spots on the back of segments		*pinnigera*, Montagu = *maculata*, Clpd.

* Not yet found in British area.

Notes on some Sagartiidæ and Zoanthidæ from Plymouth.

By

Chas. L. Walton.

Sagartia luciæ, Verrill.

THIS small species was described by Verrill in 1898, and first observed by Miss Verrill in 1892 near New Haven, U.S.A.

In 1902 Parker noted a number of new localities, and remarked upon its rapidly extending range on the American coast.

It has been known at Plymouth for a considerable period, being first observed in the Millbay Docks in 1896, and was identified by Mrs. Davenport in October, 1902. It was then to be found in the Cattewater, and I have lately observed it abundantly near high-water mark, under and upon stones in Rum Bay, and on Drake's Island in the Sound. It is thus extending its range here also in a quiet way.

It is certainly remarkable that this species should make its appearance on the American coast about 1892 and in Plymouth Docks in 1896. It is of course possible that it existed in both localities for some time previously, but it could hardly escape notice for long in a locality so constantly examined as Plymouth. As observed by Davenport (1903): "When the water becomes foul, or from other causes, it may voluntarily detach itself and float about the aquarium or hang upside down from the surface film." This I have also observed. Since it frequents docks, piers, and other situations, and near high-water mark, it is liable to become attached to the bottoms of ships, even floating to them in the still water usual in such places, and being very hardy, would survive a voyage, and again change its environment at the next port of call. It is significant that it was first noted at Plymouth in the Docks, and next in the Cattewater.

It is thus possible that it is not native to either the eastern coast of America or to South Devon, but was introduced into both areas about the same time.

In the Millbay Docks it lives upon the agglomerated masses of *Ascidiella aspersa*, which grow on the piles, valves of *Mytilus*, and upon one another, together with various *Polyzoa*, *Obelia longissima*, *Sycon coronata*, and colonies of *Botryllus*.

Height of column usually 5 or 6 mm., but I have seen adults when elongated as much as 10 mm. in height.

Column smooth, dull green, striped with orange-yellow.

Disk varies from semi-transparent greenish brown to dark green, with varying short lines or spots of greenish yellow at the base of the tentacles, and frequently one white radius.

Mouth generally raised on a cone.

Tentacles in multiples of twelve, 24, 36, 48, and 60 being observed in various individuals. Dull, semi-transparent, greenish in colour, or tinged with yellow or pink, sometimes a faint white ring near the tip.

Many of the conditions mentioned by G. C. Davenport, in "Variation in the stripes of *S. luciæ*," are observable here.

The anemone was in active subdivision on Drake's Island in early December, 1907, specimens being found with 4, 6, and 8 stripes more frequently than those with the normal 12.

Two large individuals, found on the same stone in Rum Bay, had the unusual number of 34 stripes, arranged in 17 pairs. One of these subsequently divided, and each of the resulting individuals had 17 stripes ($8\frac{1}{2}$ pairs).

Several small ones from Millbay were entirely without stripes.

I have observed one of these anemones seize and retain an amphipod of the same length as its own tentacles.

Sagartia coccinea, Gosse.

This species was named *coccinea* by Gosse, believing it to be identical with *Actinia coccinea*, Müller, Zool. Danica, 1776. Carlgren (1893) has shown, however, that the species really described by Müller was the *Stomphia churchiæ* of Gosse, which must hence be *Stomphia coccinea* (Müller), and the present species *Sagartia coccinea* Gosse.

It is to be found in abundance in the Cattewater, its presence there being in all probability due to trawl refuse, the majority being attached to the ascidian *Polycarpa pomaria*, and associated with other animals from the trawling grounds.

It however readily attaches itself to wood, leather, dead leaves, fucoids, and any other available material.

This species does not appear to be at all common, or at all events is seldom observed.

Base very irregular, generally lobed and twisted in a most peculiar manner. Fragments are constantly being split off, and speedily develop into fresh individuals.

Column very changeable in form. Surface finely corrugated, orange-buff with numerous yellowish white longitudinal lines, 12 of which are usually more prominent than the rest, paler about the base, and darker at the summit.

Disk as described by Gosse; the white radial lines and rich orange area about the tentacle bases.

Tentacles generally short and stout, but capable of considerable elongation. In many young specimens, 16 in number, 80 to 90 in the largest examined, they are colourless, with three broad white rings and marks at the base, as described by Gosse. Large specimens measured 12 mm. in diameter at the base. Height of column, 7–8 mm. Acontia emitted reluctantly and from the upper part of the column and the mouth; they are long and white. This species was seldom firmly attached, and could be removed from the ascidians, etc., with ease.

The following varieties were observed: (*a*) Some of the tentacles with two interrupted dark lines down their inner faces, somewhat as in *S. viduata*, but more to the front of the tentacles, not continuous, and never present on all the tentacles; (*b*) found upon water-logged wood, etc. Column perfectly transparent, the mesenteries showing as narrow white lines, the œsophageal region showing as an orange-red patch. The column of this form, tall and pillar-like, as in Gosse's figure, and the base less lobed. Height about 10 mm.

Disk transparent, pinkish-white, white lines as usual; the orange area reduced to thin light red lines around the bases of the tentacles. Mouth orange. Tentacles with indistinct white rings. Reproduction by longitudinal fission would appear to take place in this species. One quite small one was noted, divided into two as far down as the centre of the column. Carlgren remarks in 1896: *Studien uber Nordische Actinien*, p. 96, *Sagartia undata, var. undata β*, "Möglicherweise ist diese Form identisch mit Gosse's (nicht Müller's) *S. coccinea*."

Lack of the necessary material and literature prevent an attempt to elucidate the relationship of the form with regard to the above, to *S. viduata*, to *S. herdmani*, and to *S.* (*Actinia*) *lacerata*, and I therefore retain Gosse's name.

Sagartia sphyrodeta, Gosse.

Specimens were examined from the Asia Shoal, Reny Rocks, and other localities. They all belonged to the *var. candida* of Gosse. His variety *Xanthopis* I have not yet met with here, though it occurs on the north Cornish coast.

Some of the specimens had a pale bluish or glaucous tinge on the column, and I have seen a variety near St. Ives in which this colour predominated on the column in darker and lighter bands. The tentacles, according to Gosse, number 48 (8 + 8 + 16 + 16). Fischer (1874) gives 8 + 8 + 16 + 32 + 64. The usual number at Plymouth is 64 (8 + 8 + 16 + 32), but a few have about 100. Their form is changeable. "They are usually spread horizontally, and have their tips bent frequently downwards" (Gosse, p. 73).

Sometimes they are much inflated, and curve in all directions, and are often very active. Both these conditions are most frequent in those dredged in the deeper parts of the Sound, and in such also the column is more pellucid and the tentacles more extensile than in the littoral form. I have observed one exhibit extraordinary activity, bending all the tentacle tips, and then straightening them again all together and at the same time.

The lines encircling the tentacle bases, usually dark brown, sometimes light purple, or only the inner cycles so encircled. They are frequently irregular, spreading out as a dark coloured area, or forming dark patches at the sides of the tenacles. Acontia freely emitted. Transverse sections showed the ectoderm to be well developed (especially in the oral disk), and the mesoglœa, though not markedly developed in the body wall, mesenteries, or tentacles, is also thicker in the oral disk, and the sphincter is strong, and shows numerous small cavities. The longitudinal muscle of the mesenteries well developed, the fibres dendritic.

Paraphellia expansa, Haddon.

This species is not uncommon on the Rame-Eddystone grounds, but I have only been able to examine one living specimen from that area, which had been in captivity for some time. When completely contracted, 20 mm. in diameter, and much flattened, the base spread out, sometimes smooth, and at others crenulated, the centre slightly elevated and much wrinkled. The form is very changeable, the flattened base being partly or wholly retracted, the column elevated, and the anemone then assumes the turban shape figured by Haddon, but this is rare.

This specimen does not progress by the usual creeping method, but by drawing in the flat base, inflating one side of the column, and falling over in that direction, thus turning upside down and resting on the partly expanded oral disk and tentacles. One side of the pedal disk is next inflated, and the anemone rights itself again, and so on. The body wall was covered by a thin horn-coloured coating of hardened mucous, in which a good many sand grains were embedded. Remains of an older and thicker coating could be made out. The thin coat was easily removed, and the animal expanded more freely in consequence. The whole base and column were then seen to be "translucent buff," but with no sign of the "pinkish or flesh colour" on the scapus, as in Haddon's Irish specimen. Tentacles $6+6+12+24+48=96$, one cycle more than in Haddon's examples. They were coloured as given in his plate and description, but varied in intensity, some being largely white, others with a wash of pale chrome, especially about the base. The brown terminal spot very weak or absent. The lateral spots of brown, in two or three pairs, well marked or almost absent.

Disk pale brown, with 12 somewhat darker areas radiating from the primary tentacles to the mouth, these areas bordered by double yellowish lines (single in Haddon's specimens).

From the bases of the secondary tentacles, and on a paler ground, lines of white dots run towards the mouth.

Mouth raised in a cone, lips pale, throat same, longitudinally ribbed, and banded with dark brown. Acontia freely emitted from the mouth.

I recently obtained seven specimens adhering to stones at extreme low water at Zennor, near St. Ives, Cornwall, and as this is a new habitat and locality for this species, a short description may be of interest. An abundant growth of *Laminaria* and several layers of stones having been removed, these anemones were found adhering firmly to the sides and lower faces of the stones, together with *Corynactis viridis* and *Caryophyllia*, etc. When contracted they resembled Haddon's figure (*Trans. R., Dublin Soc.*, Vol. iv., Pl. XXXII, Fig. 2), and were invested in a thick brown, wrinkled, bark-like coating, and the scapus proved to be pale flesh colour on its removal. In no case, while in my possession, was a flat or crenulate base to be seen. This is probably limited to specimens living on a sandy bottom. Disk tawny brown. The arrangement of lines and dots was more complicated than in either the Irish or Plymouth specimens, but on the whole was very similar. The tentacles 96 in the larger specimens; in these also there were slight variations of arrangement of tint and markings.

Soon after capture several ejected shells of *Homalogyra atornus*, which is abundant on the rocks there.

P. expansa thus appears to have a fairly wide range on the western coast, and to be variable in colour and form.

Epizoanthus couchii, Johnston.

Zoanthus couchii, Johnston, 1838; Gosse, 1860.
Epizoanthus couchii, Haddon and Shackelton, 1891.

A colony dredged on December 6th, 1907, from Duke Rock, Plymouth Sound, consisted of fifteen polyps of various sizes attached to a stone. Cœnenchyme thin and irregular. The larger polyps 15 mm. in length, gradually widening toward the summit. Encrusted with sand. The lower $\frac{2}{3}$ of the column was weak, less encrusted than the summit, and incapable of supporting the upper portion. The upper $\frac{1}{3}$ contractile, and this gives these polyps a "knobbed" appearance. If irritated, the whole column stiffened somewhat, but usually lay bent over, the summit resting on the stone. The half-grown polyps all showed more or less narrowing about the base, but those of 2–4 mm. are the same thickness throughout.

Fresh polyps appear to arise as small mound-like swellings in the cœnenchyme. Small isolated individuals were also to be observed on the same stone.

Disk concave, olive with white lines. Mouth elevated. Lips opaque white. Tentacles 24 to 28, in two cycles, fairly long and transparent. Tips rather blunt and white. Marginal teeth, 12 to 16. In some cases well developed; in others less so.

Lives well in confinement; very timid, contracting at the least vibration.

Epizoanthus (?) rubicornis (Holdsworth).

Zoanthus rubicornis, Holdsworth, 1861.
Epizoanthus (?) rubicornis, Haddon and Shackleton, 1891.

Haddon and Shackleton (1891), p. 653, say: "This species has apparently not been met with since its discovery, and we are unable to do more than recast Holdsworth's description. We have no doubt that this species is an Epizoanthus."

I have examined two preserved colonies, marked "Five miles south-west of Rame Head, September, 1902."

Colonies unattached. From their conformation they would appear to have lain free on a sandy bottom, the polyps all being bent slightly upward.

Colony (a) consists of two large primary polyps growing from a centre, away from one another, and in the same plane; two secondary polyps arising in a similar manner at right angles to the first pair, and two smaller tertiary polyps arising from the bases of the primary pair.

Colony (b) is formed upon the same plan, but is more irregular in growth, and consists of seven polyps.

Greatest length of colony (a) 40 mm., largest polyp 20 mm. in length, and 5 mm. in width at the summit, and 3 mm. at the base.

Breadth of colony 22 mm., the polyps 10 mm. long. Tertiary polyps 5 mm. Measurements of (b) very similar.

In both colonies there were swellings at the base of the secondary polyps, indicating further branching.

Body wall strongly incrusted with sand, a few folds on or below the summit of the larger polyps.

Capitular ridges, 15 or 16, not strongly developed. Spaces between the ridges unincrusted.

Disk not visible. Tentacles partly retracted, stout, and white, 26 visible in one and 24 in another. Mr. A. J. Smith informs me that they were of an orange-red when fresh.

These specimens are evidently identical with that described by Holdsworth, and which was also obtained in the neighbourhood of Plymouth.

An anatomical examination was not attempted, as owing to the amount of incrusting sand, and the fact that the specimens had been five years in formalin, the result would be certain failure, to judge by an experience with *E. incrustatus*, besides mutilating the colonies. Fresh and less incrusted examples must be awaited and hoped for.

In the meanwhile I agree with previous writers as to the close affinity of this form with *E. couchii*.

Parazoanthus dixoni, Haddon and Shackleton.

One colony, preserved in alcohol. The label reads: "Millbay Channel, December 1st, 1902."

This colony, which consisted of over 50 polyps, had evidently been torn off a rock by the dredge, as fragments of stone and *Balanus* were found still adhering to the cœnenchyme.

Greatest length of colony 35 mm., breadth 27 mm. Height of largest polyps 10 mm., diameter 4 mm. Cœnenchyme soft, spongy, and abundant. Polyps rather crowded. Body wall slightly wrinkled, owing to the contraction of the polyps.

The whole colony bears a strong resemblance to that figured by Haddon and Shackleton, *Revis. Brit. Actiniæ*, Pt. II, Pl. LVIII, Fig. 37.

Polyps stout, contracting somewhat toward the summit, where they again enlarge. Margin rounded, with 16 to 18 well-developed ridges. Disk and mouth not visible.

Tentacles difficult to enumerate, almost all being retracted. Thirty were visible in one large polyp, fairly stout, and dull white in colour. Colony sand colour.

A transverse section shows the ectoderm and nematocysts, encircling sinus and canals, endoderm, etc., to be as described by Haddon and Shackleton. The incrustations, consisting of sand grains, spicules, etc., were, however, more numerous than in their specimens.

The specimens described by the above-mentioned authors were obtained off the coast of Kerry, Ireland, in 70–80 fathoms. The Millbay pit, from which the present colony was probably obtained, has a depth of from 12 to 17 fathoms.

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Actiniæ collected by the s.s. "Huxley" in the North Sea during the summer of 1907.

By

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THE following species were obtained:—

Bolocera tuediæ (Johnston).
Bolocera longicornis, Carlgren.
Tealia coriacea (Cuvier).
Rhodactinia crassicornis (O. F. Müller).
Stomphia coccinea (O. F. Müller).
Sagartia undata (O. F. Müller).
S. miniata (Gosse).
S. viduata (O. F. Müller).
S. pallida (Holdsworth).
Sagartia sp.
Chondractinia digitata (O. F. Müller).
Metridium dianthus (Ellis).
Epizoanthus incrustatus (Dub. and Kor.).
Cerianthus lloydii, Gosse.

BOLOCERA TUEDIÆ (Johnst.).

Voyage XCIII. Station 37. Northumberland ground. 40 fathoms. 1 specimen.

Voyage XCIII. Station 56. Lat. 55° 31′ N. Long. 0° 53′ W. 55 fathoms. 2 specimens.

The specimen from 93–37 was young and damaged. Expanse of disk and tentacles in a contracted condition, 30 mm.

Column much contracted and wrinkled, and of a dirty white; outer cycle of tentacles of the same colour, the inner cycles rose-pink. Disk dull uniform pinkish white, mouth the same and protruding, two pink œsophageal grooves.

Many of the tentacles were missing, especially from the inner cycles; these were three times the length of the outer. The animal, although injured, was still alive when first captured, and the tentacles underwent constant inflation and contraction; during contraction the sulcations showed strongly.

The two examples from Station 56 were large, and in size and colour agreed with the description in Gosse's *British Sea Anemones and Corals*, p. 186–7. Gosse there writes that the column is "studded somewhat sparsely with minute rounded warts, scarcely apparent when the animal is extended," etc., and also quotes Cocks to this effect; Carlgren, in 1891, discusses the matter, and concludes that the warts described were due to the contraction of the body wall. In the two examples now under consideration, no warts were to be found when living and expanded, but when preserved and contracted the body wall is thrown into innumerable wart-like folds, which any one who had not seen the animal in a living state might easily take to be genuine warts. The figure on Plate V (of Gosse) certainly does not show a fully expanded specimen, as the tentacles are contracted (for although incapable of retraction they can be considerably contracted). The number of tentacles present in the more perfect specimen amounted to 127, but so many had been thrown off that anything like an accurate enumeration was impossible.

The internal preservation was bad, but 77 pairs of mesenteries were recognisable.

Measurements fo a preserved specimen:—Breadth of pedal disk, 40 mm. Breadth of oral disk, 50 mm. Height of column, 55 mm. Length of tentacles of the inner cycle, 40 mm., of outer cycle, 15–20 mm. In colour, one approximated very nearly with Gosse's description, but paler; the other very pale, merely tinged with pink and light brown on the inner face of the tentacles, etc. The stomach protruded considerably.

BOLOCERA LONGICORNIS, Carlgren.

Voyage XC. Station 7. Great Fisher Bank. Lat. 56° 59′ N. Long. 2° 53′ E. 38 fathoms. 2 specimens.

Voyage XC. Station 10. The Gut. Lat. 56° 40′ N. Long. 1° 32′ E. 50 fathoms. Abundant, and at other stations in this area.

Voyage XCIII. Station 99. Lat. 55° 48′ N. Long. 0° 49′ E. 45 fathoms. 1 specimen.

Voyage XCIII. Station 101. Lat. 55° 48′ N. Long. 1° 4′ E. 40 fathoms. 1 specimen.

Voyage XCIII. Station 106. Lat. 55° 41′ N. Long. 2° 13′ E. 43 fathoms. 7 specimens.

Voyage XCVI. Station 1. Lat. 56° 0′ N. Long. 3° 23′ E. 38 fathoms. 4 specimens.

Voyage XCVI. Station 5. Very near last. $27\frac{1}{2}$ fathoms. 1 specimen.

This species was first described by Carlgren, in 1891, from specimens obtained on the west coast of Sweden, from depths of from 40–80 fathoms. In 1893 he gave a much more detailed account, and mentions the Gullmars-fjord, "other localities on the Swedish west coast," and the Skagerrak as its distribution.

Only a few of those obtained by the S.S. *Huxley* were in a perfect condition, the best being those taken in the Agassiz trawl during short hauls; those from beam hauls of several hours' duration being frequently almost destitute of tentacles, which would be found adhering to the mesh in all parts of the trawl.

None of the specimens attained the dimensions of those described by Carlgren, and measurements of fully expanded specimens were not easy owing to the generally great and usually unequal inflation of the body wall. The height of the column varying from 50 to 100 mm. Breadth of oral disk usually equal to the height. Length of inner cycle tentacles up to 80 mm, the outer 25–30 mm.

Pedal disk thin and not well demarcated. None were attached, but were free in the trawl, and only adhered in a slight degree to any vessel in which they were kept, and as they showed no sign of having been torn from any object it is probable that they lie loosely upon the bottom (sandy).

Column smooth and polished and thin, finely wrinkled when contracted. Tentacles 160, in six cycles in the larger specimens, stout, tapering to the tip, strongly sulcated, fairly contractile, constricted at the base, and very readily thrown off. Disk smooth, two large œsophageal grooves, stomach freely protruded and grooved.

Some few were of the colours described by Carlgren, "flesh colour all over, tentacles often brown-red on the inner side, gonidial-tubercles and primary mesenteries weak carmine." But the majority had the column chestnut or dull orange (the mesenteries showing as faint white lines during distention)

Tentacles maroon or, rarely, chestnut, the inner faces much darker than the outer, and the inner cycles darker than the outer. Disk a warm flesh tint, or light orange-brown, with numerous irregular radial lines of dark brown or maroon, of varying widths, but widest and darkest about the base of the tentacles. Œsophageal grooves flesh colour. Throat and stomach brownish pink. The colours persist well in preserved specimens. *B. longicornis* is not easy to keep alive, and soon after capture usually protrudes the stomach walls to an enormous extent, collapses to an abject flatness and dies.

RHODACTINIA CRASSICORNIS (O. F. Müller).

In 1902, O. Carlgren, in his paper on the Actiniæ of the *Olga* expedition considered that the name *Urticina* (*Tealia*) *crassicornis* really covered three species belonging to two genera, i.e., *Rhodactinia crassicornis* (O. F. Müll.), *Tealia coriacea* (Cuv.), and *Tealia lofotensis* (Dann.).

Unfortunately I did not see this paper until after the voyages, and regarded all the forms obtained as varieties of *Urticina crassicornis*. merely making notes on colour and external characters at the time of capture. In these notes I however distinguished three forms: (*a*) *U*, *crassicornis*, the normal form of the littoral area; (*b*) the large deep-water form, the *Tealia tuberculata* of Cocks and Cunningham, and (*c*) a form with small warts, occurring on the Great Fisher Bank. A subsequent anatomical examination of such specimens as were preserved shows this last to be *R. crassicornis* and the other two to be forms of *T. coriacea*. It is thus almost impossible to assign all the numerous records to their real species, only those cases where my notes actually notice the size of the warts and the preserved specimens can be safely noticed.

R. crassicornis occurred at several stations during Voyage XC about the region of the Great Fisher Bank, together with *B. longicornis* and *Chondractinia digitata*.

Almost all the specimens were large, having an expanse of from 12 to 14 cm. They were attached to valves of *Cyprina islandica* and *Modiola*, both dead and living, and *Fusus antiquus*, either living, empty, or tenanted by *Eupagurus bernhardus*, and once upon the shell of a living *F. turtonis*.

The small warts which beset the upper part of the column are arranged in irregular vertical rows, and during partial contraction the arrangement frequently appears annular. The colouration is very variable; the following were noted:—

(*a*) Much resembles Gosse's description and plate of *Bolocera eques*. The margin was frequently not retracted, even when the tentacles had been withdrawn. The disk, however, was never "pellucid," nor was the scarlet tentacular ring bounded by white, as described by Gosse.

When I first saw this I took it to be *B. eques*.

(*b*) Column dull orange, the summit white. Tentacles dull pink, the scarlet ring indistinct. Disk pale orange.

(*c*) Like the last, but the disk dull pink, and the mouth area vivid rose-red.

(*d*) Column as (*a*). Disk dull white, smudged with yellow. Tentacles a fine rose-red, inner faces darkest, scarlet ring not distinguishable, basal lines chestnut.

(*e*) Column as (*a*). Disk red. Tentacles with an indistinct white ring, no scarlet band.

(*f*) Column dull orange, summit red, the fosse blue. Disk cobalt blue, two red circles around the mouth. Tentacles dull orange-brown, red ring well defined, basal lines faint.

In others the column was blotched with scarlet.

In all cases the warts were white. The stomach frequently everted to a considerable extent.

The food of this species appeared to be varied, a full-sized *Spatangus purpureus* and larger shells of *Cardium* and *Psammobia* were ejected after capture, and considerable masses of *Tubularia*, though this may have been obtained in the trawl. Those kept alive swallowed *Dendronotus arborescens* with avidity, but refused *Tritonia hombergi*.

TEALIA CORIACEA (Cuvier).

The large deep-water form, described as *Actinia tuberculata* by Cocks and *Tealia tuberculata* by Cunningham, was obtained from various localities.

The colours are generally pale and the warts on the column large. The tentacles 160 in number; in several there was a bifurcation of one or more.

Usually attached to shells (dead). Near the coast, in shallow water, specimens resembling the ordinary shore form were obtained.

STOMPHIA COCCINEA (O. F. Müller).

Actinia coccinea, Müller, 1776.
Stomphia churchiæ, Gosse, 1859.
Stomphia coccinea, Carlgren, 1893 and 1902.

Voyage XCIII. Station 47. Off Seaham. 14 fathoms. 1 specimen.

Voyage XCIII. Station 65. Lat. 55° 35′ N. Long. 0° 50′ W. 45 fathoms. 6 specimens.

Voyage XCIII. Station 73. Lat. 55° 39′ N. Long. 1° 10′ W. 50 fathoms. 7 specimens.

Voyage XCIII. Station 75. Near the last. 50 fathoms. 11 specimens.

Voyage XCIII. Station 77. Off Holy Island. 32 fathoms. Common.

Voyage XCIII. Station 82. Off St. Abbs. 37 fathoms. 1 specimen.

Voyage XCIII. Station 83. Lat. 56° 7' N. Long. 1° 22' W. 42 fathoms. 1 specimen, and at a number of other stations in that area a few specimens, or common.

Voyage XCIV. Station 23. Lat. 53° 49' N. Long. 0° 15' E. 15 fathoms. 1 specimen.

Voyage XCVI. Station 20. Lat. 54° 11' N. Long. 1° 40' E. 22 fathoms. 1 specimen.

Adhering to stones and dead shells. Several from 93–77 were upon living shells of *Aporrhais pes-pelecani*, the dead shells used were usually *Modiola modiolus* and *Psammobia ferrœnsis*, etc. In confinement this species displays much restlessness, detach themselves and roll about the vessel or tank, re-attach and again loosen, and so on, also as Gosse observes (p. 222), "very protean in shape," and frequently assumes the shape shown in Gosse's figure (Pl. VIII).

Colours very variable; the column is always smooth, and has a satiny lustre, the crimson or yellowish white predominating according to the individual. Disk dull red or white, streaked with red; lips usually crimson; throat dull white or pink. In some specimens a circle of dull spots upon the inner third of the disk. Œsophageal grooves, two, red.

The pedal disk is frequently flecked and streaked with red of considerable intensity; this is probably corellated with the habit of living for varying periods unattached, lying on the side on hard rocky ground such as it favours. The tentacles pellucid white, with one or two bright red rings, or only one ring near the tip; sometimes the rings are indistinct or a white ring below the red ones. Red lines frequently run down the sides of the tentacles on to the disk. In some also a white spot is present at the base of each tentacle of the two inner cycles, thus forming two alternate circles of white spots. In several, from XCIII. 90, the column and disk were very pale and almost transparent, but the tentacles and throat were red.

It was noticeable that when a series of stations was worked at intervals away from the coast (Northumberland), the colours of this species became more and more faint, until the column was so transparent that the mesenteries could be counted with ease.

SAGARTIA UNDATA (O. F. Müller).

Actinia undata, Müller, 1788. Zool. Danica.
Sagartia troglodytes, Gosse, P. H., 1860.
Cylista undata, Andres, 1883.
Sagartia undata, Carlgren, O., 1893.

Voyage XCV. Station 24. S. edge of Coal Pit. 13 fathoms. 1 specimen.

A small specimen attached to a stone among *Serpulæ* and *Balanus*, and only visible when elongated and expanded.

Column cylindrical pink, white longitudinal lines near the base, some sand attached. Disk pure satiny white. Mouth flat, throat buff. Tentacles 70–80, not very long, yellowish white, barred transversely, some with two ill-defined dark lines upon the front face, and a rather prominent B mark at the foot.

SAGARTIA VIDUATA (O. F. Müller).

Voyage LXXXIX. Station 22. Lat. 54° 28′. Long. 2° 36½′ E. 18 fathoms. 1 specimen.

Voyage XC. Station 2. Off Esbjerg. Lat. 55° 22⅝′ N. Long. 8° 10½′ E. 8 fathoms. Several specimens.

Voyage XCII. Station 10. Lat. 54° 0′ N. Long. 6° 46¾′ E. 16 fathoms. 6 or 7 specimens.

Voyage XCII. Station 28. Lat. 54° 51½′. Long. 6° 38′ E. 22 fathoms. Common.

Voyage XCII. Station 31. Lat. 54° 47⅞′. Long. 6° 30′ E. 21 fathoms. Abundant.

Voyage XCII. Station. 34. Lat. 54° 2′. Long. 6° 54′ E. 14 fathoms. Several.

Voyage XCII. Station 42. Lat 54° 23′. Long. 7° 47′ E. 12 fathoms. Fairly common.

Voyage XCIV. Station 54. Sole Pit. 47 fathoms. 2 specimens.

Voyage XCIV. Station 56. Sole Pit. 45 fathoms.

Voyage XCVI. Station 15. Lat. 54° 30′ N. Long. 3° 59′ E. 25 fathoms. Fairly common.

Voyage XCVI. Station 17. Lat. 54° 20′ N. Long. 1° 43′ E. 24 fathoms. 1 specimen.

Upon stones, valves of *Ostrea*, lumps of slag and one from 89–22 in a hollow on a lump of "Moorlog," also inside empty shells of *Buccinum*.

Colours, etc., as described by Gosse, Carlgren and others, those from more than 40 fathoms paler than usual.

SAGARTIA MINIATA (Gosse).

Voyage XCII. Station 28. Lat. 54° 51½′. Long. 6° 38′ E. 22 fathoms. 8–9 specimens.

Voyage XCIII. Station 27. Off Whitby. 25 fathoms.

Voyage XCIV. Station 54. The Sole Pit. 47 fathoms. 5 specimens, and at four other stations in the same area, common.

Voyage XCV. Station 7 Smith's Knoll, L. V. 26 fathoms. 5 specimens.
Voyage XCV. Station 20. Knoll Deep. 22 fathoms. 4 specimens.
Voyage XCV. Station 24. S. edge of the Coal Pit. 13 fathoms. Fairly common.
Voyage XCVI. Stations 15 and 16. Lat. 54° 30′ N. Long. 3° 59′ E. 25 fathoms. Very common.
Voyage XCVI. Station 17. Lat. 54° 20′ N. Long. 1° 43′ E. 24 fathoms. Fairly common.
Voyage XCVI. Station 18. Lat. 54° 20′ N., near Long. 1° 43′ E. 24 fathoms. One or two.

This species usually occurs in colonies upon living and dead *Ostrea*, frequently clustered about the base of a colony of *Alcyonium digitatum* (growing on the *Ostrea* also), their bases overlapping or overlapped by the edge of the colony of *A. digitatum*, and often with *S. viduata*.

The colour as a rule is very variable, particularly as regards the outer cycles of tentacles, the "core" of these, though generally scarlet, may be orange-red, faint orange, or without any difference in colour from the inner cycles. Disk also variable, each colony usually being fairly uniform as to the colour of the outer tentacles and the number of the "gonidial" radii, one colony of 7 (from 96–15) having one very broad white radius each, and the same occurred in a colony of *S. viduata* from the same station.

Those procured in the Coal Pit in from 42 to 47 fathoms, bottom black mud, were identical in colouring (and as bright in colour) as those abundant in rock pool at low tide at East Hartlepool.

SARGARTIA PALLIDA, var. RUFA (Holdsworth).

Voyage XCVI. Station 15. Lat. 54° 30′ N. Long. 3° 59′ E. 25 fathoms. 8 or 9 specimens.

This colony was attached to a valve of *Ostrea*, together with young *Metridium dianthus*, to which, when contracted, they bore a strong superficial resemblance, and where that species is abundant would be easily passed over as the young form of one of the colour varieties.

Size of largest specimens.—Expanded diameter, 20 mm. Height, 15 mm. Length of tentacles of inner cycles, 10 mm. Column smooth and of a uniform dull orange-brown. Base somewhat spreading. Disk dusky white, mouth and throat orange ribbed. Tentacles numerous, about 200 in 5 (?) cycles, a double white spot at the base, which is also encircled by bowed bluish black lines; these lines give the disk a dusky appearance, and show through the body wall when contracted as a broad blackish band. One very young specimen had the column orange in colour and only eight tentacles; another, somewhat larger, 24 tentacles. In the first of these the basal lines were not visible; in the one with 24 tentacles they were blue, and the tentacles had a faint white core.

Acontia were emitted from both mouth and column.

These larger specimens were much more robust and darker in colour than any I have seen on the English or Welsh coasts; in such the column is generally white or pale orange (as in the young form described above), and the basal lines blue or purple.

With the exception of this species (and the next to be described) the anatomy of most of the forms obtained by the *Huxley* is well known. An attempted investigation of this species ended in failure; the tissues were hard and brittle, due to preservation in too high a percentage of formalin. The external form and colour were excellently preserved however. It would be well when several specimens are obtained to preserve those intended for anatomical purposes in alcohol, and museum specimens in formalin.

SAGARTIA SP.

Voyage XCIV. Station 56. The Sole Pit. Lat. 53° 36′ N. Long. 1° 30′ E. 45 fathoms. 1 specimen.

Attached to a dead valve of *Ostrea.* Expanded diameter, 25 mm. base slightly exceeding the column, outline irregular and lobed. Column firm, much wrinkled during contraction, slightly so when expanded. The summit smooth, margin tentaculate; a few weak suckers on the upper parts of the column. Colour of column dull white, the mesenteries showing as white longitudinal lines, especially about the base.

Disk transparent white, the mesenteries showing as numerous white radial lines; mouth large and frequently gaping; lips lobed, yellowish; throat brownish buff.

Tentacles about 96 in number, thick and swollen at the base, tapering gradually to the tip, white (showing an irregular white core during contraction), with a faint lilac tinge, stronger upon the lower parts and most pronounced during contraction. During complete contraction the tentacles show through the column wall as a broad lilac or light purple area. Examination with a lens showed this colour to occur upon the tentacle in little streaks. Acontia sparingly emitted and only after severe irritation. Much flattened upon complete contraction. I am not aware of any species of the genus to which I can safely refer this form, but it appears to be nearly allied to *S. miniata*; further material may provide additional evidence and permit of the form being examined anatomically.

CHONDRACTINIA DIGITATA (O. F. Müller).

Occurred frequently in abundance at many stations in the region of the Great Fisher Bank and about Lat. 55° 31′ N., Long. 0° 53′ W.; 55° 48′ N., 0° 49′ E.; 55° 44′ N., 1° 40′ E., and many other stations in those areas in from 34 to 55 fathoms.

Generally attached to the shells of various species of *Fusus*, either living or inhabited by *Eupagurus bernhardus*. Those from the Great Fisher Bank showed great variability in the size of the warts and colour of the column, etc.; there might be but one row of prominent warts near the summit, or they might be scattered thickly over the greater part of the column, and the colour of the column varied from dirty white to dull orange, and the tentacles from dull pale lilac to light brown.

In a few there was a tendency to mammillation in the warts thus approaching *C. nodosa*, though none could be placed in that species. Carlgren mentions similar cases, but in a region where both forms were to be found. He found it difficult to determine to which species some individuals should be assigned.

METRIDIUM DIANTHUS (Ellis).

This species was found so constantly and abundantly throughout the entire area investigated, as to render an enumeration of localities unnecessary. All the colour varieties mentioned by Gosse, Carlgren, and others were represented, with the exception of the sulphur and lemon-yellow; this appears to be somewhat rare (it is abundant in places on the coast of N. Wales). The most frequent in the North Sea is a dirty white, especially in the deeper water. Carlgren (1893, p. 102) says "Die rein weisse Varietat" (var. *sidonea*, Gosse, 1860, p. 13) "habe ich nur in tiefem Wasser angetroffen." In shallower areas the red, pink, and pale orange are abundant; the dark brown and olive forms were only taken occasionally.

This species is to be found attached to stones, wood, *Algæ*, *Alcyonidium gelatinosum*, *Buccinum*, *Fusus* (in such it usually occupies the apical region), upon the surface of *Cancer pagurus*, etc., etc. I have seen a large female *Cancer* almost entirely covered by an enormous red anemone.

Pycnogonum littorale is frequently to be found clinging about the base of this species, and on several occasions I have observed it feeding upon this and other species. The proboscis is sunk deeply into the tissues, and the claws are hooked into the body wall. It requires a sharp pull to draw out the proboscis, and the tissues around the puncture were generally discoloured, showing the proboscis to have remained inserted for some considerable time. *P. littorale* was observed feeding in a similar manner upon *Chondractinia digitata* in the region of the Great Fisher Bank, and *Sagartia miniata* from the Sole Pit, neither the tough body wall in one case nor the acontia in the other being sufficient protection. The coloured tissues of the anemone were often visible within the body and proboscis of the *Pycnogonum*, and that these attacks may prove fatal to young Actinians was observed in my aquaria in the spring of 1907 at Newquay, in Cornwall, a young *Sagartia* being speedily killed, and young *Bunodactis thallia* (Gosse) were much injured.

I have since seen it feeding upon *Actinia equine,* Linn., and young *M. dianthus* in the Plymouth aquaria.

EPIZOANTHUS INCRUSTATUS (Düb. and Kor.).

Voyage XCIII. Station 34. East of Shields. 38 fathoms. Common.

Voyage XCIII. Station 37. Northumberland ground. 40 fathoms. 5 specimens.

Voyage XCIII. Station 59. Lat. 55° 31′ N., 0° 36′ W. 47 fathoms. Common, and a number of other stations in that area in 40 to 57 fathoms.

The colonies varied greatly in size, number of polyps, etc. All were incrusting forms, forming carcinæcia by replacement of the shells of gastropod shells; the carcinæcia were inhabited by various species of *Eupagurus.* The smallest colony consisted of 4 polyps. The largest obtained measured 42 mm. in length, and the polyps varied from 12 mm. in height and 7 mm. in breadth to 6 mm. by 4 mm.

The number of polyps in a colony was usually 10, but as many as 30 were counted in one case, many of these being, of course, mere buds.

The incrustations were extremely dense, the ectoderm and mesoglœa being permeated with sand, and there was usually a considerable amount in the cœlenteron. Repeated attempts to observe the polyps expanded all failed, owing to the motion of the ship, the animals being very timid.

CERIANTHUS LLOYDII, Gosse.

Voyage XCIII. Station 36. East of Shields. 38 fathoms. 2 specimens.

Voyage XCIII. Station 39. Northumberland ground. 34 fathoms. 1 specimen.

Voyage XCIII. Station 70. Lat. 55° 39′ N. Long. 1° 10′ W. 50 fathoms. 1 specimen.

Of these only the last was in a sufficiently good condition to be of use, the others were badly injured by the trawl.

Length when living, 60 mm. In spirit, 27 mm.

Column cylindrical, tapering gradually posteriorly.

Body wall transversely wrinkled, the upper portion also grooved and ridged longitudinally, each ridge corresponding to one of the fully developed tentacles of the marginal cycle.

Tentacles of the marginal cycle about fifty in number, but difficult to determine, as many were quite small and evidently just developing. It was likewise impossible to enumerate the inner tentacles in a preserved condition as they were crowded together and broke in pieces if any attempt was made to separate them. The animal would not expand fully when alive.

When living the colouration agreed with the description given by Gosse. The column was uniform yellowish white, with a dark olive-green band at the summit, they area from which they arise white, and upon the base of the tentacles a series of maroon or purple patches. Marginal tentacles slender, not long; light yellowish brown, with indistinct bars of chestnut brown across the inner faces. The oral series very dark maroon.

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Nudibranchiata Collected in the North Sea by the s.s. "Huxley" during July and August, 1907.

By

C. L. Walton,

Assistant Naturalist on the s.s. *Huxley*.

During July and August, 1907 (Voyages XCII, XCIII, XCIV, XCV, and XCVI), the s.s. *Huxley* worked a series of stations reaching from near Cromer to St. Abb's Head more or less parallel with the coast line, and also a series further to the north, and extending around the eastern borders of the Dogger Bank.

Many of the hauls were in and about "roughs," and, as might be expected, a considerable number of species of Nudibranchs were obtained, some of them of considerable interest. The specimens were examined in the living state as thoroughly as circumstances permitted, and as often as possible in their natural environment. Unfortunately in many cases this was impossible, as the animals had become either detached in the dredge or trawl, or were found adhering to the mesh of the nets, and were in consequence more or less injured.

All the specimens were killed with menthol, preserved in formalin, and subsequently re-examined in the Laboratory at Lowestoft.

The following species were obtained :—

Aeolidiidæ.

1. *Aeolidia papillosa* (Linn.).
2. *Aeolidiella alderi* (Cocks).
3. *Aeolidiella glauca* (A. & H.).
4. *Cuthona nana* (A. & H.).
5. *Amphorina aurantiaca* (A. & H.).
6. *Cratena amœna* (A. & H.).
7. *Galvina cingulata* (A. & H.).
8. *Galvina picta* (A. & H.).
9. *Galvina tricolor* (Forbes).

10. *Coryphella gracilis* (A. & H.)
11. *C. lineata* (Lovén).
12. *C rufibranchialis* (Johnst.).
13. *C. salmonacea* (Couth.).
14. *Facelina drummondi* (Thomp.).

Lomanotidæ.

15. *Lomanotus genei* (Vérany).

Dotonidæ.

16. *Doto coronata* (Gmelin).
17. *D. fragilis* (Forbes).

Dendronotidæ.

18. *Dendronotus arborescens* (Müller).

Tritoniidæ.

19. *Tritonia hombergi*, Cuvier.
20. *T. plebeia*, Johnston.

Dorididæ.

21. *Archidoris testudinaria* (A. & H.).
22. *A. tuberculata* (Cuvier).

Polyceridæ.

23. *Acanthodoris pilosa* (Müller).
24. *A. subquadrata* (A. & H.).
25. *Lamellidoris bilamellata* (Linn.).
26. *Goniodoris castanea*, A. & H.
27. *Idaliella aspersa* (A. & H.).
28. *Ancula cristata* (Alder).

While following Bergh, Vayssière, Trinchese, and other authors in regarding *Coryphella rufibranchialis, C. pellucida* and *C. landsburgii* as synonyms, I have preferred to treat *C. gracilis* as a good species, and also describe *Coryphella salmonacea* as occurring in the British area.

ÆOLIDIA PAPILLOSA (Linn.).

Voyage XCVI. Station. 15. Lat. 54° 30′ N. Long. 3° 59′ E. 25 fathoms. 1 specimen.

Length 2 cm. The colouration almost identical with that of most littoral specimens. The triangular white mark on the head prominent. Oral tentacles of a clear white, spotted with opaque white. Body, rhinophores and papillæ, dull yellowish white, freckled with brown. Tail very obtuse.

The specimen was found upon a colony of *Alcyonium digitatum.*

ÆOLIDIELLA ALDERI (Cocks).

Voyage XCVI. Station 15. Lat. 54° 30′ N. Long. 3° 59′ E. 25 fathoms. 1 specimen.

Found on *Alcyonium digitatum.* Length about 16 mm.

When first obtained the specimen was taken to be a variety of *A. glauca*, but upon examining it in the Laboratory I found that it belonged to the present species.

Oral tentacles longer than the rhinophores, and white; rhinophores stout, wrinkled, bright orange-red, and very like those of *A. glauca.* Papillæ set in 8 or 9 rows, of a reddish chestnut colour, paler at the bases and tips, and more or less freckled with white.

The "ruff" was not well marked, but the papillæ forming it were paler than the rest. All the papillæ were erected upon irritation. Tail tapering to a fairly fine point.

The radula agreed generally with Alder & Hancock's plate and description. There were 14 plates of a clear yellowish white, tapering gradually; the central tooth rather stronger than in their figure, and the laterals 24 in number.

ÆOLIDIELLA GLAUCA (A. & H.).

Voyage XCV. Station 24. S. edge of the Coal Pit. 13 fathoms. 1 specimen.
Voyage XCVI. Station 18. Lat. 54° 16′ N. Long. 1° 46′ E. 23 fathoms. 2 specimens.

The specimen from XCV—24 was upon *Alcyonium digitatum.*

Those from XCVI—18 were found clinging to the meshes of the beam trawl, but *A. digitatum* occurred commonly in the haul.

All the individuals agreed with Alder and Hancock's specimen in form, but showed considerable variation in their colouration, especially in the colouration of the papillæ.

(*a*) In the specimen from XCV—24 the length was 14 mm. The rhinophores were somewhat wrinkled, short, stout, and tipped with white. Oral tentacles semi-transparent and freckled all over with white. Body and papillæ as in Alder and Hancock's plate. Eyes plainly visible.

(*b*) Those from XCVI—18 measured 35 and 25 mm. in length, respectively.

In both the papillæ were for almost their whole length of a dull green, freckled with opaque white, no red being seen.

In (*a*) the head and body were as figured by Alder & Hancock; in (*b*) the oral tentacles were much paler, and the head and rhinophores of a dull uniform red.

The animals showed little activity, but both crawled on the surface film on several occasions.

E. Hecht (*Contribution à l'étude des Nudibranches*, 1896) says of this species: "Remarquable par la variabilité de sa coloration, qui est parfois plus foncée que celle indiquée par Alder et Hancock, et plus souvent d'un jaune grisâtre."

CUTHONA NANA, A. & H.

Voyage XCII. Station 45. Edge of Sylt Outer Rough. 13 fathoms. Several specimens.

Voyage XCII. Station 46. Edge of Sylt Outer Rough. 13 fathoms. Several specimens.

Voyage XCIII. Station 9. N. of Dogger Rough. 13 fathoms. Several specimens.

Voyage XCIII. Station 19. Bruecy's Garden. 27 fathoms. 6 specimens.

Most of the specimens obtained were small, four of those from XCIII—19 measuring 9, 8, 6 and 4 mm.

All were feeding upon *Hydractinia echinata.*

Those from XCII—45 were upon a large specimen of *Hyas coarctatus*, which was almost covered with a growth of *Hydractinia*. Some nine individuals, mostly small, were clustered upon the under side of the head of the crab, and several others upon the crapace. All were of a transparent white, the papillæ having a light chestnut or pink core.

Those obtained at the other stations were upon *Hydractinia*, encrusting the shells of *Natica monilifera* and *Buccinum*. Leslie and Herdman (*The Invertebrate Fauna of the Firth of Forth*, 1881) also record *C. nana* on *Hydractinia* at "Morrison's Haven," collected by Dr. T. Strethill Wright.

AMPHORINA AURANTIACA (A. & H.).

Voyage XCIV. Station 47. Outer Dowsing Ground. Lat. 53° 28$\frac{3}{4}$′ N. Long. 1° 93′ E. 14$\frac{1}{2}$ fathoms. 1 specimen.

Length 1 cm. The specimen differed slightly from Alder and Hancock's plate and description, the rhinophores being wrinkled and slightly shorter than the oral tentacles. The white area below the tips of the papillæ very faint; the animal was damaged, and many of the papillæ were missing from the posterior region.

It was living upon a colony of *Tubularia larnyx,* which was growing upon a large stone. The spawn, which was similar to the figure of Alder and Hancock, was attached to the bases of the *Tubularia.*

CRATENA AMOENA (A. & H.).

Voyage XCV. Station 23. S. edge of the Coal Pit. 24 fathoms. 2 specimens.

The two examples of this most beautiful species were discovered creeping about the base of a colony of *Sertularia argenta,* growing upon a dead valve of *Pecten opercularis.*

Length 6 and 4 mm. respectively.

They differed from Alder and Hancock's plate and description in the following particulars, but otherwise were similar :—

1. The oral tentacles were not much longer than the rhinophores, and were white and without the brown band.
2. There was a prominent dark green mark on the centre of the head, probably due to the jaws showing through the tissues.
3. The red band on the rhinophores was broad, and in one specimen occupied the centre of the organ. In the other specimen the basal half of the rhinophore was red-brown and the upper half white.
4. The foot was more bilobed, and produced into rounded lobes at the sides.

The animals were active and restless, and progressed with ease on a flat surface contrary to Alder and Hancock's surmise.

Papillæ pale green, spotted with white and brown at their bases; a few white spots were present on the head region, but I could not make out any "white tubercles" in that region.

GALVINA CINGULATA, A. & H.

Voyage XCIV. Station 13. Inner Silver Pit. 43 fathoms. 1 specimen. Length 13 mm.

The specimen was in a very perfect condition, and as it differs in several minor points from the plate and description of Alder and Hancock, a detailed description may be of interest. Body dull white, shaded, patched, blotched, and streaked with brown and olive-brown, much darker in the regions from which the papillæ arise.

The rhinophores smooth and very little shorter than the oral tentacles, a band of olive near the tip, and streaks of white down to the base. Oral tentacles similar. Head olive, spotted with white. Eyes not discernible. The region immediately behind the head streaked and lined with dark olive-brown and spotted with white.

Papillæ long, stout, and irregular in outline, set in 9 transverse rows, the first somewhat remote from the others and arising close behind the rhinophores, thickest near the summit, and terminating somewhat abruptly in a small point; the inner rows held more or less curved inwards; 5 or 6 papillæ in each row.

The bases very pale, the "core" of light yellowish brown, irregularly and indistinctly tinged with olive, an olive band near the tip, which is white (due to numerous minute white crowded dots), or sometimes tinged with olive or yellow. A bare space down the centre of the back; posterior region pinkish fawn. Body rather narrow, foot as in Alder and Hancock's plate. Tail shorter than their figure.

The white spots on the body well marked, those on the rhinophores and papillæ less so.

The specimen was living on a branch of *Antennularia ramosa* growing upon a stone brought up by the conical dredge. The hydroid was crowded with yellow gonophores, and the animal was by no means conspicuous when extended with the body parallel with the stem, the general colour and form of the papillæ approximating closely to what was undoubtedly its natural environment.

GALVINA PICTA, A. & H.

Voyage XCII. Station 45. Sylt Outer Ground. 13 fathoms. 1 specimen.
Voyage XCIII. Station 30. Hartlepool Grounds. 30 fathoms. 2 specimens.

The specimens were of the normal colouration, that from CXII—45 was living upon a colony of *Sertularia cupressina*.

GALVINA TRICOLOR (Forbes).

Voyage XCIII. Station 96. Lat. 55° 50′ N. Long. 0° 35′ E. 45 fathoms. 4 specimens.
Voyage XCIII. Station 99. Lat. 55° 48′ N. Long. 0° 49′ E. 45 fathoms. 1 specimen.
Voyage XCIV. Station 11. Inner Silver Pit. 43 fathoms. 1 specimen.
,, XCV. ,, 24. S. edge of the Coal Pit. 13 fathoms. 1 specimen.
Voyage XCVI. Station 18. Lat. 54° 16′ N. Long. 1° 46′ E. 23 fathoms. 1 specimen.

Some variations were observable in the colours of the body and papillæ. In the younger specimens the yellow band near the tip of the papillæ was paler than in the adults, and in one case it was absent from some of the papillæ, though present in others; when absent the whole tip was white.

In some of the adult specimens the body was brownish and in others of a greenish yellow.

The specimen from XCIV—11 had had a number of the papillæ torn off, and fresh ones were growing in their places.

CORYPHELLA GRACILIS (A. & H.).

Voyage XCIV. Station 45. Lat. 53° 22′ N. Long. 0° 34¾ E. 15 fathoms. 5 specimens.

Voyage XCIV. Station 47. Lat. 53° 28¾′ N. Long. 1° 39′ E. 14½ fathoms. 1 specimen.

XCIV—45. Length of specimens, 8, 7, 7, 7, and 6 mm. respectively. Living on *Antennularia antennina* and *Sertularia argenta*.

Agreed in all particulars with Alder and Hancock's description, as also did the specimen from Station 47, which, however, was living upon *Tubularia larnyx*.

CORYPHELLA LINEATA (Loven).

Voyage XCIII. Station 21. West of Brucey's Garden. 40 fathoms. 3 specimens.

Voyage XCIII. Station 23. Whitby Outer Rough. 36 fathoms. 7 specimens.

Voyage XCIII. Station 25. Whitby Grounds. 34 fathoms. 6 specimens.

„ „ „ 30. Off Hartlepool. 30 fathoms. 1 specimen.

„ „ „ 32. N. of Hartlepool. A few specimens.

„ „ „ 53. Lat 55° 21′ N. Long. 1° 10′ W. 45 fathoms. 3 specimens.

The colour of the papillæ varies somewhat in shade, lighter or darker chestnut-red or carmine; the white tips also may be either well demarcated, narrower or wider, or may be continued downwards for a little way in streaks and blotches.

The papillæ arise from or about two lateral transparent ridges, which are more prominent in some individuals than others; the first pair of clusters are much the largest, and are somewhat compressed and taper rapidly to the tip.

The posterior portion of the foot is broad, and capable of considerable expansion; the animal attaches itself by this, the rest of the body swinging freely in the water (as in many other species). It can also crawl on the surface film.

The radula agrees with the figure and description of Alder and Hancock.

The food of the species appears to be *Tubularia indivisa* and *T. larnyx*.

CORYPHELLA RUFIBRANCHIALIS (Johnst.).

Voyage XCIII. Station 21. W. of Brucey's Garden. 40 fathoms. 2 specimens.

Voyage XCIII. Station 23. Whitby Outer Rough. 36 fathoms. 5 specimens.
„ „ „ 30. Off Hartlepool. 30 fathoms. Common.
„ XCV. „ 24. S. edge of the Coal Pit. 13 fathoms. 1 specimen.

With the exception of that from XCV—24, all the specimens obtained from the above, and a number of other stations off the coasts of Durham and Northumberland and to the N. of the Dogger Bank, etc., were referred when captured to the *C. pellucida* of Alder and Hancock. In size and external features almost all exactly agreed with the plate and description of those authors, but upon examining the radulæ it became evident that they must all be referred to the present species.

Some 16 specimens were examined from XCIII—21, 23, and 30. Unfortunately specimens from the other stations had not been preserved, so I can only conjecture that they were also referable to this species.

All the radulæ examined agreed very closely, and many were identical with the figures and description of Alder and Hancock. Generally of a yellowish white, the central plate with usually 15 denticles, the central cusp strong; the laterals, as described by Alder and Hancock, "of an acute triangular form with the apex turned outwards;" the denticles on their inner margins, however, very irregular in size and number, in some cases 12 to 14 and of fair size, in others the same number but much smaller, in others again only 7 or 8 might be present upon the upper portion of the tooth.

It is possible that specimens occur without any denticles on the laterals, and although the radula, figured by Alder and Hancock for *C. pellucida*, is of a different shape to any I examined, still the evidence, I think, supports the opinions of Bergh and Vayssière, who unite these species.

One specimen from XCIII—30 had a faint white bifurcating line on the head as in *C. lineata*, and in another from the same station the head region was coloured as in *C. landsburgii* (A. & H.). Oral tentacles and rhinophores amethystine, and tipped with yellowish white; length, half an inch. Both these cases also support the views of Bergh and Vayssière in uniting these species also with *C. rufibranchialis.*

Tubularia indivisa and *T. larnyx* were in every case the habitat of the species, and when crawling along the stems among the colonies the animals very closely resembled their surroundings. Some of the specimens were 4 cm. and many 3 and 3½ cm. in length.

CORYPHELLA SALMONACEA (Couth.).

Voyage XCIII. Station 59. Lat. 55° 31′ N. Long. 0° 36′ W. 47 fathoms. 1 specimen.

Voyage XCIII. Station 89. Lat. 55° 57′ N. Long. 0° 27′ W. 42 fathoms. 2 specimens.

Voyage XCIII. Station 96. Lat. 55° 50′ N. Long. 0° 35′ E. 45 fathoms. Very common.

Voyage XCIII. Station 99. Lat. 55° 48′ N. Long. 0° 49′ E. 45 fathoms. Very abundant.

Voyage XCIII. Station 101. Lat. 55° 48′ N. Long. 1° 40′ E. 40 fathoms. About 100 specimens.

Voyage XCIII. Station 103. Lat. 55° 44′ N. Long. 1° 40′ E. 43 fathoms. Several specimens.

Voyage XCVI. Station 1. Lat. 56° 00′ N. Long. 3° 23′ E. 38 fathoms. 1 specimen.

Length, 20 mm. for the largest; the greater number of specimens, 15 mm. Other measurements of a specimen of 20 mm. in length: height of body, 5 mm.; breadth, 5 mm; length of oral tentacles 5 mm.; rhinophores, 4 mm.; papillæ, 3·5 mm. (for the largest).

Form—Body firm, foot rather narrow, produced at the angles into thin points, tapers gradually to a somewhat obtuse point at the tail.

Oral tentacles broad and thick; rhinophores slightly wrinkled; eyes very small, placed behind the rhinophores; papillæ very numerous, the grouping obscure, continuous almost to the tip of the tail; a bare space continuous from head for three-quarters of the length of the back.

Colours—Body and foot semi-pellucid white; oral tentacles and rhinophores of the same colour, with frequently a line of opaque white down the front, or in the rhinophores confined to the upper third; papillæ reddish brown or fawn coloured, with a very distinct white ring just below the tip, giving an "eyed" appearance when viewed from above; this white ring speedily disappears in preserved specimens. Dorsal area frequently tinged with reddish brown, a faint white line along the dorsal surface of the tail.

Jaws very strong and of a dark horn colour.

Radula triseriate, of 16 to 18 rows, pale yellowish white in colour. Central plate broad, central cusp long and strong, with 7 to 8 denticles on either side, curved inwards and of fair size.

Laterals slender and acute, generally bearing 8 or 9 small and irregular denticles.

Almost all the specimens obtained were adhering to the meshes of the trawl or dredge, so that it is not possible to state its natural habitat. Few hydroids occurred in any of the hauls. These specimens differ from the majority of *C. salmonacea* in that the lateral teeth have only 8 or 9 denticles on their inner edges, while in typical *C. salmonacea* they are very numerous (*See* Bergh, *Danish Ingolf Expedition*, Vol. II, Pt. 3, pp. 33–34, Pl. IV, Fig. 19; and Pl. V, Fig. 9).

The numerous, closely-set, small papillæ, from among which arise the ill-defined groups of larger ones, were a constant feature in all the specimens examined.

FACELINA DRUMMONDI (Thompson).

Voyage XCIII. Station 7. W. edge of the Hills. 23 fathoms. 1 specimen.
" " " 86. Lat. 56° 20′ N. Long 0° 55′. 36 fathoms. 2 specimens.

Voyage XCIII. Station 89. Lat. 55° 57′ N. Long. 0° 23′ W. 42 fathoms. 1 specimen.

Voyage XCIV. Station 47. Lat. 53° 28¾′ N. Long. 1° 39′ E. 14½ fathoms. 1 specimen.

XCIII—86. Head orange, with white blotches between the rhinophores; back light orange, becoming patchy towards the tail, which was pellucid white, and had a white line to the tip. Oral tentacles long, somewhat wrinkled, orange, the tips lighter and spotted with white. Rhinophores laminated, dark orange, the tip white, and a white line down the front of the tip. Eyes situated in front of the rhinophores in one specimen and behind them in the other. Papillæ run on to the head around the rhinophores; many were missing, but those remaining were of a chestnut-maroon, with a prominent white ring below the pellucid tip, those nearest the rhinophores with a longitudinal white line on the front face, and the white ring absent. Length of animals, 15 and 20 mm.

XCIII—89. The body lighter in colour and semi-transparent. Foot sharply angulated, propodium deeply notched; a white line on the foot angles. Oral tentacles twice the length of the rhinophores. Papillæ dark chocolate colour.

XCIV—47. A young specimen ⅓ of an inch in length.

Foot angles produced into long fine points. Occurred upon *Tubularia larnyx*.

LOMANOTUS GENEI, Verany.

Voyage XCIII. Station 96. Lat. 55° 50′ N. Long. 0° 35′ E. 45 fathoms. 1 specimen.

Length 14 mm.

The rhinophores were of an orange-yellow colour, stout, and with about 15 closely-set laminæ, the tip produced, truncated, and smooth;

sheaths "calyx like," extending for half the length of the rhinophores, the margin divided into a number of small blunt teeth. Margins of foot rounded.

Body semi-transparent, tinged with pink; viscera yellowish and visible through the body wall. Faint pinkish brown lines on the epipodial processes.

DOTO CORONATA (Gmelin).

Voyage XCIV. Station 45. Lat. 53° 22′ N. Long. 0° 34¾′ E. 15 fathoms. Common.

Voyage XCV. Station 23. Knoll Deeps. 22 fathoms. 1 specimen.

Those from XCIV—45 were living and spawning freely upon *Gemellaria loricata* and *Hydrallmania falcata.*

DOTO FRAGILIS, Forbes.

Voyage XCIII. Station 62. Lat. 55° 31′ N. Long. 0° 19′ W. 36 fathoms. 3 specimens.

Voyage XCIV. Station 13. Inner Silver Pit. 43 fathoms. 1 specimen.

" " " 38. N. of Haisboro L.V. 14 fathoms. 1 specimen.

" XCVI. " 20. Lat. 54° 11′ N. Long. 1° 40′ E. 22 fathoms. 1 specimen.

XVIII—62. The three specimens varied in length from ·5 to 1 cm. One was upon *Tubularia larnyx,* and was much darker in colour than the other two, which were living and spawning on a species of *Halecium.*

DENDRONOTUS ARBORESCENS (Müller).

An enumeration of the stations where this species was obtained is scarcely necessary, as it occurred throughout the entire area explored. *Tubularia* would appear to be its general habitat, and it is most plentiful where *Tubularia* is likewise abundant. Three varieties are especially distinguishable.

(*a*) The body transparent or yellowish white, and the dentritic processes opaque white,

(*b*) a uniform, dull, semi-transparent pink,

(*c*) red, with darker red or red-brown blotches.

The last is the most general, and approximates well with the colonies of *Tubularia* on which it is usually found.

More rarely specimens are found with the body much spotted with white. All these varieties are mentioned by Alder and Hancock.

In one or two specimens a number of small wart-like projections were observable, scattered about the dorsal surface, particularly in the region between the rhinophores and the first pair of processes.

Several very young examples were examined, the smallest being 2 mm. in length; in this specimen the dentritic processes were simple, cylindrical, clavate, and incipiently branched in the first pair, which was much the largest; rhinophores plain and unbranched.

TRITONIA HOMBERGI, Cuvier.

This species was taken at a large number of stations.

It appears to be generally distributed, though seldom abundant; it was especially numerous where *Alcyonium digitatum* abounded. The colouration varied from white, yellowish white and grey, to light or very dark brown.

TRITONIA PLEBEIA, Johnst.

Like the last, this species was found wherever *Alcyonium digitatum* was at all abundant, and was generally to be found creeping about the base of a colony, or between the fleshy lobes. Considerable difference exists between the individuals from the white and those from the orange colonies of Alcyonium; those from the white being of a pale hue, and those from the orange a warm orange-brown with darker markings.

ARCHIDORIS TESTUDINARIA (A. & H.).

Voyage XCIII. Station 59. Lat. 55° 31′ N. Long. 0° 19′ W. 47 fathoms. 1 specimen,

Length 45 mm.; general colour dark greenish yellow.

Branchiæ 9, with a dusky fringe Rhinophores short. Warts of two sizes, low and obtuse. Mantle ample, covering the sides and foot. The radula agreed with the figures given by Eliot (*Journ. Mar. Biol. Assoc.*, Vol. VII, 1906, Pl. XI, Fig. 2).

ARCHIDORIS TUBERCULATA (Cuvier).

East Hartlepool. Rocks about low tide mark. 1 specimen.

ACANTHODORIS PILOSA (Müller).

Very common wherever *Alcyonidium gelatinosum* is at all abundant, and is widely distributed.

Varying in size from a few mm. to nearly 5 cm. in length. Usually pure white, sometimes grey, and occasionally brown or dusky. Spawn abundant upon *Alcyonidium gelatinosum*.

ACANTHODORIS SUBQUADRATA, A. & H.

Voyage XCIII. Station 77. Off Holy Island. 32 fathoms. 1 specimen.

The single example obtained agreed exactly with the description and plate of Alder and Hancock.

LAMELLIDORIS BILAMELLATA (Linn.).

Voyage XCIV. Station 47. Lat. 53° 28¾′ N. Long. 1° 39′ E. 14½ fathoms. 1 specimen.

Voyage XCIV. Station 52. Lat. 53° 30′ N. Long. 1° 80½′ E. 10 fathoms. 3 specimens.

Voyage XCV. Station 24. S. edge of the Coal Pit. 13 fathoms. Fairly common.

Voyage XCVI. Station 24. Lat. 54° 16′ N. Long. 1° 14′ E. 31 fathoms. Fairly common.

All the specimens but one were living among colonies of *Balanus*, upon stones of various sizes.

In colour they were perfectly normal, and agreed so well with their environment as to be extremely difficult to detect, and repeated searching of the colonies of Balanus was necessary to obtain all the specimens present.

The only marked variation was in the case of a specimen living upon a colony of *Alcyonium digitatum*, growing on a stone covered with *Balanus*, on which normally coloured specimens of *L. bilamellata* were living. This one specimen was of a very clear white, the only dark marks being two obscure and shadowy patches on the mantle, and a slight dusky shade on the branchiæ.

The largest specimens were not more than 16 mm. in length. It was observable that the branchiæ increased in number with age.

GONIODORIS CASTANEA, A. & H.

Voyage XCIV. Station 54. The Sole Pit. Lat. 53° 40′ N. Long. 1° 28′ E. 47 fathoms. 1 specimen.

Colour pinkish white, shaded with yellow. Rhinophores with yellowish laminæ and yellow tips.

Cloak more or less warted all over, the central and transverse ridges strongly warted, a double row on the central one.

Jaws showed through the tissues of the head as a broad purple patch. Branchiæ 7, pinkish brown, with a few white spots, especially near the bases.

The upper part of the foot paler than the mantle and with smaller tubercles.

The specimen was living upon a colony of *Botryllus*, which was attached to a large tube of *Sabella pavonina*, and upon which *A. digitatum* was growing. The animal lay in a depression eaten into the colony, to which it approximated very closely in colouration.

IDALIELLA ASPERSA (A. & H.).

Voyage XCIII. Station 77. Off Holy Island. Lat. 55° 44′ N. Long. 1° 40′ W. 32 fathoms. 1 specimen.

In all respects resembled the specimen described by Alder and Hancock.

ANCULA CRISTATA (Alder).

Voyage XCIV. Station 2. N.E. of Sherringham Bank. 11 fathoms. 1 specimen.

Colour a very transparent white; the orange line on the keel very faint.

The linear appendages surrounding the branchiæ tipped with opaque white in about half their number, the rest with the normal yellow tip; they were very irregular in length.

List of Publications Recording the Results of Researches carried out under the Auspices of the Marine Biological Association of the United Kingdom in their Laboratory at Plymouth or on the North Sea Coast from 1886–1907.

THE following list has been classified, so far as practicable, according to subjects, in order that it may be useful for purposes of reference. The list does not include publications recording the results of observations made on material supplied by the Association to workers in different parts of the country, of which a considerable amount is sent out each year.

In attempting to distinguish between economic and more purely scientific publications considerable difficulty has been experienced; indeed such a distinction is in reality impossible, since all researches bearing on the distribution and habits of marine life of any kind have a more or less direct bearing on fishery problems. All papers dealing with the distribution, habits, and young stages of fishes have been included in the economic division, whether the fishes are themselves marketable or not.

June, 1907.

Economic Publications.

FISHES.

1. *General.*

The Natural History of the Marketable Marine Fishes of the British Islands. Prepared by order of the Council of the Marine Biological Association especially for the use of those interested in the Sea-Fishing Industries. By J. T. Cunningham, M.A. With a preface by E. Ray Lankester, M.A., LL.D., F.R.S. London: Macmillan and Co., Ltd., 1896.

The Ovaries of Fishes. By J. T. Cunningham, M.A. Journ. M.B.A. N.S. iii. 1893–95, p. 154.

On the Histology of the Ovary and of the Ovarian Ova in certain Marine Fishes. By J. T. Cunningham, M.A. Quart. Journ. Micr. Sci. XL. 1897, p. 101.

A Contribution to the Knowledge of the Ovary and Intra-ovarian Egg in Teleosteans (with Plates XI. and XII.). By W. L. Calderwood. Journ. M.B.A. N.S. ii. 1891–92, p. 298.

Observations on Ovarian Ova and Follicles in certain Teleostean and Elasmobranch Fishes. By W. Wallace, M.A. Quart. Journ. Micr. Sci., vol. xlvii. p. 161.

A Record of the Teleostean Eggs and Larvæ observed at Plymouth in 1897. By E. W. L. Holt and S. D. Scott, B.A. Journ. M.B.A. N.S. v. 1897–99, p. 156.

Studies on the Reproduction and Development of Teleostean Fishes occurring in the neighbourhood of Plymouth (with Plates I.–VI.) By J. T Cunningham, M.A. Journ. M.B.A. N.S. i. 1889–90, p. 10.

On some Larval Stages of Fishes (with Plates III. and IV.) By J. T. Cunningham, M.A. Journ. M.B.A. N.S. ii. 1891–92, p. 68.

On Some Disputed Points in Teleostean Embryology. By J. T. Cunningham, M.A. Ann. and Mag. Nat. Hist. 1891.

Recherches sur la Reproduction des Poissons osseux. Par E. W. L. Holt. Ann. Mus. Hist. Nat. Marseille, v., 1899.

Preliminary notes on the Reproduction of Teleostean Fishes in the South-Western District. By E. W. L. Holt. Journ. M.B.A. N.S. v. 1897–99, p. 41.

Notes on the Reproduction of Teleostean Fishes in the South-Western District. By E. W. L. Holt and L. W. Byrne, B.A. Journ. M.B.A. N.S. v. 1897–99, p. 333.

Report on the Eggs and Larvæ of Teleostean Fishes observed at Plymouth in the Spring of 1902. By F. Balfour Browne, M.A. Journ. M.B.A. vi. 1903, p. 598.

Notes on the Reproduction of Teleostean Fishes in the South-Western District. By E. W. L. Holt. Journ. M.B.A. N.S. v. 1897–99, p. 107.

Report on a Collection of Very Young Fishes obtained by Dr. G. H. Fowler in the Faeroë Channel. By E. W. L. Holt. Proceed. Zool. Soc., London. 1898, p. 550.

The Rate of Growth of some Sea Fishes and their Distribution at Different Ages. By J. T. Cunningham, M.A. Journ. M.B.A. N.S. ii. 1891–92, p. 95.

On the rate of Growth of some Sea Fishes and the Age and Size at which they begin to breed. By J. T. Cunningham, M.A. Journ. M.B.A. N.S. ii. 1891–92, p. 222.

Report on the Probable Ages of Young Fish collected by Mr. Holt in the North Sea. By J. T. Cunningham, M.A. Journ. M.B.A. N.S. ii. 1891–92, p. 344.

On the Relation of Size to Sexual Maturity in Pleuronectids. (North Sea Investigations.) By E. W. L. Holt. Journ. M.B.A. N.S. ii. 1891–92, p. 363.

On the Relation of Size to Sexual Maturity in Round-fish. (North Sea Investigations.) By E. W. L. Holt. Journ. M.B.A. N.S. iii. 1893–95, p. 78.

On the Relations of the Generative Organs and of the Sexes in some Fishes. (North Sea Investigations.) By J. T. Cunningham, M.A. Journ. M.B.A. N.S. iv. 1895–97, p. 28.

Hybridism in Marine Fishes. By H. M. Kyle, D.Sc. Journ. M.B.A. vi. 1903, p. 623.

An Examination of the Present State of the Grimsby Trawl Fishery, with especial reference to the Destruction of Immature Fish. By E. W. L. Holt. Journ. M.B.A. N.S. iii. 1893–95, p. 339. (Cf. N.S. iv. 1895–97, p. 410.) Also issued as a separate publication.

Destruction of Immature Fish. By G. C. Bourne, M.A. Journ. M.B.A. N.S. i. 1889–90, p. 153.

On the Destruction of Immature Fish in the North Sea. Remedial Measures. (North Sea Investigations.) By E. W. L. Holt. Journ. M.B.A. N.S. ii. 1891–92, pp. 380, 388.

The Immature Fish Question. By J. T. Cunningham, M.A. Journ. M.B.A. N.S. iii. 1893–95, p. 54.

Growth and Distribution of Young Food-fishes. By J. T. Cunningham, M.A. Journ. M.B.A. N.S. iii. 1893–95, p. 272.

On the Destruction of Immature Fish in the North Sea. (North Sea Investigations.) By E. W. L. Holt. Journ. M.B.A. N.S. iii. 1893–95, pp. 81, 123, 169, 288.

Statistics of Small Fish landed at Grimsby. (North Sea Investigations.) By J. T. Cunningham, M.A. Journ. M.B.A. N.S. iv. 1895–97, p. 10.

The Impoverishment of the Sea. By W. Garstang, M.A. Journ. M.B.A. N.S. vi. 1900, p. 1.

Notes on the Fishing Industry of Plymouth. By Walter Heape, M.A. Journ. M.B.A. Old Series. No. 1. 1887, p. 45.

Monthly Reports on the Fishing in the neighbourhood of Plymouth (with 8 charts). By W. L. Calderwood. Journ. M.B.A. N.S. ii. 1891–92, p. 277 and p. 394. N.S. iii. 1893–95, p. 107.

Preliminary Note on Trawling Experiments in certain Bays on the South Coast of Devon. By F. B. Stead, B.A. Journ. M.B.A. N.S. iv. 1895–97, p. 90.

Report on Trawling in Bays on the South Coast of Devon. By E. W. L. Holt. Journ. M.B.A. N.S. v. 1897–99, p. 296.

Report on Trawling and other Investigations carried out in the Bays on the South-east Coast of Devon during 1901 and 1902. Prepared for the information of the Devon Sea Fisheries Committee by Walter Garstang, M.A. Journ. M.B.A. N.S. vi. 1903, p. 435.

Notes on Rare or Interesting Specimens (*Clupea alosa, Auxis Rochei, Thynnus thynnus, Myliobatis aquila*). By J. T. Cunningham, M.A. Journ. M.B.A. N.S. iii. 1893–95, p. 274.

North Sea Investigations. Preliminary. By E. W. L. Holt. Journ. M.B.A. N.S. ii. 1891–92, p. 216.

On the Territorial Fishing Ground of Scarborough and its Neighbourhood. (North Sea Investigations.) By E. W. L. Holt. Journ. M.B.A. N.S. iii. 1893–95, p. 176.

On the Iceland Trawl Fishery, with some Remarks on the History of the North Sea Trawling Grounds. (North Sea Investigations.) By E. W. L. Holt. Journ. M.B.A. N.S. iii. 1893–95, p. 129.

Two Trips to the Eastern Grounds. (North Sea Investigations.) By J. T. Cunningham, M.A. Journ. M.B.A. N.S. iv. 1895–97, p. 33.

Notes on the General Course of the Fishing. (North Sea Investigations.) By J. T. Cunningham, M.A. Journ. M.B.A. N.S. iv. 1895–97, p. 12.

Observations at Sea and in the Markets — Grimsby, Scarborough, Hull, Lowestoft. (North Sea Investigations.) By J. T. Cunningham, M.A. Journ. M.B.A. N.S. iv. 1895–97, p. 108.

Account of a Voyage in the Smack *Albert* to the Newfoundland Fishing Banks. By W. T. Grenfell, M.R.C.S. Journ. M.B.A. N.S. iii. 1893–95, p. 143.

Causes of the Observed Distribution of Fish in the North Sea. (North Sea Investigations.) By J. T. Cunningham, M.A. Journ. M.B.A. N.S. iv. 1895–97, p. 133.

General Report on the Fishery Investigations. By Walter Garstang, M.A. Internat. Fish. Investigations. Mar. Biol. Assoc. Report I. 1902–03 (Cd. 2670). 1905, p. 1.

Report on Experiments with Marked Fish during 1902–03. By Walter Garstang, M.A. Internat. Fish. Investigations, Mar. Biol. Assoc. Report I. 1902–03 (Cd. 2670). 1905, p. 13.

Report on the Trawling Investigations, 1902–3, with especial reference to the distribution of the Plaice. By Walter Garstang, M.A. Internat. Fish. Investigations, Mar. Biol. Assoc. Report I. 1902–03 (Cd. 2670). 1905, p. 67.

Report on the Food of Fishes collected during 1903. By R. A. Todd, B.Sc. Internat. Fish. Investigations, Mar. Biol. Assoc. Report I. 1902–03 (Cd. 2670). 1905, p. 227.

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Breeding of Fish in the Aquarium. By J. T. Cunningham, M.A. Journ. M.B.A. N.S. ii. 1891–92, p. 195.

Experiments on the Rearing of Fish-Larvæ in the Season of 1894. By J. T. Cunningham, M.A. Journ. M.B.A. N.S. iii. 1893–95, p. 206.

Growth of Fishes in the Aquarium. By J. T. Cunningham, M.A. Journ. M.B.A. N.S. iii. 1893–95, p. 167.

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Experiments on Sea-Fish Culture. By W. Garstang, M.A. Report Brit. Assoc., 1899.

Preliminary Experiments on the Rearing of Sea-Fish Larvæ. By W. Garstang, M.A. Journ. M.B.A. N.S. vi. 1900, p. 70.

On the First Successful Experiment with Importation of European Sea Fishes to Australian Waters. By H. C. Dannevig. Fisheries of New South Wales. Annual Report for 1902, II.

The Sense-Organs and Perceptions of Fishes, with Remarks on the Supply of Bait (with Plate XX.). By W. Bateson, M.A. Journ. M.B.A. N.S. i. 1889–90, p. 225.

Modes in which Fish are affected by Artificial Light. By W. Bateson, M.A. Journ. M.B.A. N.S. i. 1889–90, p. 216.

Experiments on the Production of Artificial Baits. By Frank Hughes. Journ. M.B.A. N.S. ii. 1891–92, pp. 91 and 220.

Notes on How Fish Find Food. (Report on the occupation of Table.) By Gregg Wilson, M.A., B.Sc. Report Brit. Assoc., 1893, p. 548.

Notes on the Invertebrate Fauna and Fish-food of the Bays between the Start and Exmouth. By R. A. Todd, B.Sc. Journ. M.B.A. vi. 1903, p. 541.

The Amount of Fat in Different Fishes. By F. Hughes. Journ. M.B.A. N.S. ii. 1891-92, p. 196.

The Vernacular Names of Common Fishes. By J. T. Cunningham, M.A. Journ. M.B.A. N.S. i. 1889–90, p. 92.

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2. *The Eel Family.*

The Breeding of the Conger. By J. T. Cunningham, M.A. Journ. M.B.A., Old Series, No. 2. 1888, p. 245.

On the Reproduction and Development of the Conger. By J. T. Cunningham, M.A. Journ. M.B.A. N.S. ii. 1891–92, p. 16.

On a Specimen of *Leptocephalus Morisii.* By J. T. Cunningham, M.A. Journ. M.B.A. N.S. iv. 1895–97, p. 73.

Sudden Colour-changes in Conger. By W. Bateson, M.A. Journ. M.B.A. N.S. i. 1889–90, p. 214.

The Larva of the Eel. By J. T. Cunningham, M.A. Journ. M.B.A. N.S. iii. 1893–95, p. 278.

The Reproductive Maturity of the Common Eel. By J. T. Cunningham, M.A. Journ. M.B.A. N.S. iv. 1895–97, p. 87.

Eels and Sticklebacks in Sea-water. By W. L. Calderwood. Journ. M.B.A. N.S. ii. 1891–92, p. 77.

Note on *Muraena helena*, Linn. By E. W. L. Holt. Journ. M.B.A. N.S. v. 1897–99, p. 91.

3. *The Herring Family.*

Anchovies in the English Channel (with an illustration in the text). By J. T. Cunningham, M.A. Journ. M.B.A. N.S. i. 1889–90, p. 328.

Probable Relation between Temperature and the Annual Catch of Anchovies in the Schelde District (with Plate XXIV.). By G. H. Fowler, B.A., PH.D. Journ. M.B.A. N.S. i. 1889–90, p. 340.

Experiments on the Relative Abundance of Anchovies off the South Coast of England. By W. L. Calderwood. Journ. M.B.A. N.S. ii. 1891–92, p. 268.

The Migration of the Anchovy. By J. T. Cunningham, M.A. Journ. M.B.A. N.S. iii. 1893–95, p. 300.

Ichthyological Contributions. iv. Growth of Young Herring in the Thames Estuary. By J. T. Cunningham, M.A. Journ. M.B.A. N.S. ii. 1891–92, p. 330.

On the Occurrence of Large Numbers of Larval Herrings at the Surface. By Matthias Dunn. Journ. M.B.A. N.S. v. 1897–99, p. 184.

Notes on the Herring, Long-line and Pilchard Fisheries of Plymouth during the Winter 1889–90. By W. Roach. Journ. M.B.A. N.S. i. 1889–90, p. 382.

Notes on Herring, Long-line and Pilchard Fisheries of Plymouth. By W. Roach. Journ. M.B.A. N.S. ii. 1891–92, p. 180.

The Spawn of the Pilchard. By J. T. Cunningham, M.A. Journ. M.B.A. Old Series, No. 2. 1888, p. 247.

The Reproduction and Growth of the Pilchard (with Plate X.). By J. T. Cunningham, M.A. Journ. M.B.A. N.S. ii. 1891–92, p. 151.

Year-old Pilchards. By J. T. Cunningham, M.A. Journ. M.B.A. N.S. ii. 1891–92, p. 398.

The Life History of the Pilchard. By J. T. Cunningham, M.A. Journ. M.B.A. N.S. iii. 1893–95, p. 148.

4. *The Salmon Family.*

The Great Silver Smelt, *Argentina silus,* Nilsson, an addition to the List of British Fishes. By E. W. L. Holt. Journ. M.B.A. N.S. v. 1897–99, p. 341.

Grayling and Loch Leven Trout in Salt Water. By W. L. Calderwood. Journ. M.B.A. N.S. v. 1891–92, p. 76.

5. *Flat-fish Family.*

Diagnostic characters in Flat-fishes. By J. T. Cunningham, M.A. Journ. M.B.A. N.S. v. 1893–95, p. 247.

The Development of the Egg in Flat-fishes and Pipe-fishes. By J. T. Cunningham, M.A. Journ. M.B.A. N.S. iii. 1893–95, p. 258.

A Treatise on the Common Sole (*Solea vulgaris*), considered both as an organism and as a commodity. Prepared for the Marine Biological Association of the United Kingdom. By J. T. Cunningham, M.A., Plymouth. Published by the Association. 1890 (4to, pp. 147, with eighteen plates).

Reproductive Organs of the Common Sole. By J. T. Cunningham, M.A. Journ. M.B.A. Old Series, No. 2. 1888, p. 248.

Ichthyological Contributions. ii. On a Stage in the Metamorphosis of Solea. By J. T. Cunningham, M.A. Journ. M.B.A. N.S. ii. 1891–92, p. 327.

Report on the Spawning of the Common Sole in the Aquarium of the Marine Biological Association's Laboratory during April and May, 1895. By G. W. Butler, B.A. Journ. M.B.A. N.S. iv. 1895–97, p. 3.

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Preliminary Investigations on the Age and Growth-Rate of Plaice. By William Wallace, D.Sc. Internat. Fish. Investigations, Mar. Biol. Assoc. Report I. 1902–03 (Cd. 2670). 1905, p. 199.

Note on *Pleuronectes microcephalus*, Donov. By E. W. L. Holt. Journ. M.B.A. N.S. iii. 1893–95, p. 121.

Rhombus maximus, Linn. (The Turbot). By E. W. L. Holt. Journ. M.B.A. N.S. ii. 1891–92, p. 399.

Note on some Supposed Hybrids between the Turbot and the Brill. (North Sea Investigations.) By E. W. L. Holt. Journ. M.B.A. N.S. iii. 1893–95, p. 292.

Note on *Phrynorhombus unimaculatus*, Risso. By E. W. L. Holt. Journ. M.B.A. N.S. v. 1897–99, p. 343.

Hippoglossus vulgaris, Linn. (The Halibut). By E. W. L. Holt. Journ. M.B.A. N.S. ii. 1891–92, p. 399.

On Secondary Sexual Characters in *Arnoglossus*. By J. T. Cunningham, M.A. Proceed. Zool. Soc. 1890, p. 540.

Note on *Arnoglossus laterna*, Walb. By E. W. L. Holt. Journ. M.B.A. N.S. ii. 1891–92, p. 283.

Note on *Arnoglossus Grohmanni*, Bonaparte. By E. W. L. Holt. Journ. M.B.A. N.S. v. 1897–99, p. 89.

Ichthyological Contributions. i. *Zeugopterus norvegicus*. (Günther.) By J. T. Cunningham, M.A. Journ. M.B.A. N.S. ii. 1891–92, p. 325.

Young Stages of *Zeugopterus punctatus*. By J. T. Cunningham, M.A. Journ. M.B.A. N.S. iii. 1893–95, p. 202.

6. *The Cod Family.*

Note on *Gadus Esmarkii*, Nilss. By E. W. L. Holt. Journ. M.B.A. N.S. ii. 1891–92, p. 282.

Gadus Esmarkii, Nilsson, the Norway Pout, an addition to the Fish Fauna of the English South-Western District. By E. W. L. Holt and Matthias Dunn. Journ. M.B.A. N.S. v. 1897–99, p. 79.

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Sense of Touch in the Rockling (*Motella*). By W. Bateson, M.A. Journ. M.B.A. N.S. i. 1889–90, p. 214.

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Note on *Raniceps raninus*, Linn. By E. W. L. Holt. Journ. M.B.A. N.S. iii. 1893–95, p. 119.

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The Pelagic Post-larval Stages of the Atlantic Species of Gadus. By Johs. Schmidt. Meddel. Komm. Havunders. Fiskeri., Bd. I. Nr. 4.

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7. *The Stickleback Family.*

Note on *Gastrosteus pungitius*, Linn. By E. W. L. Holt. Journ. M.B.A. N.S. iii. 1893–95, p. 120.

8. *Cepolidae.*

Note on *Cepola rubescens*, Linn. By E. W. L. Holt. Journ. M.B.A. N.S. v. 1897–99, p. 197.

9. *The Blenny Family.*

Note on *Lumpenus lampetraeformis*, Walbaum. By E. W. L. Holt. Journ. M.B.A. N.S. iii. 1893–95, p. 120.

Note on the Young of *Blennius galerita*, Linn. (Montagu's Blenny). By L. W. Byrne. Journ. M.B.A. N.S. vi. 1902, p. 383.

10. *The Lepadogaster Family.*

On *Lepadogaster*. By E. W. L. Holt and L. W. Byrne, B.A. Proceed. Zool. Soc. London. 1898, p. 589.

11. *The Dragonet Family.*

On the Breeding of *Callionymus lyra* in the Marine Biological Association's Aquarium at Plymouth. By E. W. L. Holt. Proceed. Zool. Soc. London. 1898, p. 281.

The Egg and Larva of *Callionymus lyra* (with Plate V.). By J. T. Cunningham, M.A. Journ. M.B.A. N.S. ii. 1891–92, p. 89.

Note on *Callionymus maculatus*, Bonaparte. By E. W. L. Holt. Journ. M.B.A. N.S. v. 1897–99, p. 90.

Note on *Callionymus maculatus*, Bonaparte. By E. W. L. Holt. Journ. M.B.A. N.S. v. 1897–99, p. 343.

12. *The Goby Family.*

Note on *Gobius Jeffreysii*, Günther. By E. W. L. Holt. Journ. M.B.A. N.S. v. 1897–99, p. 89.

The distribution of *Crystallogobius Nilssonii.* By J. T. Cunningham, M.A. Journ. M.B.A. N.S. ii. 1891–92, p. 158.

Note on *Crystallogobius Nilssonii*, Düb. and Kor. By E. W. L. Holt. Journ. M.B.A. N.S. ii. 1891–92, p. 283.

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13. *The John Dory Family.*

The Habits of the Cuckoo or Boar Fish. By J. T. Cunningham, M.A. Journ. M.B.A. Old Series, No. 2. 1888, p. 243.

14. *The Horse-Mackerel Family.*

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I.—UNIVERSITIES, UNIVERSITY COLLEGES, AND RESEARCH LABORATORIES.

Department of Comparative Anatomy, Oxford.
Geological Laboratory, Oxford.

Zoological Laboratory, Cambridge.
Balfour Laboratory, Cambridge.
The Botany School, Cambridge.

The University of London.
Bedford College for Women, London.
Birkbeck College, London.
Charing Cross Hospital Medical College.
Guy's Hospital Medical College.
King's College, London.
The Lister Institute of Preventive Medicine.
London Hospital Medical School.
London School of Medicine for Women.
Middlesex Hospital.
Royal College of Science, South Kensington.
Royal Veterinary College, Camden Town.
St. Mary's Hospital Medical School, London.
St. Thomas's Hospital, London.
University College, London.

University of Aberdeen.
University College, Aberystwyth.
Queen's College, Belfast.
The University of Birmingham.
University College, Bristol.
University College, Cardiff.
Queen's College, Cork.
Department of Agriculture (Fisheries Branch), Dublin.

School of Physic, Trinity College, Dublin.
Royal University of Ireland, Dublin.
University College, Dublin.
The Medical School, Cealia Street, Dublin.
University College, Dundee.
The University of Edinburgh.
The Royal Albert Memorial College, Exeter.
The University of Glasgow.
St. Mungo's College, Glasgow.
The University of Leeds.
The University of Liverpool.
Victoria University, Manchester.
Armstrong College, Newcastle-on-Tyne.
University College, Nottingham.
University College, Reading.
Gatty Marine Laboratory, St. Andrews.
The University of Sheffield.
Hartley University College, Southampton.

School of Medicine, Cairo.
Canterbury College, New Zealand.
South African College, Cape Town.
Government College, Lahore, India.
McGill University, Montreal.
Stazione Zoologica, Naples.
Fergusson College, Poona, British India.
Princeton University, New Jersey, U.S.A.
Zoologisches Institut, Tübingen, Germany.

II. MUSEUMS.

University Museum of Zoology, Cambridge.
University Museum, Oxford.

British Museum (Natural History).
Horniman Museum and Art Gallery, London.
Royal College of Surgeons.
Stepney Borough Museum.

Chadwick Museum, Bolton.
The Welsh Museum, Cardiff.
Essex Museum of Natural History.
Royal Albert Memorial Museum, Exeter.
Free Library and Museum, Gt. Yarmouth.
Plymouth Museum and Art Gallery.

Königliche Zoologisches Museum, Berlin.
Dresden Sea Aquarium.
Academia Polytechnica do Porto (Muzen de Zoologica), Portugal.

III. TECHNICAL AND OTHER SCHOOLS.

University Tutorial College, London.
Dulwich College, London.
East London College.
The Grove School, Highgate.
Mary Datchelor Girls' School, Camberwell.
Merchant Taylors' School, London.
Northern Polytechnic Institute, Holloway.
The Polytechnic, London.
St. Olave's Grammar School, London.
St. Paul's School, West Kensington.
South-Western Polytechnic, Chelsea.
Berkhamstead School.
King Edward's High School, Birmingham.
Technical School, Bradford.
The Training College, Brighton.
Merchant Venturers Technical College, Bristol.
Municipal Science, Art and Technical School, Burnley.
The Mining School, Camborne.
The Leys School, Cambridge.
The Whitgift School, Croydon.
Municipal Technical College, Derby.
Felstead School, Essex.
Glasgow and West of Scotland Technical College.
Charterhouse School, Godalming.
The Ladies College, Harrogate.
The School, Harrow.
Haileybury College, Hertford.
Technical College, Huddersfield.
Manchester High School for Girls.
Trent College, Nottingham.
Hulme Girls Grammar School, Oldham.
Penkridge Evening School.
Technical School, Plymouth.
Municipal Technical School, Rochdale.
Central Secondary School, Orchard Lane, Sheffield.
St. Mary's Hall, Stonyhurst.
Central Technical Schools, Truro.
Municipal Secondary School, West Bromwich.
Eton College, Windsor.
Grammar School, Wirksworth.

Transvaal Technical Institute, Johannesburg.

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 Professor 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.

The Laboratory and its fittings were completed in June, 1888, at a cost of some £12,000. Since that time investigations, practical and scientific, have been constantly pursued at Plymouth. Practical investigations upon matters connected with sea-fishing are carried on under the direction of the Council; in addition, naturalists from England and from abroad have come to the Laboratory, to carry on their own independent researches, and have made valuable additions to zoological and botanical science, at the expense of a small rent for the use of a working table in the Laboratory and other appliances. The number of naturalists who can be employed by the Association in special investigations on fishery questions, and definitely retained for the purpose of carrying on those researches throughout the year, must depend on the funds subscribed by private individuals and public bodies for the purpose. The first charges on the revenue of the Association are the working of the sea-water circulation in the tanks, stocking the tanks with fish and feeding the latter, the payment of servants and fishermen, the hire and maintenance of fishing-boats, and the salary of the Resident Director and Staff. At the commencement of this number will be found the names of the gentlemen on the staff.

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.

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NOTICE.

The Council of the Marine Biological Association wish it to be understood that they do not accept responsibility for statements published in this Journal excepting when those statements are contained in an official report of the Council.

TERMS OF MEMBERSHIP.

		£	s.	d.
Annual Members	per annum	1	1	0
Life Members	Composition Fee	15	15	0
Founders		100	0	0
Governors		500	0	0

Members of the Association have the following rights and privileges: they elect annually the Officers and Council; they receive the Journal of the Association free by post; they are admitted to view the Laboratory at Plymouth, and may introduce friends with them; they have the first claim to rent a place in the Laboratory for research, with use of tanks, boats, &c.; and have access to the books in the Library at Plymouth.

All correspondence should be addressed to the Director, The Laboratory, Plymouth.