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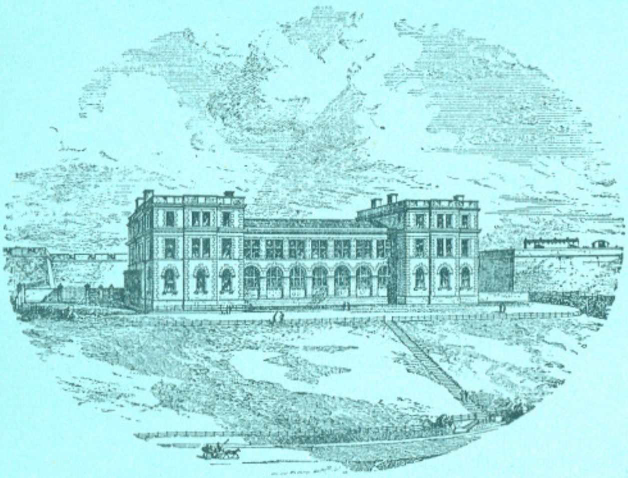

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Notes on the Reproduction of Teleostean Fishes in the South-Western District.

By

Ernest W. L. Holt.

THESE notes are intended to be explanatory of the record of tow-net stages of Teleosteans kept by Mr. S. D. Scott and myself. Although my own name appears alone under the title, it must be understood that the observations were in the sole charge of Mr. Scott until the beginning of March. The record of the 5th April is also Mr. Scott's. The rest were kept by myself. The credit of any scientific result that may accrue from the observations previous to the 30th March belongs therefore solely to Mr. Scott, since his notes and figures are so complete as to render my own share of this part of the work a very simple one.

This journal is not designed for the publication of such profusely illustrated papers as are best suited for the explanation of the earliest stages of Teleosteans. It so happens that in the present instance I am able in most cases to refer either to figures already published, or to others now in the press. A series of notes made at Professor Marion's laboratory at Endoûme, Marseilles, was prepared for the press during 1897. Observations made at Plymouth during the same period were found to have an obvious bearing on the subject-matter of my researches at Marseilles, and by the generous permission of Professor Marion I have been allowed to include in a paper shortly to be published in the *Annales du Musée de Marseille** a number of drawings made from Plymouth specimens. I am therefore able in many instances to eke out somewhat inadequate descriptions by references to figures in the *Annales*.

The subjoined notes on the reproduction of different species call for no introductory remarks; but one feature which has not, as I believe, been hitherto noticed, appears to require a little attention. That the largest fish are the earliest spawners is, as I imagine, the general

* "Sur La Reproduction des Poissons osseux, surtout dans le Golfe de Marseille," *loc. cit.*, v., Fasc. II., 1898.

experience of those who have had occasion to examine spawning fish; but that the larger fish of a species lay the larger eggs is a proposition which I have not seen in print, at least as regards marine forms. I am led to believe that this is the case from measurements of the ova of several species during successive months, both at Plymouth and Marseilles. My observations are at present of a sporadic nature, and suggestive rather than conclusive. I hope to continue them during the present year in a more methodical manner. I have previously alluded to the experience of the late Sir J. Gibson-Maitland, to the effect that among the Salmonidæ the larger parents of a species give rise to the larger eggs, from which alone, speaking generally, offspring of large potential size can be procured. If, as my experience leads me to expect, the same relation of size of egg to size of parent holds good for marine fishes or for some of them, it is not unreasonable to suspect that the young derived from the smaller and later spawned eggs are, like their representatives among the Salmonidæ, of little account in the up-keep of specimens of large size. The question has obviously a most important bearing on measures that may be adopted for the preservation of our marine fisheries. I have been myself an enthusiastic advocate of the protection of immature fishes; but if the contention which I now advance holds good, it must be recognised that this measure will not alone secure an abundance of large specimens. It cannot, by itself, go further than to protect fish until the period at which they become capable of producing offspring incapable for the most part of attaining a respectable size. That over-fishing results, whether in a river or at sea, not so much in the reduction of the numbers of a species as in a diminution of fine specimens, if not entirely a matter of common knowledge, has, at any rate, been pointed out by Herdman some years ago (*Trans. Liv. Biol. Assoc.*, vii., 1892, p. 121). Its explanation seems to be that though many fish survive to the first breeding season, comparatively few reach a size at which they are capable of producing vigorous and potentially large offspring. The proposition, if applied to domestic stock, would be by no means startling to breeders. In the case of fish I suspect that there may be found a certain correspondence between the size of the adolescent fish at spawning and the average potential size of its offspring. It may, perhaps, be reasonably suspected that the rate of growth of the offspring of small parents differs considerably from that of the young of large specimens; a condition which, however difficult to tabulate, furnishes some clue to the extraordinary variation in this respect, which must be familiar to everyone who has endeavoured to understand the apparent anomalies of the sizes of young fish taken in company.

I do not propose to discuss, except incidentally, the developmental habitat of the species dealt with, these notes being only designed to assist in the determination of the young stages. A word is necessary with regard to the references given under various species to M'Intosh and Masterman's *Life Histories of British Fishes.* This book conveniently summarises the numerous and important observations of Professor M'Intosh, which appeared originally in a great number of papers in the Scottish Fishery Board reports and elsewhere; it may also be taken as setting forth his most recent opinion on matters of doubt. I have therefore referred to it in preference to the original papers.

Trigla lineata. *Gm. Linn.* Polperro bull-dog, Parrot gurnard.

The Polperro bull-dog, as it is generally called at Plymouth, is one of the commonest gurnards of the district. It frequents the rather deep water from a few miles beyond the Breakwater outwards, though I have known it to be taken on one occasion in Cawsand Bay. The young stages have not been found in the estuary or inshore waters, and I do not think that we have ever taken the ova in tow-nets. It therefore spawns in all probability on off-shore grounds, and apparently towards the end of the summer. A female taken on the 31st July, 1897, proved to be nearly ready to spawn, since the ovaries contained a few translucent eggs. Artificial fertilisation was attempted. After the lapse of an hour and thirty-five minutes three eggs were still floating. One had reached the two-cell stage, the others may or may not have been impregnated.

These eggs measure from 1·29 to 1·33 mm. in diameter. The single dark, but not conspicuously coloured oil-globule measures, in all three cases, ·24 mm. The zona is strongly ridged, but this is probably an ovarian character. The ova were all dead on the following day.

Trigla hirundo. *Bloch.* Tub (Plymouth), Latchett (North Sea).

? Marion, A. F., *Annales Mus. Mars.*, iv., 1891, I., p. 120, Pl. II., Fig. 19. *Early larva.*

Holt, E. W. L., *Ann. Mus. Mars.*, v., Fasc. II., 1898. *Tow-net egg, larva, young pelagic form.*

The Tub is the most economically important gurnard of the Plymouth district; but, although young specimens are common throughout the year, the adults appear to leave the grounds near Plymouth before the breeding season. I have never had an opportunity of submitting ova, obtained directly from the parent, to exact observation. Speaking rather generally, I can say that spawning takes place in the summer or early autumn.

Trigloid ova obtained at Marseilles by Marion, and subsequently by myself, appear, from local considerations, to be referable to this species. The only two which I observed measured 1·25 and 1·36 mm. in diameter, with a single oil-globule of ·26 and ·28 mm. The characters of the larva, according to my notes, cannot be stated in such a way as to clearly distinguish the species from either *T. gurnardus* or *T. pini*, and I suspect that all gurnards are practically identical in conformation and pigment in the vitelligerous condition.

Since the tub attains a large size in the Mediterranean I suppose that the dimensions of ova taken in that district may be of some service in the determination of Plymouth tow-net material. I have therefore assigned with due reserve to this species a Trigloid egg taken between the Eddystone and Hand deeps on the 27th July. It measures 1·35 mm. in diameter, with an oil-globule of ·28 mm. It is chiefly the large size of the globule that inclines me to refer it to the tub rather than to the Polperro bull-dog.

Only two species of gurnard, viz., the tub and the grey gurnard, *T. gurnardus*, appear to make their way into the Plymouth estuary. Neither of them would appear to breed to any great extent in the neighbourhood, yet the young of the season appear in some numbers in the river in the autumn and winter. I do not propose to discuss the matter here, but will merely remark that the *Trigla nigripes* of Malm is certainly the young of *T. hirundo*. Smitt, who gives (*Hist. Scand. Fish.*, Ed. ii., 1895, I.) a figure of one of Malm's specimens, seems to incline to the same view; but makes a reservation to the effect that (1) the fin-rays of *T. nigripes* may increase in number in the further development of the individual, so as to bring it in harmony with some species other than *T. hirundo;* (2) the ossicles of the lateral line of *T. nigripes* are not present in the adult.

Malm's specimen is about 20 mm. long. Plymouth examples of about 30 mm. agree equally well in fin-ray formula with *T. hirundo*, so that it seems probable no increase of fin-rays takes place. The double row of lateral-line ossicles is quite distinct from the single row of much stouter bony structures in a *T. gurnardus* which is only a little larger than the young *T. hirundo.*

It appears from Smitt's remarks that the Scandinavian naturalists have found a difficulty in associating *T. nigripes* with *T. hirundo* on account of the rarity of the latter. But the Tub or Latchett is not rare on the Danish coast in summer, and the drift of the surface water has been shown by Fulton to pass, under certain conditions of wind, from the Danish to the Scandinavian coast. The young *T. hirundo* seems to have a longer pelagic existence than other gurnards, since a specimen of about 30 mm. has been taken during 1897 at the surface,* while there is no record, that I know of, of the occurrence of any other species at the surface at such an advanced stage of development.† The Bohüslan examples of *T. nigripes* may therefore be derived, in all probability, from North Sea parents rather than from the few adults of the Norwegian coast.

Callionymus lyra. *Linn.* Dragonet, Skulpin, Sting-fish.

M'Intosh, W. C., *Ann. Nat. Hist.*, 1885, p. 480. *Ovarian egg.*
Holt, E. W. L., *Sci. Trans. R. Dub. Soc.*, S. II., iv., 1891, p. 442, Pl. LI. *Egg and larva of C. lyra or C. maculatus.*
Cunningham, J. T., *Journ. M. B. Assoc.*, N.S., ii., 1891, p. 89, Pl. V. *Egg and larva.*
Prince, E. E., *Ninth Ann. Rep. S.F.B.*, 1891, p. 349, Pl. XIII. *Egg and larva.*
Holt, E. W. L., *Sci. Trans. R. Dub. Soc.*, S. II., 1893, p. 36, Pl. III. *Egg, larva, metamorphosing stages.*

Mr. Scott's observations show that the dragonet begins to spawn in January. It is one of the commonest fishes in the Plymouth district, and I think that our records show that the eggs are deposited, in some instances, in or near the Sound, as well as out towards the Eddystone, which seems to be one of the chief haunts of the larger members of the species.

The other British member of the genus, *C. maculatus*, has only recently been found on the south-west coast, one specimen having been trawled in Falmouth Bay and another off the Plymouth Mewstone. It is probable that the two species lay eggs which closely resemble each other, but as *C. lyra* is a far larger form than *C. maculatus*, I imagine that a corresponding difference holds good with regard to the ovarian products. I have been able to assign a Mediterranean tow-net egg, with a reasonable degree of probability, to *C. maculatus*. It is ·73 mm. in diameter, and the early larva is quite destitute of black pigment. The zona radiata resembles that of *C. lyra*, but the latter species is extremely rare at Marseilles.

In the first description which I gave of the larva of *C. lyra*, from the Irish coast, I omitted all mention of black chromatophores, having failed to observe any. The correctness of my description in this respect was challenged independently by Cunningham and Prince, while I myself had noticed black pigment in embryos of *C. lyra* before the papers referred to appeared. A re-examination of the only preserved specimen of those on which I had based my first description,

* In July, exact date not recorded: another was seen about the same time.

† I am not speaking of large specimens. I have been credibly informed of instances of a large gurnard pursuing smaller fish at the surface. As a matter of fact the only species identified was *T. hirundo.*

substantially bore out its correctness, and, on making acquaintance with the Mediterranean egg which probably belongs to *C. maculatus*, I concluded that I must really have been dealing with that species. *C. maculatus* is apparently not very rare on the Irish coast, and I had not measured the eggs from which my first Irish larvæ were hatched.

However, it is a fact that black pigment is not invariably present in the early larva of *C. lyra*. In examining a drawing made by Mr. Scott in January from a larva a few hours old, I noticed that no black chromatophores were shown. The specimen was again examined by Mr. Scott and by myself, and the drawing proved to be correct. The egg from which the larva was hatched measured ·90 mm. in diameter, and belonged without any doubt to *C. lyra*. The absence of black pigment must, nevertheless, be regarded as exceptional, since I was careful to examine all subsequent ova of Callionymus, and in all cases the embryo or larva exhibited some black chromatophores.

I think that without much doubt all the ova we obtained are those of *C. lyra*, since the difference in size observed seems to be roughly in accord with the date, though by no means all the eggs obtained were measured. The sizes run as follows:—January, ·90; February, ·83; March, ·91 and ·92; April, no observations; May, ·78 to ·84. I hope that it may be possible during 1898 to pay more continuous attention to the subject.

Scomber scomber. *Linn.* Mackerel.

? Agassiz and Whitman, *Mem. Mus. Comp. Zool. Harv.*, xiv., 1885, p. 36, Pl. XVII. *Unidentified Sp.* 10, *in part.*

Cunningham, J. T., *Journ. M.B. Assoc.*, N.S., i., 1889, p. 25, Pls. III., IV. *Egg.*

Cunningham, J. T., *ibid.*, N.S., ii., 1891, p. 71, Pl. IV. *Vitelligerous larva.*

Holt, E. W. L., *Sci. Trans. R. Dub. Soc.*, S. II., v., 1893, p. 10, Pl. I. *Egg, vitelligerous stages of larva.*

Holt, E. W. L., *Journ. M.B. Assoc.*, N.S., ii., 1892, p. 396. *Late larval stages.*

Holt, E. W. L., *Ann. Mus. Marseille*, 1898, *Sp.* I., *egg and larva referred to Mediterranean mackerel.*

Young stages of the mackerel are conspicuously absent from our tow-net records for 1897, although the fish was common enough in the neighbourhood in June. The spawning period is protracted at least as late as that month, and the eggs and larvæ are quite familiar to me. I must therefore conclude that little if any spawning took place on the grounds over which the tow-nets were worked, or at any point close to them. It will be observed that our expeditions did not extend beyond four or five miles off the Mewstone in the early part of the month, while during the latter part of May the *Busy Bee* was occupied in the bays east of the Start.

It is a matter of common knowledge that Mediterranean mackerel are much smaller than their Atlantic brethren. I believe that certain pelagic ova which I found at Marseilles in 1895 belong to the local variety of the species. They are smaller than those of mackerel from the British coasts, which is not remarkable. The larva, however, while closely resembling that of an Atlantic mackerel (*vide* Cunningham, Holt, *op. cit.*), differs from it in having an additional patch of yellow pigment in the middle of the tail. So far as my experience goes this patch is always present in the larva, so that, if it is really a mackerel, the Mediterranean race of the species shows a distinctive character at the very earliest stage. I have already noted that the unknown egg, Sp. 10, of Agassiz and Whitman, strongly resembles that of the mackerel. If this egg is rightly associated with the tow-net larvæ figured on the same plate, it would appear that the American race also differs in larval pigment from the British. The authors, however, do not insist upon the identity of the egg and larvæ, and the younger larva figured appears to be distinct. The older larva bears a much closer resemblance to the British form.

Some years ago I gave a brief description of some young mackerel taken in the eastern part of the North Sea (*vide* Journal, N.S., ii., 1892, p. 396). So far as I know they are the only specimens which have come under the notice of a naturalist, and it appears advisable to give a somewhat fuller account of them.

Including all my material, the details of locality and date are as follows:—

9th July, 1892, 20 to 22 mi. N.N.E. of Horn Reef, Denmark.
12 specimens, 6 to 9·5 mm.

23rd July, 1892, 250 mi. E., ½ N. of Spurn Head.
2 specimens, 14 and 19 mm. *ca.*

27th and 28th July, 1892, "Clay Deep," 150 mi. E. by N. of Spurn Head.
3 specimens, 13·5 to 19·25 mm.

The bearings are magnetic, and it will be seen from the map at the end of vol. iii. of this journal that all the specimens were taken between the Dogger Bank and the Danish and German coasts, and at considerable distances from land. The capture was effected by means of a ring tow-net of mosquito mesh, towed at the surface by a steam-trawler while trawling. As the strain was often sufficient to burst the net, it may be imagined that the smaller specimens suffered considerably.

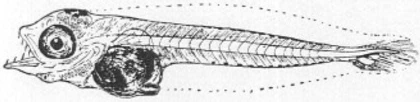
Indeed, with regard to the smallest specimens, it can only be said that they agree in pigmentation with mackerel larvæ reared from the egg. A specimen of 7 mm. is fairly well preserved, at least on one side, and while agreeing in pigment and conformation with the smallest it can clearly be associated with the older forms, which, though incompletely metamorphosed, are quite recognisable by the characters of the adult.

The specimen of 7 mm. (Fig. 1) is in its present state of preservation somewhat laterally compressed; the abdomen projects boldly below the plane of the ventral contour of the caudal part of the trunk. The pre-anal region, exclusive of the lower jaw, occupies two-fifths of the total length. The snout is pointed, the lower jaw the longer, and both jaws bear a single series of large recurved and rather widely set teeth. The eye measures rather more than one-third of the length of the head. The post-anal region is still elongate and rather slender, though markedly deeper than in the vitelligerous stages; its extremity is slightly upturned by a trilobate hypural mass, beset with developing rays, and similar rays are also present dorsally. The marginal fins are mostly frayed away; the pectorals, also in bad condition, seem to have been of moderate size. The eye, noted at the time of capture to be blue, is now a dense black; a patch of black chromatophores is present on the top of the head, probably in the pia mater, and the roof of the peritoneum (and in part its sides) is beset with black chromatophores. From a short distance behind the anal region dorsal and ventral rows of black chromatophores run back as far as the caudal peduncle, and a few small black specks are present hypurally. Yellow pigment was not observed at the time of capture; it would not in any case be visible in the preserved condition, unless very profuse or in large corpuscles.

Allowing for the difference in age, the specimen of 7 mm. agrees in all respects with the late vitelligerous stage shown in Pl. I., Fig. 7, of my Irish paper. This figure was drawn from a larva of nine days, 4·88 mm. in length. With regard to the pigment the two specimens are practically identical.

Another specimen (Fig. 2) in fairly good preservation is 9·5 mm. long. The pre-anal region is still shorter than the post-anal part, but the distance between the anus and the tip of the urochord only exceeds the pre-anal length by less than one-eighth of the latter. The ventral contour of the abdomen is much less abrupt, though its hinder part still projects somewhat from the caudal part of the trunk. The pointed snout is nearly as long as the eye; both jaws have teeth as in the preceding stage, but relatively smaller. The tail of a larval fish of some sort protrudes from the mouth, while the head can be detected far back in the abdomen.

The metamorphosis of the tail (of the mackerel larva) is advanced,



G. 1. Young Mackerel. Specimen 7 mm. long × 8.

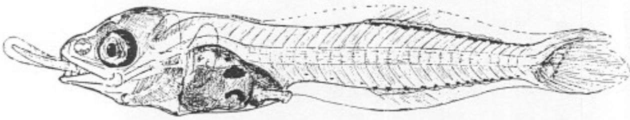


Fig. 2. Young Mackerel. Specimen 9·5 mm. long × 8.

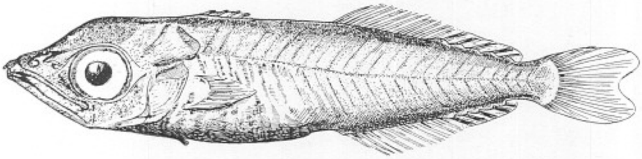


Fig. 3. Young Mackerel. Specimen 14 mm. long × 6.

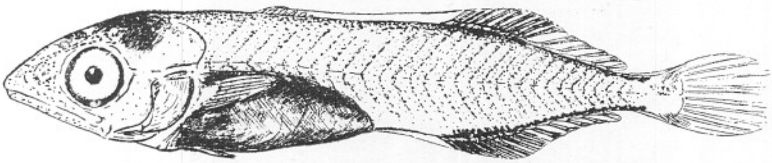


Fig. 4. Young Mackerel. Specimen 18 mm. long × 6.

the urochord with its embryonic rays being boldly thrust upwards by the hypural mass, the margin of which is still oblique. The caudal part of the trunk is most elevated at about half-way from the anal region to the caudal peduncle; on the slightly salient dorsal and ventral edges appear the interspinous ridges of the future second dorsal and anal fins. Each ridge (dorsal and anal) is continuous, but while the basal lobes of the anterior part are closely crowded together the most posterior of the series appear as rather widely separate nodules, or elevations of the crest of the ridge. Five of these isolated crests, the bases of the future finlets, can be counted on the dorsum. The anal fin region is not so well preserved. The ridges terminate at a point considerably anterior to the caudal fin. The embryonic marginal fin is continuous, but much collapsed in the present state of the specimen. A slight dorsal ridge about half-way from the shoulder to the level of the anus perhaps represents the first dorsal, but is by no means distinct. The black pigment is very similar in distribution to the last stage; but the dorsal post-anal chromatophores are larger and more numerous, forming a practically continuous line on either side of the ridge of the second dorsal and its finlets.

A badly-preserved specimen of about 13 mm. differs from the last chiefly in the greater length and more pointed contour of the snout, and in the elongation of the abdominal region. It forms a transitional stage to the more advanced condition shown in Figures 3 and 4. Fig. 3 is drawn from an example about 14 mm. in length, viewed as an opaque object; it is somewhat shorter and deeper than the specimen of about 18 mm. shown in Fig. 4, but the stage of development seems to be about the same. The bones of the head are well defined. There are no cephalic spines, but a strong longitudinal ridge at the upper extremity of the gill-cover may represent a part of the spinous armature of the young *Naucrates*. The outline of the head in Fig. 3 is probably unnatural, since three out of four specimens at about the same stage have the convex antero-superior profile of Fig. 4. The jaws are sub-equal, but the upper projects slightly, and is furnished with a pair of hooked teeth quite outside the gape. The general conformation can be gathered from the figures, the body being laterally compressed, but not more so than usual in young fish of similar stages. So far as I can gather from the examination of my material, the natural condition of the dorsal and anal fins is shown in Fig. 4. In frayed examples the finlets appear separated, but I am satisfied that the marginal fin really extends without any serious break in its outline from the first dorsal to the end of the dorsal series of finlets, and ventrally from the anus to the end of the anal finlets. It does not appear to be continuous, either dorsally or ventrally, with the caudal fin. I cannot count the rays of the dorsal and anal in any of my specimens; they are not fully developed, but seem in general agreement with the adult formula. As regards the finlets, judging from my best specimens, each isolated basal lobe bears at its apex a single stout somewhat fan-shaped ray, divided distally into numerous fibres. The caudal is injured in most of my specimens. It appears to be slightly forked, as in Fig. 3. Small dark chromatophores are present on nearly all parts of the head and trunk. Larger chromatophores occur on the top of the head and along the dorsum, especially along the base of the second dorsal and dorsal finlets, while there is a corresponding ventral band at the base of the anal fin and finlets. The sides and under-surface of the abdomen are somewhat silvery. On the sides of the trunk the chromatophores are set more thickly at the lines of division of the myomeres than elsewhere. I never saw these large specimens in the fresh condition. As I received them, a few days after they were placed in alcohol, they appeared to have been of a general bluish-grey colour, with silvery eye, gill-cover and abdomen.

Caranx trachurus. *Linn.* Scad, Horse-mackerel.

Holt, E. W. L., *Journ. M. B. Assoc.*, N.S., iii., 1894, p. 190. *Ripe ovarian egg.*
(?) M'Intosh, W. C., *Eleventh Ann. Rep. S. F. B.*, 1893, p. 245, Pl. IX., fig. 8. *Unidentified egg*, 1·2954 *mm. in diameter.*
Holt, E. W. L., *Annales du Musée de Marseille*, 1898. *Egg, larvæ, various stages of metamorphosis.*

My previous communication on the reproduction of this species dealt with ova obtained from dead North Sea specimens. Though milt was added to the water into which the female fish were stripped, I do not think that the eggs were fertilised, since the expansion of the zona and the development of the protoplasmic mound, which I then described, is often if not always achieved by ripe ovarian eggs without any aid from the male product. The observation served to demonstrate the pelagic nature and extreme buoyancy of the egg, and the complete segmentation of the yolk.

At the time of writing I had not access to Agassiz and Whitman's memoir on the "Pelagic stages" (*Mem. Mus. Comp. Zool. Harv.*, xiv., 1885, p. 12, Pls. IV., V.), and erroneously asserted that the scad furnished the only instance of an Acanthopterygian egg with completely segmented yolk. As a matter of fact these authors have given a beautifully illustrated account of the egg of *Temnodon saltator*, a Carangoid allied to Caranx, and their figures showing the gradual phases in the segmentation of the yolk are probably equally applicable to the scad, in which I was able to note that the formation of the yolk spherules is accomplished, at least in part, after the deposition of the egg. The unidentified form doubtfully assigned by Raffaele to Coryphæna furnishes probably another instance of a completely segmented yolk in the Acanthopterygian group.

I have failed to secure any further scad in spawning condition, but have no hesitation in assigning to this species certain tow-net ova obtained first at Marseilles in 1895 and again at Plymouth in 1897. I have described and figured these eggs, with the larvæ hatched from them, and some later stages, in the *Annales du Musée de Marseille*, and must refer to that publication for the illustration of my present remarks.

It will be remembered that the ripe ovarian eggs obtained at Grimsby exhibited an oil-globule, indifferently cupreous, yellow or colourless, and usually divided into several small globules at the time of spawning. The Plymouth eggs are smaller than the Grimsby specimens, but larger than those met with at Marseilles.

	Diameter of egg.		Diameter of oil-globule.
*Grimsby . .	1·03–1·09 mm.	...	·26–·27 mm.
Plymouth . .	·81– ·93 „	...	·22–·23 „
Marseilles . .	·76– ·78 „	...	·19–·20 „

I believe that this difference corresponds to the size of the parent fish in the several localities. As between the North Sea and the south-west coast I am not sure that the difference is considerable, but as spawning seems to be at its height in the North Sea in May, and my Plymouth ova were not taken before July, I suppose that the latter were derived from the smallest parents, which seem to spawn as a rule later than the large ones. As to the Mediterranean scad, all that I saw at Marseilles were very much smaller than the large Atlantic variety or race, and I imagine that in comparative size the scad differs, in the two seas, as the mackerel and pilchard are well known to differ.

Apart from the difference of dimensions the Plymouth and Marseilles ova are identical, and agree in character with the ovarian egg of the scad. The yolk appears to me to be absorbed rather more quickly than in the majority of pelagic eggs, having regard to the degree of development of the embryo, a circumstance which seems to be possibly explained by the greater extent of the protoplasmic element, limited in most ova to the periblast, but here extending inwards as the walls

* An unidentified egg, 1·29 mm. in diameter with an oil-globule of ·19 mm., is described and figured by M'Intosh (*loc. cit.*) from the east coast of Scotland. It may possibly be that of *C. trachurus*, but the nature of the markings shown on the yolk, which rather resemble yolk segments, was not ascertained. As the author observes, they may be simply superficial.

of the yolk segments. Be this as it may, while the egg has but an inconsiderable perivitelline space in its early stages, towards the time of hatching the embryo has ample room within the confines of the zona. A characteristic feature is the transverse elongation of the yolk at this stage. Yellow and black pigment is present when the embryo has acquired a short tail. A few pairs of large yellow patches occur along the head and trunk, accompanied by irregular black chromatophores. Yellow and black pigment is present about the oil-globule.

The early vitelligerous larva bears a close resemblance to that of *Temnodon saltator*, but the oil-globule is always anterior instead of posterior, a feature which also serves, *inter alia*, to distinguish the scad larva from that attributed by Raffaele to Coryphæna. At the stage at which the larva seems to be usually liberated, the anus is about median in position and therefore somewhat widely separated from the hind end of the yolk. The marginal fins are rather wide, but the dorsal does not extend in front of the head. Yellow pigment occurs in variable quantity along the dorsal and ventral region, except on the posterior half of the tail. Submarginal yellow patches, often of conspicuous size, are or may be present on the dorsal and ventral marginal fins, except on the posterior half of the tail. Yellow pigment occurs also about the rectum, the oil-globule, and to a variable extent over the general surface of the yolk. Black chromatophores, nowhere numerous, and variable in number, coexist with the yellow, and extend far back along the tail. The notochord is multicolumnar, the vacuoles being arranged in about two series. Except for the rather reduced condition of the yolk the larva cannot be said to be unusually far advanced at the time of hatching.

A larva, hatched at Marseilles from an egg which I did not measure, was much less advanced than any other which I have seen. The yolk was very large, the larva had only a very short tail, and the gut ended indefinitely a little behind the yolk. A day later the larva had acquired much the same size and conformation as those which hatched at what appears to be the normal stage, but the marginal fins were still devoid of pigment. This, however, judging from the analogy of Temnodon, appears unimportant.

A Plymouth larva, about fifteen hours after hatching, measures 3·03 mm. A Mediterranean specimen, at about the same stage, is 2·47 mm. long. The Mediterranean larva last referred to as exceptional was only 1·71 mm. long when first observed, but had reached a length of 2·63 mm. a day later. I have not succeeded in keeping these larvæ alive for more than a few days. They are exceedingly active, and rapidly injure themselves if confined in small vessels.

I do not imagine that there is any doubt as to the identity of these forms. The characters of the ova correspond to those observed in the ovarian egg of the scad, and that fish is common both at Marseilles and at Plymouth. Its ally, *Capros aper*, is known to possess quite a different egg. The egg of the John dory, *Zeus faber*, is certainly unknown. It is perhaps permissible to suppose that it will be found to resemble that of Capros rather than the form now under discussion.

An advanced larva taken at the surface of Plymouth Sound on the 6th August, 1897, is undoubtedly a scad, as is sufficiently indicated by the fin-ray formula, though the spines of the dorsal are as yet short, and those of the anal are not separated by a notch from the succeeding soft rays. The conformation is of interest.

The head is very large, its length contained about $2\frac{5}{6}$ times in the total length without the caudal fin. The height of the body is a little less than the length of the head. Both head and trunk are laterally compressed, and the general contour bears a resemblance to that of the adult Capros. The total length is 11·5 mm. The colour is olive-green, clouded almost uniformly with large black stellate chromatophores, but the median fins and the caudal peduncle are unpigmented.

The next stages known to me are represented by a number of examples taken by Mr. F. W. Gamble in August, 1896, from under the umbrella of a large Rhizostoma in the Irish Sea. There are seventy-nine little scad altogether, ranging in size, as preserved, from 16 to about 45 mm. The smallest have lost the somewhat abruptly elevated contour of the specimen of 11·5 mm., and the whole series are fusiform in shape, the elevation of the body being naturally greatest in the smaller examples. Of the British Carangoids they may be most readily compared to Lichia. At a length of 31 mm. the transverse keels of the lateral line scales are present on the posterior part of that structure. At 44 mm. the line is keeled throughout its length, but the scales do not appear to acquire the full development of the adult condition until the fish is about 54 mm. in length. Shoals of little scad from about 50 mm. upwards appeared in the estuaries of the Tamar and Plym during the autumn, so that, with the forms already referred to, we have most of the stages in the life-history of the species. Cephalic spines are not represented in any stage which I have examined.

An important gap is left between the vitelligerous larva and the specimen of 11·5 mm. At the latter size we may say that the scad is Capros-like in conformation, passing thence into an intermediate Lichia stage, from which the true Caranx conformation is finally evolved. So far as fishery matters are concerned the scad is important only as a nuisance, but the metamorphosis which we have been able to follow seems to throw an important light on the phylogeny of the whole Scombroid tribe. It appears almost certain that Caranx has been evolved from a somewhat elevated laterally compressed ancestor, bearing in this respect a resemblance to the Capros of the present day. An elevated compressed form may therefore have been a primitive feature in the evolution of a part of the tribe, intensified in the evolution of various genera, such as Zeus and Platax, reduced in others, as certainly in Caranx, and perhaps in Lichia. Scomber has lost in its ontogeny all trace of an elevated ancestry, if it ever possessed one. The importance of a primitive elevated and compressed form may extend far beyond the limits of those fish which are usually associated in the broadest sense as Scombroids. As a matter of pure conjecture it may even be suspected to throw light on the systematic position of the Pleuronectidæ. I have already suggested (*Proc. Zool. Soc.*, 1894, p. 438) that these fish are derived from vertically swimming but elevated and laterally compressed ancestors, and the absence of stout spines in the fin-rays, considering the requirements of the habit evolution, requires no explanation at all.

Capros aper. *Linn.* Cuckoo, Boarfish.

Cunningham, J. T., *Journ. M. B. Assoc.*, N.S., i., 1889, p. 10. *Early stages of egg derived from parent.*

Holt, E. W. L., *ibid.*, v., 1897, p. 41. *Egg and larvæ derived from parent; tow-net egg and larva; late larvæ referred to C. aper.*

Holt, E. W. L., *Ann. Mus. Mars.*, v., 1898, Fasc. II. *As above, illustrated by numerous figures.*

With regard to the ova, I have little to add to the observations published in the last number of the journal. It will be seen from our records that the species must have been spawning in the neighbourhood of Plymouth from the beginning of June to the end of August. Trawlers regard it as a vagabond, here one day and gone the next, but never moving very far as long as it favours the coastal waters with its unwelcome presence. It was noted on the 3rd August that no cuckoos were caught in the trawl, though their ova, in an early stage of development, were fairly numerous on the surface above the ground trawled. So closely do these fish seem to congregate that a large shoal may have been quite near us at the time.

It appears worth while to recapitulate from our records the sizes of the eggs measured on different dates, in order to set forth what evidence we have of the diminution in size towards the end of the season. The notes of interrogation signify a doubt as to the correct determination of the species.

April	27	·98	mm. ?
June	4	·96–1·01	"
"	4	1·04	" ?
"	12	·90	"
"	25	·97– ·99	"
"	29	·99	" ?
July	6	·93– ·99	"
"	23	·96	"
"	27	·93– ·97	"
"	29	·93	"
August	25	·91	"
"	27	·93	"

In describing some late larvæ taken off the Fowey river on the 29th and 30th June, I omitted to point out the close resemblance which they bear, in pigmentation, to young Lepadogaster of about the same size. The arrangement of the black chromatophores is practically identical. The supposed Capros are, however, deeper in the body. I cannot find, examining them either as opaque objects or clarified in xylol, that they have any trace of a sucker, while at 5·5 mm. the development of the tail is much more advanced than in a *Lepadogaster bimaculatus* (with well-developed sucker) of 7·5 mm. The condition of the dorsal and anal fins would refer the supposed Capros larvæ to that species of Lepadogaster, if to any. The differences noted above dispose of such a suggestion, but the resemblance in pigmentation is interesting.

Lophius piscatorius. *Linn.* Monk, &c.

The ripe ovaries of a monk were brought to the Laboratory on the 20th January, 1898. I saw, but did not closely examine, the ovaries of another specimen on the same day; they appeared also to be ripe. Thompson, according to Day, observed a female with advanced ovaries in December, so that the spawning season would appear to commence very early in the year.

The ovaries were placed in sea-water, and as much as possible of the delicate ovarian wall stripped off. The mucous sheet soon swelled to a considerable width, and the spawn-mass floated for an hour or more. The oil-globules imparted to the whole a brilliant orange or salmon-colour. They were found to be divided, in a number of eggs examined, into numerous particles of various sizes. The mucous matter was only slightly adherent externally.

As is well known, the spawn, although a very conspicuous object, is rarely encountered at the surface. Is it possible that the parent manages to hitch it in some way to a submarine object?

Blennius ocellaris. *Linn.* Butterfly blenny.

1889 Cunningham, J. T., *Journ. M. B. Assoc.*, N.S., i., ~~1891~~, p. 36, Fig. XXV. *Egg.*
Holt, E. W. L., *Ann. Mus. Marseille*, v., 1898, Fasc. II. *Newly hatched and late pelagic larva.*

This blenny must probably be regarded as difficult to catch rather than as actually rare in the Plymouth district. Two adults, both males, were taken in 1897. Cunningham has already described the ova, which were found in an ox-bone, and identified by the presence of the male parent.

On the 20th June, 1896, Mr. Beaumont dredged a large whelk-shell off the Plymouth Mewstone. In the mouth of the shell was a male Butterfly blenny, guarding a great number of eggs. Higher up in the shell a *Lepadogaster bimaculatus* was similarly occupied. I did not specially examine the eggs of the blenny, but Guitel's researches (*Arch. Zool. Exper.*, S. iii., I., 1893, p. 325) render it very probable that in this species, as in others, the egg adheres by means of a series of long attachment filaments situate around the micropyle. The eggs were in various advanced stages of development, and many had hatched before the *Busy Bee* arrived at the Laboratory, but some had not hatched on the following day. Very probably they had not all been spawned at the same time. All unhatched eggs appeared bright red, the colour being that of the yolk.

A larva, from twelve to twenty-four hours old, measures 6·30 mm., of which the greater part is occupied by the tail. The distance between the snout and the hind end of the yolk is only 1·85 mm., and of this ·95 mm. pertains to the head. The rectum occurs immediately behind the yolk. The head is bluntly rounded in contour, and the edges of the marginal fins show a bold inflection towards the end of the tail, the caudal part being spatulate. The pectoral fin is large, with well-developed rays, the longest of which, when laid parallel to the body, extend ·12 mm. beyond the anus. This fin is yellow, with black chromatophores along the rays. The brain and anterior tissues generally are buff by transmitted light. Black chromatophores occur on the top of the head and about the posterior end of the trunk. The marginal fins are devoid of pigment. The notochord is multicolumnar.

I was unable to study any later stages as an accident to the escape pipe caused the loss of all my material. The larvæ appeared delicate, since many died soon after hatching; but as they were exceedingly active it is quite possible that they injured themselves against the sides of the bell-jar in which they were confined.

A much more advanced larva, taken in the little bay under Professor Marion's laboratory, at Endoûme, appears to belong to the species now under consideration. The total length is 18 mm. The conformation approaches that of the adult, and the fin-ray formula agrees with that of *B. ocellaris;* while local considerations seem to eliminate from the list of probable parents such other blennies as exhibit a practically identical formula. The pectorals, 5 mm. in length, are olive-green, finely dotted with black—a character of *B. ocellaris.* The head and anterior part of the body are pale yellow; several olive-green bands radiate from the large blue eye. There is a patch of olive-green on the top of the head, a band along the middle of the side, and another along the base of the anterior part of the anal. Anteriorly a series of short bars descend from the dorsum. The dorsal and anal fins are colourless, and there is no pigment whatever on the hinder half of the post-anal region. There are no well-developed cephalic tentacles, and the dorsal, though deeply notched, is not conspicuously elevated in front. The little fish, when first observed, was swimming at the surface, the pigmented parts being alone visible. The resemblance to a butterfly was very much more apparent than in the adult condition.

The relatively enormous pectorals of the larva, though vigorously employed, cannot be regarded as very effective organs of locomotion, since the result achieved is by no means remarkable either for pace or staying power. Their significance is, perhaps, ancestral rather than adaptive. The resemblance, not only in the pectoral development but also in the contour of the head, to Dactylopterus, may be, so to speak, accidental. The young blenny is entirely devoid of cephalic armature. Both of the larval stages described above are figured in the *Annales du Musée de Marseille.*

Blennius pholis. *Linn.* Shanny.

M'Intosh and Masterman, *Life-Histories Brit. Food-Fish.*, 1897, p. 206. *Late larval stages.*

Holt, E. W. L., *Ann. Mus. Mars.*, 1898, v., Fasc. II. *Pelagic larval stage, with figure.*

The early development of the shanny seems never to have been the object of exact observation. The later larval stages have been dealt with by M'Intosh and Masterman.

On the 15th July, 1897, a larva of 15·5 mm. was found by Mr. Beaumont and myself in a dahlia flower which was floating under St. Anthony lighthouse, Falmouth. The fin-ray formula is that of the adult; in other respects the specimen is very similar to the young *B. ocellaris* of 18 mm., but the colours are different. The dorsal and anal fins and the hinder half of the post-anal region are entirely devoid of pigment. The ground colour of the anterior parts is canary-yellow, with a deeper patch near the middle of the post-anal region. Several bands of black chromatophores radiate from the eye; there is a black patch on the top of the head and a row of black chromatophores on the cheeks. A band of black, notched at intervals, occurs on the dorsum, a row of black along the base of the anterior part of the anal, and there are some small black chromatophores along the lateral line. The pectorals are reddish brown, with very large transversely elongated black chromatophores, or groups of chromatophores, arranged on the interradial membrane so as to form rows transverse to the long axis of the fin. The pigment differs thus in colour rather than in general distribution from that of *B. ocellaris.* The pigmentation of the pectoral is practically that of the adult *Dactylopterus volitans.* The specimen is figured in the Marseilles paper.

On the same day I saw, but failed to catch, what were probably similar larvæ. They were among the Laminaria at the sides of a tidal pool near the place of capture of the specimen described. A day later we found another—a little larger—in the Helford river zostera bed, at low water. Older specimens, 19·5 and 20 mm. long, were taken at the surface in Plymouth Sound on the 7th September, but I omitted to note the presence or absence of any floating body to which they might have been clinging. A feature of note is the extraordinary activity of the larva when out of its native element. Its leaping powers are most respectable, and no injury seems to ensue from contact with terrestrial matters. I suppose that its locomotion on land is accomplished in the same way as that of Periophthalmus; but my specimens were a great deal too lively to make sure of this. I imagine that the young shanny is not infrequently stranded by the falling tide, in which case its jumping powers may serve it in good stead.

Ctenolabrus rupestris. *Linn.*

Holt, E. W. L., *Sci. Trans. R. Dub. Soc.*, S. II., iv., 1891, p. 465, Pls. XLVIII., XLIX. *Tow-net egg and larva, Sp.* iv.

Pelagic ova taken on the west coast of Ireland were referred to this species on account of the close resemblance they bore to those of the American connor, *C. adspersus.* This identification has never been confirmed by the evidence of ovarian eggs, and perhaps hardly requires such confirmation. A glance at our records will show the frequency with which the egg has been taken in the Plymouth district during 1897. This is by no means surprising, as the parent species is exceedingly abundant on rocky ground both in the Sound and outside the Breakwater. It occurs also, if one may judge from the evidence of tow-net eggs, on the outlying Eddystone rocks. Young examples are common in the zostera beds of Cawsand Bay and the Yealm estuary, but adults are rarely taken, at least by the Laboratory boats, on any ground fit for trawling. It would appear from our records that there is no special migration in connection with the spawning instinct, but that the ova are liberated on the grounds ordinarily inhabited by the species. The breeding season appears to be prolonged from April to August, and such measurements as were made afford evidence of a diminution in the size of the ova as the season advances. The actual numbers will be found in the records, while the subjoined list may be taken as a summary:—

April	·90 to 1·01 mm.
May	·87 „ ·94 „
June	·84 „ ·87 „
July	·78 „ ·82 „
August. . . .	·72

An egg of ·67 mm., taken on the 28th June, can probably be assigned to this species; as it presents certain indications of immaturity, it cannot fairly be utilised as evidence of size variation. Excluding this specimen, the variation is ·29 mm., or more than one-fourth of the size of the largest specimen.

It may be urged that the ova which we have assigned to *C. rupestris* may really have been contributed by more than one species of wrasse, but I do not think that this is the case. The common wrasses of Plymouth are *L. maculatus, L. mixtus, Cr. melops, Ce. exoletus,* and *Ct. rupestris.* The first three may be discarded, since their ova are demersal. Of the ova of *Centrolabrus exoletus* I know nothing, but I found at Marseilles, where *C. exoletus* is not known to exist, a similar variation and seasonal diminution in the size of tow-net ova referable to *Ct. rupestris.*

April	·80, ·83 mm.
May	no observations.
June	·75, ·76 mm.
July	·70 mm.

Moreover the occurrence of young specimens in the Plymouth zostera beds affords evidence that the spawning season is really as prolonged as would appear from the tow-net gatherings. Preliminary experiments indicate that the species can easily be reared from a very small size, and it may be possible to study its development continuously.

I 2

Unidentified Labroid, resembling **Coris.**

Holt, E. W. L., *Sci. Trans. R. Dub. Soc.*, S. II., iv., 1891, p. 467, Pls. XLVIII., LI., *Sp.* v., Coris-like.

Holt, E. W. L., *Ann. Mus. Marseille*, v., 1898, Fasc. II. *Egg and larva, with figure.*

An egg which appears to have unquestionable Labroid affinities was taken in the Plymouth district in July and August, 1897. Our records show that it occurred on more or less off-shore grounds. I have no doubt but that it is identical with ova already described from the west coast of Ireland, but the parentage remains in doubt.

The Irish specimens measured from ·80 to ·83 mm. in diameter, the oil-globule measuring ·15 mm. Those taken at Plymouth measure from ·78 to ·81, the oil-globule from ·13 to ·15 mm. The yolk is homogeneous, the oil-globule colourless, but, in the Plymouth examples at all events, very dark. A larva, measured very soon after hatching, is 2·21 mm. long. A somewhat more advanced specimen from Ireland measured 2·44 mm. The conformation of the larva bears a striking resemblance to *Coris julis* (*vide* Raffaele, *Mittheil. Zool. Stat. Neap.*, viii., 1888, Tav. II., Figs. 18, 19). The yolk is pyriform, its narrow end, having the globule at the apex, projecting boldly in front of the head. The rectum is separated by a considerable interval from the hind end of the yolk. The marginal fins are of moderate width, the dorsal arising behind the head. My notes distinctly state that the edges of the marginal fins are not serrated as in Coris. The notochord, in Irish specimens, is of a peculiar type. For the most part arranged in a double series, the vacuoles are occasionally unicolumnar. This appears to me a strong indication of Labroid affinity, since both Coris and Ctenolabrus exhibit a notochord intermediate in character between the unicolumnar and multicolumnar conditions, though the approach to the former condition is much more marked than in the form before us. I must add that I did not find any unicolumnar cells in a Plymouth example which I examined; it is probably a variable feature, but, on account of its rarity, in so far as my knowledge extends, in other groups of fishes, not the less useful.

The pigment is all black, and has the same distribution as in Coris, but resembles perhaps even more closely that of Mullus. Indeed, save for the presence of cortical yolk segments in Mullus and for the separation of the yolk and rectum in our unidentified larva, the two forms are extremely alike.

I believe that the Labroid affinities of the parent are fairly well demonstrated by the characters of the embryo and larva. The difficulty is to find a Labroid parent. Labrus, Crenilabrus, and Ctenolabrus are naturally eliminated. *Centrolabrus exoletus* spawns, at least in great part, at a season earlier than the date of capture of the ova, as is demonstrated by the presence of the young in the zostera beds. It seems also to be a rather littoral fish, and it is quite possible that its ova are demersal. *Acantholabrus Palloni* may exist in the Plymouth district, but is only known to British zoology by a few examples recorded by Couch from the Cornish coast. *Coris julis* has been taken at Plymouth, but not to my knowledge in recent years, while the eggs of Mediterranean specimens, according to Raffaele's observations and my own, measure from ·58 to ·70 mm. in diameter, with an oil-globule of ·12 to ·14 (·18) mm., and, as already noted, the fin-edges of the larva are serrated. The difference is thus not only one of dimensions, though it is possible that I overrate the importance of the fin serration as a constant character.

The Mediterranean *Coris speciosa* of Risso is regarded by Marion (*Annales Mus. Mars.*, i., 1882, Mem. 2, p. 20, foot-note 3) as a deep-water variety of the common littoral *C. julis*. So far as my knowledge of the forms allows me to hold an opinion, it is in agreement with that of Marion. *C. speciosa* is known only from large specimens and may be, as I suppose, simply the ultimate phase of the development of *C. julis*; but, on the other hand, since its anterior dorsal rays are proportionately shorter than those of the fully developed *C. julis* of coastal waters, it may be a true variety. I have not had an opportunity of examining the British Museum specimens of Coris from the S.W. coast, but Day's remarks appear to indicate that at least one specimen is of the *C. speciosa* type.

Since Coris is little liable to capture by ordinary British fishing apparatus, it is quite possible that it really exists in some numbers in our district, and our undetermined ova may be thus accounted for, assuming that the British variety is larger and lays larger eggs than the Mediterranean coastal form, and that the serration of the larval fin is either variable or only present in the offspring of the smaller form or stage.

It is quite possible that our undetermined form is not a Labroid at all, but referable to one of the too numerous common fishes of which the early stages are still unknown to us. I do not think that this is the case, imperfect as is our present knowledge of Teleostean development.

The Topknots. Zeugopterus and Phrynorhombus.

Brook, G., *4th Ann. Rep. S.F.B.*, 1886, p. 226. *Ovarian egg of P. unimaculatus.*
M'Intosh, W. C., M'Intosh and Prince. *See M'Intosh and Masterman.*
Cunningham, J. T., *Journ. M. B. Assoc.*, N.S., ii., 1892, p. 325. *Ovarian egg of Rh. norvegicus.*
Holt, E. W. L., *Sci. Trans. R. Dub. Soc.*, S. II., iv., 1893, pp. 96 to 103. Pls. II., VII., VIII. *Sp.* x., xi., *and* xii., *undetermined tow-net eggs, now referred indiscriminately to the topknots.*
Holt, E. W. L., p. 104, Pl. XI., *Sp.* xiii., *Metamorphosing larvæ, now referred to P. unimaculatus.*
Holt, E. W. L., p. 111, Pl. XII. *Sp.* xiv., *Metamorphosing larvæ with periotic spines, now referred to Rh. punctatus.*
Cunningham, J. T., *Journ. M. B. Assoc.*, N.S., iii., 1894, p. 202. *Rh. punctatus, advanced metamorphosing larvæ with periotic spines.*
Petersen, C. G. J., *Rep. Dan. Biol. Stat.*, 1893 (1894), p. 135, Pl. II., Fig. 16. *Late metamorphosing larva of Rh. norvegicus.*
Ehrenbaum, E., *Wiss. Meeresuntersuch, Komm. deutsch. Meer. Biol. Anst. Helgoland, Neue Folge*, ii., 1897, i., p. 317. *Tow-net egg referred to Sp. F. of M'Intosh and Prince.*
M'Intosh and Masterman, *Life-Hist. Brit. Mar. Food-Fish.*, 1897. *Summary of previous observations by M'Intosh and M'Intosh and Prince. Ovarian egg of Rh. punctatus; tow-net eggs referred by authors to same. Metamorphosing larvæ with periotic spines, provisionally referred by authors to Rh. norvegicus. Metamorphosing larvæ without periotic spines, referred by authors to Rh. punctatus.*
Holt, E. W. L., *Journ. M. B. Assoc.*, N.S., v., 1897, p. 45. *Egg and larva of P. unimaculatus.*
Holt, E. W. L., *Annales Mus. Nat. Hist. Marseille*, v., 1898, Fasc. II. *Larva of P. unimaculatus, early larva of Rh. punctatus with periotic spines, figures.*

Under the designation of Topknot, our record includes a number of eggs taken between the 24th February and the 5th April, with, perhaps, another which occurred on the 4th June. It is impossible to decide to how many species these eggs really belong. The three British topknots all occur in the neighbourhood of Plymouth, and one, at least, of them must be very common there, namely *Rhombus norvegicus.* Another, *Rh. punctatus,* is certainly not rare. The third, *Phrynorhombus unimaculatus,* is less often met with, but as these fish by no means lend themselves to capture by the ordinary methods of fishing, it is impossible to make any exact statement as to their comparative abundance.

With regard to the spawning period in this district, Cunningham has recorded a ripe female of *Rh. norvegicus* taken on the 21st March, and I have trawled two *Phr. unimaculatus* in similar condition on the 1st June. I do not know of any record of the spawning of *Rh. punctatus* from the S.W. coast, but M'Intosh and Prince give the 16th May as the date of the capture of a ripe female at St. Andrews. Judging by the analogy of other species, this topknot should spawn on the S.W. coast at least as early as on the N.E. of Great Britain.

Rh. norvegicus and *Rh. punctatus* may therefore be safely regarded as early spawners. *P. unimaculatus* may or may not spawn, as a species, a little later than the others. So far as the few recorded observations go, there seems to be no possibility of distinguishing their eggs by dimensions alone. Thus, from a single example of each species, the various authors who have dealt with them give the following sizes:—

Rh. punctatus, unfertilised . .	d.	1·05 *ca.*	o.g.	0·20 mm. *ca.*
Rh. norvegicus, „ . . .	„	·90	„	·15 „
P. unimaculatus, „ . .		·92–·93	„	(·16–·18) mm.

Fertilised ova from the last specimen measured from ·90 to ·99 mm. in diameter, the oil-globule from ·16 to ·18 mm.

If the fertilised eggs of a single parent show a variation *inter se* of ·09 mm., it is more than probable that the variation of the eggs of the species as a whole is really much greater. For *P. unimaculatus*, Brooks' measurement of the ripe ovarian egg, after preservation, is ·96 mm. Without further words, I think it will be plain that the eggs of the three species overlap each other in so far as dimensions are concerned, although in all probability the egg of *Rh. punctatus* is on an average the largest, that of *Rh. norvegicus* the smallest of the three. Such comparative sizes of the eggs conform to those of the parent species, so far as they are known to me.

The eggs taken in our tow-nets may be recapitulated as follows, the dimensions of each individual egg being given:—

	Diam. of egg.	Diam. of oil-globule.
February 24 . .	1·05	
„ 26 . .	1·02	... ·19
March 1 . . .	1·04	... ·21
	·99	... ·18
	1·05	... ·17
	1·08	... ·19
March 30 . . .	·90	... ·13
	·91	... ·13
	1·04	... ·19
	1·07	... ·21
	1·07	... ·21
April 5 . . .	1·03	... ·17
June 4 . . .	1·04	... ·20

The egg of June 4th, only observed in its early condition, belongs perhaps more probably to *Capros aper* than to a Topknot.

With regard to the rest it appears at first sight possible to select two, measuring ·90 and ·91 mm. in diameter, as differing markedly from the rest; but it is necessary to remember that the difference of ·15 mm. which separates the smallest of these two from the largest of the whole series is no more than is met with in a single species having ova of about the same size. For instance, tow-net ova, which can be referred with reasonable certainty to *Callionymus lyra* and *Ctenolabrus rupestris*, show variations of ·12 and ·29 mm. respectively (*vide* pp. 112 and 125). The discrepancy in size cannot therefore be regarded as of specific moment.

Appeal to the characters of the embryo and larva does not afford much positive assistance, since of the three Topknots but one is certainly known in its early stages, and that only from a few artificially-fertilised eggs and a single newly-hatched larva. This larva has been described in the last number of the journal, and will be figured in the *Annales du Musée de Marseille*. The Plymouth tow-net eggs yield larvæ which do not appear to offer important differences, though in certain characters they are certainly variable. Taking those which have come under my own observation, apparently similar to those studied by Mr. Scott during the earlier part of the season, the larvæ may be said to be identical with some Irish examples which I have described and figured under the title of Sp. xi. Moreover, it now appears to me that my Species x. and xii. were separated from the last on insufficient grounds. I do not wish to assert that all the eggs which I have described under those titles were spawned by one and the same species; but that, in the light of the Plymouth specimens, I now hesitate to rely on the characters which I formerly considered as specific.

Sp. x. is a St. Andrews form, and is no doubt identical with an egg and larva subsequently attributed by M'Intosh (*Twelfth Ann. Rep. S. F. B.*, 1894, p. 222, Pl. IV.), who appears to have overlooked my previous description in this journal of the ova and larvæ of the turbot, to that important food-fish. According to my observations the egg, which occurred at St. Andrews in April, May, and July, and in Clew Bay, Ireland, in April, has a diameter of 1·00 to 1·05, and an oil-globule of ·18 to ·20 mm.

Sp. xi. is from Ireland, March and April; the diameter is from 1·01 to 1·07, that of the oil-globule ·18 mm.

Sp. xii. is a title applied for the sake of continuity to a form already described by M'Intosh and Prince as Sp. F. According to my own measurements in Scotland and Ireland the diameter of the egg is from ·75 to ·85 mm., that of the oil-globule from ·14 to ·15 mm. According to M'Intosh it may reach a diameter of ·9906 mm. The same egg has been found by Ehrenbaum at Heligoland.

Sp. F. or xii. differs from the rest in that the epidermis is beset with small papillæ or tubercles, connected with each other by a network of fine raised lines. I have already explained in the last number of this journal that I can no longer regard this epidermal feature as of specific importance. It is a common, perhaps a normal feature of the embryo of Arnoglossus, but it is not constant, even in the species of that genus. In typical specimens of Sp. F or xii. it is extremely well marked, but the Topknot eggs which I have seen at Plymouth do not lend themselves to discrimination by this character. Two of them, and it is necessary to remark that these two (·90, ·91, 0·9, ·13) are the smallest of the series, have the reticulo-papillate epidermal character most strongly marked, but the rest are variable. Some have the skin practically smooth. In others it is more or less papillate, with an approach in some instances to reticulation. Moreover, the typically reticulo-papillate condition was observed as an exceptional, perhaps a pathological feature in a species which does not appear from the characters of the larva to be a Pleuronectid (*vide* the egg and larva temporarily assigned to a Gadoid, p. 145).

Apart from the papillation of the skin, I now believe that the various early Topknot larvæ, which have been described from tow-net ova, cannot be distinguished by characters of pigment and conformation. Those which have come under my notice at Plymouth seemed to be referable to my Species x., xi., and xii., but, on the other hand, they appeared capable of bridging over the differences which I had supposed sufficient to separate those species. Species x. was originally supposed by myself to have a Trigloid affinity, on account of the rather precocious development of the pectoral fin and a certain Trigloid character of the pigment of the marginal fins. I am now convinced of error in this respect, and it appears reasonably certain that all our British Triglæ have much larger eggs.

An inevitable want of continuity in our tow-netting operations during the period when these eggs occurred, seems to me to greatly prejudice any discussion based on the comparative sizes of the eggs taken. As to the general question of the determination, by the characters of the vitelligerous larva, of the eggs of the several species of Topknot, I do not think it is possible, as yet, to pronounce a definite opinion. The single larva which I was able to rear from artificially fertilised ova of *P. unimaculatus* seems to me to suggest that some of the ova which have been described under Sp. F belong to that form. Further, it would appear that the reticulo-papillate larva is perhaps more commonly hatched from the smaller of the eggs which may safely be assigned to Topknots. M'Intosh and Masterman deal with the egg and larva F under *Rh. punctatus*, but it does not appear that they wish to definitely identify them with that species. It seems at least possible that the reticulo-papillate condition may be more or less pathological; and if, as I suppose to be the case, the smaller spawning members of a species give rise to small and often weakly offspring, it is quite possible that the occurrence of the character rather in small eggs than large may be explained in this way. On such a supposition one must class the smaller ova with reticulo-papillate larvæ merely as the offspring of small individuals, of one or more species, and not as a distinct species. I put forward the suggestion for what it may be worth. A papillate condition of the skin is certainly a pathological condition in the larvæ of many species, but is certainly present in some cases in individuals which appear to be quite healthy.

There is, I imagine, no means of deciding how many Topknots have contributed to the ova taken in our tow-nets this spring, although the apparent lateness of the spawning period and certain characters of my solitary larva of *P. unimaculatus* seem to indicate that the share of that species is, at any rate, unimportant. Failing any observation of larvæ derived from the artificially fertilised eggs of *Rh. punctatus* and *Rh. norvegicus*, it is impossible to say whether one or both of these species are represented.

Some help may perhaps be derived from a consideration of the few metamorphosing larvæ of Topknots which were obtained during the year.

I have described from Ireland, as Sp. xiv., a very conspicuously characterised pleuronectid larva, which can now be referred, without any doubt, to a Topknot. It is most readily recognised by the presence of a pair of relatively enormous spines on each otocyst, and is further characterised by a very distinctly banded black pigmentation. In discussing the affinities of this larva, I at first considered that it must belong either to the Brill (*Rh. lævis*) or to *Rh. norvegicus*. Confirmation of Raffaele's earlier observation of the young stages of the Brill has shown that it is certainly not the parent of the larva with periotic spines. On the other hand, Cunningham seems to me to have proved, by the examination of older stages, that *Rh. punctatus* has a spined larva similar to my Sp. xiv. A specimen examined by this author has D. 90, A. 69, and he rightly contends that, of the possible parents, *Rh. punctatus* is by far the most probable. My largest specimen had D. 80 *ca.*, A. 66 *ca.* It was not possible to count all the rays. Cunningham makes the reservation that there may be more than one species with a spined larval condition.

A larva with periotic spines was formerly considered by M'Intosh to be possibly a young *Rh. punctatus*, representing an older stage of another larval form apparently similar to that which I doubtfully assigned, under Sp. xiii., to *P. unimaculatus*. His latest discussion of the matter (M'Intosh and Masterman) refers the last-named larva, which has no periotic spines, to *Rh. punctatus*, while the former, including my Sp. xiv., is assigned with some reserve to *Rh. norvegicus.* No St. Andrews larva is assigned to *P. unimaculatus,* because that species has never been recorded in the district, but the capture of a single specimen of *Rh. norvegicus* seems to be considered to have afforded sufficient warrant for changing the determination of the spined larva.

The Irish larva without periotic spines, Sp. xiii., is, if one takes into account the stages of the metamorphosis which the two forms exhibit, much smaller than the spined Sp. xiv. Thus at a length of 10·62 mm. the latter is still nearly symmetrical, with a heterocercal tail, while at 9·37 mm. the former has the eye at the ridge, and the tail quite homocercal. I should imagine that the larva which, at any given size, has the metamorphosis most advanced, would be universally held to belong to the smaller species. Yet M'Intosh and Masterman put forward the same comparison as an argument in favour of an exactly converse conclusion.

Cunningham's observation of the later stages of the spined larva seems to me too positive to permit of any doubt as to the spinigerous nature of the larva of *Rh. punctatus,* unless, as is most unlikely, he was dealing with a specimen with an exceptionally large number of fin-rays. The St. Andrews authors, however, refer the larva without spines to that species, with the simple remark that they are unable to concur with Cunningham's opinion.

During the present season we have twice taken a larva with periotic spines, corresponding exactly in this respect, and in the disposition of the pigment, with my Irish series, but less advanced in metamorphosis. They measure respectively 5·11 and 4·5 *ca.* mm., the latter specimen being bent and difficult to measure with accuracy. The body is still elongated, and shows no signs of elevation. The contour of the head is still rounded, although the jaws protrude somewhat, and the general appearance is that of a larva not long after the final absorption of the yolk. Yet the periotic spines are conspicuously developed, the upper one being somewhat the larger, and rather backwardly deflected. The larvæ, which will be figured in the *Annales de Musée de Marseille,* are certainly identical with the Irish forms, and I refer them without hesitation to *Rh. punctatus.*

They occurred on the 8th and 24th of April (*vide* record), that is to say at the end of the period of occurrence of the Topknot ova, while Cunningham's advanced larvæ were taken on the 4th May. Taking into consideration dates and localities, one is led to suppose that these larvæ must be derived from ova similar to those which have been referred to the Topknot generally. In other words the said eggs are in part, at least, those of *Rh. punctatus.*

From the date, locality, and dimensions of the ova, it is obviously probable enough that some of the latter may belong to *Rh. norvegicus*, but I do not think that there is any satisfactory evidence of the nature of the metamorphosing larva of that species. It may, as M'Intosh and Masterman suppose, be characterised by the possession of periotic spines, but I should say that the conformation of the St. Andrews specimen of 11 mm. (if correctly represented by M'Intosh and Masterman), referred to *Rh. norvegicus*, bears certainly a greater resemblance to that of *Rh. punctatus*.

Apart from the spinigerous forms there is another larva or group of larvæ which can be definitely associated with the Topknots.

Under Sp. xiii. a typical series of this form, from the symmetrical condition to an advanced stage of metamorphosis, has been figured and described by myself. It has no spines at all, and at parallel stages of the metamorphosis is very much smaller than the spined form, and shows moreover no trace of the bold pigmentation of the latter. From the conformation at the most advanced stages, and from the fin-ray formula, I considered that this form belonged to *P. unimaculatus*, and so far as is possible, the appearance of the early vitelligerous larva of that species confirms my opinion.

Metamorphosing larvæ, either identical with or at least very similar to the Irish specimens, have been met with at St. Andrews, and are referred, as we have seen, by M'Intosh and Masterman to *Rh. punctatus*. As that species has certainly a spined larva, it appears to me that the spineless forms from St. Andrews must belong either to *P. unimaculatus* or to *Rh. norvegicus*. It is simply a question of whether the larva of the last-named has periotic spines or has none.

The few spineless sinistral larvæ which have been taken at Plymouth in 1897 leave the matter in doubt. One, 8 mm. in length, presents the stage of metamorphosis of an Irish specimen of 8·87 mm. (*op. cit.*, Pl. XI., Fig. 92). The two are very much alike, but the Plymouth example is somewhat more profusely and generally pigmented. Does the difference in size justify us in supposing that the Plymouth larva belongs to a smaller species than *P. unimaculatus?* I should say that it is possible, but not certain, since individual larvæ vary in the size at which they assume the different phases of metamorphosis. Another larva, about 3 mm. long after preservation, connects itself more readily with the younger stages of the St. Andrews spineless larvæ than with any of the Irish series. The head is large, but the trunk is narrow and elongate, without any trace of Pleuronectid metamorphosis, but the abdomen is relatively enormous, a condition apparently due to the viscera being distended with food. Whether naturally or by accident, the abdomen is laterallly compressed. Pigment is present in the form of minute black chromatophores scattered over the general surface, but scarce about the middle of the tail; larger black chromatophores occur along the edges of the dorsal and of the posterior part of the ventral marginal fins.

Seeing that they were taken on the inner Eddystone ground, a haunt of *Rh. norvegicus*, it is not improbable that these larvæ belong to that species, but in view of the resemblance of the larger specimen to the Irish larvæ, which appear to belong to *P. unimaculatus*, I am not inclined to make any positive assertion without further material.

A larger sinistral larva, taken from the stomach of a gurnard (*T. lineata*) on the 10th June, is so macerated that it is only possible to say that it has no spines and bears, in conformation, a fair resemblance to *Rh. norvegicus*. The total length is about 9·5 mm.; the eye is on the ridge.

Arnoglossus laterna. *Günther.* Scaldfish, Scaldback.

Since the last number of this journal was published I have had no further opportunity of measuring ova taken from the parent, but, as may be seen from the records, tow-net specimens, certainly referable to this species, were taken up to the 29th July. They cannot be regarded either as particularly rare or as specially confined to the lower strata of the water. The last egg belonging to the genus was observed on the 3rd August.

The difference already noted as existing between ova taken from the small undifferentiated females and those from large specimens with elongated dorsal rays seems to be accidental. Large females yielded ova of ·75 to ·76 mm., with a globule of ·12 to ·13 mm., while small females gave ova of ·67 to ·69 mm., with a globule of ·14 to ·15 mm. The difference in the size of the egg might be regarded as correlated to the size of the parent, but it was not apparent why the smaller egg should have the larger globule, if the two forms belong to the same species.

Tow-net eggs have since been found measuring ·63 and ·66 mm., in both cases with an oil-globule of ·13 mm. They can be identified from the characters of the larva with *A. laterna*. It follows that the full variation in the dimensions of the ova of this species, and of the proportionate size of the oil-globule, are not represented by the measurements which I took from the spawn of a few specimens.

Regarding *A. conspersus* of the Mediterranean as not entitled to specific distinction from *A. laterna*, my observations suggest that the northern representatives have larger eggs than the southern. Ova measured at Marseilles range from ·61 to ·68 mm., with an oil-globule of ·11 to ·13 mm. The larva is also smaller, but, allowing for variation observed in both localities, identical in pigment and other characters with the northern form. Both British and Mediterranean examples are illustrated in my paper in the *Annales*. So far as I know, large differentiated Scaldfish have never been observed at Marseilles, though they are known from other parts of the Mediterranean.

Arnoglossus Grohmanni. *Bonap.*

Raffaele, F., *Mittheil. Zool. Stat. Neap.*, viii., 1888, p. 49, Tav. iv. *Larva hatched from tow-net eggs resembling those of various species of Arnoglossus, Rhomboidichthys, and Citharus.*

Holt, E. W. L., *Annales Mus. Mars.*, v., 1897, Fasc. I., Note 4., p. 33. *Preliminary notice of egg and larva provisionally referred to A. Grohmanni.*

Holt, E. W. L., *ibid.*, v., 1898, Fasc. II. *Ova and larvæ, Mediterranean and British, referred to A. Grohmanni; with figures.*

In all, eight specimens of *A. Grohmanni* were trawled by the *Busy Bee* in 1897 and in January, 1898, viz., six at Plymouth and two in Falmouth Bay. The latter, taken on the 8th July, were females, very nearly ready to spawn. The species can no longer be regarded as extremely rare on our south-western coast. I have never noticed it among the large numbers of large *A. laterna* which have been brought to me from the off-shore trawling grounds; it seems rather to prefer the neighbourhood of rocks or rough ground nearer the shore, and may perhaps be common in actually rocky places inaccessible to trawling.

I associate with this species ova measuring ·67 to ·68 mm., oil-globule ·12 to ·13 mm., at Marseilles, and ·72 and ·74 mm., oil-globule ·12 mm., at Plymouth. The Plymouth specimens, with another not measured, occurred in July.

The larva, which is certainly that figured by Raffaele (*loc. cit.*), is readily distinguished from *A. laterna* by the presence of two post-anal pigment bars or patches, of which the last is near the caudal extremity. *A. laterna*, apart from some pigment sometimes present about the origin of the tail, has only one, approximately median, post-anal band or patch of pigment.

The pigment is perhaps more vividly red or orange in *A. Grohmanni*. In general conformation, in the unicolumnar character of the notochord, in the presence of digitiform cells along the edge of the marginal fin, and in the frequently reticulo-papillate condition of the skin, the two larvæ are identical. A newly-hatched larva of *A. Grohmanni* (Plymouth) measures 2·32 mm. Allowing for individual variation in the degree of development at which hatching takes place, Mediterranean examples appear to be of about the same size, or a little smaller.

By those who may still regard *A. laterna* and *A. lophotes* (the large form with elongated dorsal rays) as distinct species, it may be suggested that the larva which I refer to *A. Grohmanni* may be really that of

A. lophotes. The latter, however, as has already been noted, seems to be unknown at Marseilles, where *A. Grohmanni* is common. It is not likely that so well-marked a form as *A. lophotes* would have escaped the keen attention of Professor Marion and his subordinates, if it ever ventured into a region whence the very rapidly developing ova could have found their way into our hand-net, never employed far out at sea. The economic value even of such a comparatively small fish as the scaldback in its "Lophotes" form, would certainly ensure its prompt recognition in the Marseilles market; although, as we know, its worthlessness from the point of view of the British consumer long concealed the very same fish from the knowledge of naturalists in this country. I think it is almost certain that the scaldback is only present in the Marseilles grounds in its small undifferentiated form.

On our own coast, when I have trawled large differentiated and small undifferentiated *A. laterna* in company, I have found the ovaries of the first the more advanced, whereas the tow-net eggs of *A. laterna* began to occur before those referred to *A. Grohmanni.* This argument, it must be confessed, would have more weight if the numbers were larger.

Solea variegata. *Donov.* Thick-back.

Cunningham, J. T., *Journ. M. B. Assoc.*, N.S., i., 1889, p. 23, Figs. 14, 15. *Ovarian egg and tow-net egg referred to S. variegata.*

Cunningham, J. T., *Treatise on the Common Sole*, 1890, p. 90, Pls. XVI., XVII. *Egg, vitelligerous larva.*

Only one egg of this species was taken during 1897. It occurred on the 27th July between the Eddystone and Hand deeps. The adult seems to be oftener found outside the Eddystone than on the grounds nearer shore. The egg was first examined by Mr. Beaumont, and had died before I looked at it on the following day; there was, however, but little evidence of decomposition. The embryo, devoid of a caudal rudiment, showed only yellow pigment. The cortical vesicles of the yolk were quite apparent. I counted in all thirty-seven yellow oil-globules ranging in diameter from ·03 to ·11 mm., but for the most part exceeding ·05 mm. Mr. Beaumont observed no material change in this respect since the egg was examined on the previous day. The diameter of the whole egg was 1·11 mm.

I have made no effort to ascertain the duration of the spawning season, but as Cunningham records the occurrence of a ripe female on the 30th May, it is evident that our specimen belongs to a late clutch. The diameter is ·20 less than that of the tow-net egg recorded by Cunningham as having occurred on the 17th July.

Solea lascaris. *Risso.* Sand sole.

(?) Holt, E. W. L., *Sci. Trans. R. Dub. Soc.*, S. II., iv., 1891, p. 457, Pls. XLIX., L., *Solea, Sp.* i. *Advanced egg and larva.*

(?) Holt, E. W. L., *Ann. Mus. Mars.*, v., 1898, Fasc. II. *Early and advanced egg referred, with above, to S. lascaris.*

S. lascaris was common enough in the Plymouth market in the early part of 1897, but could not be found during the spawning season, which, as I computed, would occur a little later than that of *S. vulgaris.* The ovarian egg remains unknown, and I have no reason to think that *S. lascaris* is represented among the few eggs of Solea entered in our records.

I have described and figured in the *Annales* two stages of a sole egg taken at Marseilles. At an early stage of development the egg does not essentially differ in the character and arrangement of its globules from that of *S. vulgaris,* but as development proceeds the originally minute globules tend to coalesce so as to form larger ones. In this condition the egg appears identical with the Irish Solea Sp. i. The dimensions agree closely. I have set forth in my Marseilles paper the considerations which suggest that *S. lascaris* is probably the parent of both forms. Other tow-net ova are provisionally referred, in the same paper, to *S. Kleinii* and *S. hispida.*

Gadus.

The most abundant Gadus in the inshore waters of this district is the pollack, *G. pollachius.* The bib or blind and the pout (the names have no constancy of specific application), *G. luscus* and *G. minutus,* are commonest outside the Sound—the former about outlying rocks, the latter on the Eddystone trawling grounds. The whiting, *G. merlangus,* is at times abundant, but erratic in its distribution. The cod, *G. morrhua,* is not very plentiful, while the haddock, *G. æglefinus,* and the coal-fish or "roamer," *G. virens,* are decidedly exceptional.

In spite of much that has been written about them, the young stages, especially of those with which we are here concerned, are very difficult to distinguish one from the other. The ova approach each other closely in dimensions, and the variations in this respect have not hitherto been studied in a methodic manner. It is only possible, therefore, to identify the ova mentioned in our records in a provisional manner.

Gadus luscus. *Will.* Bib, Blind, Pout, Brassie.

Cunningham, J. T., *Journal M. B. Assoc.*, N.S., i., p. 46, Fig. 35: *Tow-net egg and larva.* P. 375: *Dimensions of ripe egg.*

Cunningham provisionally identified with this fish tow-net ova, 1·13 mm. in diameter, taken on January 20th, 1888. Ripe ova taken from a female in the Aquarium in March, were found by the same author to measure 1·05 to 1·15 mm. The larva, hatched from a tow-net egg, is figured. It has an irregular series of dorsal and ventral black chromatophores from the head to near the extremity of the tail.

Observations in January, 1898, show that large examples of *G. luscus* contained ripe ova, of which the largest measured 1·13 mm. one hour after extrusion into sea-water, on the 10th of the month. This dimension would be subject to further increase, but the eggs were not fertilised and died. Ova of corresponding dimensions, giving rise to larvæ resembling Cunningham's figure, first appeared on the 4th January, 1898, from grounds known to be frequented by *G. luscus.* It is therefore reasonably certain that Cunningham's identification is correct, and we have therefore associated with *G. luscus* those forms which in date, dimensions, and larval characters appear to sufficiently fulfil the required conditions. It will be seen that these ova, observed by Mr. Scott, occurred from the 28th January to the 6th February. The diameter ranges from ·90 to 1·10 mm., so that the eggs are rather small as compared with those obtained from parents in January of the present year. The smallest ova I have as yet found are derived from a female twelve inches long (20th Jan., 1898), and measure ·98 mm. after twenty-two hours' immersion in sea-water. If I am right in supposing that the smaller members of the species spawn later and have smaller eggs than their larger sisters, the small size of some of the 1897 tow-net ova is accounted for. The dimensions do not serve to distinguish them from eggs of *G. minutus,* but such evidence as I have points to a rather later spawning season for that species. Ten females, examined on the 12th January, 1898, were still far from ripe.

In every case when the development of the embryo was followed, the ova entered as *G. luscus* can be associated with the larva that appears to belong to this form. It is characterised by a *rather regular double series of dorsal and ventral black chromatophores,* extending from the head to the neighbourhood of the caudal extremity. In larvæ of a few days old the supra-cephalic ampullation, common to several if not to all Gadus larvæ, is well developed. *Only black pigment is usually visible,* but I am able to affirm the presence of yellow chromatophores also, an observation which explains existing discrepancies in the descriptions of various authors of other Gadus larvæ.

In the larvæ (of *G. luscus*) which I have observed no coloured chromatophores can be made out as long as the specimen is in full health and vigour; but a greenish or yellowish refraction is noticeable, often very faintly, on the salient parts, such as the front end of the yolk or the head. I have not succeeded by any manipulation of the light in detecting the presence of coloured chromatophores, and as a similar tinge is often visible in the blastodermic mound of a fish-egg, and certainly is not due in that case to pigment, I concluded that only black pigment was present. However, it so happened that a larva injured itself on the stage of my microscope, and during the development of the usual morbid symptoms I became aware of the presence of minute yellow chromatophores, rather closely set over the greater part of the skin.

It appears therefore that yellow chromatophores, though present in large numbers, cannot (in all cases, if at all) be detected in healthy larvæ. So far as my experience goes, a larva of *G. luscus* with conspicuous (*i.e.* contracted) yellow chromatophores would be exceptional.

In the case of *G. minutus*, I have seen and described Irish tow-net specimens, almost certainly belonging to the species, in which no yellow chromatophores were visible. The larva of this form was first described from the Mediterranean by Raffaele, its correct identification being beyond doubt. Only black pigment was observed; and larvæ observed by myself at Marseilles agree in this respect with Raffaele's description and figure; while, though only tow-net material was studied, the identification was, from the known fauna of the district, beyond doubt. I have seen similar larvæ at St. Andrews, yet M'Intosh's, the only British specimens hatched from artificially fertilised ova, are very conspicuously decorated with yellow chromatophores. (M'Intosh and Masterman. Pl. X., Figs. 1–3.) The absence of yellow pigment from Mediterranean larvæ may be actual as well as apparent, since a regional variation may very well exist in this particular. As to British forms, the figures (1 and 2) of M'Intosh's youngest larvæ appear to have been drawn from unhealthy specimens, and the yellow chromatophores appear to be contracted. It is possible, though I do not insist on the suggestion, that in perfectly normal British larvæ of *G. minutus* the yellow chromatophores may be too diffusely expanded to be conspicuous.

The larvæ of the cod and haddock have been so extensively studied that I do not think that yellow chromatophores, if present, could have failed to attract observation, for the other characters of these two species are sufficient to ensure their distinction (if occasionally coloured). Larvæ of the whiting have been described by M'Intosh and Prince, from artificially fertilised eggs, and by myself, from tow-net material, as profusely adorned with yellow. On the other hand Cunningham (*Journal*, N.S., i., p. 46, Fig. 34) makes no mention of yellow pigment in a larva which he refers to the whiting. It is possible that the yellow pigment, which seems to be usually conspicuous in this species, may be occasionally invisible as in *G. luscus.* Cunningham's ova, from which the supposed whiting larva was derived, measured 1·23 mm. in diameter, and were taken on the 6th February, 1888. I should myself regard this date as rather early for the species, but as my observations are far from complete, I am not inclined to set my own opinion against Cunningham's.

To return to *Gadus luscus*, the smallest Gadoid fish which can with certainty be referred to this species is 18 mm. long. The depth of the body is quite characteristic. Rows of dark chromatophores extend at the bases of the dorsal and anal fins to the first third of the posterior fin: each series is connected by a more or less continuous sheet of chromatophores which extends forwards, supra-abdominally to the top of the head. Dark patches are present on the distal part of the first and second dorsal and first anal fin. As this and a few other specimens of only a slightly larger size occurred at the end of May and beginning of June, it would appear that the rate of growth is slow, unless, as is probable enough, these examples were derived from late-spawned ova of small parents.

Gadus pollachius. *Linn.* Pollack, lythe.

M'Intosh, W. C. *11th Ann. Rep.*, *S. F. B.*, 1893, p. 246: *Dimensions of egg.* *14th Ann. Rep.*, 1896, p. 171, Pl. V.: *Egg, larva.*
Holt, E. W. L. *Sci. Trans. R. Dub. Soc.*, S. II., v., 1893, p. 55. *Egg.*

So far as they have been observed from material directly derived from the parent the egg measures, after fertilisation, from 1·10 to 1·14 mm., but as there is a large range of size among female pollack which have attained to sexual maturity, it is probable that the eggs show a more extensive variation than has been noted. The larva is only known from a prematurely hatched and obviously abnormal specimen figured by M'Intosh. It is impossible to say how far the pigmentation is characteristic of the normal condition, but Mr. Scott's notes deal with a larva which closely corresponds in this respect to M'Intosh's figure, and which appears to be perfectly healthy. It was hatched from ova of 1·40 to 1·45 mm. in diameter, taken a mile outside the Breakwater, on the 5th February. The larva measures 4·2 mm. in length, and has a single lateral row of stellate black chromatophores extending from the head to about midway along the tail. No other pigment was observed. The conformation, being that common to the genus, calls for no special remark. Mr. Scott has noted the resemblance, in character of egg and larva, to the haddock, *G. æglefinus.* The pigment, however, is more regular than in the haddock, which, in any case, is on account of its rarity practically eliminated from consideration. I believe that we have to do with the offspring of a large pollack, and that Mr. Scott has been the first to observe a normal larva of that species. I have no exact knowledge of the spawning season of the pollack on this coast, but the first young Gadus to appear in the tow-nets seem to connect themselves with older forms, having the specific characters of *G. pollachius*, so that this fish would appear to be one of the earliest spawners of the genus.

A smaller larva, 3 mm. in length, hatched from ova taken on the 15th February, is described by Mr. Scott as having no pigment at all. The eggs were not measured. I have seen a similar larva, hatched in transmission from the west coast of Ireland, but a yellowish tinge in this specimen may have been due to the presence of yellow chromatophores. It is possible that both these forms may be somewhat abnormal pollack, since the species seems to have but little black pigment as compared with others, although *G. minutus* has certainly not very much.

With regard to other ova of Gadus entered in our records I have only to say that they have been provisionally named in accordance with their apparent relationships. The dimensions, where noted, are given; the same remarks apply to the later stages, with which it is proposed to deal more fully when sufficient material has been accumulated.

Motella.—The Rocklings.

Our records comprise a great number of eggs which can be referred with certainty to the genus Motella. I do not think it is at present possible to identify them, in all cases, with any particular species. Ova directly derived from *M. mustela* and *M. tricirrata* have been described by Brook and M'Intosh and Prince (*M. mustela*) and by Raffaele (*M. tricirrata*). The descriptions do not, however, materially assist us to distinguish tow-net specimens, since the observed differences of dimensions might easily be obscured by variation in this respect. It is well-known that the newly extruded egg has usually a number of oil-globules which subsequently fuse into one. In the case of both the species mentioned the ova hitherto described as directly derived from the parent showed no colouration of the oil-globule. Raffaele, nevertheless, identifies with *M. tricirrata* a tow-net egg, having an oil-globule the colour of olive-oil. It is quite possible that this identification is correct, since the oil-globules of Solea (and Trachinus ?) do not acquire their characteristic colouration until some time after extrusion. Other forms, which need not be recapitulated, give rise to ova in which the globules are coloured even before the egg is ripe, but this is not necessarily a constant feature. Thus from different females of *Trigla cuculus* and *Caranx trachurus* I have pressed ova of which the globules showed various phases of colouration, from a well-marked cupreous tint through paler shades to a practical absence of any distinct colour at all. The variation, in so far as I have observed it, usually affects individual parents and not individual ova from the same parent, but, while preparing these notes for press, I find among the ova just liberated by a large *Motella mustela* some few with distinctly cupreous globules, while those of the majority are colourless or only very faintly tinted. Its explanation probably involves a physiological and chemical discussion, which I am not qualified to enter upon. For my present purpose it suffices to point out that the known existence of such a variation renders it very unsafe to rely on resemblances or differences in colouration of the oil-globule for purposes of specific determination. I must plead guilty to having done so myself, since the Motella Sp. iii. of my Irish series (*Trans. R. Dub. Soc.*, S. II., iv., 1891, p. 464, Pl. XLVII.; and v., 1893, p. 95, Pl. VI.) is chiefly based on the greenish colour of the oil-globule. I must add that I have since found that this greenish colour is identical with the olive-oil yellow of Raffaele, the former being converted into the latter by the use of a condenser. I am therefore of opinion that my Species iii. can no longer be regarded as sufficiently characterised.

M'Intosh and Masterman (*Life-Hist. Brit. Fish.*, 1897, p. 284) consider that they can distinguish three species of rockling eggs in the tow-net material of their district. I am in a less fortunate position here, for I cannot find among the large number collected any distinctive character which I consider absolutely reliable. Two rocklings, *M. mustela* and *M. tricirrata*, are certainly common here, and no doubt the eggs of both species have frequently come under the observation of Mr. Scott and myself, but it has not so far been possible to check the tow-net material by observation of the spawning of both species. I know that *M. mustela* was spawning in March, 1897, while it has been taken full of roe in January, 1898.*

Of the spawning of *M. tricirrata* in this district I know nothing definite; and the question is further complicated by the undoubted existence in the district of *M. cimbria* and *M. maculata*, and possibly of other forms which may require specific distinction. I do not suppose that the ova of *M. maculata* are small enough to be readily mistaken for

* During the months mentioned females full of roe were seined in the estuary, at the mouth of the Lynher in March, at the same place and also a little higher up the river in January. A specimen transferred to the Laboratory, on the 12th January, spawned at least as early as the 19th, since great numbers of eggs were found in the tank on that date. On the same day rockling eggs were found in Plymouth Sound in water which Mr. Garstang pronounced to be estuarine in character, so that it is practically certain that *M. mustela* spawns to some extent in the estuary. Rockling are known from Petersen's observations to spawn in the Limfjord.

those of other British species, but *M. cimbria* does not seem to be a very large form. The pelagic larval rockling, commonly known as "Mackerel midges," would afford more assistance to a knowledge of the spawning season if it were possible to identify them with absolute certainty, but it seems quite possible that those usually associated with *M. tricirrata* may not all belong to that species.

On the whole I do not think it would be profitable to enter at present upon a detailed discussion of the probable parentage to the tow-net ova. It may be noted that the eggs with colourless globules correspond in character with the descriptions of *M. mustela*, and in date with the known spawning period of that species at Plymouth. The cupreous colour of the globule, noted in several ova by Mr. Scott in January, is the same as has been referred to above as observed in newly extruded ova of the same species. The yellow, which under different conditions of illumination is either the "olive-oil" of Raffaele or the green of my Irish notes, has not been noted in ova directly derived from the female of any species. The ova with yellow globules, first observed in January, continued to occur until the middle of September, and after April were much commoner than those with colourless globules, of which the last was observed in June. If the yellow colour is really a constant character and occurs only in one species, then that species must have a spawning season of nine months. I have failed to recognise any differences in the pigmentation of larvæ with colourless and yellow globules respectively. In our records the colour of the oil-globule is stated whenever it was noted. The record of dimensions was very insufficiently kept by myself during the later months of the year, and it is partly on this account that I defer a discussion of this part of the question. It appears, however, sufficiently plain that there is considerable variation, not only in the diameter of the egg, but in that of the oil-globule, proportionally as well as actual, in ova which are similar in colouration of the globule and in embryonic and larval characters.

Mr. Scott's notes contain references to, and a drawing of, an egg with very numerous oil-globules. It is identical with a form described by M'Intosh and Masterman (p. 396, Pl. IV., Fig. 13) as closely allied to *Solea lutea*, and is in reality the egg of a rockling, probably liberated before it was perfectly ripe. I have seen very similar ova at St. Andrews, which ultimately, by coalescence of the oil-globules, assumed the ordinary appearance, and have also obtained them at Plymouth directly from a female of *M. mustela.* I do not think that any of the tow-net specimens were fertilised.

A "definite pale area, slightly refractive and apparently differentiated from the yolk," noticed by M'Intosh and Masterman (p. 296) in the egg of a rockling, is a common feature in unfertilised eggs of *G. luscus.* It is there associated evidently with imperfect maturation of the vitellus, and has probably no taxonomic value. If my recollection serves me, it occurs not infrequently in eggs other than those of the Gadidæ.

Unidentified egg, with apparently Gadoid characters.

Holt, E. W. L., *Sci. Trans. R. Dub. Soc.*, S. II., iv., 1891, p. 471, Pls. XLIX., L. *Unidentified egg and larva, Sp.* viii.

Holt, E. W. L., *Ann. Mus. Mars.*, v., 1898, Fasc. II. *Egg and larva.*

This species, the "unidentified Gadoid (?)" of our record, is certainly identical with the species of my Irish paper. I am able to add some details omitted in my former description, and have given more detailed figures in my paper in the *Annales du Musée de Marseille.*

The Irish specimens, taken in June, measured ·775 mm. with an oil-globule of ·14 mm. Examples taken at Plymouth in June and July are from ·84 to ·91 mm., the oil-globule from ·16 to ·17 mm.; in August from ·78 to ·84 mm., the oil-globule ·15 to ·17 mm. Two out of eleven eggs examined had two oil-globules in the early stages of development.

The yolk is homogeneous, the oil-globule dark but colourless, the perivitelline space small. The zona is devoid of any distinctive characteristics.

At about the epoch of the appearance of the caudal rudiment numerous minute black chromatophores appear on the trunk of the embryo and about the posterior hemisphere of the yolk. Very soon afterwards small yellow chromatophores are seen in company with the black. They are of a canary-yellow by reflected, golden-brown by transmitted light. Usually they rapidly assume a dendritic form, imparting to the region affected a diffuse yellow colouration, and practically masking the black chromatophores. In some cases, however, they remain simple, and the appearance of the embryo is greatly affected by their condition. Individuals showing the extremes of expansion and contraction of the chromatophores might readily be referred to separate species.

As is shown in my figures in the *Sci. Trans. R. Dub. Soc.*, Pl. X., Fig. 54, the larva appears to be Gadoid in character, that is to say the intestine terminates below the trunk, and does not extend to the edge of the ventral marginal fin-fold. This condition is well known to occur, exceptionally, in larvæ in no way related to the Gadoids, but its occurrence as a constant feature has only been observed within the limits of that group. Our knowledge of the Teleostean larvæ generally is not such as to justify us in saying that a larva of this character is necessarily Gadoid, although the presumption, whatever it may be worth, points in that direction.

I have examined at Plymouth five larvæ. All are recently hatched, and all have dendritic yellow pigment, so that it is probable that the chromatophores always assume this form before hatching takes place. The pigment has much the distribution shown in the figure of the Irish larva, but in the most recently hatched specimens there is none on the dorsal fin, which has no elevation anteriorly. Black chromatophores are present, but are almost entirely masked by the yellow. I suspect that they occurred also in the Irish specimen, but escaped my observation owing to the cabin of the s. s. *Fingal* being very badly lighted. In one Plymouth specimen there is no post-anal pigment except a single patch near the middle of the tail. The larvæ were exceedingly delicate, and only one survived even to the early stage of the Irish figure. It had acquired the same elevation of the anterior part of the dorsal marginal fin, accompanied, as in the Irish larva, by pigment. A Plymouth larva, apparently newly hatched, measures 2·02 mm. The Irish specimen, about twelve hours old, measured 2·68 mm.

I imagine that the normal larva exhibits no epidermal peculiarity. None was present in the Irish specimen, nor in one of the Plymouth examples. In others the skin was tuberculated, while in one I observed a reticulo-papillate condition exactly similar to that met with in Arnoglossus and in Sp. F of M'Intosh and Prince. The absence of submarginal pigment patches from the dorsal fin, coupled with the anterior elevation of that fin, sufficiently distinguishes the form before us from Sp. F, but otherwise a papillate specimen in which the connecting ridges are also developed comes very near to that supposed species; a fact which illustrates the danger of relying on the reticulo-papillate epidermal character for purposes of specific determination. The Laboratory was often very hot during the months in which these larvæ were obtained. My specimens, necessarily confined in small vessels for periodic observation, suffered great mortality, and I have no doubt that the tuberculation of the skin was simply pathological.

The question of the parent species must remain for the present quite uncertain. I am not at all satisfied that we are dealing with a Gadoid, but as the characters appear to connect the larva with that group rather than any other, it may be as well to consider whether any local Gadoid species can be reasonably regarded as the parent. It is unnecessary to recapitulate the forms of which the young stages are known, since their larvæ cannot possibly be confused with the one before us. There remain but a few species worthy of serious consideration. These include some of the rarer rocklings, Motella. *M. mustela* and *M. tricirrata* need not be considered. Their ova and larvæ, however difficult to distinguish from each other, are well known. *M. cimbria* exists, and may be common in the district, though rarely observed. *M. maculata* is known to me from a single specimen taken in Start

Bay. As it is not a shore species, it is quite impossible to say whether it is common or rare, since rockling can keep out of the way of ordinary fishing gear. I do not know to what extent we are justified in supposing that the ova and larvæ of the rocklings resemble each other. I certainly imagine that *M. cimbria* in its young stages resembles *M. mustela* and *M. tricirrata*, but *M. maculata* is a much larger and more brilliantly coloured fish. It is possibly, though not, as I think, very probably, the parent of the larva before us.

Phycis blennioides is regarded by the local fishermen as rare. I do not know any reason why it should not be often caught, if common. It is a deep-water fish on our coasts, but I have known one taken in Kenmare Bay in Ireland, and another was trawled here in Cawsand Bay some years ago, so that the species cannot be exclusively confined to deep water. Nothing is known of its ova and larvæ. The larva with which we are dealing shows an elevation of the dorsal fin, accompanied by pigment; a condition sometimes associated with the development of a filamentous ray, such as Phycis possesses in front of the first dorsal. Most of our ova were taken some way outside the Breakwater, though one occurred, on the ebb, in Cawsand Bay. I do not think that the balance of the evidence points very strongly to Phycis as the parent.

It must, in any case, be borne in mind that our records cover only a single year, and that, in certain features, an exceptional one. Mackerel were present in the inshore waters of Plymouth in the summer and autumn in very unusual quantity. "Mackerel Britt," that is to say young sprats and probably other young Clupeoids also, and scad old and young were also exceedingly abundant. Whether the young sprats were more abundant than usual I have no means of knowing, but whatever cause induced the influx of mackerel may have influenced other fish as well, while predaceous forms may have followed the mackerel. It is therefore quite possible that our ova and larvæ may belong to some species which does not usually occur, at any rate in the spawning season, in the neighbourhood of Plymouth. Their occurrence or absence in succeeding years may throw some light on this point.

Atherina presbyter. *Linn.* Sand smelt.

I believe that the young stages of the sand smelt are for the first time described and figured by myself in the *Annales du Musée de Marseille*, 1898. Agassiz, however, long ago figured the larvæ of the American *Atherinichthys notata* (*Proc. Amer. Acad.*, xvii., 1882, p. 277, Pls. X., XI.), which are very similar. The ova and larvæ of the Mediterranean *A. hepsetus* have been described by Raffaele (*Mittheil. Zool. Stat. Neap.*, ix., 1889, p. 306), and of this species a description, with figures, of the egg and early larva has been given by Marion (*Ann. Mus. Mars.*, iv., 1891, Fasc. I., VIII., p. 93, Pl. I.). Various larval stages of *A. Boyeri*, which is said to have occurred in British waters, are figured and described by myself in the paper alluded to.

It is rather remarkable that the presumably conspicuous eggs of the sand smelt have never come under the notice of naturalists. Such Atherine ova as are known are of large size, and furnished with long attachment filaments arising from all parts of the zona. In this character they are indistinguishable from the ova of the Scombresocidæ. In both families, as far as one can judge from limited material, the yolk appears to be translucent and practically homogeneous. One or more species of Atherina exhibit a number of small oil-globules, while in one species of Belone there are none. It is impossible to say to what extent the members of the respective families adhere to this distinction, which is, after all, of little importance. The fact remains that in the general characters of the egg the Atherinidæ and Scombresocidæ, though not apparently very closely related, are practically identical.

The larvæ of all Atherines seem to be very much alike. I found no difficulty in identifying those of *A. presbyter* from their resemblance to Agassiz's figures of *A. notata*. My specimens were found swimming at the surface in rock pools at Penzance on the 22nd June, 1891. They were in two shoals, each occupying about the space of the palm of a hand, the individuals very closely packed and hardly visible but for the large blue eyes and the black patch on the pia mater of the mid-brain. Each shoal consisted, as I suppose, of the hatch of a single clutch of eggs; in any case, the individuals were all of about the same size. A specimen from the younger shoal measured 9 mm., one from the older shoal 11·5 mm. The figures of Agassiz, Raffaele, Marion, and my own illustrate equally well the general conformation. The main features are the rounded head, large eye, very short abdomen, and very long tail. In the specimens of 9 mm. the pre-anal length is only 2·09 mm. In those of 11·5 mm. the same region measures 3·15 mm.

The smaller specimens, judging by Marion's figures of *A. hepsetus*, are probably, at most, a few days old, but the organs of the head are well developed, although the large otocyst shows but little internal complication. The yolk appears to have been entirely absorbed; an air-bladder is present, though not clearly visible on account of the dense black pigmentation of the abdominal roof. In serial transverse sections I failed to find any connection between the bladder and the alimentary canal. The large fan-shaped pectorals extend some way beyond the anus; they are entirely devoid of pigment. In this respect, therefore, the young Atherine offers a marked contrast to the young Blenny, which it otherwise resembles rather closely. The end of the multicolumnar notochord is not yet upturned, but there is a slight opacity of the sub-notochordal region, marked by a black chromatophore and by a number of embryonic caudal rays. The marginal fins are of moderate width. The dorsal arises a little behind the level of the anus: both dorsal and anal are constricted in the peduncular region, expanding again to form the spatulate caudal. The notochord is multicolumnar. The brain-tissues are of a bright yellow colour, not apparently due to pigment. Very large black chromatophores occur in the pia mater of the mid-brain in variable number. The roof of the peritoneal cavity is densely coated with black, intermingled with yellow pigment. Elongated black chromatophores occur at intervals along the lateral line. Black chromatophores occur variably along the dorsal and ventral margin of the post-anal region. The marginal fins are devoid of pigment.

In the specimens of 11·5 mm. the trunk is deeper, the snout longer and more pointed. The abdomen is, proportionally as well as actually, somewhat elongated. The gills have become pectinate. The notochord shows signs of segmentation, and its extremity is upturned by the development of a tri-lobed hypural mass. Embryonic fin-rays mark the sites of the second dorsal and anal fins. The axis of the pectoral is obliquely rotated. Pigment changes are chiefly confined to a backward extension of the dorsal cephalic chromatophores.

I did not again meet with the young sand smelt until the 14th July, 1897, when I caught several at low water in Falmouth Harbour, above St. Mawes. They were swimming in a small shoal near the surface at the point of a projecting rock, a habit I have noticed in similar stages of the Mediterranean *A. Boyeri.* The specimens caught were of various sizes. Apart from the fact that *A. presbyter* is practically the only British Atherine, the larger specimens can readily be identified with that species by the fin-ray formula.

A specimen of 12 mm. has the abdomen relatively short, the anus still remote from the anal fin. The pelvics are in the form of small flaps on either side of, and a little above, the anus. A conspicuous fold of embryonic fin is present in front of the true anal, and, in fact, the embryonic marginal fin is still continuous. The tail is in the heterocercal condition, the urochord projecting freely. At 18 mm. the pelvics, with well-developed rays, have united on the ventral surface, the anus having migrated in a posterior direction. The caudal fin is homocercal. An isolated fragment of the embryonic marginal fin persists between the anus and the anal fin.

At 22 mm. the fragment of embryonic fin is still present. The anus has nearly, but not quite, reached the limit of its posterior migration. Even in the adult condition there is between the anus and the anal fin a greater interval than in most Teleosteans, and I imagine that this may be due to the rather recent suppression of an anterior part of the anal, now represented only by the vestige of the embryonic fin fold. The second dorsal and the anal fins have the adult formula, viz., 1/14, 1/16. The first dorsal is still but little developed. No scales are as yet visible.

Compared with similar stages of *A. Boyeri* the larva of *A. presbyter* can be distinguished by the smaller eye, and by the greater length in relation to the degree of development. A young *A. Boyeri* of 32·5 mm. exhibits a stumpy fin-ray midway between the first and second dorsal fins, and in front of and behind this ray are a series of tubercles which are evidently of a similar nature.* These structures represent, I imagine, the vestiges of a continuous dorsal fin, and afford support to the supposition that the restriction of the dorsal and anal fins is of comparatively recent date.

The larval *A. presbyter* of 22 mm., though presenting the broad features of adult Atherine conformation, is still far from exhibiting the adult pigmentation. The lateral "stole" in particular is very imperfectly represented. Young *A. Boyeri* of the same size are much more advanced in this respect as in others.

I suppose that sand smelts, on account of the robust character of the larva, and its capability of assimilating comparatively large organisms, could be artificially reared with much less trouble than most other marine food-fishes, but their economical value is hardly sufficient to encourage the attempt. The larval stages appear to me to be chiefly interesting from the taxonomic point of view. It is generally conceded that the Atherines and the Grey Mullets are closely allied, yet in their ontogeny they differ most widely. The eggs of the former are, as we have seen, large, demersal, and furnished with long attachment processes. Some, at least, of the Grey Mullets have

* Vestigial fin-rays have been observed in the larvæ of another fish; but I cannot recall either the species or the name of the observer.

small pelagic eggs, and none, I believe, are known to have eggs furnished with attachment processes. It is true that Ryder at one time supposed that the ova of *Mugil albula* resembled those of the Atherines;* but as no observations have been brought forward in proof it may be supposed that this view was subsequently abandoned. *M. albula*, a species of which Günther could find no description (Cat. iii., p. 410), has been subsequently identified by naturalists of the U.S. Fish Commission with *M. cephalus*.

It has recently been stated by Sir James Hector (*Protection of Mullet*, Parliamentary paper, New Zealand, Sess. II., 1897, H.–17) that the eggs of the New Zealand *M. Perusii* are demersal, the proof being that ova described as ripe sank in sea-water. Further observations, especially with material the ripeness of which can be demonstrated by its impregnation, are certainly desirable, since the controversy as to the pelagic or demersal nature of the pilchard's egg furnishes ample proof that naturalists of considerable experience may sometimes be mistaken on this point. The matter is, however, of no great importance in connection with my present remarks, for the marked difference which exists between the ova of Atherines and Grey Mullets is not materially lessened by some of the latter being demersal.

The difference in the larvæ of the two families is at least as striking. One naturally expects that the larva newly hatched from a large demersal egg will be larger and more advanced in development than a larva from a small pelagic egg, and this holds good in most respects in the case before us. But in one particular, viz., the elongation of the abdominal region, the larva of the Grey Mullet is, at hatching, very far in advance of the young Atherine. In fact a glance at Raffaele's figure (*op. cit.*, Pl. II., Fig. 17) shows that an extensive elongation of the abdominal region has no part in the metamorphosis of the larva. The much more advanced larva referred by Cunningham (*Journ. M. B. Assoc.*, N.S., ii., 1891, p. 73, Pl. IV.) to *M. chelo* confirms this, while the larvæ entered in our records illustrate a further point. These larvæ are similar in size and conformation to Cunningham's, and require no separate description beyond the remark that the positions of the second dorsal and of the anal fin are clearly indicated by the developing fin-rays. The anus is just in front of the anal fin, a position never attained in the backward migration of the anus in the Atherine larva.

In comparing the Atherine with the Grey Mullet larva it therefore

* *Bull. U.S. Fish Comm.*, i., 1881, p. 283.

appears that the former passes through a long-tailed phase, which is not at all represented in the latter. The question is, Has this phase been suppressed in the ontogeny of the Grey Mullet, or has it been evolved as a specialised feature in the phylogeny of the Atherine? since the adult resemblances probably justify us in regarding both as derived from a common stock. I do not think that the knowledge which we at present possess of the systematic relations of individual groups of Teleostean fishes furnishes us with any answer. I believe it is generally held that the forms with elongated abdominal cavities are the more primitive, or it may rather be said that an elongated abdomen is most commonly met with in what appear to be the more primitive members of the Teleostomi. So far as concerns the families with which we are now dealing, the elongated abdomen appears less primitive, since the arrest in this elongation in Atherina would seem, from the evidence of the persistent ventral embryonic fin and of the vestigial dorsal rays, to result from the more recent restriction of the permanent dorsal and anal fins in that genus to the proportions which are now common to the adults of both families. The force of this evidence depends of course on the assumption that a continuously rayed fin-fold is a primitive condition, and is never achieved by a reversion from an intermediate detached-finned condition.

I am not acquainted with any British larvæ of Mugil except those already alluded to; but a Mediterranean specimen of 14 mm. (figured in my paper in *Ann. Mus. Mars.*, and referred from local considerations to *M. auratus*), appears to afford some evidence of the relative antiquity of the Atherines and the Grey Mullets. In essential features of conformation it is a true Mugil, but it exhibits a most distinct black "stole" or lateral pigment band. This is a feature of the adult Atherine, but not of the adult of any Grey Mullet with which the specimen can be associated; nor, as far as I know, of any Mugil at all. The appearance of this "stole" as a transitional larval pigment-phase of Mugil and its retention in Atherina must be regarded, if of any value as evidence of phylogeny, as indicating that the latter is the more primitive form. The resemblance, however, may be merely superficial, since I cannot say that the pigment stripe of the young Mugil is ever associated with the peculiar characters of the "stole" of the adult Atherine.

Coming to the characters of the ova, the large demersal type appears, *prima facie*, to be that most suitable to the requirements of the presumably fluviatile ancestors of modern Teleostei, which is perhaps the most conclusive argument forthcoming. The attachment process of the zona of the Atherine egg certainly indicates a high degree of specialisation; but, as such would presumably be lost in the evolution of the pelagic from the demersal type, they are not necessarily important in this connection. It may be noted, however, that the ova of all the Blennies studied by Guitel have precisely similar filaments for attachment, only they are confined to the neighbourhood of the micropyle. It has already been remarked that the early Atherine larva closely resembles that of the Blenny, a form in which the ontogeny is marked by no material change of conformation and by hardly any reduction of the embryonic fin area. It is chiefly by the absence of marked Acanthopterygian characters that the Mugiliformes and Blenniiformes are placed close together in modern classifications, and the larval resemblances are perhaps evidence of the correctness of their proximity.

So far as I can see, the points noted above certainly appear to suggest that the Mugilidæ have been evolved from an Atherine-like type, the long-tailed larval phase being suppressed in the ontogeny, while there is a further suggestion that both Atherines and Blennies are derived from a common ancestor resembling the latter in general characters.

I am, however, far from seeking to imply that all Teleosteans with elongated abdomen are similarly derived. In fact it can hardly be doubted that the Blenny-like form is, in respect to the abbreviation of the abdomen, already far from primitive. This is the conclusion arrived at by Raffaele, who has discussed in beautifully illustrated detail the migration of the anus in *A. hepsetus.* He regards as primitive the condition in such fish as the Clupeoids and Salmonoids. The secondary condition is retained throughout life in the Blennies, while a tertiary condition is attained by such an ontogenetic migration as takes place in Atherina. My own contention is that Mugil, which Raffaele does not seem to have had an opportunity of studying, belongs also to this tertiary group, an ancestral secondary phase being suppressed in its ontogeny.

Unidentified larva.

I am unable to identify a vitelligerous larva found by Mr. E. T. Browne in tow-net material from near the merchant moorings in Plymouth Sound on the 22nd September. I did not see it until after it had been preserved in formol.

The total length is 2·09 mm., of which the pre-anal part occupies ·90 mm. The rectum is separated from the yolk by an interval of ·21 mm. The yolk is still fairly large, there is no oil-globule; and I cannot make out any cortical segments, though such may have been present at an earlier stage. The marginal fins are broad, the dorsal commencing in front of the head. Black chromatophores are present on the head, along the dorsum in a continuous row as far as the middle of the tail. A few occur on the ventral part of the trunk and on the rectum. There are several large dendritic black chromatophores on the dorsal near its margin, while two are seen on the post-anal part of the ventral. A patch of pigment occurs above and below the caudal extremity. In all cases the black pigment of the marginal fins is accompanied by paler chromatophores, the colour of which has been destroyed by the reagent. I cannot speak definitely as to the nature of the notochord. The stage of development suggests most strongly that the larva is derived from a pelagic egg. It may possibly be a belated specimen of *Callionymus lyra,* but it does not closely agree with any example of that species which I have seen.

Clupea harengus.—*Linn.* Herring.

The young stages of the herring may be most conveniently reserved for consideration in connection with the distribution of young fishes in the Plymouth district. I only purpose at present to call attention to the occasional occurrence of an abnormal feature in the egg. It is well known that the ova of the pilchard and sardine and of the shads are characterised by the formation, after immersion in sea water, of a very large perivitelline space. The sprat ovum has only a very small perivitelline space, while that of the herring ovum is normally of moderate proportions. It is difficult to take accurate measurements if the spawn is allowed to adhere together, since the zona is then apt to assume a polyhedral form, but this can be obviated by the use of starch as recommended in the United States *Manual of Fish Culture.* I find among the spawn of three fish treated in this way, that the largest normal eggs measure 1·76 mm. in total diameter, the yolk mass measuring 1·25 mm., 24 hours after fertilisation. There are, however, several eggs of a much larger size. One slightly elliptical, but not at all flattened, has the greatest diameter 2·42 mm., the least 2·34 mm.; it appears to be as large as any. It must be remarked that these specimens are all dead, as in all previous instances of abnormally large herring eggs which have come under my notice. So far as I can judge, the excess in size is confined to the perivitelline space, but it is not the case that dead herring ova have usually a larger space, that is to say a more inflated zona, than living specimens. The latter are usually the larger, at least when death takes place at an early stage.

I do not suppose that this observation is new to those who have had to deal with herring spawn, but I do not remember to have seen it recorded. It shows that the perivitelline space may exhibit exceptionally an approach to the dimensions normal in the shads and pilchard. It may also help us to an appreciation of the due value of the perivitelline space as a character in the determination of undescribed ova. Cunningham has made known the occurrence in the egg of the pilchard of an exactly converse variation (*Journal*, N.S., iii., p. 150).

A Record of the Teleostean Eggs and Larvæ observed at Plymouth in 1897.

By

Ernest W. L. Holt and S. D. Scott, B.A.

Abbreviations employed: sev. = several; m. = many; v.m. = very many; o.g. = oil globule.

For convenience of tabulation the different stages of development have been divided into three groups: Stage I. = if fertilised, stages up to the outgrowth of the eyes; II. = from I. up to the appearance of the caudal rudiment; III. = from II. up to hatching.

Since the ova were not always examined immediately after their capture, it has been necessary in many cases to compute the stage exhibited at that time. The divisions indicated above being fairly broad, the results set forth below are probably near the mark. Confusion is most liable to have occurred between Stages II. and III.

All dimensions are given in millimetres.

Date.	Locality.	Position of Net.	EGGS.					LARVÆ.		
			No.	Species.	Diam. of Egg.	Diam. of oil globule.	Stage of Development.	No.	Species.	Length.
					mm.	mm.				mm.
Jan. 18.	1 to 3 miles off	...	m.	*Clupea sprattus.*	1·00					
	Mewstone.	...	1	Motella, o.g. colourless.	·70	...	I.	sev.	Clupea harengus.	
	...	...	2 or 3	Motella, o.g. colourless.	·78–·80					
	...	...	2	*Pleuronectes platessa.*						
,, 27.	2 mls. S. of Breakwater Fort.	...	...	C. sprattus.	...	...	...	1	Motella.	7·
		...	1	Motella, o.g. ∞	·66					
	...	...	...	Motella, o.g. colourless.						
,, 28.	Off Mewstone.	...	1 or 2	C. sprattus.						
	...	...	1	Motella, o.g. yellow.	·75					
	...	...	4	Motella, o.g. cupreous.	·675	...	I.			
	...	...	m.	Motella, o.g. colourless.	·75	...	I.			
	...	...	2	*Gadus luscus.*	1·1	...	III.			

					mm.	mm.				mm.
Jan. 29.	1 mile S.W. of Eddystone.	...	v.m.	C. sprattus.	·97–1·1	...	I., II., III.			
		...	3	Pl. platessa.	1·75–1·80					
	...	...	2	*Pl. microcephalus.*	1·3–1·5	...	II., III.			
	...	...	sev.	G. luscus.	·96	...	III.			
	...	...	6	*Callionymus lyra.*	·90	...	III.			
Feb. 1.	1 mile S. of Breakwater Fort.	...	m.	C. sprattus (mostly 1·00 mm.).	·95–1·05	...	...	1	Agonus cataphractus.	8·
	...	...	3	G. luscus.	·97, 1·, 1·05					
	...	...	sev.	Motella, o.g. colourless.	·75 (·70–·78)	...	I.			
	...	...	3	Motella, o.g. colourless.	·75	...	II.			
	...	...	1	Motella, o.g. colourless.	·82	...	III.			
,, 4.	W. Channel, 1 mile from Breakwater.	Surface.	nil.	...	...	...	...	nil.		
		Midwater.	70–80	Motella, o.g. colourless.	(mean) ·75	...	I.	1	Centronotus gunnellus.	7·
	...	Bottom.	3	G. luscus.	·93–·95					
,, 5.	1 mile S. of E. end of Breakwater.	...	v.m.	C. sprattus.						
		...	m.	G. luscus.	·93 (·9–·99)	...	III.			
	...	...	4	*Gadus pollachius.*	1·4–1·45	...	III.			
	...	...	3	C. lyra.	·83					
	...	Surface.	...	...	...	...	...	m.	C. harengus.	
	...	Bottom.	...	...	...	...	...	m.	C. harengus.	
,, 6.	½ mile S. of Breakwater Fort.	...	1	C. sprattus.	1·00					
		...	4	G. luscus.	·90, ·95, ·97, ·97					
	...	...	2	Gadus sp.	1·19, 1·20					
	...	...	2	Motella, o.g. colourless.	·75					
	...	...	2	Motella, o.g. colourless.	·73					
,, 8.	Off Mewstone.	Bottom.	∞	C. sprattus.	·98–1·30	...	I.	m.	C. harengus.	
	...	Surface.	m.	C. sprattus.	...	...	I., III.	sev.	C. harengus.	
	...	...	2	Pl. platessa.	1·85, 1·93	...	III.			
	...	...	2	Pl. microcephalus.	1·40, 1·43	...	III.			
	...	...	2	G. pollachius (?).	1·23	...	II.			
	...	...	...	G. luscus.	·95–1·00	...	I., II., III.			
	...	...	v.m.	Motella, o.g. colourless.	·75	...	I., II., III.			

Date.	Locality.	Position of Net.	EGGS. No.	EGGS. Species.	EGGS. Diam. of Egg.	EGGS. Diam. of oil globule.	EGGS. Stage of Development.	LARVÆ. No.	LARVÆ. Species.	LARVÆ. Length.
					mm.	mm.				mm.
Feb. 9.	West Channel.	Surface.	f.	Motella, o.g. colourless?	...	...	...	f.	C. harengus.	
	...	Midwater.	nil.	...	...					
	...	Bottom.	nil.	...	...					
,, 10.	West Channel.	...	nil.	...	...	...	...	2	A. cataphractus.	7·, 9·
,, 11.	West Channel.	...	nil.	...	...	...	...	1	A. cataphractus.	6·5
,, 12.	½ mile S.W. of Yealm Head.	...	v.m.	Motella.	·70–·83					
		...	...	C. sprattus.	...					
	...	Bottom.	...	Gadus sp.	·95–1·00					
,, 15.	1 mile S. of Mewstone.	Surface.	600	Motella, o.g. colourless?	...	...	I.			
		...	1	Motella, o.g. ∞	·76	...	I.			
	...	...	20	C. sprattus.	...	...	I.			
	...	...	6	G. pollachius?	...					
	...	...	1	*Topknot.*	1·06					
	...	Bottom.	3	Motella.						
	...	...	3	C. sprattus.						
	...	...	1	G. pollachius.						
,, 19.	West Channel.	Surface.	50	Motella, o.g. colourless.	...	...	...	1	Cottus bubalis.	7·3
	...	...	1	C. sprattus.	...	...	...	1	Gobius minutus?	3·4
	...	...	1	Gadus sp.						
	...	Bottom.	50	Motella.						
	...	...	2	C. sprattus.						
	...	...	5	Gadus sp.						
	...	...	1	Pl. microcephalus.	...	...	III.			
,, 23.	½ m. S. of Breakwater Fort. (2 hauls.)	Surface.	23	Motella, o.g. colourless?						
		...	18	C. sprattus.						

					mm.	mm.				mm.
Feb. 23.	½ mile S. of Break-	Surface.	7	Gadus sp.		...				
	water Fort.	...	2	G. pollachius.	1·14, 1·15		III.			
	(2 hauls.)	...	1	C. lyra.						
	...	Bottom.	7	Motella, o.g. colourless ?	...	..	...	1	Unidentified.	8·6
	...	...	2	C. sprattus.						
	...	...	7	Gadus sp.	·92					
	...	...	2	G. pollachius ?	1·13, 1·22					
	...	...	1	C. lyra.						
	...	...	...	...			...			
,, 24.	3 miles S.W. of	Surface.	150 ca.	Motella, o.g. colourless ?	...	...	Most I.			
	Breakwater	...	1	C. sprattus.						
	Light.	...	1	Gadus sp.						
	(2 hauls.)	...	1	Pl. microcephalus ?	1·25					
	...	...	1	Topknot.	1·05					
	...	Bottom.	240	Motella, o.g. colourless ?						
	...	...	3	C. sprattus.						
	...	...	9	Gadus sp.						
	...	...	1	G. pollachius ?	1·26					
	...	...	1	Pl. microcephalus.	1.46					
	...	...	1	Pl. platessa.	1·85					
,, 25.	Plymouth Sound.	...	240 ca.	Motella, o.g. colourless ?						
	...	...	1	Pl. microcephalus.	1·40					
,, 26.	½ mile S. of Break-	Surface.	37	Motella, o.g. colourless ?						
	water Fort.	Midwater.	60	Motella, o.g. colourless ?						
	...	...	1	G. pollachius ?						
	...	...	1	Topknot.	1·02	·19				
	...	Bottom.	17	Motella.						
	...	...	1	Gadus sp.						
Mar. 1.	½ mile S. of Break-	Surface.	120	Motella, o.g. colourless ?						
	water Light.	(2)	2	Motella, o.g. ∞	...	∞	I.			
	...	...	3	C. sprattus.						
	...	...	1	Topknot.	1·04	·21	II.			
	...	...	3	Topknot.	·99, 1·05, 1·08	{·18, ·17, ·19}	I.			
	...	...	7	Gadus sp.						

Date.	Locality.	Position of Net.	EGGS. No.	Species.	Diam. of Egg.	Diam. of oil globule.	Stage of Development.	LARVÆ. No.	Species.	Length.
					mm.	mm.				mm.
Mar. 1.	½ mile S. of Breakwater Light.	Surface.	1	G. pollachius ?	1·2	...	I.			
		Bottom.	20	Motella, o.g. colourless ?						
	...	...	1	C. sprattus.						
,, 30.	Off Mewstone.	...	54	C. sprattus.	·87–·96	...	I., II., III.	1	G. pollachius ?	3·93
	...	...	1	Motella, o.g. colourless ?	·80	·12				
	...	...	8	Pl. flesus.	·96–1·13	...	I., II.			
	...	...	1	Pleuronectes sp.	1·23	...	I.			
	...	...	1	*Gadus merlangus.*	1·21	...	II.			
	...	...	1	G. pollachius ?	1·19	...	II.			
	...	...	1	C. lyra.	·91	...	III.			
	...	...	1	*Trigla gurnardus ?*	1·53	·30	III.			
	...	...	2	Topknot.	·90–·91	·13	III.			
	...	...	3	Topknot.	1·04–1·07	·19–·21	III.			
April 5.	Cawsand Bay.	Surface.	1	G. merlangus.	1·20	...	II.			
	...	...	1	Not identified.	·954					
	...	...	1	C. lyra.						
	...	...	1	Topknot.	1·033	·173				
	...	...	5	Motella, o.g. colourless ?	·73–·87					
,, 8.	Off Mewstone.	...	...	Eggs not recorded.	...	...	...	1	Rhombus punctatus (periotic spines).	5·11
	...	...	...	...	...	...	...	sev.	Rh. punctatus ? (vitelligerous).	
	...	...	...	...	...	...	...	1	Solea vulgaris.	
	...	...	...	...	...	...	...	sev.	Unidentified.	
,, 22.	Jennicliff Bay.	Surface.	2	*Solea vulgaris.*	...	...	III.	2	G. pollachius ?	7·
	Plymouth Sound.	...	1	C. lyra.	...	...	II.	3	Pl. flesus.	9·–9·75
	...	...	...	...	...	...	...	2	C. sprattus.	9·, 10·

					mm.	mm.				mm.
Ap. 24.	Jennicliff Bay.	Surface.	...	Eggs not observed.	...	...	...	1	G. pollachius.	10·
	...	...	...	...	...	...	...	1	Agonus cataphractus.	16·25
	...	...	...	...	...	...	...	1	Rh. punctatus (periotic spines).	4·5 ca.
,, 27.	Outermost Buoy of West Channel.	Surface.	4+	Motella, o.g. colourless.	·75	·14	I.	3	G. pollachius ?	11·–14·
		...	4	Motella, o.g. yellow.	·69–·81	·15–·17	I.	6	Pl. platessa ?	10·5–12·
	...	...	8	*Ctenolabrus rupestris.*	·90–1·01	...	I.			
	...	...	2	C. sprattus.	·96	...	I.			
	...	...	15+	Topknot.	·98–1·04	·16–·18	I.			
	...	...	1	Topknot.	1·02	·21	I.			
,, 29.	Jennicliff Bay.	Surface.	1	G. merlangus ?	1·15	...	I.			
	...	...	m.	Motella, o.g. colourless.	...	...	I.	2	G. pollachius ?	6·5, 10·
	...	...	5 ca.	Motella, o.g. yellow.	·69, ·72	·15, ·16	I., III.	5	C. sprattus	8·–13·
	...	...	...	...	...	...	...	9	Pl. flesus.	9·–11·5
May 3.	W. Channel, outer Knap Buoy.	Surface.	1	C. sprattus.	·96	...	III.	3	G. pollachius.	4·75–9·5
		...	2	*Gadus minutus* ?	·94, ·96	...	I., III.			
	...	...	2	C. lyra.	·85, ·87					
	...	...	6	Motella, o.g. yellow.	·70–·74	·15–·18	I.			
	...	...	1	Motella, o.g. yellow.	·80	·15	I.			
,, 5.	1 mile S.S.W. of Breakwater Light.	Surface.	...	C. lyra.	...	...	...	1	G. pollachius ?	
		...	1	G. merlangus.	1·2 ca.	...	...	6	G. pollachius.	5·–9·
	...	...	...	...	...	...	...	1	Liparis.	4·25
	...	...	...	...	...	...	..	1	C. lyra.	3·5
	...	...	...	...	...	...	...	2	Gobius minutus ?	4·5, 6·5
,, 7.	Off Mewstone.	Surface.	1	C. lyra.	...	...	II.			
	...	...	2	C. sprattus.						
	...	...	4	Motella, o.g. yellow.	·67–·72	·16–·17	III.			
	...	...	2	Motella, o.g. colourless.	·68, ·70	·14	I.			
	...	Bottom.	...	Eggs not recorded.	...	...	...	5	Gadus minutus ?	5·–9·
	...	Bottom.	2	Motella, o.g. yellow.	·72, ·75	·15, ·16	I.			
	...	...	1	Motella.	...	...	III.			
	..	..	1	C. lyra.	·80	...	I.			

Date.	Locality.	Position of Net.	EGGS. No.	EGGS. Species.	EGGS. Diam. of Egg.	EGGS. Diam. of oil globule.	EGGS. Stage of Development.	LARVÆ. No.	LARVÆ. Species.	LARVÆ. Length.
					mm.	mm.				mm.
May 8.	1 mile N.E. of Eddystone.	Surface.	1	C. lyra.	·85	...	II.	10	G. pollachius.	7·–20·75
		...	3	C. rupestris.	·90–·92	...	I.	1	Motella.	6·
	...	...	...	...	...	...	...	1	Motella.	18·
	...	...	...	...	...	...	...	1	Aphia.	
	...	Bottom.	...	Eggs, if present, not examined.	...	...	...	9	Gadus minutus ?	5·–6·5
	...	...	...		...	...	...	1	Motella.	5·
	...	...	...	...	...	...	...	1	Motelloid ? (very long pelvics).	6·5
	...	...	...	...	...	...	...	3	Pl. limanda.	9·
	...	...	...	...	...	...	...	1	C. lyra.	3·5
	...	...	...	...	...	...	...	2	Belone vulgaris.	10·, 14·
	...	...	...	...	...	...	...	2	Topknot (no cephalic spines).	3·, 5·, 8·
	...	...	...	...	...	...	...	2	Pl. microcephalus.	6·5, 10·25
	...	...	...	...	...	...	...	2	Solea vulgaris.	7·5, 8·
,, 13.	Inner part of Whitsand Bay.	Surface.	sev.	C. lyra.	...	...	...	1	G. pollachius.	10·
		...	1	G. merlangus.	1·27					
	...	Bottom.	...	...	...	...	...	2	G. pollachius.	8·, 10·
	...	...	...	...	...	...	...	9	Pl. limanda.	11·–19·
	...	...	...	...	...	...	...	1	Liparis.	9·
,, 15.	Tamar River above Saltash.	Bottom.	nil.	...	...	...	...	2	G. pollachius.	11·, 14·5
		...	...	...	...	...	...	1	Pl. limanda.	14·
	...	...	...	...	...	...	...	1	Mugil chelo.	11·5
	...	...	...	...	...	...	...	4	C. harengus.	20·–30·
	...	...	...	...	...	...	...	2	Gobius minutus.	15·, 15·5
,, 17.	Yealm Zostera Bed.	Bottom.	...	...	...	...	...	1	G. pollachius.	23·5
		...	...	...	...	...	...	1	Pl. limanda.	14·
	...	...	...	...	...	...	...	1	M. chelo.	11·5

					mm.	mm.				mm.
May 18.	Tamar River, below Saltash.	Bottom.	...	...	...	...	...	5	Gobius minutus ?	5·9, 15–5
		...	...	...	...	...	...	1	M. chelo.	9·
		...	...	...	...	...	...	2	C. harengus.	24·, 29.
,, 19.	Cawsand Bay.	Bottom.	...	...	...	...	...	1	Gadus minutus.	18·5
	...	...	...	...	...	...	...	30 +	G. pollachius.	19·–24·
	Jennicliff Bay.	Bottom.	...	...	...	...	...	2	Gadus minutus.	18·, 34·
,, 20.	1½ mile S. by E. of Mewstone.	Midwater.	nil.	...	...	...	...	nil.		
		Surface.	4	C. rupestris.	...	...	I.	1	G. pollachius.	24·
	...	...	...	...	...	...	...	2	G. pollachius.	12, 14·5
,, 21.	Jennicliff Bay.	Surface.	3	C. rupestris.	·87	...	I.	4	Gadus minutus ?	9·–11.
	...	...	2	Motella, o.g. yellow.	...	...	...	4	Motella.	3·25–7·
	...	...	...	...	...	...	...	1	Motella.	19·
	...	...	...	...	...	...	...	1	Ammodytes sp.	6·5
	...	Bottom.	...	...	...	...	...	5	G. pollachius.	14·5–20·
	...	...	...	...	...	...	...	3	Pl. limanda.	13·–14·5
,, 22.	Jennicliff Bay.	Surface.	...	...	...	...	...	1	C. lyra.	8·
	...	...	...	...	...	...	...	2	Gadus minutus ?	9·, 11·
	...	Bottom.	...	...	...	...	...	1	Gobius minutus ?	8 ca.
	...	...	...	...	...	...	...	7	Aphia pellucida.	8·–10·5
,, 25.	400 yards off the Start.	Surface.	1	Motella, o g. yellow.	...	...	I.	1	Solea vulgaris.	11·
		...	...	...	...	...	...	1	Gadus minutus ?	10·5
	Start Bay, 150 yds. off Slapton Sands.	Bottom.	...	...	...	...	...	2	Gadus luscus.	18·, 20·5
		...	...	...	...	...	...	21	Gadus minutus.	16·5–28·5
	Start Bay, 100 yds. off Slapton Sands.	Bottom.	...	...	...	...	...	10	Gadus minutus.	17·5–25·
	Start Bay, off N. end of Slapton Sands.	Bottom.	...	...	...	...	...	1	Solea vulgaris.	10·5
		...	...	...	...	...	...	...	Pl. limanda.	
,, 26.	Start Bay, trawling ground.	Surface.	1	*Solea lutea.*						
		Bottom.	...	...	...	...	...	1	Pl. limanda.	17·75
		...	...	...	...	...	...	2	Pl. limanda ?	10·
	Start Bay, Black-pool.	Bottom.	...	...	...	...	...	17	Pl. limanda.	14·5–18·*
		...	...	...	...	...	...	1	Solea vulgaris.	11·5
	...	...	...	...	...	...	...			

* Including several from 25th.

Date.	Locality.	Position of Net.	EGGS. No.	EGGS. Species.	EGGS. Diam. of Egg.	EGGS. Diam. of oil globule.	EGGS. Stage of Development.	LARVÆ. No.	LARVÆ. Species.	LARVÆ. Length.
					mm.	mm.				mm.
May 27.	Start Bay, trawling	Surface.	5 ca.	C. rupestris.	...	...	I.			
	ground.	...	m.	S. lutea.						
	...	...	1	C. aper ?	·98	·17				
	...	...	1	Motella, o.g. colourless.						
	...	...	1	Motella, o.g. yellow.						
	...	Bottom.	...	...	...	...	...	1	C. lyra.	10·
	...	...	...	...	...	...	...	1	S. vulgaris.	10·5
	...	...	...	...	...	...	...	2	Pl. limanda.	17·5, 18·
	Start Bay, outer	Bottom.	...	...	...	...	...	1	Gobius sp. ?	8· ca.
	ground.	...	...	...	...	...	...	1	Gadus minutus.	12· ca
June 1.	Teignmouth Bay,	Surface.	3	C. lyra.	·84, ·87	...	2 II., III.			
	trawling ground.	...	1	C. sprattus.	...	...	I.			
	...	...	1	T. vipera.	1·16	...	I.			
	...	...	4	S. lutea.	...	...	III.			
	...	...	1	*Arnoglossus laterna ?*	·66	.14	I.			
	...	Bottom.	...	...	...	...	...	1	G. luscus.	20·5
,, 2.	Off Paignton Ness.	Bottom.	...	...	...	...	...	5	Gobius minutus.	10·–19·
	Torbay, trawling	Surface.	1	Motella.	...	...				
	ground.	...	...	Other eggs, not identified						
,, 3.	Start Bay, trawling	Surface.	1	*Trachinus vipera.*	...	...	I.			
	ground.	...	7	S. lutea.						
	...	...	1	Motella.						
	...	...	1	C. rupestris ?	·87	...	I.			
	...	Bottom.	...	...	...	...	...	1	Gadus ?	
	Start Bay, off Street Road.	Bottom.	...	...	...	...	...	1	Gobius sp.	10· ca.
	1 mile off the Start.	Surface.	nil.	...	...	...	...	1	Gadus minutus ?	10
	...	...	...	...	...	...	...	5	Motella tricirrata.	13·–18·
	...	...	...	...	...	...	...	1	Motella tricirrata.	31·

					mm.	mm.				mm.
June 4.	4–5 miles S. of Mewstone.	Surface.	6	*Clupea pilchardus.*	{(yolk) ·96 (one) 2·38}	·16	I.			
	...	...	7	*Capros aper.*	·96–1·01	·14–·16	I.			
	...	...	1	*Capros aper?*	1·04	·20	I.			
	...	...	4	C. rupestris.	...	...	I.			
	...	...	1	*Trigla pini?* (rugose zona).	1·49	·28	I.			
	...	...	2	*Arnoglossus laterna.*	...	...	III.			
,, 8.	Off Rame Head.	Surface.	...	...	...	...	...	1	Motella.	22·
	...	...	...	...	...	...	...	2	G. pollachius.	19·
	Jennicliff Bay	Surface.	...	...	...	...	...	2	G. pollachius.	21·, 22·
	Inner part of Whitsand Bay.	Surface.	2	Motella, o.g. yellow.	...	...	I.			
		...	3	C. rupestris.	...	...	I.			
	...	Bottom.	...	...	...	...	...	1	P. limanda.	·18
,, 9.	Cawsand Bay.	Surface.	1	Motella.	...	...	III.			
	...	...	1	Motella, o.g. yellow.	...	...	I.			
	...	...	14	C. rupestris.	(one) ·87					
	...	Bottom.	...	...	...	...	...	3	P. limanda.	20·–24·
	...	...	...	...	...	...	...	m.	G. pollachius.	26·–42·
	...	...	...	...	...	...	..	1	Agonus cataphractus.	36·
	...	...	...	...	...	...	...	m.	Gobius minutus.	12·–17·
,, 10.	2½ miles S. of Mewstone.	Surface.	1	C. rupestris.	...	...	II.			
		Bottom.	...	...	...	...	...	1	Phrynorhombus?	9·5
,, 11.	1 mile S. of Mewstone.	Surface?	sev.	Not identified.	...	...	...	20-30	Motella.	17·5–28·
		...	...	...	...	...	...	1	G. pollachius.	18·
,, 12.	Jennicliff Bay.	Surface.	...	...	...	...	...	1	C. sprattus.	34·
	Off Mewstone.	Surface.	1	C. aper?	·90	·18	I.			
	...	...	4	C. rupestris.						
	...	Bottom.	nil.							
,, 14.	Drake's Island, pools.	Surface.	...	...	...	...	...	1	P. limanda.	18·5
	1 m. off Breakwater.	Surface.	5+	Motella, o.g. yellow.	...	...	III.	2	Rhombus maximus.	15·, 22·

Date.	Locality.	Position of Net.	EGGS.					LARVÆ.		
			No.	Species.	Diam. of Egg.	Diam. of oil globule.	Stage of Development.	No.	Species.	Length.
					mm.	mm.				mm.
June 14.	1 m. off Breakwater.	Surface.	8 +	C. rupestris.	(two) ·84					
,, 15.	1 mile S. of Mewstone.	Surface.	2	C. rupestris.	...	...	I., III.			
		Midwater.	2	C. rupestris.	...	...	I., III.			
,, 16.	Cawsand Bay.	Surface.	nil.	...	...	...	...	2	Rhombus maximus.	15·, 22·
,, 17.	200 yds. S. of Drake's Island, ebb.	Surface.	1	C. rupestris.	...	...	...	1	C. sprattus.	16·
		...	...	...	...	...	...	m.	C. sprattus.	21·–26·5
	...	...	...	...	...	...	...	4	C. sprattus.	31
	...	...	...	...	...	...	...	15	Gadus minutus ?	10·–15·
	...	...	...	...	...	...	...	1	G. pollachius.	23·
,, 19.	Hamoaze.	Surface.	...	...	...	...	...	1	Motella mustela.	27·
,, 23.	1 mile S. of Mewstone, early ebb.	Surface.	1	Unidentified (asperous zona).	1·06	...	I.			
	...	...	1	T. vipera.	...	...	III.			
	...	...	6	C rupestris.	...	...	I., II., III.			
	...	...	...	Motella, o.g. yellow.						
	...	Bottom.	12	C. rupestris.						
	...	...	1	Motella, o.g. yellow.						
,, 25.	2 miles N.E.¼E. of Eddystone.	Surface.	17	C. aper.	·97–·99	·15–·16	I., II.			
		...	...	No record of other species						
,, 26.	Outer Knap Buoy.	Surface.	...	...	...	...	...	1	Motella ?	4·5
,, 28.	¼ mile S. by E. of Mewstone Buoy.	Surface.	20 ca.	C. rupestris.	...	...	I., II., III.			
		...	2	Motella, o.g. yellow.	...	...	III.			
	¼ to ½ mile off Breakwater.	Surface.	4	C. rupestris.						
		...	1	C. rupestris ?	...	·67	I.			

					mm.	mm.				mm.
June 28.	¼ to ½ mile off Breakwater.	½ to 1 fath. down.	12	C. rupestris.	...	...	I., II., III.			
	...	...	3	Motella, o.g. yellow.	...	...	I., II.			
	..	...	1	T. vipera.						
,, 29.	2 miles off Fowey River.	Surface.	nil.	...		...	...	nil.		
		Bottom.	m.	C. rupestris.	(one) ·84	...	...	2	Ammodytes sp.	6·5, 7·5
	...	...	...	Motella, o.g. yellow.		...	...	1	Motella.	9·5
	...	...	...	C. aper?	·99	·15	I.	1	Gobius sp.	4·
	...	...	...	...		...	...	4	C. aper?	4·5–6·
,, 30.	2 miles off Fowey River.	1 fathom down.	nil.							
	...	...	1	T. pini?	1·43	·23	I.			
	...	Bottom.	3	*Unidentified Gadoid (?).*	·86–·91	·16	II.			
	...	...	1	?............................	·96	·17	II.			
	...	...	1	A. laterna.	·66	·13	III.	1	Ammodytes sp.	9·5 ca.
	...	...	2	C. rupestris.	...	...	...	9	C. aper?	4·–6·5
	...	...	1	Motella, o.g. yellow.						
July 6.	2 miles S.W. by S. of Mewstone.	Surface.	nil.							
		Bottom.	4	C. aper.	·93–·99	·16–·17	I., II.			
,, 7.	Gerrans Bay.	...	1	C. rupestris.						
	...	...	4	Motella, o.g. yellow.						
				Other eggs not recorded.						
,, 20.	4 miles off Mewstone.	Midwater.	2	Unidentified Gadoid (?).						
		...	2	C. rupestris.						
,, 23.	2 to 3 miles S. of Breakwater.	Surface.	2	*Coris-like Labroid.*	·78–·80	·14	I.			
		...	1	C. aper.	·96	·16				
	...	...	4	C. rupestris.	·78–·82					
	...	...	1	Motella, o.g. yellow.						
	...	4 fathoms down.	1	Unidentified Gadoid (?).	·84	·16	III.			
	...	...	1	*Caranx trachurus.*	·91	·22	II.			
	...	...	1	A. laterna.	·63	·12	II.			

Date.	Locality.	Position of Net.	EGGS. No.	EGGS. Species.	EGGS. Diam. of Egg.	EGGS. Diam. of oil globule.	EGGS. Stage of Development.	LARVÆ. No.	LARVÆ. Species.	LARVÆ. Length.
					mm.	mm.				mm.
July 23.	2 to 3 miles S. of Breakwater.	4 fathoms down.	1	C. rupestris.	·81	...	III.			
			1	Motella o.g. yellow.						
,, 26.	Jennicliff Bay.	Bottom.	...	...	...	...	...	1	Trigla gurnardus.	38· ca.
	...	...	...	...	...	...	...	1	Trigla hirundo.	30· ca.
,, 27.	Between Eddystone and Hand deeps.	Surface.	v.m.	C. aper.	...	...	I., II., III.			
		...	2	C. trachurus.	·81–·93	·22–·23	II.			
	...	...	2	*Arnoglossus Grohmanni.*	·72, ·74	·12, ·12	II.			
	...	...	1	*Trigla hirundo?*	1·35	·28	II.			
	...	...	1	Coris-like Labroid.	·82	·14				
	...	Midwater.	...	Eggs less plentiful than at surface, but more plentiful than at bottom.						
	...	Bottom.	3	C. aper.	·93–·97	·15–·17	I.			
	...	...	1	*Solea variegata.*	1·16	·03–·11	II.			
	...	...	1	C. rupestris.						
	...	...	1	Motella, o.g. colourless.						
,, 29.	2 miles S.W. of Mewstone.	Surface.	1	C. aper.	·93	·15	I.			
		...	2	Coris-like labroid.	·81	·13	III.			
	...	...	17	C. rupestris.	...	...	III.			
	...	...	5	Motella, o.g. yellow.	...	...	I., III.			
	...	...	8	A. laterna.	...	...	III.			
	...	...	1	A. Grohmanni.	...	...	III.			
	4 miles S. by W. of Mewstone.	Surface to midwater.	1	C. trachurus.	...	...	III.			
			6	C. aper.	...	...	III.			
	...	...	1	C. rupestris.	...	...	III.			
	...	...	1	Motella, o.g. yellow.	...	...	III.			
	...	Midwater to bottom.	2	C. aper?	·96	·14	I.			

					mm.	mm.				mm.
July 30.	Off Mewstone.	Surface.	...	Eggs rather abundant, not examined.						
,, 31.	4 miles S.W. by S.	Surface.	12	C. aper.	...	...	III.			
	of Mewstone.	...	2	C. pilchardus.	...	...	III.			
Aug. 3.	3 to 4 miles W.S.W.	Surface.	17	C. aper.	...	...	I.			
	of Rame Head.	...	1	Arnoglossus sp.	...	...	I.			
	...	...	1	Coris-like labroid.	·78	·15				
,, 4.	Bigbury Bay.	Surface.	...	Few eggs, not identified.	...	...	...	2	Blennius pholis.	19·5, 20·
	...	...	...	...	...	...	...	1	Trachinus vipera.	13·
,, 6.	Jennicliff Bay.	Surface.	...	...	...	...	...	1	Caranx trachurus.	11·5
	...	...	...	...	...	...	...	m.	C. sprattus (pilchardus?)	21·–27·5
,, 19.	Cawsand Bay.	Surface.	nil.							
	...	...	nil.							
,, 23.	4 miles off Break-	Surface.	nil.							
	water.	Midwater.	nil.							
	...	Bottom.	nil.							
,, 24.	Cawsand Bay.	Surface.	nil.							
	...	Midwater.	nil.							
,, 25.	1 mile S.W. of	Surface.	1	C. aper.	·91	·15	II.			
	Breakwater Fort.	...	1	Unidentified Gadoid (?).	·80	·16	II.			
	...	...	8	Motella, o.g. yellow.	·65–·68	·12–·17	Var.			
	...	Midwater.	1	Unidentified Gadoid (?).	·78	·15				
	...	Bottom.	2	Motella, o.g. yellow.	...	...	I.			
,, 27.	1 mile off Break-	Surface.	1	C. aper.	·93	·15	II.			
	water Light.	...	1	Unidentified Gadoid (?).	·84					
	...	...	1	C. rupestris.	·72	...	I.			
	...	...	5	Motella, o.g. yellow.						
	...	Midwater.	nil.							
	...	Bottom.	1	Motella, o.g. yellow.						

Date.	Locality.	Position of Net.	EGGS.					LARVÆ.		
			No.	Species.	Diam. of Egg.	Diam. of oil globule.	Stage of Development.	No.	Species.	Length.
					mm.	mm.				mm.
Aug. 28.	Cawsand Bay.	Surface.	1	Unidentified Gadoid (?).	·83	·17	III.			
,, 30.	200 yards inside Breakwater.	Midwater.	3	Motella, o.g. yellow.						
		Bottom.	1	Motella, o.g. yellow.						
	Jennicliff Bay.	Surface.	nil.	...						
	...	1 fathom down.	2	Motella, o.g. yellow.						
Sept. 1.	Inside Breakwater.	Bottom.	nil.							
,, 3.	Cawsand Bay.	Bottom.	nil.							
	...	Bottom ?	...	...	...	...	...	4	Lepadogaster bimaculatus.	3·–4·5
	1 mile off Breakwater.	Bottom.	...	...	...	...	...	1	Lepadogaster bimaculatus.	7·5
,, 6.	Cawsand Bay.	Bottom.	nil.							
,, 7.	4 miles off Breakwater.	Surface.	nil.							
		Midwater.	nil.							
	...	Bottom.	nil.							
,, 8.	2–3 miles S.W. of Mewstone.	Surface.	nil.							
		Midwater.	nil.							
	Plymouth Sound.	...	1	Motella, o.g. yellow.						
,, 10.	3 miles N.E. to N. of Eddystone.	Surface.	nil.							
,, 13.	Off Mewstone.	...	nil.							
,, 14.	¼ mile off Penlee.	Bottom.	1	Motella, o.g. yellow.						

						mm.	mm.				mm.
Sept.	14.	Cawsand Bay.	Surface.	1	Motella.						
,,	16.	Cawsand Bay.	Bottom.	...	...	...	...	...	1	Lepadogaster bimaculatus.	15·5
,,	21.	Plymouth Sound.	...	...	...	...	...	...	...	Early larva, sp. ?	2·09
Oct.		No records of townets.	...	...							
Nov.		No records of townets.	...	...							
Dec.	2.	2 miles S. of Mewstone.	Bottom.	nil.							
,,	3.	Whitsand Bay.	Surface.	nil.							
		...	Bottom.	nil.							
,,	11.	Off Breakwater.	...	nil.							
,,	14.	West Channel.	Surface.	nil.							
		...	Bottom.	nil.							
,,	20.	Between Mewstone and Shagstone.	2 fathoms down.	nil.							
		...	Bottom.	nil.							
,,	21.	Between Mewstone and Shagstone.	Midwater.	nil.							
,,	22.	¼ mile off Breakwater.	Bottom.	nil.							

Preliminary Report on the Results of Statistical and Ichthyological Investigations made at the Plymouth Laboratory.

By

Georg Duncker, Ph. D.

DURING my stay, from August to October, 1897, at the Laboratory of the Marine Biological Association of the United Kingdom, I was especially engaged in investigating the variability of *Pleuronectes flesus*, Linn., and *Siphonostoma typhle*, Linn. Of the results so obtained, some of more local faunistic importance are briefly reported here.

I take this opportunity of expressing my hearty thanks to the officers of the Laboratory, especially to the Director, Mr. E. J. Allen, for their help and kind interest in my researches. A paper containing a full statement of the statistical results has been prepared, and will be published shortly.

1. Pleuronectes flesus, *Linn.*

The flounders of Plymouth, when compared with those of the Baltic and the south-eastern parts of the North Sea, form a distinct race. The characteristics of this race are:

1. A high number of fin-rays in the dorsal and anal fin (average, dorsal 61–62, anal 43–44).

2. Almost entirely smooth squamation on the blind side. In both respects it is similar to the variety *Pleuronectes italicus*, Günther, of the Mediterranean.

The variation in the number of fin-rays has been studied in 1120 individuals, of which 602 (=53·75 per cent.) were males, and 518 (=46·25 per cent.) were females. Of the males 40 (=6·6 per cent.) had the eyes on the left side of the head, of the females only 20 (=3·8 per cent.). On drawing the curves representing the observed total lengths for each sex separately, a distinct size group, similar to those suggested by Petersen,* was found only for the small individuals from 7 to 14 cm. In other portions of the curve no distinct humps were observed.

The males proved more variable than the females in the number of fin-rays. Table I. gives the indices of variability (Airy's error of mean square $\sqrt{\frac{\Sigma(x^2)}{n}}$) for each fin in both male and female.

TABLE I., *showing the Indices of variability of the number of fin-rays.*

	Males.			Females.		
	Index.		Number of Individuals.	Index.		Number of Individuals.
Dorsal fin * . .	2·4445	...	602	2·3118	...	518
Anal fin * . .	1·6521	...	602	1·5397	...	518
Left Pectoral fin † .	0·7454	...	562	0·6978	...	498
Right Pectoral fin † .	0·7152	...	562	0·6993	...	498
Left Ventral fin † .	0·3318	...	562	0·3483	...	498
Right Ventral fin † .	0·3147	...	562	0·2225	...	498

* Right- and left-eyed individuals.
† Right-eyed individuals only.

Differences of age or sex corresponding to differences in the number of fin-rays were not distinctly shown in the dorsal, anal, and ventral fins. In both pectoral fins a slight increase of the numbers of rays seems to occur with age (*i.e.* with increase of total length).

Table II. gives the arithmetical mean values of the number of fin-rays in six size groups of both sexes. Group I. contains individuals below 10 cm. in total length; group II., from 10 to 14·9 cm., etc.; group VI., above 30 cm. (See page 174.)

The variation is normal in three cases; in three (dorsal and both ventral fins) it is skew, according to Pearson's Type IV. (*Phil. Trans. Roy. Soc.*, Vol. 186 A.); in the dorsal, however, this skewness is only slight. The correlation (according to Pearson's† formula) between the numbers of fin-rays of the dorsal and anal fin is very high, r = 0·672.‡ This is higher even than that of the pectoral fins, r = 0·588. The latter I find to be less than in the symmetrical species mentioned below, in which r = 0·700 and 0·720 respectively. The correlation of the ventral fins is only 0·2085.

* *Report of the Danish Biol. Station*, IV., 1893, "The Biology of our Flatfishes."

† *Phil. Trans. Roy. Soc.*, Vol. 187 A, p. 265.

‡ Compare this with the corresponding values of the Acanthopterygians *Acerina cernua*, Linn., r = 0·238, and *Cottus gobio*, Linn., r = 0·300.

TABLE II., *showing the size-differences in the average number of fin-rays (right-eyed individuals only).*

Size.	Dorsal Fin.		Anal Fin.		Left Pectoral.		Right Pectoral		Left Ventral.		Right Ventral.		Number of Individuals.	
	Male.	Female.	Male.	Female.	Male.	Female.	Male.	Female.	Male.	Female	Male.	Female.	Male.	Female.
I. . .	61·52 ...	61·95	43·80 ...	43·75	9·96 ...	10·05	10·44 ...	10·75	6·00 ...	5·75	6·00 ...	6·05	25 ...	20
II. . .	61·27 ...	61·25	43·68 ...	43·28	9·86 ...	9·74	10·60 ...	10·56	5·96 ...	5·95	6·01 ...	5·99	113 ...	115
III. . .	61·74 ...	61·91	43·84 ...	43·56	10·22 ...	10·02	10·88 ...	10·63	5·93 ...	5·96	5·95 ..	5·95	148 ...	116
IV. . .	61·76 ...	62·11	43·46 ...	44·03	10·26 ...	10·31	10·93 ...	10·93	5·97 ...	5·95	5·99 ...	5·96	170 ...	127
V. . .	61·59 ...	61·72	43·43 ...	43·78	10·34 ...	10·40	11·03 ...	10·93	5·94 ...	5·95	5·93 ...	5·98	100 ...	82
VI. . .	62·17 ...	61·95	43·50 ...	43·87	10·00 ...	10·29	11·33 ...	10·71	6·00 ...	5·95	6·00 ...	6·00	6 ...	38
TOTAL (average)	61·7214		43·6098		10·1425		10·8036		5·9500		5·9745		1060	

2. Syngnathus rostellatus, *Nilss.*

The reasons for separating this common and widely-distributed species from *S. acus,* Linn., are the following:—

1. The differences between the two forms are so distinct and of such a degree that they are not likely to be due to differences of age.

A comparison between twenty-two individuals of the former species and forty-seven of the latter, gives the following ranges of variation :—

	S. rostellatus, Nilss.		*S. acus.*
Ann. corp.	13–15	...	19–20
Ann. caud.	39–41	...	43–46
Summa ann.	52–56	...	62–66
Ann. p. dors.	10–12	...	8–11
Rad. p. dors.	36–44	...	36–45
Ann. burs. gen.	20–25	...	25–28
Observed Total Length	7·7–16·4 cm.	...	16·0–44·8 cm.

2. The individual variation in the number of body rings in the *Syngnathidae* (corresponding to the individual variation of abdominal vertebræ in other fishes) is a very low one. (*Siphonostoma typhle,* Linn. *Syngnathus pelagicus.*)

3. The fully-developed young in the brood-pouches of the males of both forms differ by the same number of rings as the adult, as well as differing in their total lengths. (They are about 1·5 cm. and 2·5 cm. respectively.)

4. Sexual maturity has been observed in individuals of *S. rostellatus,* Nilss., above 11 cm. long, in *S. acus* not below 30 cm.

5. Cross-breeding between the two forms seems unlikely, in consequence of the difference of the sizes of the eggs and brood-pouches in the two cases.

At Plymouth I obtained *S. rostellatus,* Nilss., from Cawsand Bay and from the Yealm River; *S. acus* from the same places and from the Hamoaze. I also possess specimens of *S. rostellatus,* Nilss., from the western Baltic, the North Sea, and the Mediterranean. Through the kindness of Mr. E. W. L. Holt I was also able to compare some specimens from the River Humber.

On Keeping Medusae Alive in an Aquarium.

By

Edward T. Browne,
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I HAVE made several attempts to keep medusae alive in an aquarium, but have only recently been successful. A medusa when first placed in an aquarium swims actively about, but in a few hours it sinks to the bottom apparently tired out. After an interval of rest it takes another swim and again sinks to the bottom. This is repeated until the medusa becomes completely exhausted; then it stays at the bottom and slowly dies. In spite of every attention, plenty of clean sea-water, plenty of copepods, and a suitable temperature, I found that my medusae often used to die within a day of their capture.

When I have been watching medusae at the surface of the sea, I have noticed that they simply float along with the tide without often pulsating the umbrella. In my bell-jars the water was perfectly motionless, so that a medusa had to pulsate its umbrella in order to keep afloat, and as soon as the pulsations stopped it began to sink. There are some species, like those belonging to the *Bougainvillidae*, which live longer in confinement, as they are able to poise themselves in the water by the extension of their tentacles and remain motionless for long periods, but even these finally reach the bottom of the bell-jar, and a long period at the bottom ends in death.

It appeared to me that to keep medusae alive in an aquarium it was necessary to have the water in motion so that a medusa could float about just as it does in the sea, without having constantly to pulsate its umbrella. The intervals of floating are periods of rest.

I pass over the early experiments and describe a simple method for keeping water in motion in a bell-jar, which has given excellent results and has enabled me to keep medusae alive for many weeks in perfect condition. The current in the water is obtained by simply moving up and down, fairly slowly, a glass plate inside a bell-jar. Owing to the downward plunge the plate made in the early experiments it was called a "plunger," and this name I have retained for the want of a simpler one. (Fig. 1.)

The plunger consists of a flat glass plate with a small hole in the centre; through the hole passes a glass rod which is suspended to one end of a long wooden rod, the "beam." The glass rod has a knob at the bottom upon which the plate rests, and it is slightly bent so as to give a slope to the plate. The sloping of the plate prevents the medusae

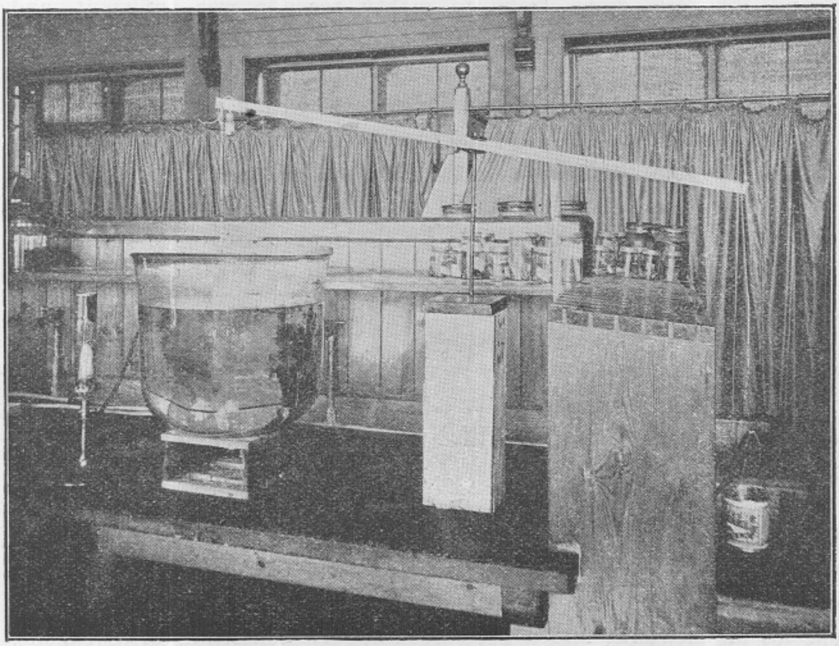

Fig. 1. Bell-jar with Glass Plunger.

being caught between the plate and the surface-film when the plunger moves up.

The beam rests near its centre on a pivot, like the beam of a balance. and at one end is suspended the plunger, and at the other end a small bucket made of tin, fitted with a large siphon. A rubber-tube conveys a constant flow of water (from the fresh-water supply) into the bucket which, when full, quickly empties itself through the siphon. When the bucket has been emptied by the siphon, the plunger is at the bottom of the bell-jar, as the plunger end of the beam is heavier than the bucket end. The plunger need only be a little heavier than the bucket; and the weight can be easily regulated by means of a bottle containing shot, attached to the beam.

The siphon to empty the bucket must be of large bore, so as to carry away the water faster than it comes in. As soon as the siphon has stopped running the bucket begins to fill, and when the weight of the bucket exceeds that of the plunger, the bucket slowly goes down, and the plunger comes up to the surface. The length of the stroke is regulated by two stops, which prevent the beam moving too far up or down. The plunger remains at the surface until the water has reached the top of the siphon, and directly the siphon begins to act the bucket is quickly emptied, and the plunger goes down nearly to the bottom. I found that one down-stroke in eighty seconds was sufficient, and regulated the apparatus so that the down-stroke was a little faster than the up-stroke.

The top of the bell-jar has a wooden cover with a narrow slit cut in the centre to act as a guide to the plunger-rod, and to prevent the plate knocking against the bell-jar on the downward plunge.

The movement of the plunger produces numerous eddies in the water, which are rendered visible by the movements of the copepods and the medusae. The medusae are carried from one side of the bell-jar to the other, or from the bottom to the top. This movement the medusae appear thoroughly to enjoy, and during the intervals in which the plunger is at rest they may be seen either taking a swim or floating with their tentacles expanded, or else playing an active copepod, caught on the end of a tentacle, as skilfully as an expert angler plays a large fish.

The first plunger bell-jar was started in the Plymouth Laboratory on 4th of September. (Fig. 1.) The bell-jar contained about ten gallons of water, which had been in it about three months, and the glass was well coated with algae. In this bell-jar were placed at intervals different species of medusae, and a good food-supply consisting of copepods, crustacean larvae, &c. I kept this bell-jar under close observation until the 9th of October, when my visit to Plymouth terminated. The temperature of the water was often taken, especially on hot days, and occasionally the specific gravity. The temperature varied from 14·75° C. to 17·5° C., and it was kept down on hot days by placing round the outside of the bell-jar a strip of flannel, upon which played a jet of fresh water. This acted very well, for when the temperature of the room was about 21° C., the water in the bell-jar remained about 16° C.

All the species of medusae placed in this bell-jar not only lived longer, but were in a better condition than if kept in still water. Some species lived longer than others, which tends to show that much has yet to be learnt on keeping medusae. Perhaps for some species a slow revolving current would be better; it could easily be obtained by turning a screw-propeller in the water.

The following notes on the inhabitants of the bell-jar may be of interest: About eighty specimens of *Obelia* lived very well for about ten days, and then began to die off. For the first week they kept in splendid condition, and were very active, but were not seen catching copepods. *Obelia* in an aquarium with still water usually lives about twenty-four hours.

Phialidium generally lives about three days in still water, but in the "plunger" bell-jar one specimen (*P. buskianum*) lived six weeks, increased in size, and developed more tentacles. Its umbrella was as transparent as the clearest glass, and its tentacles were often seen stretched out, when fishing for copepods, to the fineness of a spider's web.

Another old inhabitant of the bell-jar was *Phialidium cymbaloideum.* In twenty-five days it added five new tentacles and five marginal bulbs.

The medusa of *Lar sabellarum* (*Willsia stellata,* Forbes) died suddenly after five weeks' captivity. It also added new tentacles, and increased the size of its umbrella. A specimen of *Margelis* lived seventeen days, and during this period added two new tentacles in each of the four marginal groups, and the oral tentacles twice dichotomously divided.

A single specimen of *Sarsia gemmifera* was placed in on the 16th of September. It started with six medusa-buds upon the manubrium; three of these developed into medusae which were liberated, and the others had nearly completed their development by the 9th of October.

These experiments I think show that it is possible to keep medusae alive in confinement for several weeks without any change of water, and that they increase in size and develop more tentacles.

In this bell-jar I placed copepods and crustacean and worm larvae as a food supply for the medusae. Whatever I placed in the bell-jar I examined with a microscope, to see that the specimens were in good condition. This applies not only to the medusae (it is useless to place them in if at all damaged or about half dead), but also to the copepods, &c.

Fresh copepods were added when the stock became low; some died a natural death, and many others were captured by the medusae. I did not try to keep alive the various pelagic larvae that were placed in the bell-jar, but I noticed that they throve wonderfully well. The larval form of *Magelona* was alive when I left Plymouth. It had been several weeks in the bell-jar, and was often seen floating with its two long tentacles stretched out to a considerable length. One worm safely passed through its larval stages, and built a tube on the bottom of the bell-jar. Mr. Garstang identified the adult form as *Capitella capitata.* Several of the crustacean larvae passed through their larval stages. I saw an adult form of a shrimp, and Mr. Hodgson identified another crustacean for me as the adult of *Nika edulis.*

In another plunger bell-jar I placed a colony of *Syncoryne.* It soon sent out long stolons attached to the glass. I measured and made drawings, at intervals, of the new growth of the colony. In thirteen days the total length of the new stolons and branches amounted to 773 mm., and ninety-nine new hydranths appeared. In this bell-jar I also kept some medusae liberated from hydroid colonies of *Perigonimus.* When the medusa leaves the colony it has two long perradial tentacles. In twelve days one specimen possessed four long perradial tentacles, four interradial bulbs, and one adradial bulb. The other specimens were not quite so far advanced.

I tried the experiment of starting with a perfectly clean bell-jar and using filtered sea-water, in which a plunger worked. Into this bell-jar, holding about two gallons, I placed about three dozen medusae and a good supply of copepods. The medusae were not specially selected, but taken as a sample of a day's tow-netting. I did not interfere with them for ten days, but only added copepods when the supply became low, when I found thirty-one specimens alive, and more than half of them were in excellent condition.

I must express my sincere thanks to my friend Mr. E. J. Allen for the great amount of trouble and the many useful suggestions which he made when we fitted up the apparatus for working the first plunger bell-jar. It was his suggestions which led to the plunger being worked by such a simple method.

The "Bottle-nose Ray" (*? R. alba,* Lacép.) and its Egg-purse.

By

Ernest W. L. Holt.

For a number of years our tanks have from time to time contained a very large and easily-recognised Skate-purse, but its specific identity has remained a matter of uncertainty. Fishermen attributed it to the "Bottle-nose ray," a species not to be found, so far as I am aware, in ichthyological works.

In the spring of 1897 I happened to be on the Plymouth fish-quay, when a large ray was landed from the Bay of Biscay. It was pronounced by the universal consensus of piscatorial opinion to be the "Bottle-nose." I have since seen several other specimens, and, by extracting the purses, have ascertained that the opinion of fishermen respecting their origin was perfectly correct.

With regard to the fish itself, it is a well-marked species, but its correct nomenclature is involved in considerable confusion. It is the "Burton Skate" of Couch, the *R. alba* of Day, though I am far from certain that all the records compiled by the last-named author really refer to the fish with which we are dealing. Smitt concludes that it is identical with the ray known to him as *R. lintea,* but this seems also uncertain.

Possibly *R. marginata,* which almost certainly applies to the young of the "Bottle-nose," may prove to be the name which has given rise to least confusion, but as I have not at present access to the older literature of the subject, I do not propose to deal seriously with the synonymy.

Calderwood has given in this Journal (N.S., ii., 1892, p. 283) a description of a female specimen, which is probably sufficient to ensure its recognition. To define it very roughly, the "Bottle-nose" may be said to be a very large, thick ray, with a moderately long and very sharply-pointed snout. Apart from the male sexual spines, which include not only the alar series but also a group at the margin opposite the eyes, the dorsal surface is generally destitute of large spines. Some are present on the snout and on the supra-orbital ridges. On the tail is a single median series, extending some way on to the back, and a lateral sub-marginal series, which, if sometimes single, may frequently be complex. *The ventral surface is generally smooth, except along the anterior margin of the disk, which is occupied by a very distinct border of asperities and spines. There are no black or grey markings of any sort on the ventral surface, which in large examples is dead white, without any pigment whatever.* Young examples have a border of dark pigment on the ventral surface of the wings; the under side of the tail is also dark. The teeth are pointed in both sexes.

The egg-purse does not greatly differ, in so far as concerns the shape of its body, from that of the common grey skate, *R. batis.* Using the topographical terms which are applicable while the purse remains in the ovary, the body is roughly oblong, but slightly constricted posteriorly. The anterior margin is truncate, the posterior margin broadly concave. Its greatest length in the middle line is 17·4 cm. ($6\frac{7}{8}$ inches), and its greatest width 13·8 cm. ($5\frac{7}{16}$ inches); but the actual cavity is only about 13·3 by 10·5 cm. ($5\frac{1}{4}$ by $4\frac{1}{8}$ inches).

The purse is thus of a very large size, apart from the attachment processes. Dorsally and ventrally the surface of the egg-cavity is somewhat inflated, but the convexity is greatest dorsally, and the lateral edges of the purse are rolled up in a ventral direction.

The attachment processes are characteristic. The posterior processes, about 8·7 cm. ($3\frac{7}{16}$ inches) in length, as measured from the level of the anterior edge of the body, are stout, but flattened, tapering to a width of ·9 cm. ($\frac{3}{8}$ in.) at the roughly truncate extremity. They are strongly bent in a ventral direction, and incline somewhat towards each other. The anterior processes are long and ribbon-like. Tapering from a width of 2·2 cm. ($\frac{7}{8}$ in.) at their origin to one of about ·6 cm. ($\frac{1}{4}$ in.) at the extremity,* they measure about 24·5 cm. ($9\frac{5}{8}$ inches) in total length. They are very thin, but supported by a thickened longitudinal ridge. Each process is inwardly curved so as to meet and cross its fellow at about two-thirds of its length, the curve being thereafter continued in a backward direction. The axis is gradually rotated so that the outer edge of the distal part of each filament is ventral in position.

In texture the purse is opaque, and, after exposure to sea water, of a dark olive-brown colour, as is the case with the purses of most rays. The fine longitudinal ridges are most distinctly beaded: each

* The process terminates, in some specimens, in an indefinite gelatinous tissue, which is probably produced in others as a filament.

is, in fact, beset by minute transverse crests. So far as I know this beaded appearance is quite characteristic. At all events, in combination with the peculiar character of the processes, it should ensure the recognition of the purse.

Mr. Allen has drawn my attention to Couch's description of a purse attributed by that author to the Eagle-ray, *Myliobatis aquila* (*British Fishes*, i., p. 137). A similar purse is mentioned by Day (*Fish. Gt. Brit.*, ii., p. 353) on the authority of Buckland; but reference is also made to Moreau's assertion of the viviparous condition of the Eagle-ray. The descriptions given by the authors named leave no doubt as to the identity of the purses, which are certainly those of the "Bottle-nose ray."

On the Occurrence of large Numbers of Larval Herring at the Surface.

A Letter from

Mr. Matthias Dunn.

"MEVAGISSEY, *26th January*, 1898.

"IT may interest you to know that on Friday, 14th January, the weather being very fine, and the wind from the S.E., as the fishing-boat *Sea Belle* (Mr. Blamey, master), was proceeding to the pilchard ground some four or five miles south of the Deadman headland, when about two miles from land they fell in with masses of muddy brown matter in strings, some of which were three or four hundred yards long and from two to seven feet wide, floating quite on the surface. They had not proceeded far along these lanes or path-like forms on the sea before they observed that pilchards were feeding on them ravenously; so they tacked their boat among them for a mile or more, and the further they went the more abundant were the pilchards. About four miles from land and in thirty fathoms of water the anxious gulls indicated the outmost limit of these strangely coloured bands, and here the pilchards were the most plentiful, almost rabid in their mad rush on the lessening streaks, causing the water to boil and whirl violently. Certainly some of the shoals of pilchards could not have had less than thirty to sixty thousand fish in them, for they coloured the water a dark red when concentrated on the brown matter.

"Of course our fishermen expected a more than ordinary catch of pilchards when setting their nets; but, strange to tell, with the decline of the light, having fed to repletion, they sank down below the nets, and the catch was a small one, amounting to some two or three thousand fish.

"Mr. Blamey, being anxious to know what the pilchards had been so fond of, brought me in a quantity of this floating matter, which proved to be young herrings in their first stage, with the yolk still large. In the bucket they were quite transparent, although, as already stated, of a decided brown colour when packed together in millions, and crowding in long lanes. Several other of our fishermen, although some miles from the *Sea Belle,* saw these young herrings with pilchards feeding on them under like conditions.

"MATTHIAS DUNN."

Mr. Dunn's letter requires no introduction ; I have merely to say that some well-preserved material forwarded to me proves the correctness of his identification. The larval herring are at most a few days old, some appearing to be quite recently hatched. Mr. Dunn also sent, at my request, some pilchards taken about the same place a few days later. This fish decomposes very rapidly, and in any case larval herring would be hardly recognisable after being subjected a few hours to the action of the gastric secretions. Though I found no larvæ, the stomach of one pilchard contained unmistakable herring ova, some of which contained far advanced embryos. The fish must therefore have been feeding on the herring spawn at the bottom, a habit of the pilchard previously unknown, at any rate to myself. I do not know of any previous record of the presence of such enormous numbers of very early herring larvæ at the surface, nor of their serving as food to the pilchard. Considering the importance of both species, Mr. Dunn's evidence is most valuable.

E. W. L. H.

On the Pelagic Fauna of Plymouth for September, 1897.

By

Edward T. Browne,

University College, London.

In the Journal of this Association for 1896 (Vol. IV., No. 2, p. 168) I published a few notes on the Pelagic Fauna of Plymouth for September, 1893 and 1895. This year (1897) I again occupied a table in the Laboratory during September for the study of medusae, and also made a few entries in my notebook on the occurrence of certain animals belonging to other groups, and kept a special look-out for the animals which I noted in previous years. Unfortunately I was not able to visit Plymouth during September in 1894 and 1896, consequently the record is broken by two blank years, and spoilt for an accurate comparison of one year with another, but it shows that more Atlantic forms were present in 1895 than in 1893 or 1897.

The pelagic animals of the Plymouth district may be conveniently divided into two sets:—

1. Local forms, to which belong the larval stages of animals living on the bottom, and the medusae liberated from Hydroids.
2. Atlantic forms, which come up the Channel.

It is the latter set which produces the great yearly changes in the fauna, and which gives the greatest interest to pelagic work.

The Atlantic forms often arrive suddenly, occasionally in great shoals, like *Thalia* in June, 1893, and *Doliolum* in 1895, but usually they are rather scarce in numbers.

It is in the neighbourhood of the Eddystone, where the main Channel tide runs, that the richest tow-nettings are taken, and I have noticed that there is a difference between the fauna off the Eddystone and in the Sound. On certain days I was able to obtain tow-nettings from the Sound in the morning and from the Eddystone in the afternoon; the results were in favour of the Eddystone tow-nettings, both in quality and quantity.

As a rule three nets were used, attached to a single rope and placed at different depths, the coarsest mesh near the bottom and the finest close to the surface.

I have drawn up two lists of medusae for September, one to show simply the presence or absence of a species for the three different years, the other to convey an idea of the abundance of medusae during September, 1897. In the latter table I have given in some cases the actual number of specimens taken, and in other cases have conveyed a general idea of the abundance of a species by using Roman numerals as symbols.

Most of the species given in the lists have been described and figured in the *Proc. Zool. Soc.*, 1895, and another contribution to that journal is in preparation.

The table for September, 1897, shows clearly that medusae were by no means plentiful, except two species—*Obelia lucifera* and *Phialidium buskianum*—and on certain days were very scarce. Most of the species taken are liberated from hydroids, so that their appearance and their quantity in September depend upon the breeding-time and breeding-capacity of the hydroids, which are usually conspicuous by their absence or scarcity.

During my stay at Plymouth a considerable amount of dredging was done in various localities, extending from the Sound to the Eddystone. I examined the material carefully for hydroids, especially for the minute forms, and preserved a large number of specimens for further examination. The great bulk of the hydroids taken belonged to genera which do not liberate medusae, such as *Halecium*, *Sertularella*, *Plumularia*, etc., and the hydroids which do liberate medusae were, with a few exceptions, *Clytia*, *Obelia*, and *Perigonimus*, scarce or absent. I have noticed this scarcity of the hydroids with medusae in other localities, and am not able at present to account for it. The medusae of *Lar sabellarum* are by no means uncommon at Plymouth and other places, yet the hydroid has only been taken once at Ilfracombe, over twenty years ago. The medusae of *Hybocodon prolifer* have been recorded from many parts of the British seas, including Plymouth. They sometimes occur in vast numbers, yet the hydroid has never been recorded on this side of the Atlantic, and I believe has only been taken in Massachusetts Bay. The hydroid form must be somewhere in the neighbourhood, as the medusa carries the ova upon the manubrium until the actinula stage is reached, and this stage I have taken in the tow-net.

It is quite possible that the hydroids with medusae are really scarce. A single colony is capable of liberating a vast number of medusae. A colony of *Bougainvillia ramosa* was dredged off the Eddystone in

October and placed in an aquarium. In three days it liberated not less than 4450 medusae, and when the colony was preserved there was still left a good stock of young medusa buds upon the branches. (See page 189.)

NOTES ON MEDUSAE. (SEPTEMBER, 1897.)

Obelia lucifera.—This was by far the most abundant medusa during September. On some days thousands were taken in the tow-nets.

Phialidium buskianum.—Specimens of this species were nearly always present, from the earliest to the adult stage.

Phialidium cymbaloideum.—Most of the specimens belonged to the earliest stage, with four tentacles; a few belonged to the second stage, with eight tentacles. The adult was not taken.

Lar sabellarum.—The earlier and intermediate stages were usually taken. The adult form was very scarce.

Amphinema dinema.—Nearly all belonged to early stages.

Cytæandra areolata.—Only the intermediate stages present. (For description and figures of this species see *Proc. Zool. Soc.*, part iv., 1897.)

Lizzia blondina.—This medusa begins its free-swimming existence with four single perradial tentacles and four single interradial tentacles, and as it grows the perradial tentacles only increase in number until there are three tentacles in each of the perradial groups. The early stages have been described as distinct species, and are recorded in Haeckel's *System der Medusen* under the following names:—

First stage: Eight single tentacles = *Dysmorphosa minima*.

Second stage: Four perradial groups with two tentacles and four single interradial tentacles = *Lizzia claparedei*.

Third stage: Four perradial groups with three tentacles and four single interradial tentacles = *Lizzia blondina*.

In the first and second stages the medusa usually buds off medusae from the wall of the stomach, and in the third stage the generative cells make their appearance. The first and second stages have also been described with ripe generative cells, and consequently regarded as adult medusae and distinct species.

During my visit to Plymouth in 1895, and also at Port Erin and Valencia Island, I have always taken the first and second stages with medusa-buds and the third stage with generative cells. This year at Plymouth I obtained specimens of the first and second stages in the same tow-netting, some with medusa-buds and others with genera-

A TABLE *showing the Distribution of Medusae during September*, 1897.

1897.—SEPTEMBER	1	3	6	7	7	8	8	10	13	15	15	16	17	17	18	21	22	23	24	28	30	30
LOCALITY	The Sound.	1 mile S. of Breakwater.	The Sound.	The Sound.	4 miles S. of Breakwater.	The Sound.	3 miles S.W. of Mewstone.	5 miles E. of Eddystone.	½ mile off Mewstone.	The Sound.	2 miles S.W. of Eddystone.	Cawsand Bay.	The Sound. E. entrance.	Cawsand Bay.	The Sound.	The Sound.	The Sound.	The Sound.	The Sound.	Near the Mewstone.	The Sound.	Near the Eddystone.
Obelia lucifera	V.	IV.	VII.	V.	VII.	III.	VII.	IV.	IV.	II.	III.	—	I.	II.	II.	I.	II.	II.	IV.	V.	V.	IV.
Phialidium buskianum	II.	6	4	I.	6	I.	II.	I.	II.	4	III.	II.	—	2	2	I.	1	2	1	V.	IV.	III.
Phialidium cymbaloideum	1	—	1	—	1	—	2	—	2	2	—	—	—	2	—	—	3	1	1	3	1	—
Lar sabellarum	2	2	—	—	1	—	III.	—	1	—	—	—	—	4	—	—	—	—	2	1	—	—
Amphinema dinema	3	—	—	—	5	—	4	8	1	—	—	1	—	—	—	—	—	—	—	—	1	—
Cytæandra areolata	1	—	—	—	1	1	1	—	1	2	—	—	—	1	—	—	—	—	—	1	—	—
Lizzia blondina	4	1	—	—	1	—	2	III.	—	6	VII.	—	1	V.	1	—	—	1	1	I.	—	1
Eutima insignis	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Cytæis sp?	—	—	—	2	—	5	—	—	—	4	—	3	2	10	4	—	2	—	3	—	—	—
Tiara pileata	—	—	—	—	2	—	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Euphysa aurata	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Irene pellucida	—	—	—	—	—	1	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Saphenia mirabilis	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Margelis sp?	—	—	—	—	—	—	1	—	—	—	1	—	—	2	—	1	—	—	—	—	—	—
Mitrocomium sp?	—	—	—	—	—	—	1	—	II.	—	I.	—	—	—	—	—	—	1	—	—	—	—
Sarsia sp?	—	—	—	—	—	—	1	—	—	1	—	—	2	1	1	—	—	—	—	—	—	—
Liriantha appendiculata	—	—	—	—	—	—	—	3	1	1	III.	—	—	—	—	—	—	—	3	III.	1	II.
Sarsia gemmifera	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—
Gemmaria implexa	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—
Ectopleura dumortieri	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—

I. Very scarce. II. Scarce. III. Few. IV. Fairly common. V. Common. VI. Abundant. VII. Very abundant.

tive cells. The third stage was not seen this year. I have noticed in other species of medusae that the gonads may become mature in a medusa which has not reached its maximum growth. The generative cells sometimes develop and ripen faster than the medusa grows, and consequently the ova or spermatozoa are shed earlier. It is possible that a medusa may sometimes begin to shed ova at an intermediate stage of growth and continue to shed them at intervals, until it reaches its maximum growth. All the ova are not usually ripe at one time.

The early ripening of the generative cells has led to many medusae being described as distinct species. It has given me considerable trouble in tracing the life-history of a species, as it is difficult without a large number of specimens to trace and connect the different stages.

Margellium octopunctatum has often ripe gonads in the later stages, and the specimens which show the maximum growth are scarce. I have only taken them in Valencia Harbour. The maximum growth of a medusa is apparently only reached under very favourable conditions. *Hybocodon prolifer* when fully grown has three tentacles, but ripe generative cells are often present in forms with two tentacles. Medusae belonging to the genus *Phialidium* show often the early ripening of the generative cells in the intermediate stages, which has led to the description of a large number of spurious species. I believe that *Saphenia mirabilis* will ultimately be shown to be a stage in the development of *Eutima insignis*, yet both forms are frequently taken with ripe generative cells. In the present list of species both names are given, as my observations require further proof.

Cytæis sp. (?).—This medusa is not described in Haeckel's *Monograph.* I have only found it in Plymouth Sound—a few specimens in 1893 and many in 1897. A description of the medusa, with figures, is now in preparation.

Tiara pileata.—Only young stages seen.

Euphysa aurata.—A single specimen taken. This species is new to the fauna of Plymouth.

Irene pellucida.—Only young stages seen.

Mitrocomium sp. (?).—This medusa is not described in Haeckel's *Monograph.* A description of the species is in preparation, as enough specimens have now been collected to connect the different stages. I obtained few specimens in 1893 and 1895.

Liriantha appendiculata.—All the specimens belonged to early stages.

Sarsia gemmifera.—A young stage with medusa-buds.

Gemmaria implexa.—An early stage. The hydroid form has not been recorded for Plymouth.

Ectopleura dumortieri.—An early stage. This is an addition to the fauna of Plymouth. The hydroid form has not yet been recorded for Plymouth.

Agastra mira, Hartlaub.—A single specimen taken in the Sound on 31st of August. It is an addition to the Plymouth fauna. (For a description of the medusa see *Proc. Zool. Soc.*, pt. iv., 1897.)

A List of Medusae for September only.

	1893.	1895.	1897.
Obelia lucifera	P.	P.	P.
Phialidium buskianum	P.	P.	P.
Lar sabellarum	P.	P.	P.
Amphinema dinema	P.	P.	P.
Eutima insignis	P.	P.	P.
Saphenia mirabilis	P.	P.	P.
Irene pellucida	P.	P.	P.
Mitrocomium sp ?	P.	P.	P.
Liriantha appendiculata	P.	P.	P.
Phialidium cymbaloideum	P.	A.	P.
Cytæandra areolata	P.	A.	P.
Cytæis sp ?	P.	A.	P.
Dipurena halterata	P.	A.	A.
Lizzia blondina	A.	P.	P.
Gemmaria implexa	A.	P.	P.
Solmaris sp ?	A.	P.	A.
Octorchis gegenbauri	A.	P.	A.
Tiara pileata	A.	A.	P.
Euphysa aurata	A.	A.	P.
Sarsia gemmifera	A.	A.	P.
Ectopleura dumortieri	A.	A.	P.

P. = Present. A. = Absent.

An Incomplete List of Animals found in the Tow-nets during September only.

	1893.	1895.	1897.
Muggiæa atlantica	P.	P.	P.
Terebella larvae	P.	P.	P.
Magelona larvae	P.	P.	P.
Doliolum tritonis	P.	P.	A.
Noctiluca miliaris	P.	A.	P.
Chætopterus larvae	P.	A.	P.
Actinotrocha	A.	P.	P.
Tornaria	A.	P.	P.
Beroe	A.	P.	A.
Pilidium	A.	P.	A.
Mitraria	A.	P.	A.
Bipinnaria	A.	P.	A.
Thalia democratica	A.	P.	A.
Amphioxus (larva)	A.	P.	A.

P. = Present. A. = Absent.

Noctiluca miliaris.—Specimens were first taken on 7th of September, about four miles outside the Breakwater. It was abundant on the 8th, three miles S.W. of the Mewstone, and on the 10th, five miles East of the Eddystone. Tow-nettings taken close to the Mewstone on the 13th did not contain any specimens. On the 15th, specimens were first taken inside the Breakwater. From the 15th to the end of the month, *Noctiluca* was usually present in the tow-nets. The quantity varied considerably, but it was more abundant outside than inside the Breakwater.

Cydippe.—One or two specimens were usually found in the tow-nets. They all belonged to very early stages, about 2 to 3 mm. in diameter.

Magelona.—The larval stages of this worm were fairly common throughout the month.

Chætopterus.—Five larval stages were taken on the 7th of September, four miles south of the Breakwater, and single specimens on the 13th, 21st, and 30th. Only once taken inside the Breakwater.

Terebella.—The larval stage, living in a little tube, was fairly common until the 8th September, but very scarce during the latter half of the month. Only four specimens taken after the 19th.

Tomopteris onisciformis.—Only four specimens seen. Three taken outside and one inside the Breakwater. About 3 mm. in length.

Actinotrocha.—Single specimens taken on the 10th, 15th, 18th, 28th, and 30th of September. Only once taken inside the Breakwater.

Tornaria.—Single specimens taken on the 10th and 15th of September, off the Eddystone.

Notes and Memoranda.

An Observation of the Colour-changes of a Wrasse.
Labrus maculatus. **Donovan.**

THE common wrasse of our coasts is well known to exhibit, as a species, an almost endless variation of colour. To what extent the different colour-patterns are individual or congenital, and to what extent they may be produced in the same individual by different stimuli, appears to be a question worthy of careful examination. We propose at present to deal chiefly with the observation of a single specimen.

On the 4th October, 1897, trawling among the red-weed and zostera beds at the mouth of the Yealm, we took a wrasse 16 inches in total length. Captured most probably in the zostera, it exhibited a uniform green colour, without any markings except the inevitable indistinct dark spot at the base of the last dorsal rays.

Confined for a few hours in a tub on board the launch, it underwent no colour-change. It was then placed in a shallow, open tank, with black walls, under an iron shed at the back (N.) of the Laboratory. The next morning, while retaining the general green colour, it showed also some faint grey transverse patches on the sides. The fish remained in this tank until the 2nd December, when it was found to have undergone a further change. The ground colour was pale olive-grey, diversified with dark grey transverse bars and patches on the back and sides, and with whitish blotches on the fore part of the abdomen. This pattern is very common in the Plymouth district. It may be described with sufficient exactness as follows: A number (often four) of dark transverse bars pass from the dorsum to the region of the lateral line. The first originates below the first rays of the dorsal fin, the last below the extremity of that organ. These bars have no regularity of outline and are often split into two by the intervention of a pale transverse stripe. Another bar occurs on the caudal peduncle. About the lateral line the dorsal transverse bars are irregularly continued backwards by short longitudinal patches; below these originate a series of ventral transverse bars which alternate more or less in position with their dorsal fellows, and are connected one with another by an irregular network of dark lines. The pale antero-ventral blotches are of more variable occurrence, and the ground colour and the colour of the dark markings are in no way constant.

On the south side of the Aquarium is a large tank devoted to bream and wrasse. It is lined at the back and sides with rock-work of red granite, now become brownish by the accumulation of foreign matter. A large projecting boulder forms a cavern at the back of the tank, much frequented by the prominent members of the wrasse community. The bottom is gravel of a light colour.

The wrasse with which we are dealing was pitched into this tank as soon as its colours had been noted. It immediately bolted into the cavern already mentioned, and, in the course of the initiation ceremonies inevitable on the admission of a new member, was summarily ejected a few minutes later. But, whereas it went in grey with dark bars, &c., it came out green with only very faint grey marblings. The sun being still in the east and the atmosphere dull, the illumination of the tank was decidedly dim, but as the fish rested on the botton near the glass its colours could easily be seen. After retaining the colour phase just noted for perhaps a few minutes, the dark bars were suddenly resumed within an interval of a few seconds, but the green ground colour remained. The fish has since remained in this tank, but varies constantly in colour, retaining, however, the general scheme of grey markings on a green or olive-green ground. On the 2nd January, 1898, it was observed to be for a short time almost uniformly green, but on the posterior part of the side, from the level of the soft dorsal backwards, it was noted that a number of the scales exhibited a pale roundish spot. Such a marking could not have escaped notice at an earlier date. It is, in fact, an approach to what we may call the typical colouration of the species, in which every scale shows a pale spot and the fins are similarly spotted, though the darker ground colour is extremely variable.

Our observation, such as it is, demonstrates clearly enough that the uniform green, and the barred and patched liveries, can be achieved by the manipulation of the chromatophores of a single individual, according to the stimulus. It suggests, as we suppose, that the typical spotted livery may not be distinct from the others, but does not go far enough to show whether it is a question of the manipulation of chromatophores capable of presenting the other liveries, or a gradual alteration of the chromatophores themselves. As to the nature of the stimuli which effect the colour-changes we have no evidence, except that the colour environment is certainly not constant in its effect. For in the same tank, under the same circumstances of illumination and environment, may be seen wrasse of several different liveries.

The uncertainty of the nature of the stimulus is further borne out by the observation of five small *L. maculatus* taken in the Yealm zostera beds on the same date as the large one.

These specimens measured from 2¼ to 3 inches in length. During a period of 48 hours they were transferred to different vessels in the following order:—

1. White porcelain pots sheltered from bright sunlight.
2. Glass bell-jars similarly sheltered.
3. A table-tank with black sides and bottom.

(*a*) 3 inches long, uniform bright green on reaching the Laboratory, unchanged in 1 and 2; escaped from 2 and died.

(*b*) 3 inches long, uniform dark olive in 1, uniform but brighter and greener in 2, duller with very faint bars in 3.

(*c*) 3 inches long, uniform pale olive in 1, uniform buff in 2.

(*d*) 2¾ inches long, uniform pale olive in 1, uniform darker olive in 2.

(*e*) 2¼ inches long, uniform pale olive in 1, slightly darker olive with faint bars in 2.

c, d, and *e* all assumed in 3 the ordinary olive ground colour with faint bars.

E. W. L. H. and L. W. B.

The Incubation of the Skate-leech.

Pontobdella muricata. Linn.

The ova of the skate-leech are probably familiar to most marine zoologists, and, apart from any literature on the subject, can almost always be recognised by the presence of the parent. The shell is hard and chitinous, of an olive-brown colour. It is almost spherical, about 4 to 5 mm. in diameter, and attached by the flattened base of a short peduncle to the object selected by the parent. On either side of the spherical part of the shell is a rounded fenestra, of which one at least is simply closed by dark membranous matter. The chitinous matter of the other appears to be, at all events occasionally, imperforate. The ova are deposited separately, but for the most part close to each other, either on an old shell or on some other convenient object.

On the 31st July, 1897, about four miles W.S.W. of the Plymouth Mewstone, the trawl brought up a large and fairly recent scallop shell, *Pecten maximus*, the valves still united by the hinge. Inside was a skate-leech mounting guard over a group of eggs attached to the flat valve, rather near the hinge. A few eggs were also attached to the outer side of the same valve.

Parent and progeny were placed in a small bell-jar under a siphon. The circulation was occasionally stopped by accident, and a large quantity of dirt accumulated from time to time at the bottom of the jar around the eggs and parent. In spite of these drawbacks the latter survived, and the eggs began to hatch out on the 1st December of the same year. Most of them had hatched by the 10th December. The newly-hatched young, about 22 mm. in length, more or less according to the state of contraction, are reddish yellow in colour, and have, essentially, the external features of the parent.

The eggs, when trawled, were velvety in appearance, subsequently becoming smooth and shiny, and finally, by the accumulation of dirt, rather rough. No examination of the embryo was made at the time of capture, but the appearance of the shell may probably indicate that the eggs had not long been deposited. In any case it is evident that the incubation of this particular clutch occupied at least 123 days, and may reasonably be supposed to have been somewhat accelerated by the warmer temperature of the Laboratory. After 136 days the parent was still alive, though by no means vigorous. It was not observed to make any attempt to leave the bell-jar, although there was nothing to prevent it doing so, nor was it noticed to occupy any constant position in relation to its eggs. No food whatever was supplied.

For what purpose the skate-leech remains with its eggs during incubation appears uncertain. One may presume that their protection is the chief object: whether from active enemies or from the mere accumulation of sand, &c., is doubtful. The flocculent diatomaceous dirt which accumulated in the vessel in which our specimen was confined was too light to be removed, and appears to have been quite innocuous. No experiments were made with sand or other matters.

Hatching is accomplished by the perforation of the membrane of one of the fenestræ. The chitinous part of the shell is not ruptured in any way.

Larval Lobsters at the Surface. Although young lobsters must be plentiful, they are but rarely encountered in our tow-nets. During 1897 we have only taken them on three occasions. On the 10th July, while the *Busy Bee* was trawling in the outer part of Falmouth Bay, Mr. Vallentin caught one in a hand-net. The sea was absolutely calm, and we saw a great many "mackerel-midges" (*pelagic Motellæ*) and caught a quantity of brachyurous zoëæ, apparently Portunus. These were either swimming freely, or, more frequently, resting on drift blades of zostera. Many fragments of this were literally crowded by them, but we saw no more young lobsters on this occasion. On the 23rd of the same month the surface otter-net, which has a mouth about 15 or 20 feet wide and about 6 feet deep, caught one larval lobster two or three miles outside the breakwater of Plymouth Sound. The sea was calm, with a long swell, and mackerel were schooling all round us. On the following day, as we lay to taking temperatures, &c., about a mile and a half outside the Breakwater, I noticed a lobster at the surface, and in a short space of time we dipped up over two dozen as they drifted alongside. They occurred singly, not in a shoal. The sea was quiet, but not calm, as a fair breeze was blowing from the east. On all occasions the larvæ were either newly hatched or had only passed their first moult.

Cepola rubescens. *Linn.* Two red ribbon-fish, 30·8 cm. ($12\frac{1}{8}$ in.) and 27·4 cm. ($10\frac{3}{4}$ in.) in length, were caught in shrimp-trawls in Plymouth Sound on the 17th and 22nd December, 1897, and brought to the Laboratory alive. Both proved to be females, the larger one having the ovaries swollen but far from ripe.

The red ribbon-fish can hardly be considered rare on the S.W. coast of England and S. and W. coasts of Ireland, but it is not very often caught. I have known or heard of several instances in which a number of specimens have been caught at about the same date, none having previously occurred. Day concludes that it occurs most frequently on our own coasts after heavy weather, but its sporadic appearances may really be due to some normal phase of its habits about which little is known.

Trachinus draco. *Linn.* The greater Weever is said by Day to reach a length of at least 17 inches. A specimen landed at Plymouth on 20th November, 1897, measures $17\frac{1}{4}$ inches, 43·8 cm. *ca.* It is a female, with ovaries rather enlarged.

Trigla obscura. *Linn.* On the 2nd March, 1897, I saw a number of specimens mixed up with young *T. pini* and *T. gurnardus* in the Plymouth market. I was told that they came from the rough ground off the Start, are locally known as "Offing Gurnard," and are not uncommon in the district. None of these items of information were derived from the actual captors, and may all be erroneous, though the accompanying species suggest a British origin. I have never been able to find any more specimens among the small gurnards brought in by trawlers. In view of the confused synonymy of the gurnards, recently assisted by Smitt's revival of forgotten names, it is, perhaps, necessary to state that the species now under discussion is characterised by the attenuated form of the body and by the great elongation of the second dorsal spine.

Trygon pastinaca. *Linn.* Sting-ray. Two small examples were trawled 20 miles off Plymouth on the 19th January, 1898. Several were taken on the trawling ground off Salcombe a few days previously. The fish is well known to local fishermen, and perhaps hardly deserves especial mention as a rare form.—E. W. L. H.

Myliobatis aquila. *Linn.* Eagle-ray. A female, taken in company with the sting-rays previously mentioned, was brought to the Laboratory on the 19th January, 1898. It measures 34 inches across the disk, and shows what we suppose to be an interesting phase of the renewal of the caudal spine. A large spine occupies the normal position, and is backwardly directed; a shorter and slightly curved spine, originating a little in front of the other, passes forward on the right side of the dorsal fin. We suppose that, as the larger spine becomes obsolete, the smaller is rotated backwards, but the condition may possibly be abnormal. We have not dissected the basal parts. A large Trygon has one spine directly overlying the other.

In another place one of us has shown that the egg-purse attributed by Couch to the Eagle-ray belongs in reality to a Raia. Myliobatis is known to be viviparous; in our specimen the oviducts lead directly into a pair of "uteri," apposed together in the middle line. The strong muscular walls are continuous externally. Internally each uterine chamber is thickly clothed with long vascular villi. The shell-gland, if represented at all, was not found. So far only a hasty examination has been possible.—E. W. L. H. and W. G.

Report on the Surface Drift of the English Channel and neighbouring Seas during 1897.

By

Walter Garstang, M.A.,

Naturalist in charge of Fishery Investigations, M.B.A.

I. Introduction.

Some eighteen months ago the Director of the Plymouth Laboratory of the Marine Biological Association decided to carry out a series of investigations concerning the surface currents of the English Channel at different seasons of the year, and for a series of years, by means of properly devised floating bodies which would attract attention when stranded on the shore, and the recovery of which could without difficulty be recorded. At the commencement of the investigation Mr. Allen communicated his scheme to the editors of the west-country Press, and these gentlemen kindly gave publicity to the plan, the success of which depended very largely upon the co-operation of residents and visitors frequenting the sea-shore. Mr. Allen's letter expresses so clearly the object and method of the investigation, that I cannot do better than reproduce it here:—

"THE DRIFT OF FLOATING FISH-EGGS IN THE CHANNEL.

"*January 27th*, 1897.

"SIR,—I should be obliged if through the medium of your paper you would be good enough to give publicity to a series of experiments which have just been commenced by the Marine Biological Association, with a view to determine the direction of the drift of floating bodies in the western part of the English Channel. The experiments are of such a nature that any of your readers, who either from business or pleasure frequent the sea-shore, may be able to assist materially in their successful completion.

"We are preparing a large number of ordinary egg-shaped soda-water bottles, weighted with shot in such a way that they float vertically in sea-water, with only a very small portion of the neck exposed. In each bottle a stamped and numbered post card is placed, and the bottle is corked and sealed. Each post card has the following notice upon it :—

"'*For Scientific Enquiry into the Currents of the Sea.*

"'Whoever finds this is earnestly requested to write distinctly the *Date* and *Locality*, with full particulars, in the space below, and to put the card in the nearest post office. [No.]

"'Locality where found ....

"'Date when found..............................

"'Name and address of sender ....'

"We are placing the bottles in the sea at various points, the exact locality where each starts upon its journey being recorded. It is hoped that several gross of bottles will be put out during the next few months.

"Might I ask, therefore, that anyone who may find such a bottle washed up on the shore will break it, take out the post card, fill in the required information, and put the card in the nearest post office?

"Teachers in the schools of the various towns and villages along the south coast could do us a great service by asking their boys to look out for the bottles, and in case of any being found, seeing that the post cards were correctly filled in.

"It might interest your readers if I explain shortly the reason for making these experiments. It is now a well-known fact that the majority of the food-fishes spawn in the sea at some distance from the coast, and that the eggs float in the water. These floating eggs are carried about by the currents for some considerable time before they are hatched, and the little fish (larva), when it leaves the egg, is still so small and light that it is at the mercy of the wind and waves. Now it is a fact that although the fish generally spawn at some distance from the coast, the young fish are usually found close inshore. This is particularly the case with flat-fishes. For instance, there are important spawning grounds for plaice south-east of the Eddystone, whilst young plaice, under one inch long, are found only in shallow water in sandy bays or estuaries, such as Whitsand Bay or the mouth of the river Exe. These very young fish have probably been brought ashore by currents, when they were floating eggs or larvæ carried about by the sea. It is very important, therefore, to know the direction of these currents, in order that we may be able to tell where the eggs from the fish spawning upon any particular ground will be carried. At present we do not know whether the eggs from the plaice spawning on the Eddystone grounds are carried towards Plymouth and Whitsand Bay, or whether they are carried eastward towards some point on the Devonshire coast, or westward to the coast of Cornwall. Upon questions of this kind our experiments should throw light.

"Investigations of a similar kind have been made in the Irish Sea by Professor Herdman, and in the North Sea by the Scottish Fishery Board. In the case of the experiments in the Irish Sea, about 35 per cent. of the bottles put out were found and the post cards properly filled up and returned, whilst in the case of the North Sea experiments from 20 to 30 per cent. were recovered. The latter experiments showed that the inshore waters of the Firth of Forth and St. Andrews Bay derive their main supplies of young fish, not from the waters lying contiguous to them to the eastward, but from areas further north, such as the spawning grounds off the Bell Rock and those of the Forfarshire coast. It was also shown that a southerly current runs down the eastern side of Scotland and England to the coast of Norfolk, where it turns to the eastward and crosses the North Sea. Of the bottles set free off the east coast of Scotland many were picked up on the east coast of England as far south as Norfolk, but none further south than this. Many were, however, carried across the North Sea and found on the coasts of Schleswig and Jutland. This will explain the immense nurseries of young fish which are found in the eastern portions of the North Sea—the so-called 'Eastern Grounds,' so well known from the large number of immature flat-fish which are trawled there. E. J. ALLEN.

"Marine Biological Association, Plymouth."

It will be seen in the sequel that Mr. Allen's experiments to determine the currents in the neighbourhood of the Eddystone grounds have provided data not only for the settlement of these local problems of importance to the west-country fisheries, but for determining many matters connected with the surface currents of all the three seas which wash the shores of England. The majority of the bottles put overboard near the Eddystone have been recovered on the south coast, along the whole length of the English Channel; but a very large number have made a safe passage through the Straits of Dover, stranding eventually on the shores of Holland, Germany, Denmark, Sweden, and Norway; a few have rounded the Land's End and travelled as far as Barnstaple Bay; and others put out in the Irish Sea and St. George's Channel have stranded on the west coasts of England, Wales, and Scotland, even so far to the northward as the Isle of Colonsay in the Firth of Lorne.

Most of the drift-bottles have been put overboard in the neighbourhood of the Eddystone by different members of the scientific staff of the Marine Biological Association in the ordinary course of their trawling and dredging excursions; but, as the *Busy Bee* is incapable of making long journeys far from land, we have always been glad to accept the services of others who have kindly come to our assistance in this part of the work. We are under a particular debt of gratitude to Admiral the Hon. Sir E. R. Fremantle, K.C.B., C.M.G., in this connection. He very kindly permitted the distribution of a number of the bottles among the torpedo-boat destroyers cruising from Devonport, and to him, to Commander Shirley, of H.M.S. *Decoy*, and to the commanding officers of H.M.S. *Lynx*, H.M.S. *Skate*, H.M.S. *Sunfish*, H.M.S. *Opossum*, and H.M.S. *Ferret*, we desire to express our warm thanks for the material assistance they rendered us in this part of the work.

We are also indebted to H. E. M. Studdy, Esq., and other yachtsmen, for similar assistance kindly given us.

It gives us particular pleasure to thank the officers and boatmen of H.M. Coastguard at innumerable points along the coast for the promptitude with which they have returned the post cards to us upon the recovery of any bottles. We owe a very considerable number of our records to the vigilance of the members of this efficient branch of the service.

We desire also to thank the numerous private individuals and fishermen, both home and foreign, who have increased the value of these experiments by properly inscribing and returning the post cards contained in bottles they have found, and for the information they have always been willing to convey in reply to our inquiries.

For the meteorological work of this report I have received valuable data from Edward Kitto, Esq., Superintendent of the Falmouth Observatory; C. E. Peek, Esq., Superintendent of the Rousdon Observatory, Lyme Regis; Alfred Chandler, Esq., Borough Meteorologist, Torquay; and H. Victor Prigg, Esq., Meteorologist to the Borough of Plymouth. To these gentlemen I beg to convey my warm thanks for their assistance, which has been generously given.

II. The Drift-bottles.

Various objects have been employed by different investigators in their experiments upon surface currents. The Prince of Monaco employed small floating vessels of copper, specially prepared, but their fitness to indicate accurately the course of surface currents has been criticised owing to the ease with which they could be propelled at the surface of the water by the direct action of the winds. Any small buoyant object of spherical and, still more so, of cylindrical form, floating at the sea-surface and bobbing up and down under the action of the waves, inevitably exposes a considerable part of its bulk to the direct action of the winds, and experiments founded upon the journeys of such objects are vitiated in proportion to the relative bulk of the part exposed to wind-action. Mr. Allen selected common "egg-shaped" soda-water bottles (used by Schweppe and other manufacturers of aërated waters) for our experiments, and their admirable adaptability to the purpose will be generally conceded. These bottles are 9 inches long (varying between 9 inches and $9\frac{1}{4}$ inches), and their maximum diameter is a little below the middle of the bottle, at $5\frac{1}{2}$ inches from the mouth. From this zone the bottle tapers towards each extremity, being conical at the closed end, but produced into a cylindrical neck at the open end. This neck is $2\frac{1}{2}$ inches long, and its diameter is 1 inch. The mouth is surrounded by a slight rim $\frac{3}{4}$-inch deep, which increases the outside diameter of the neck in this region to a maximum diameter varying between $1\frac{1}{8}$ and $1\frac{1}{4}$ inches.

The preparation of these common objects for their scientific mission is as follows:—The bottles are washed and thoroughly dried. A piece of wire, the counterpoise of the post card to be eventually enclosed, is inserted, a piece of hard paraffin is dropped inside, and small quantities of leaden shot are added until the bottle floats upright in sea-water, with its mouth all but submerged. The wire is then removed and the bottle placed upright in a pail of hot water until the paraffin is melted, when it is placed aside—still in a vertical position—until the paraffin has thoroughly hardened again. The object attained by this means is to prevent the shot from rolling about inside the bottle, and so displacing the centre of gravity. The post card and a conspicuous notice marked "Break the Bottle" are then introduced, and the bottle is thoroughly corked, the cork being pushed in flush with the mouth of the bottle and sealed with paraffin wax. The whole of the neck and upper half of the bottle is then painted with red enamel paint, so as to render the bottle conspicuous.

III. Results of Experiments.

The actual localities where our bottles have been sent adrift and where they have been subsequently recovered are given in tabular form at the end of this report. The experiments fall into two categories dealing with distinct areas, viz.: (1) the English Channel and North Sea, and (2) St. George's Channel and the Irish Sea. Only the former group of experiments approaches completeness, and in the subsequent discussion of the results I shall deal more particularly with this area.

In the course of the year 430 bottles were sent adrift in 53 batches in the English Channel, and 117 bottles belonging to 40 batches have been recovered up to the present time (Feb. 28, 1898). Thus 27 % of the bottles, or rather less than one-third, have been recovered from the Channel lots.

In the Irish Sea and St. George's Channel 36 bottles were sent adrift in 6 batches, all on the 30th of March, and 20 bottles, representing all six batches, have been recovered. This gives the high percentage of 55, or rather more than half of the total number put out.

The total percentage of recoveries from both areas combined is 29·4 %.

1. The English Channel and North Sea.

§ 1. *The Direction of Drift.*—The general direction and rate of the surface drift in this area are well seen by reference to Table I., batch no. III. Out of 27 bottles sent adrift near the Eddystone in the latter part of January, 10 have been recovered, and these were picked up at places successively further away to the E. and N.E., the only break in the sequence being the recovery of a bottle at Terschelling on August 15th, twelve days after a bottle had been found at Schiermonnikoog, 40 miles to the eastward. The general rate of drift is seen from the table to be about 3 miles a day, which yields about 90 miles a month. Fjellbacka, on the west coast of Sweden, was reached in October—a distance of over 900 miles—in little more than nine months.

The regularity of this drift to the north-eastward is, however, frequently departed from; for example, out of six bottles sent adrift off the Lizard on March 31st (batch no. XXX.) two bottles were picked up at Sennen Cove, situated round the corner of Land's End, on April 6th—a journey of 35 miles to the westward in six days, at an average rate of nearly six miles a day.

Again, a drift may begin in one direction and end in another, as is shown very clearly by batch no. XL. In this case bottles put out near the Eddystone on May 11th went westwards to Mounts Bay, arriving at Penzance on June 2nd; they then rounded the Land's End and arrived at Croyde, on the north coast of Devon, three weeks later. Here their progress appears to have been arrested, and apparently a retrograde movement set in, for on August 20th a bottle was picked up at Bude, in North Cornwall, and—still more remarkable—another was recovered at Eastbourne three months later.

The general features of the direction of drift throughout the year may conveniently be summarised by plotting out for each successive month the number of batches recovered to eastward or westward of their position in the preceding month. The following table contains the results of an analysis of this kind for the English Channel, the North Sea records being for the present omitted :—

Monthly Summary showing the direction taken by drift-bottles in the English Channel, 1897.

Commencement of Drift.	No. of batches put out.	Month of Recovery.	Direction of Drift.	No. of batches recovered.	Remarks.
January.	3	January.	...	0	January batches were in the North Sea after the end of March.
		February.	[E.]	0 (but cf. III. 1).	
		March.	E.	2	
February.	20	February.	W.	*1 (X.)	February batches were mostly near Calais in May, and in the North Sea subsequently.
		March.	E.	6	
		April.	E.	1	
		May.	E.	4	
		June.	E.	2	
		August.	E.	1	
March.	7	March.	W.	*1 (XXV.)	Batch no. XXX. was put out on March 31st, and properly speaking, illustrates April and not March conditions.
		April.	W.	1 (XXX.)	
April.	9	April.	N.	*1 (XXXII.)	The westward drifts here recorded for the summer months were subsequently overpowered by the preponderating eastward movement.
		April.	W.	2	
		May.	W.	1	
		June.	W.	2	
		August.	E.	2	
		December.	E.	1	
May.	4	May.	W.	1	Temporary westward drifts subsequently overpowered by eastward movement.
		June.	W.	1	
		October.	E.	1	
		Nov.	E.	1	
June.	3	July.	E.	1	These cases show that even in summer the preponderating drift was eastwards.
		August.	E.	2	
		Sept.	E.	1	
		October.	E.	1	
July.	2	July.	E.	1	
		August.	E.	2	
		August.	N.	1 (XLVIII.)	
		Sept.	E.	1	
September.	4	October.	W.	4	Marked westward drift in October.
		October.	E.	1 (LI., 1).	
		December.	W.	1 (XLIX.)	
October.	1	October.	W.	1	

* These drifts were of very short duration (only one day each).

If now we condense this summary into a statement of the aggregate number of westward and eastward drifts for each month in the year (neglecting, however, the three cases of drifts not exceeding twenty-four hours' duration) we obtain the following results:—

Direction.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Westward.	—	0	0	3	2	3	0	0	0	5	0	1	... 14
Eastward.	—	[all]	8	1	4	2	2	7	2	2	1	1	... 30

This table shows that the surface drift was markedly to the eastward in March and August, and also to the eastward, although not so conspicuously so, in July and September. The drift was variable in direction in April, May, June, and October, with a marked westward preponderance in April and October. The evidence in regard to November and December is equivocal, owing to the small number of recoveries in these months, and to the long lapse of time between the recovery of the bottles and the time when they were sent adrift. The drift in February was clearly to the eastward, although no recoveries are recorded for this month; but the stranding near St. Alban's Head on March 1st of a bottle which was put overboard near the Eddystone on January 29th leaves no doubt about the matter.

There was, accordingly, for the whole year 1897, a preponderating drift to the eastward in the English Channel, the proportion of eastward to westward drifts being as 30 : 14. This eastward movement of the surface water attained its maximum in March and August, but was strong in February, and not inconsiderable in July and September. In October, on the other hand, a westward movement predominated, and this was also distinct during parts of April. In May and June the drift, as already remarked, was variable in direction.

§ 2. *The Direction of the Local Winds.*—It is desirable at once to compare these data with the direction and force of the wind during the successive months of the year. On the upper line of the following table I give the resultant wind for each month at Plymouth (which may be taken roughly as representative of the general state of the wind in the Channel); on the second line, the force of the resultant wind; and in the third and fourth lines I give an abstract of the monthly summary concerning the winds of the British Islands as a whole from the publications of the Meteorological Office.

The great gale in November, which I specially mention, will be remembered as that which, springing from the West, and veering to N.W., caused immense damage on our east and south-east coasts, owing to the exceptional height of the tide forced up. Cases of this kind are important from our point of view, since the enormous volume of water banked up along the coast has eventually to settle down to a uniform level, and this process entails the formation of currents along the path of least resistance which may be completely different from the direction of the wind at the time. The currents produced on this occasion must have profoundly modified the course taken by those of our bottles which were in the southern part of the North Sea at the end of November and beginning of December.

	January.	February.	March.	April.	May.	June.
Plymouth .	N.E., moderate.	W.S.W., strong.	S.W. by W., very strong.	S., weak.	N.W., weak.	W.S.W., weak.
British Isles .	N.E., variable.	S. to W., light gales.	S.W. to W., stormy.	E. strongest, variable.	Very variable.	Very variable.

	July.	August.	September.	October.	November.	December.
Plymouth .	W., weak.	S.W. by S., very strong.	W., moderate.	E.S.E., stiff.	E. by S., moderate.	S.W., strong.
British Isles .	S.W. to N.W. variable.	S. to W., gales in west, none in east.	S.W. to N.W. variable in south-west.	S.E., variable in south-east.	Variable, great gale from N.W., 28th to 29th.	S. to W., some east on south coast.

It will at once be seen that there was a close correspondence in 1897 between the direction of the surface drift in the Channel at different times of the year and that of the winds for the same periods. It is unnecessary to go into details, but I may point out that, in view of this general correspondence, the non-recovery of drift-bottles in January and February is probably to be explained by the marked northerly element in the winds of January. Bottles sent adrift off the Eddystone in this month must have drifted out towards mid-Channel, requiring the strong south-westerly winds which prevailed during the whole of February to bring them ashore at the beginning of March. By a method to be described below, moreover, I have calculated that by the end of February the bottles sent adrift between the 15th and 18th of that month had in all probability been carried north-eastwards into the great bight formed by Lyme Bay, where the conditions as regards wind and tide differ considerably from those prevailing in the fairway of the Channel.

An equally complete analysis of the northward and southward drifts is unnecessary, since the recovery of almost all the bottles on the northern coasts of the Channel speaks for itself. Almost all the drifts, whether to eastward or to westward—but especially in the former case —had a northward element, which carried the bottles to some part or other of the English coast. Two cases of due northward drift are included in the preceding table, one for April, the other for August. In the former case the drift was short and rapid (ten miles in 27 hours, no. XXXII.); in the latter the resultant distance was equally short, but the duration was prolonged to 22 days (assuming here, as elsewhere, that the bottle was picked up soon after getting ashore), thus depriving the case of any special significance.

The only period of marked southward drift which is actually indicated by the bottles was in the month of May, when—between the 13th and the 19th of the month—as many as five bottles, belonging to four February batches, were stranded on the French coast in the neighbourhood of Calais. It is clear also, from evidence supplied by batches XXXVIII. and XL., that similar conditions prevailed at the opposite extremity of the Channel during the same period, which was characterised, as already remarked, by a preponderance of north-westerly winds in the Channel.

The only other month during which northerly winds prevailed was January, and I have already mentioned that the negative evidence supplied by the non-recovery of bottles in February, in spite of strong southerly winds during that month, points clearly to the conclusion that a strong southward drift occurred in January as well.

A temporary southward drift probably occurred also about the middle of June, at any rate in the eastern portion of the Channel, since two bottles, belonging to different batches, stranded at Calais and Boulogne on the 18th and 19th of that month. It is, moreover, difficult to account for the curious data supplied by batch no. XL., except by the assumption that there was a surface current to the southward on the north coast of Cornwall between the middle of June and the middle of August, and again during September. These were periods of variable winds.

§ 3. *Other Causes of Surface Currents in the Channel.*—By the use of the word "drift" in connection with the movements of the surface water which have been described above, I have already indicated that these movements are principally due to the driving power of the wind exerted upon the surface of the water. My employment of the word is amply justified by the close correspondence between the movements of wind and water in the Channel revealed in the preceding section of this report. But it is desirable, before we assume that the local winds have been the only factors concerned in the production of these surface currents, that we should consider for a moment the other causes which may be expected to affect the circulation of the water in the regions under discussion.

In the first place we have to entertain the possibility of a current setting normally through the Channel, independently of the local winds, in connection with the general circulation of Atlantic water. As the Channel is open to the eastward through the Straits of Dover, we might, *à priori*, expect a continuance through it of the great eastward drift of the North Atlantic. Into the Bay of Biscay this drift sets with a velocity varying between 8 and 30 miles a day, while to the north of Scotland, over the Wyville-Thomson ridge, it sets towards the Norwegian coast with a velocity of 5 miles a day. But it has to be borne in mind that the orifice of the Dover Straits is very small and the depth exceedingly shallow, scarcely exceeding 20 fathoms along a line drawn from Dungeness to Boulogne, while the depth of water over the Wyville-Thomson ridge, with which comparison is invited, is 300 fathoms. Moreover, the whole bed of the English Channel scarcely exceeds a depth of 50 fathoms in any part. Friction with the bed of the Channel, combined with the obstacles to further progress presented by the narrowness and shallowness of the Straits of Dover, would appear to be sufficient to prevent the ingress into the English Channel of any serious portion of the general Atlantic drift already retarded by the shallowness of the sea between France and Ireland. That this is actually the case appears from the Admiralty chart of Atlantic surface currents (1875). The bifurcation of the Atlantic drift (the time-honoured Gulf Stream) takes place opposite the entrance to the English Channel, outside a line connecting Ushant with the west of Ireland, thus indicating the serious nature of the obstacle presented by the shallow bed of the Channel; and in this part of the chart the currents are marked as "variable and uncertain."

The improbability of any serious current setting through the Channel as an offset from the general Atlantic drift is in agreement with the results of our experiments. The surface currents in the Channel have been shown to be in general agreement with the direction of the local winds from time to time; and in July, at any rate, there is some direct evidence from our bottles that the water in windless weather is stationary, except for the regular swing imparted to it by the tides. Out of a number of bottles put overboard on the 17th July, during a voyage of the *Busy Bee* from Falmouth, two, at any rate, were recovered three days later afloat in practically the same spot as that in which they were sent adrift. The weather during this period was almost dead calm, none but the lightest of southerly airs being perceptible. Had any appreciable current, say, of 4 miles a day, been setting up-Channel at the time, the position of the bottles would have been deflected a corresponding amount to the eastwards—12 miles in the example taken. The velocity of the tidal stream at springs in this region is small, from $\frac{1}{2}$ to $\frac{3}{4}$ knot.

At the same time, as the velocity of the Atlantic drift is admittedly dependent on the force of the winds blowing over that ocean, these considerations do not preclude the possible occurrence of eastward currents in the Channel, independently of local winds, after unusually heavy gales to the west of our islands. We shall, I think, be able to determine the existence of such occasional currents by applying to the data provided by drift-bottles a method of analysis to be described below.

The possibility of a permanent westward current through the Channel from the North Sea is precluded by the results of Fulton's experiments, which were briefly summarised in Mr. Allen's letter at the commencement of this report.

A second cause of surface currents independent of local winds is to be found in the tides. The tidal stream in the Channel runs with a velocity which in different parts varies from about half a mile to about three miles an hour. There is no need to sum up here the peculiarities of the Channel tides, but as the courses of the flood and ebb streams are approximately parallel over the greater part of the Channel, it does not appear that the course of drift-bottles would be materially affected by them in the long run, except in certain well-defined regions of the Channel. These are principally the two orifices of the Channel, together with Lyme Bay, the neighbourhood of the Solent and Spit Head, and the Gulf of St. Malo.

At the western entrance to the Channel the West Channel tidal stream runs in opposite directions to the oceanic tidal stream, and where the two streams meet the tides are rotary, with scarcely any interval of slack water. Off Mounts Bay the ebb, or west-going stream, runs longer and stronger than the flood, or east-going stream, so that a vessel leaving Mounts Bay at half ebb counts upon a nine hours' tide to carry her up the Bristol Channel. This preponderance of the westward current is due partly to the meeting of the two tidal streams referred to, and partly to the indraught into the Bristol Channel during flood tide. The effect of the tidal currents in this neighbourhood is clearly seen in the case of two of our batches of drift-bottles, nos. XXX. and XL., as will be shown below.

The conditions in the Straits of Dover are similar in principle, though more complicated in detail. Here the West and East Channel streams meet at high water and separate at low water, and there is the phenomenon of an "intermediate tide," which is found running along the shore at high and low water when the main streams are at rest. The Strait of Dover thus never has slack water throughout its extent at any one time, and, as stated in the *Channel Pilot*, "if a vessel having come up Channel with the last of the West Channel stream running E. enters the intermediate tide running E. off Hastings, she will have a continuation of it for four hours longer, and, if sailing eight knots, will carry it to the N. Foreland."

On the other hand, at the commencement of flood in the southern portion of the Straits, owing to a simultaneous set of the intermediate tide to the south-westward and of the West Channel stream to the south-eastward, there is a strong convergence towards the French coast between Dieppe and Boulogne. I have not, however, examined minutely the effects of the Dover tides upon any of our drift-bottles on the present occasion. The general occurrence of a southerly component in the Channel winds renders it probable that most of our bottles entered the Straits on the English side, where the net resultant of the tidal influences appears to be in the same direction as the prevalent winds, whose drift they would merely reinforce. In the case of Mounts Bay, as already pointed out, the stronger currents are in the opposite direction.

The influence of the tidal indraught towards Boulogne possibly accounts for the fact that the only bottles recovered on the French coast west of Calais were found at Le Portel, near Boulogne—one on June 19th, the other on August 5th (batches XX. and XXII.).

The strong tidal currents at the entrances to the Gulf of St. Malo may have to be considered in future reports; but as only one batch of our bottles approached this region last year, it does not appear to be profitable to discuss their course on the present occasion.

In Lyme Bay, however, partly owing to the conformation of the coast line, and partly to the indraught of the great tides in the Gulf of St. Malo, the tidal currents are very weak, and, instead of a parallel ebb and flow in the northern part of the bay, the tidal stream in this position is rotary in direction, changing, with the hands of a clock, "round the compass, with little or no velocity." The slight velocity of this vortex, compared with that due to wind-action, enables us to neglect its effects upon the surface drift under ordinary circumstances. But on the eastern side of the bay a stream runs to the south-eastwards for nine hours out of the twelve, after apparently making the circuit of the bay from the Start to Portland. Off Portland Bill the well-known "Race" is due to a combination of this outset from the bay, which has gradually increased in velocity along its course, and a counter-stream from East Portland Bay which sets for 9½ hours. In N. winds the race extends nearly two miles from the Bill, with great overfalls beyond that distance; but with S. winds it scarcely exceeds half a mile. The velocity of the race at springs is six or seven knots.

It is clear that drift-bottles in the eastern part of Lyme Bay will tend to the southward, independently of the winds, as a direct result of the tidal currents here. In the western part of the bay they are not only protected from the direct action of westerly and south-westerly winds, but as a result of the slow tidal vortex tend to be carried northwards and then eastwards with the stream which sets to Portland. It is a remarkable fact that only two of our bottles were recovered on the shores of Lyme Bay: one on August 22nd on Chisel Beach, the other on August 30th at Charmouth, near Lyme Regis. Yet there is every reason to believe, as will be shown below, that most of the February bottles were in the western part of Lyme Bay at the end of that month. We are conducting a special series of experiments in this region during the current year.

It appears accordingly, as a result of the above considerations, that the general eastward drift of the Atlantic is probably not continued through the English Channel as a current independently of the local winds; and that the deflecting influence of the tides upon the surface drift is immaterial in the fairway of the Channel, but may be considerable in certain well-defined regions of the Channel in proximity to the shore.

The motion of the surface currents in the Channel will therefore depend principally on the force and direction of the local winds, but will be subject to modification by tidal currents in the regions enumerated.

§ 4. *The Law of Drift.*—When discussing the influence of the local winds upon the course of our bottles in § 1 the matter of direction was alone considered, questions of velocity being entirely neglected.

But as the exact route taken by the bottles is of considerable importance, it is desirable that some attempt should be made to determine the ratio between the velocity (or force) of the winds and the velocity of the surface currents set up by their action, even though we can only hope to attain a limited degree of accuracy.

The only investigation upon this point with which I am acquainted is contained in Mohn's classical memoir on the circulation of the North Ocean, published in the *Reports of the Norwegian North Atlantic Expedition* (1887, pp. 117–123). According to Mohn, a wind of force 3·9 on the Beaufort scale produces a drift having a velocity of 15 nautical miles per diem. Converting the force of the wind to its velocity according to Scott's table, he gets:

Wind force 3·9 = wind velocity 22·5 miles per hour = drift velocity 15 miles per diem.

This result was gained by computing the mean velocities of the equatorial current and of the trade winds from a large number of cases in which the mean directions of the current and wind approximately coincided. The resultants of the two sets of calculations were then regarded as respectively equivalent.

The velocity of the drift in this and subsequent cases considered by Mohn was taken to be directly proportional to the velocity of the wind.

It seems to me to be clear from this account that Mohn's drift equivalent is only applicable to cases of permanent currents. In his datum case a wind of force 3·9 was not shown to be capable of producing a current of velocity 15 miles per diem *from rest;* it is merely the force of wind sufficient to maintain such a current when already in motion with that velocity. It provides a datum for estimating the mean velocity of a permanent drift when the velocities of the winds in the same region are known, or conversely. But it does not establish a means of determining the effect of the wind upon the sea in a region not subject to a regular circulation, such as the English Channel, if I am right in my attitude upon this point. The currents in the Channel have to be raised practically from rest, since the great variability of the winds prevents the formation of currents with any such momentum as that of the permanent currents.

As, however, the wind frequently blows from the same quarter for several days in succession, its effect upon the water will be relatively greater under these circumstances than when blowing intermittently. The momentum of the drift produced by high winds will be considerably greater than for low winds, and the waves raised by strong winds will enable these winds to exert a propelling force upon the water, in addition to the normal dragging force. All these circumstances seem to me to show that the velocity of a current raised in a given time will be relatively very much greater when raised by a high wind than by a low wind. Without therefore attempting to treat the matter from the difficult point of view of hydrodynamics, it nevertheless seems justifiable to regard the velocity of the current as approximately proportional to the pressure rather than to the velocity of the wind, the pressure being a constant fraction of the square of the velocity.

§ 5. *Empirical Datum.*—On examining the results of the year's experiments one case of drift stood out clearly from the remainder as supplying a datum, comparatively free from sources of error, in regard to the measurable effect of the wind in producing a surface drift, viz., batch no. XXXIX. Out of five bottles put out near the Eddystone on April 22nd one was recovered exactly three days later (73 hours) at Portscatho, situated 25 miles to the westward. The wind during this period was remarkably uniform in force and direction from the eastward, owing to an area of high pressure lying to the N.E. of our islands; and the duration of drift was sufficiently long to allow the oscillating effect of the tides to be discounted. The winds during April, moreover, were very variable, so that we may assume this particular drift to have been raised from rest, especially as on the day preceding that on which the batch was put out a calm prevailed in this portion of the Channel. This assumption is confirmed by the fact that a bottle of batch XXXVII., put out in the same place on the preceding day (April

21st), was recovered at Portscatho also on the 25th. The two bottles were recovered by different individuals at different times of the day. We may assume, therefore, that they had not lain long on the shore before being picked up.

The force of the wind was taken to be the mean of the forces recorded at Prawle Point, Plymouth, and Falmouth. The records for Prawle Point and Plymouth are expressed in terms of the Beaufort scale, the former being extracted from the Daily Weather Reports of the Meteorological Office, and the latter being supplied to me by the Borough Meteorologist at Plymouth. The Falmouth records are the readings of the automatic anemograph at the Falmouth Observatory, and are expressed in units of velocity (miles per hour). To compare these records I have employed Scott's table of the velocity-equivalents of the various figures of the Beaufort scale. The recorded direction of the wind during the period was approximately the same at all three stations, *i.e.*, about E.N.E., but the records of the force of the wind showed more discrepancy than might have been expected. At Prawle Point the force varied between 5 and 7 throughout the period, the average being 6; at Plymouth it was more variable, and the average was 4; while at Falmouth the resultant average velocity compiled from the 73 hourly records during the period only amounted to 13·9 miles per hour, which is equivalent to a force intermediate between 2 and 3 on the Beaufort scale, but much nearer 2 than 3. It is reasonable to expect that the force of an E.N.E. wind blowing over the southern part of our islands should be weaker at Plymouth than at Prawle Point, owing to the retarding effects of greater friction, for such a wind at Prawle Point would come to an observer there direct from the sea (Lyme Bay), while at Plymouth it would be distinctly a land breeze. But it is difficult to understand the low readings of the anemograph at Falmouth during this period, especially as there was no corresponding reduction in the force of the wind further westward, the force at Scilly being recorded in the Daily Weather Reports as varying between 4 and 6, the average being 5. The error introduced by the employment of a table of velocity-equivalents of the Beaufort forces no doubt partly accounts for the lack of correspondence between the data, and the records at Prawle Point were possibly in this case slightly in excess of the actual velocities; but there is still a residuum of error which must apparently be attributed to the effects of local environment upon the velocity of the wind recorded at the Falmouth Observatory.

However, by taking the mean of the observations at Prawle, Plymouth, and Falmouth we shall probably eliminate the errors of observation and measurement, and obtain a fairly true measure of the force of the winds over the sea in this district for the period in question. The resultant winds were calculated independently in each case in terms of pressure, by constructing a polygon of forces from each set of data, the length of each line being made proportional to the sum of the wind pressures from the corresponding quarter. The records on the Beaufort scale and those in terms of velocity were reduced to terms of pressure by means of the following table* of equivalents:—

Force, Beaufort scale . .	0	1	2	3	4	5	6	7	8	9	10	11	12
Velocity, miles per hour .	3	8	13	18	23	28	34	40	48	56	65	75	90
Pressure, pounds per foot .	0·05	0·3	0·8	1·5	2·5	4	6	8	11·5	15	21	28	40

This method is founded on that employed by Dr. Fulton † in his report on the drift-bottle experiments of the Scottish Fishery Board, but differs, for reasons already stated, in the employment of terms of pressure instead of terms of "force" for the construction of the polygon. The practical result of this change is easily seen from the following examples: —On Fulton's method a wind of force 9 is regarded as only 3 times as effective (in the production of currents) as a wind of force 3; by using terms of pressure, however, the same wind is regarded as 10 times as effective $\left(\frac{15}{1\cdot5} = 10\right)$. Similarly on Fulton's method a wind of force 8 is only twice as effective as one of force 4; on mine it is regarded as between 4 and 5 times as effective $\left(\frac{11\cdot5}{2\cdot5} = 4\cdot6\right)$.

In the case of the Prawle winds the observations taken daily at 8 a.m. and 6 p.m. were used, for Plymouth those at 9 a.m. and 9 p.m., while at Falmouth the hourly records were used, amounting to 73 in all for this period of drift. As the bottle was put overboard at 3 p.m. on April 22nd, and recovered at 4 p.m. on the 25th, half the wind-pressure on the evening of the 22nd was combined with half the pressure on the morning of the 25th in the Prawle and Plymouth cases. The results, as determined by the length of the resultant line in the polygons, was as follows:—

Prawle Point—Resultant sum of Pressures			= 38	} based on 2 observations daily.
Plymouth ...	Ditto	ditto	= 15·5	}
Falmouth ...	Ditto	ditto	= 76·7	" 24 " "

Dividing the Falmouth resultant by 12, in order to put it on a par

* This is the table authorised by the Meteorological Office in 1875 after the publication of Scott's paper, with the addition of a table of pressure-equivalents. The latter are computed from the velocities by multiplying the squares of the velocities by the factor 0·005, and expressing the results as far as possible in whole numbers. A more recent table of velocity-equivalents by Mr. Curtis (*Quart. Jour. Met. Soc.*, XXIII., 1897), has been kindly forwarded to me by Mr. Scott, but reached me too late for use in the present report. It differs from Mr. Scott's table in assigning somewhat lower velocities to all the figures of the Beaufort scale.

† *Fifteenth Annual Report of the S.F.B.*, Part III., 1897, p. 357.

with the other figures based only upon two observations daily, we get the mean of these three resultants as follows :—

$$\text{Mean} = \frac{38 + 15{\cdot}5 + 6{\cdot}3}{3} = \frac{59{\cdot}8}{3} = 19{\cdot}9, \text{ or, practically } 20,$$

which is the measure in pounds per foot of the resultant of the wind-pressures, taken twice daily, during the period of drift.

The mean average pressure is, of course, this sum divided by the number of days and the number of observations per diem, or $\frac{20}{3 \times 2} = 3{\cdot}3$, which is equivalent to a velocity of 26 miles per hour, or a "force" intermediate between 4 and 5 (4·6) on the Beaufort scale.

The resultant or minimum distance traversed by the drift-bottle from the Eddystone to Portscatho = 25 geographical miles.

We conclude therefore that a wind exerting a horizontal pressure of 3·3 pounds per foot (= a velocity of 26 miles per hour, or a force intermediate between 4 and 5), and blowing steadily for three days, will cause a surface drift in the same direction of 25 miles in that time, *i.e.*, a current having a surface velocity of 8·3 miles per diem.

This result is considerably lower than that attained by Mohn, and bears out my remarks concerning the inapplicability of Mohn's current-equivalent to cases of currents produced by the wind from rest.

Having thus determined the drift-equivalent, it is easy to construct a factor from it by which the resultant wind pressure for any period may be quickly converted into the number of miles travelled by the surface drift for the same period.

If D be the Distance travelled in miles, and P_2 the resultant Wind-Pressure in pounds per foot computed from 2 observations daily,

$$\text{then } D : P_2 :: 25 : 20,$$

$$\text{or } D = \frac{5\,P_2}{4};$$

and since P_2 may be taken as merely $\frac{2}{n}$ (P_n), where P_n is the Resultant Pressure determined from n observations daily, we have the general formula

$$D = \frac{5\,P_2}{4} = \frac{5\left(\frac{2}{n}\,P_n\right)}{4} = \frac{5 \times 2\,P_n}{4 \times n} = \frac{5\ P_n}{2n}.$$

In most cases it is, of course, sufficient to determine the resultant wind and wind pressure for any period from the observations recorded twice daily at different stations, and the factor then becomes simply $\frac{5}{4}$; or

$D = \frac{5 \times \text{Resultant Pressure}}{4}$, which gives us the number of miles drifted.

The accuracy of this equivalent can only be determined by the frequency with which its results accord with those of direct experiment. It depends on an assumption which may invite criticism, viz., that the velocity of the drift varies as the pressure of the wind, and not directly as its velocity. This pressure-ratio is confessedly only an approximation to the true law of drift, but I consider it to be nearer the truth than the velocity-ratio adopted by Mohn, which assumes the existence of a level sea for winds of all velocities.

§ 6. *Application of Factor to cases of Drift.*—The use of drift-bottles for estimating the velocity of drift is attended by a possible source of serious error, viz., the difficulty of determining the length of time between the actual stranding of a bottle and its subsequent recovery. In some cases this source of error is removed by the statements made by the finders of the bottles, but in most cases it must always remain as a condition to be taken into account. On the whole, however, I believe that the maximum error due to this cause is inconsiderable except when the bottles have been recovered in unfrequented parts of the coast. Most bottles are picked up in the neighbourhood of towns and fishing ports where the shore is much frequented, and in other regions the coastguardsmen are always on the look-out. The conspicuousness of our bottles must also tend to reduce the error due to this cause. Altogether I should estimate the average error as amounting to not more than 12 hours in summer and 24 hours in winter, which is inconsiderable except for short journeys. I would particularly point to the records of batches LII. and LIII. in support of these remarks. The simultaneity with which so many of these bottles were recovered by different individuals after drifting for more than a fortnight is well worthy of note, and we have had still more striking examples of the same thing this year.

The following table shows the results of an application of the drift-factor to certain cases of drift recorded in Table I. Open water and an absence of deflecting currents are assumed. The actual direction and distance of drift are compared side by side with the estimated direction and distance of drift, and these have been calculated from the winds prevailing at the time by the employment of the factor and the method already described. The wind records, except those of Rousdon and Falmouth, were extracted from the Daily Weather Reports of the Meteorological Office.

Table comparing the Estimated and Actual Drift for various periods.

Batch.	Direction of Drift.		Distance.		Position at end of Drift.		Records of Wind Employed.
	Estimated.	Actual.	Estimated.	Actual.	Estimated.	Actual.	
II. 1.	E. 18° N.	E. 11° N.	172	180	23 miles N.N.W. of Eastbourne.	Eastbourne.	Jan. 22–Feb. 28. Prawle Point. March 1–March 16. Mean between Dungeness and Hurst Castle.
III. 1.	E. 20° N.	E. 17° N.	99	90	10 miles N.E. of Chapman's Pool.	Chapman's Pool.	Jan. 29–Feb. 28. Prawle Point.
VII. 1.	E. 23° N.	E. 15° N.	216	175	51 miles N.E. of Seaford. (Sheppey.)	Seaford.	Feb. 16–28. Prawle Point. March 1–15. Rousdon (Lyme Regis). March 16–31. Mean between Hurst Castle and Dungeness April 1–17. North Foreland.
2.	E. 14° N.	E. 14° N.	210	240	30 miles W. by S. of Calais.	Calais.	Feb. 16–March 31. As for VII. 1. April 1–May 13. North Foreland. May 14–19. Cape Gris Nez.
VIII. 1.	E. 15° N.	E. 15° N.	237	260	28 miles W. by S. of Dunkerque.	Dunkerque.	Feb. 17–May 13. As for VII. 2. May 14–15. Cape Gris Nez
IX. 1.	E. 18° N.	E. 18° N.	120	120	Sandown Bay.	Sandown Bay.	Feb. 17–28. Prawle Point. March 1–15. Rousdon. March 16. Hurst Castle.
2.	E. 15° N.	E. 14° N.	237	235	8 miles N. by E. of Calais.	Calais.	Feb. 17 to May 15. As for VIII. 1.
XIV. 1.	E. 15° N.	E. 15° N.	240	255	15 miles W. by S. of Calais.	Calais.	Feb. 18–May 13. As for VII. 1.
XXX. 1.	W. 6° N.	W. 6° N.	7	35	28 miles E. ½ S. of Sennen.	Sennen Cove.	March 31–April 6. Scilly.
XL. 1.	S. 32° W.	W. 13° S.	52	50	36 miles S.S.E. of Mullion.	Mullion.	May 11–27. Mean between Prawle Point and Scilly.

It is seen from the preceding table that in only one out of ten cases of drift does my calculated drift exactly coincide with the records of the bottles (IX. 1); but in several other cases the results correspond in a sufficiently close manner for all practical purposes. Some further examination, however, is necessary before the reliability of my method can be depended upon, because the estimated results depend upon the assumption of open water, and this cannot always be conceded.

In the case of II. 1 there is an angular error of 7° in a course of 180 miles, the estimated and actual distance of drift being practically identical. In this instance there can be no question of any deflection of the drift by the proximity of the shore. My calculations from the winds at Prawle Point, from January 22nd to January 28th, give an estimated drift of 34 miles in a S. by E. direction, which would thus convey the bottles well into mid-Channel. The Prawle winds for the ensuing period, January 29th to February 28th, give an estimated drift of 99 miles in an E.N.E. direction, bringing the bottles to a position about 26 miles S. by W. of the Needles. The direction of the drift during March 1st to 16th was estimated as N.E. $\frac{1}{2}$ E. in this part of the Channel. The direction of the strong winds immediately before the recovery of the bottle was as follows:—March 16th, S. to S.S.W.; March 15th, S.S.W.; March 14th, S. to S.S.E. Clearly the bottle was not driven to Eastbourne from the westward side of Beachy Head by a current parallel with the shore, but must have been almost due S., or even S.S.E., of Eastbourne when overtaken by the gale, as the recovery of another bottle to the eastward a few days later also shows. The error in my estimate is not due therefore to shore-deflection, but to an excess in the southerly component of the wind records employed This is just what one would expect under the circumstances, since the records employed were those of Prawle Point, Hurst Castle, and Dungeness. All of these stations are situated on the northern coast of the Channel, and are consequently more exposed to the full force of southerly than of northerly breezes. The course of the bottles, however, was in mid-Channel for a considerable distance, and thus equally subject to the influence of winds from north and south. That this is the true explanation is seen from the fact that while the resultant wind for March 1st to 16th was S.W. $\frac{3}{4}$ S. at Hurst Castle, and S.W. $\frac{1}{3}$ W. at Dungeness, it was nearly W.S.W. at Jersey (S.W. by W. $\frac{1}{2}$ W.), the force at the three stations being approximately the same. The error could have been avoided by taking the mean between these three winds for the period; but I have preserved my estimate in its original form in order to show by an example the precautions in this respect which must be taken when very accurate results are desired.

In the second case (III. 1) we have again an angular error to the northward, but of small value (3°). The disturbing effects of Portland Race perhaps account for this slight discrepancy; but a closer estimate would probably have been obtained by taking the mean between the Prawle Point and Rousdon winds. During March, when the state of the wind was very similar to that in February, I found that the records at Rousdon indicated a stronger component from the northward than did those at Prawle Point.

The six succeeding cases deal with batches all of which were represented in the neighbourhood of Calais by bottles recovered between the 13th and 19th May. They are, therefore, of particular interest as throwing light on the whole course of drift. There is a glaring discrepancy between the estimated and actual drift of the Seaford bottle (VII. 1); but the remainder conform moderately well, especially when the length of the journeys involved is taken into account. From the close correspondence between estimated and actual drift in cases IX. 1 and 2 we may, I think, conclude that the inferences to be drawn from the use of the drift-factor in all these cases are reliable. In the Seaford case there is an angular error of 8°, a distance error of 41 miles, and a serious geographical discrepancy of position. Had there been open water in the estimated direction of drift, the Seaford bottle should have been on the east coast of Sheppey on April 17th. We see, however, from IX. 1 that these bottles, which from their eventual destination we may shortly term the Calais bottles, were off the south coast of the Isle of Wight about March 16th, and so violent were the westerly gales of the latter half of March that the estimated drift during that period was 120 miles in a N.E. by E. direction, which would bring the bottles to a position 5 or 6 miles E.N.E. of the Nore Lightship off the mouth of the Thames. The Sussex coast, however, would interpose an impassable barrier to such a course, and two alternatives would present themselves: (1) the bottles must drive at once ashore, or (2) the bottles must be deflected from their estimated course by a current racing eastwards along the shore towards the Straits of Dover. The latter course appears to have been taken in most cases, and the bottles were probably in the lower part of the North Sea, between the Essex and Belgian coasts, at the end of the month. That the passage of the Straits was made at this time in spite of the southerly component in the winds is rendered all the more probable because a bottle of batch II., which was off the coast of Eastbourne on March 16th, was recovered at Terschelling on March 30th. This is equivalent to a distance of 250 miles in 14 days, or almost 18 miles a day. Now the estimated drift, directly dependent on the pressure of the wind during this period, was 120, or at most 140 miles. This velocity was therefore nearly doubled, no doubt partly owing to the head of water accumulated in the eastern part of the Channel during the gales, and partly to the narrowing of the Channel in this region. This result accords with the experience of navigators, for, according to the *Pilot's Handbook* (12th ed., 1893, p. 142), "strong W. gales prolong the intermediate stream running E., and retard the stream running S.W. At such times the streams at the Ridge shoal have been found to run 8 hours to the N.E., and only 4 hours to the S.W."

But there is no reason to assign to any of the Calais bottles the remarkable velocity attained by this Eastbourne-Terschelling bottle (II. 3) during the latter half of March. The latter bottle would begin to experience the acceleration caused by the narrowing of the English Channel almost immediately after the commencement of the westerly gales in mid-March, as Beachy Head marks the western boundary of the funnel-shaped extremity of the Channel; but the Calais bottles at this time (March 16th) were 50 miles to the westward, off the east coast of the Isle of Wight, in one of the widest parts of the Channel. During the third week of March, therefore, although the direction of drift of the Calais bottles would be deflected to a course parallel with the coast, their velocity would scarcely differ from that directly due to the pressure of the wind, which we have already seen was calculated to be 120 miles for the fortnight, or 60 miles for the week, which would bring them slightly to the eastward of Beachy Head. From this point they would begin to experience an accelerated velocity; and, if we assume that they travelled at the same average rate as the Eastbourne-Terschelling bottle (18 miles a day), their position at the end of March would be 125 miles to the north-eastward of Eastbourne, or somewhere in a line between Harwich and the Hook of Holland, and probably on the westward side of the middle of this line. Such a position would be about 60 miles N.N.E. or N. by E. of Calais. Now the estimated direction of drift in this region from April 1st to 30th, based on the North Foreland winds, was W. $\frac{1}{2}$ S., 29 miles, which would bring the bottles to a position slightly south of Harwich, off the Naze, by the end of that month. The Naze is rather under 60 miles N.N.W. of Calais. The estimated drift from May 1st to 13th, based on N. Foreland winds, was approximately E.S.E. (actually S.E. by E. $\frac{7}{8}$ E.), 56 miles; or, based on the winds of Cape Gris Nez, S.E. $\frac{1}{8}$ S., 59 miles; so that, obeying this drift, the bottles on May 13th would be within a mile or two of the French coast between Calais and Dunkerque, a result which coincides remarkably with the actual position of the bottles about that time, and demonstrates the general accuracy of the method employed in this report for deducing the course of drift from the direction and pressure of the winds.

Apart from the employment of this quantitative method, a mere survey of the records contained in the table showing the recovery of drift-bottles would have led one to the conclusion that the eastward drift of these bottles was a more or less steady and continuous one from March 16th, when they were off the Isle of Wight, until the middle of May, when they were stranded on the French coast. The recovery of a bottle at Seaford in April points clearly to such a conclusion, and the direction of the resultant winds at Dungeness during the latter half of April (E.N.E., light) and the first half of May (W. by N., moderately strong) appeared to me at first sight to accord with the view that all the Calais bottles were in the neighbourhood of Seaford in mid-April. It was not until I made the extensive calculations required for the above analysis that I finally convinced myself of the serious error of this view, and of the certainty that the Calais bottles had already made the passage of the Dover Straits in the last week of March, owing to the production of a current along the coast of Sussex at an angle with the direction of the wind during the last fortnight of March.

In order to explain the case of the Seaford bottle we must go back to the position of the Calais bottles prior to the southerly gale of March 16th, which drove so many ashore. On March 16th and 17th several bottles were stranded on the S.E. coast of the Isle of Wight by this gale, but one, at least (XI. 1), was stranded about the same time on the S.W. coast of the same island, and another was recovered in the Solent on March 31st (XIII. 1.). Now this latter batch did not arrive at Calais until June 18th. It is probable, therefore, that the cause of retardation in this case was that these bottles had not easted sufficiently by the 15th March to be able to round St. Catherine's Point when the southerly gale of the 16th overtook them. Those which were to the eastward of the Point, and escaped stranding, were driven rapidly along the Sussex shore to the Straits of Dover; but those which were to the westward of the Point were either driven ashore on the west coast of the island or into the Solent. Their course through the Solent and Spithead to the eastward would be distinctly slow, as they would lose a considerable portion of the direct effect of the westerly gales; and I imagine that the Seaford bottle may have been retarded in this way, while others of the same batch succeeded in clearing St. Catherine's Point, and pursuing an unobstructed course. A difference of a few miles between the positions of bottles on the 15th of March would be sufficient to determine whether they would be carried to the eastward or westward of St. Catherine's Point. If the Seaford bottle actually took the course here suggested it must have slowly drifted eastwards through the Solent and Spithead, and emerged off Selsea Bill during the last few days of March, pursuing a course along the Sussex coast under the influence of the westerly winds. The resultant westerly wind of April 1st to 17th was estimated from the winds at Dungeness to produce a drift of 24 miles in an E.N.E. direction (actually N.E. by E. ½ E.). The distance of Seaford from Selsea Bill is 34 miles. This suggestion as to the course of the Seaford bottle, therefore, is sufficiently consistent with the conditions prevailing at the time, and with the remainder of our records, to render it the probable explanation of the conspicuous lack of correspondence between actual and estimated drift in this case. Another alternative is that the bottle may have been driven ashore between the 16th and 19th March on the east coast of the Isle of Wight, or on the Sussex shore west of Selsea Bill, as occurred in the case of III. 4, and that it remained ashore until the latter end of March, when it resumed its eastward drift; but I consider this theory much less probable. What I hold to have established is that the course of the Seaford bottle was quite exceptional, and that its position on the 17th April does not indicate the position of the remaining bottles of the same batch on that date; for there was a general tendency for bottles put out near the Eddystone between the 16th and 18th of February to arrive on the French coast between Calais and Dunkerque between the 13th and 19th May, and I have shown that this could be achieved, provided the bottles passed through the Straits of Dover in the last week of March. It was, on the other hand, impossible, if the bottles were in the neighbourhood of Seaford in mid-April. The distance from Seaford to Calais is 70 miles, the direction E. 12° N.; but the estimated drift for the period April 17th to May 13th (based on the winds at Dungeness) is only 35 miles, and the direction E. 30° S., an error both of direction and distance which is too serious to be due to the method of computation, and which admits of no explanation from the nature of the winds prevailing at the time.

The two last cases in the table now require consideration. The first of these (XXX. 1) is the drift of *two* bottles from the Manacles to Sennen Cove, a distance of 35 miles, during the first week of April. The fact that two bottles pursued the same course shows that the causes of the drift were very constant. The case is the more remarkable as two headlands—the Lizard and the Land's End—had to be rounded during the drift. Now my estimated drift for this period, though in the right direction, is remarkably deficient in distance. Indeed, so variable were the winds in this part of the Channel during this period that it is quite impossible to attribute the drift in this case to the action of the wind. As a check upon my estimate based on the Scilly records, I have also made a calculation as to the direction and distance of drift based on the winds at Falmouth, using the complete set of hourly records of the anemograph for the period. The result is equally inadequate. I have also estimated the drift on the assumption that the rate of drift is proportional to the *velocity* of the wind, which only made matters worse, since it yielded an estimated drift of only 3 miles in a direction W. 24° N. It is obvious that in this case the rapidity of the drift round the Cornish headlands was due to some cause other than the winds, and, as already described in an earlier section of this report, the known peculiarities of the tidal streams in this region provide an adequate explanation. The indraught into the Bristol Channel during the flood-tide here causes a marked set to the northward round the Land's End, and this brings about a predominance of the westward tide over the eastward tide in this part of the English Channel. In fact, the English Channel supplies more water to the Bristol Channel during flood-tide than returns to it on the ebb from the same region.

The last case of all (XL. 1) appears to illustrate the same point. There is an angular error of 45° in my calculated drift, but the estimated distance is approximately correct. The deflecting cause may be regarded as equivalent to a current in a N.N.W. direction having an average velocity of 36 miles in 16 days, *i.e.*, rather over 2 miles per diem. There seems to be no reason for doubting that this deflection was due to the influence of the resultant northward tendency of the tides in the western region of the Channel, which is determined by the indraught into the Bristol Channel during flood-tide in that region. We have seen in the preceding case (XXX. 1) that the force of this indraught determines a current round the Lizard and Land's End of some 30 miles in 6 days, *i.e.*, 5 miles a day; so that, although this deflecting influence was not fully felt during the whole period of drift in the present case, we are probably correct in attributing the observed deviation to the same cause, since the south-westward drift caused by the winds would bring the bottles nearer to the influence of the indraught on each successive day; and, in order to complete the distance between the eventual estimated and actual positions, it would suffice if the full influence of the indraught (5 miles per diem) were only felt during the last seven days of drift.

§ 7. *Conclusions.*—Enough has been said, I think, to show that the method employed here for tracing the actual influence of the winds on the water is sufficiently accurate for practical purposes, and that by its employment, with proper precautions, the influence of the winds may be separated from that of other factors which operate in the production of surface currents. From this point of view the method may be of considerable use in the future for determining the existence of currents not produced by local wind-action. At the same time the method requires to be tested extensively before it can be used as a basis for conclusions. The present report pretends only to show that the relation between wind-action and surface currents is capable of quantitative study, and that the results obtained by the use of the methods here described are sufficiently accurate to encourage the further use of them. This we are doing during the present year on a larger scale, and the results will be set out in next year's report. It is very desirable that experiments should be made to determine the depth of the currents induced by wind-action, and we propose to attempt this work during the present year. A comparison of results obtained by bottles floating at the surface, and by other objects designed to come under the influence of lower strata of water, should yield results of considerable value. Until such experiments are made, however, it does not appear to be desirable to say too much upon the practical aspects of the experiments described in this report. We have obtained a general view of the movements of the uppermost layer of water, and we may be certain that similar, though slower, movements also affect the layers immediately subjacent; but the actual depth to which this movement would be communicated under different conditions of wind and tide is a matter of too much practical importance to be left to mere guesswork. As Mohn has well said: "Neither argument nor estimate, but carefully worked-out computations alone, can lead to a lasting result."

II. St. George's Channel and Irish Sea.

Owing to the fact that our experiments in this area only cover the summer and autumn months, it does not appear to be advisable to make any attempt to generalise the results obtained, the data given in Table II. being self-explanatory. I may remark, however, that in all the cases which I have specially analysed, the actual drift differs from the estimated drift in taking a more northward direction. This result appears to agree with that obtained by Professor Herdman in his experiments in the Irish Sea. (*Proc. Liverpool Biol. Soc.*, vol. x.).

Note.—In the tables which follow, as well as in the preceding portion of this report, the positions of places and directions of currents are invariably indicated by their true geographical bearings, and not by their compass (magnetic) bearings. As the directions of winds are uniformly indicated in true geographical terms, and as compass bearings differ with latitude and longitude, it seemed desirable to use true geographical bearings throughout this report, in order to avoid the possibility of confusion.

TABLE I.—ENGLISH CHANNEL AND NORTH SEA.

BOTTLES SENT ADRIFT.				BOTTLES RECOVERED.			DISTANCE AND RATE OF DRIFT.		
No. of Batch.	Date.	Locality.	No. of Bottles.	No. of Bottle.	Date.	Locality.	Minimum distance (Geog. miles).	Time occupied (days).	Rate of Drift (miles per day).
I.	Jan. 19.	4 miles E. of Eddystone.	7	1	May 11.	Terschelling I., Holland—(afloat).	430	112	3·8
				2	,, 13.	Ditto (ashore).	430	114	3·8
II.	,, 22.	3½ miles N.E. of Eddystone.	6	1	Mar. 16.	Eastbourne, Sussex.	180	53	3·4
				2	,, 19.	Bexhill-on-Sea, Sussex.	190	56	3·4
				3	,, 30.	Terschelling I.	430	67	6·4
				4	May 25.	Borkum I. (Germany).	480	123	3·9
III.	,, 29.	2 to 3 miles off the Eddystone. (E., S., and S.S.W. from the Lighthouse.)	27	1	Mar. 1.	Chapman's Pool, nr. St. Alban's Head, Dorset.	90	31	2·9
				2	,, 16.	Sandown Bay, I. of Wight.	130	46	2·8
				3	,, 17.	Ditto ditto	130	47	2·7
				4	,, 18.	East Withering, Sussex.	145	48	3·0
				5	July 10.	Texel I., Holland (3 miles off shore).	400	162	2·4
				6	Aug. 3.	Schiermonnikoog I., Holland.	470	186	2·5
				7	,, 15.	Terschelling I., Holland.	430	198	2·1
				8	Sep. 3.	Thyboron Kanal, Denmark.	650	217	2·5
				9	Oct. 12.	Fjellbacka, Sweden.	930	256	3·6
				10	,, 21.	Vordkosterön, Strömstad, Sweden.	940	265	3·5
IV.	Feb. 15.	3 miles S.W. of Eddystone.	6	1	Mar. 20.	Warbarrow Bay, Dorset.	90	33	2·7
				2	,, 28.	Portland Beach, Dorset.—(Card only; bottle broken.)	85	41	2·0
				3	Nov. 24.	Bröns, Nordschleswig, Germany.	590	282	2·0
V.	,, 16.	5 miles E. by S. of Eddystone.	6	1	July 20.	Zuiderzee, near Nieuweschild, Holland.	430	154	2·8
VI.	,, 16.	18 miles S.E. ¾ S. from Eddystone. { Lat. 49° 57′ 10″ N. Long. 4° 0′ 30″ W. }	6	1	Oct. 15.	Bröns, Nord Schleswig.	585	241	2·4
VII.	,, 16.	10½ miles S.S.E. from Eddystone.	6	1	Apr. 17.	Seaford, Sussex.	175	60	2·9
				2	May 19.	Calais, France.	240	92	2·6
				3	Aug. 2.	Langeoog I., Germany.	520	167	3·1

VII.	Feb. 16.	10½ miles S.S.E. from Eddystone.		4	Aug. 15.	1 mile S.E. of Heligoland.	540	180	3·0
VIII.	,, 17.	11 miles S.S.E. ½ S. from Eddystone.	6	1	May 15.	Dunkerque, France.	260	87	2·9
				2	,, 19.	Baraques, near Calais.	240	91	2·6
				3	June 27.	North Sea, 26 miles N.W. by N. from the Hook of Holland—(afloat).	345	130	2·6
				4	July 31.	Amiland I., Holland.	450	164	2·7
IX.	,, 17.	11 miles S. by W. from Bolt Tail, S. Devon.	6	1	Mar. 17.	Sandown Bay, I. of Wight.	120	28	4·2
				2	May 19.	Calais.	235	91	2·5
X.	,, 17.	10 miles S.S.W. of Bolt Tail (2 miles to N.W. of IX.).	6	1	Feb. 18.	E. end of Plymouth Breakwater.	15	24h.	15·0
				2	Mar. 3.	Laira, Plymouth.	18	14	1·2
XI.	,, 17.	11 miles S.S.E. from Dodman Point, Cornwall.	6	1	Mar. 18.	Brighstone Bay, I. of Wight.	135	29	4·6
XII.	,, 18.	5 miles S.S.W. from Eddystone.	6	1	Oct. 13.	Nymindegab, Denmark.	600	237	2·5
XIII.	,, 18.	17 miles S.S.W. ½ S. from Eddystone.	6	1	Mar. 31.	Solent.	125	41	3·0
				2	June 18.	Calais.	255	120	2·1
XIV.	,, 18.	18½ miles S.S.W. from Eddystone. (2 miles to W.S.W. from XIII.)	6	1	May 13.	Calais.	255	84	3·0
				2	Nov. 10.	Nymindegab, Denmark.	605	265	2·2
XV.	,, 23.	10 miles W. ¾ S. from Lizard Point.	6						
XVI.	,, 23.	5 miles S.S.E. from Wolf Rock.	6	1	Mar. 3.	Porthleven Harbour, Cornwall.	22	8	2·7
XVII.	,, 23.	12½ miles E. ¼ S. from Start Lighthouse.	6						
XVIII.	,, 23.	14 miles from Start Lighthouse (? S. ¾ W.).	6	1	Sep. 14.	Juist I., Germany.	485	203	2·3
XIX.	,, 24.	10 miles S.S.E. from St. Mary's Sound, Scilly Is.	6						
XX.	,, 24.	7½ miles E. ½ S. from Eddystone.	6	1	June 19.	Le Portel, near Boulogne, France.	225	115	1·9
XXI.	,, 24.	2 miles W. ¼ N. from Eddystone.	6						
XXII.	,, 24.	5 miles W.S.W. from Eddystone.	6	1	Mar. 1.	Sharping Point, Bigbury Bay, Devon.	20	5	4·0
				2	Aug. 5.	Le Portel, France.	210	162	1·3
XXIII.	,, 25.	8 miles W. ¾ S. from Eddystone.	6						
XXIV.	Mar. 11.	3 miles N.N.E. of Eddystone.	6						
XXV.	,, 11.	2½ miles S.S.E. from Rame Head.	6	1	Mar. 12.	Whitsand Bay, Cornwall (between Coastguard Station and Tregantle Fort).	4	1	4
XXVI.	,, 11.	¾ mile S.S.W. of Breakwater Lighthouse, Plymouth.	5						
XXVII.	,, 15.	5 miles S.W. from Eddystone.	6						
XXVIII.	,, 31. 1 a.m.	4 miles W. ¾ S. of Wolf Lighthouse.	6						

ENGLISH CHANNEL AND NORTH SEA—*continued.*

BOTTLES SENT ADRIFT.				BOTTLES RECOVERED.			DISTANCE AND RATE OF DRIFT.		
No. of Batch.	Date.	Locality.	No. of Bottles.	No. of Bottle.	Date.	Locality.	Minimum distance (Geog. miles).	Time occupied (days).	Rate of Drift (miles per day).
XXIX.	Mar. 31. 2 a.m.	Off Wolf Lighthouse (? E.S.E.).	6						
XXX.	,, 31. 4 a.m.	8 miles N.E. by E. of Lizard.	6	1	Apr. 6. 9 a.m.	Sennen Cove, near Land's End, Cornwall.	35	6	5·8
				2	,, 6. 12-30p.m	Sennen Cove, near Land's End, Cornwall.	35	6	5·8
XXXI.	Apr. 11	3 to 4 miles outside Eddystone.	4						
XXXII.	,, 12.	4 to 5 miles westwards of Eddystone.	4	1 2	,, 13.	Windsworth, 2 miles E. of Looe, Cornwall.	10	1 d. 3 h.	8·8
XXXIII.	,, 13.	9 miles E. of Eddystone.	6	1	Aug. 22.	Chisel Beach, Dorset.	77	131	·6
				2	Oct. 14.	Oesterhever, Eiderstedt, Schleswig Holstein, Germany.	565	184	3·0
XXXIV.	,, 16.	3 to 4 miles S.W. of Eddystone.	6	1	Aug. 31.	Seaford, Sussex.	178	137	1·3
				2	Oct. 14.	Wieringen I., Holland.	415	181	2·2
XXXV.	,, 21.	2 miles E.S.E. of Wolf Rock.	6	1	Feb. 21, 1898.	Amrum I., Schleswig, Germany.	643	306	2.1
XXXVI.	,, 21.	5 miles E.S.E. of Eddystone.	6	1	Dec. 21.	Ramsgate, Kent.	250	244	1·0
XXXVII.	,, 21.	3 to 4 miles S.W. of Eddystone.	5	1	Apr. 25.	Portscatho, Gerrans Bay, Cornwall.	25	3 d. 21 h.	6·4
				2	June 2.	Penzance, Cornwall.	52	42	1·2
XXXVIII.	,, 22.	10 miles W. ¾ S. of Wolf Rock.	6	1	May 7.	Bryher, Scilly Isles.	15	15	1·0
				2	June 2	18 miles S.W. ¾ S. of Bishop Lighthouse, Scilly Isles.	30	41	0·7
XXXIX.	,, 22.	3 to 4 miles S.W. of Eddystone.	5	1	Apr. 25.	Portscatho, Cornwall.	25	3 d. 1 h.	8·2
XL.	May 11.	3 miles E. ½ N. of Eddystone.	18	1	May 27.	Mullion, Mounts Bay, Cornwall.	50	16	3·1
				2	June 2.	Penzance, Cornwall.	60	22	2·7
				3	,, 22.	Croyde, N. Devon.	160	42	3·8
		[*Distance calculated to Croyde, then back to Bude and Eastbourne.*]		4	Aug. 20.	Bude, North Cornwall.	190	101	1·8
				5	Nov. 17.	Eastbourne, Sussex.	500	190	2·6
XLI.	,, 25.	22 to 25 miles S. by E. from Mewstone, Plymouth.	2						

XLII.	May 25.	55 to 60 miles S. by E. from Mewstone, Plymouth.	2						
XLIII.	,, 27.	4 to 5 miles S.S.W. from Eddystone.	2	1	Oct. 27.	Eastbourne, Sussex.	187	153	1·2
XLIV.	June 1.	15 miles S.E. by S. from Eddystone.	6	1	Aug. 25.	Brook, Isle of Wight.	115	85	1 3
				2	Sep. 1.	Hamble Battery, Southampton Water, Hants.	125	92	1·3
				3	Oct. 29	Bexhill-on-Sea, Sussex.	190	150	1·2
XLV.	,, 14. 8 p.m.	34 miles S. ¾ E. from Eddystone. { Lat. 49° 37′ N. { Long. 4° 9′ W.	6	1	July 8.	6 miles S.W. from Les Hanois Lighthouse, Guernsey.	55	24	2·2
				2	Aug. 25.	Vauville, Manche, France.	90	72	1 2
				3	Feb. 19. 1898.	Near Farsund, Norway.	750	248	3·0
XLVI.	,, 15. 11-30 a.m	18 miles S. by E. from Eddystone. { Lat. 49° 53′ N. { Long. 4° 10′ W.	6	1	,, 12.	Farsund, Norway.	750	241	3·1
XLVII.	July 17.	6 (?) miles S. from Looe I., Cornwall. [*Dead reckoning* 22 *miles E.* ½ *S.* (*magnetic*) *from St. Anthony's Buoy, Falmouth ; thick fog.*]	18	1	July 20.	Off Polperro, Cornwall; 10 miles E.S.E. of Dodman Point—(afloat).	8 (?)	3	2·6
				2	,, 20.	6 miles S.S.E. of Polperro—(afloat).	1 (?)	3	0·3
				3	,, 20.	Ditto ditto ditto	1 (?)	3	0·3
				4	Aug. 15.	Barn Pool, Plymouth Sound—(afloat)	15	29	0·5
				5	,, 16.	Polhawn, Whitsand Bay, Cornwall.	10	30	0·3
				6	,, 16.	Kingsbridge, S. Devon.	30	30	1·0
				7	,, 17.	Estuary of R. Erme, S. Devon.	20	31	0·6
				8	,, 18.	Portwrinkle, Whitsand Bay.	9	32	0·3
				9	,, 18.	Challaborough, Bigbury Bay, S. Devon.	21	32	0·6
				10	,, 21	Bridgend, Yealm Estuary, S. Devon.	16	35	0·4
				11	,, 25.	Mouth of R. Erme, S. Devon.	19	39	0·5
				12	Sep. 2.	Compton Bay, I. of Wight.	130	47	2·7
XLVIII.	,, 27.	3 miles N.W. by W. from Eddystone.	18	1	Aug. 18.	Portwrinkle, Cornwall.	10	22	0·4
				2	,, 30.	Charmouth, Dorset.	70	34	2·0
XLIX.	Sep. 10.	4 miles E.N.E. from Eddystone. [*Tide going W., one hour to run.*]	13	1	Oct. 17.	Charlestown, Cornwall.	24	37	0·6
				2	,, 24.	Mevagissey, Cornwall.	24	44	0·5
				3	., 25.	Golant (3 m. up the Fowey R.), Cornwall.	23	45	0·5
				4	Dec. 4.	Helford River, Cornwall.	40	85	0·4
L.	,, 10.	4 miles E.N.E. from Eddystone. [*Tide going E., just commenced.*]	12	1	Oct. 18.	Par, Cornwall.	23	38	0·6
				2	,, 19.	Ditto	23	39	0·6
LI.	,, 15.	1 mile W. by S. from Eddystone.	21	1	,, 25.	Yealm Estuary, S. Devon.	12	40	0·3

ENGLISH CHANNEL AND NORTH SEA—*continued.*

BOTTLES SENT ADRIFT.				BOTTLES RECOVERED.			DISTANCE AND RATE OF DRIFT.		
No. of Batch.	Date.	Locality.	No. of Bottles.	No. of Bottle.	Date.	Locality.	Minimum distance (Geog. miles).	Time occupied (days).	Rate of Drift (miles per day).
LI.	Sep. 15.	1 mile W. by S. from Eddystone.	21	2	Oct. 27.	Maenporth, near Falmouth.	33	42	0·8
				3	,, 28.	Ditto ditto	33	43	0·7
LII.	,, 30.	3 miles N.E. by E. from Eddystone.	24	1	,, 17.	Windsworth (between Looe and Downderry), Cornwall (card only, bottle broken).	13	17	0·7
				2	,, 17.	Downderry, Cornwall.	13	17	0·7
				3	,, 17.	Ditto ditto	13	17	0·7
				4	,, 17.	Ditto ditto	13	17	0·7
				5	,, 17.	Ditto ditto	13	17	0·7
LIII.	Oct. 1.	4 miles S.S.W. from Rame Head, near Plymouth.	33	1	,, 16.	Par, Cornwall.	20	15	1·3
				2	,, 16.	Ditto	20	15	1·3
				3	,, 16.	Ditto	20	15	1·3
				4	,, 16.	Polkerris, near Par.	19	15	1·2
				5	,, 16.	Ditto ditto	19	15	1·2
				6	,, 16.	Pridmouth, near Fowey.	17	15	1·1
				7	,, 17.	Lansallos (between Fowey and Polperro), Cornwall.	13	16	0·8
				8	,, 17.	Ditto ditto	13	16	0·8
				9	,, 17.	Ditto ditto	13	16	0·8
				10	,, 18.	Par, Cornwall.	20	17	1·2
				11	,, 18.	Ditto	20	17	1·2
				12	,, 18.	Ditto	20	17	1·2
				13	,, 18.	Lansallos, Cornwall.	13	17	0·8
				14	,, 19.	Fowey, ½ mile from shore.	16	18	0·9
				15	,, 19.	Par Bay, 1 mile from shore.	19	18	1·0
				16	,, 20.	Par.	20	19	1·0
				17	,, 23.	Bodinnick, Fowey estuary.	17	22	0·7
				18	,, 27.	Golant, 3 miles up Fowey River.	19	26	0·7

Table II.—ST. GEORGE'S CHANNEL AND IRISH SEA.

BOTTLES SENT ADRIFT.				BOTTLES RECOVERED.			DISTANCE AND RATE OF DRIFT.		
No. of Batch.	Date.	Locality.	No. of Bottles.	No. of Bottle.	Date.	Locality.	Minimum distance (Geog. Miles).	Time occupied (days).	Rate of Drift (miles per day).
I.	Mar. 30. (11 a.m.)	10 miles N.N.W. of Great Orme's Head, N. Wales.	6	1	May 11.	Duddon Sands, Asham-in-Furness, Lancashire.	50	42	1·2
		[*Distance calculated viâ the east of the Isle of Man.*]		2	June 9.	Black Head, Antrim, Ireland.	115	71	1·6
				3	July 7.	Ardwell Bay, Stoneykirk, Wigtown, N.B.	90	99	0·9
				4	,, 26.	Fleetwood Beach, Lancashire.	45	118	0·4
II.	Mar. 30. (1 p.m.)	12 miles S.S.W. of South Stack Lighthouse, Anglesey.	6	1	,, 26.	Dally Beach, 2½ miles S. of Corsewall Lighthouse, Wigtown, N.B.	115	118	1·0
				2	Sept. 5.	Glenluce, Wigtown, N.B.	108	159	0·7
				3	Nov. 22.	Colonsay I., Argyleshire, N.B.	210	237	0·9
III.	Mar. 30. (3 p.m.)	52 miles S.S.W. of South Stack, Anglesey.	6	1	May 1.	Trearddur Bay, Holyhead.	52	32	1·6
				2	,, 8.	Ditto ditto	52	39	1·3
				3	,, 10.	Pontlyfni, 8 miles S. of Carnarvon.	47	41	1·1
				4	June 23.	Aberffraw Bay, Anglesey.	50	85	0·6
IV.	Mar. 30. (4 p.m.)	17 miles N.N.W. of South Bishop Lighthouse, Pembroke.	6	1	,, 23.	Ditto ditto	77	85	0·9
				2	Sep. 21.	Lendalfoot, Ayrshire, N.B.	190	175	1·1
				3	Nov. 7.	Bay of Rigg, E. coast of Wigtownshire, N.B.	175	222	0·8
V.	Mar. 30. (6 p.m.)	1 mile N.N.W. of the Smalls Lighthouse, Pembrokeshire.	6	1	May 13.	Abercastle, Pembrokeshire.	27	44	0·6
				2	June 22.	Cymyran, Anglesey.	101	84	1·2
				3	Aug. 7.	Rhosnegir, Carnarvon Bay, Anglesey.	100	130	0·8
VI.	Mar. 30. (8 p.m.)	37 miles S. of the Smalls Lighthouse.	6	1	May 13.	Off Abercastle, Pembroke.	61	44	1·4
				2	July 10.	Barmouth, Merioneth.	122	102	1·2
				3	Aug. 31.	Borgue Shore, Kirkcudbright, N.B.	236	154	1·5

Director's Report.

THE various researches detailed in my last Report, which are being conducted by the Association's Naturalists, have been continued during the winter. Mr. Garstang has been chiefly occupied in investigations relating to the migratory pelagic fishes, giving special attention to the characteristics of mackerel from different localities, some 1500 of these fish having been subjected to detailed examination in the course of this enquiry. The samples of mackerel have been obtained from the south-west of Ireland (through H.M. Inspectors of Irish Fisheries), from the North Sea and from America, in addition to those captured near Plymouth. As the results so far obtained refer only to the autumn fish, it has been thought better to defer their publication until after the coming spring fishery, when further samples from the same localities, as well as from the Mediterranean and from Norway, will be examined.

Mr. Garstang has also given much time to working out the results of the drift-bottle experiments, a report of which for the year 1897 will be found at p. 199. These experiments have proved more interesting and successful than we had anticipated when they were undertaken, and we purpose continuing and extending them during the coming year.

Mr. Holt's papers in the present number of the Journal represent but a portion of the many observations which he has been able to make during the year on the eggs and larvæ of fishes. He has also given much attention to the question of the distribution of fish at different ages in this neighbourhood.

The following is the list of workers at the Laboratory since my last Report:—

Brebner, G., August 17th to August 31st (*Marine Algæ*).

Browne, E. T., B.A., August 24th to October 9th (*Medusæ*).

Church, A. H., B.A., December 20th to January 20th (*Marine Algæ*).

Cunningham, J. T., M.A. (*Crabs*).

Jenkinson, J. W., B.A., September 9th to September 30th (*Crustacean Larvæ*).

Lanchester, W. F., August 24th to September 29th (*Phoronis*).

Lubbock, M., M.D., August 9th to September 9th (*Fishes*).

Minchin, E. A., M.A., January 8th to January 19th (*Protozoa*).

Taylor, T. H., M.A., August 25th to September 12th (*Polyzoa*).

Weldon, Prof., F.R.S., December 20th to January 10th (*Variation of Crabs*).

Wylde, N., October 11th to November 11th (*Variation of Galathea*).

In another part of this number of the Journal Mr. E. T. Browne describes the use of an apparatus for keeping medusæ and other pelagic organisms alive in confinement, which has given very satisfactory results. With a view to using the method upon a more extended scale, and of applying it to the hatching and rearing of pelagic fish-eggs and larvæ, I have fitted up in the Laboratory an arrangement of a similar kind upon a larger scale, so that many of the glass plungers can now be worked without difficulty. In some cases a glass funnel, with a small hole in the top, has been used in place of the glass plate described in Mr. Browne's apparatus. By this arrangement a funnel-full of air is carried down each time the plunger descends, and the escape of this air through the hole in the top assists in the aeration of the water. We have found the glass plungers to give very good results when used for hatching purposes, and the method is in many ways much simpler to work than those previously employed, in which the eggs were kept in motion by means of a constant current of sea-water.

The specimens of different stages in the development of food-fishes and of invertebrate animals which serve as food for fishes, exhibited during the summer at the Yachting and Fisheries Exhibition held at the Imperial Institute, have been returned to Plymouth, and have, during the winter, been arranged in a room adjoining the Aquarium, where they could be seen by visitors.

I am glad to be able to report that the appeal made in the last number of the Journal on behalf of our Library has not been without success. Our thanks are due to the Council of the Zoological Society for an almost complete set of their *Proceedings* from the year 1832, and all the *Transactions* from 1862. Mr. J. P. Thomasson, who has on so many former occasions generously supported the Association, has sent a donation of £20 for the purchase of books and for binding. With the help of this donation we have been able to obtain for the library a copy of Smitt's costly work on Scandinavian Fishes, and also to bind the complete set of the publications of the Zoological Society.

We have also to thank Mr. W. F. Sinclair for a donation of ten guineas, and Mr. W. R. Adams for one of three guineas towards the Steamboat Fund, and Messrs. J. Straker and W. F. Lanchester for subscriptions of £15 each as life-members of the Association.

E. J. ALLEN.

March, 1898.

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BY

J. T. CUNNINGHAM, M.A.,

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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 Duke of ARGYLL, Sir LYON PLAYFAIR, Sir JOHN LUBBOCK, 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 no case does any one salary exceed £250.

The Association has received some £29,000, of which £13,000 has been granted by the Treasury. The annual revenue which can be at present counted on is about £1,820, of which £1,000 a year is granted by the Treasury, the remainder being principally made up in Subscriptions.

The admirable Marine Biological Laboratory at Naples, founded and directed by Dr. Dohrn, has cost about £20,000, including steam launches, &c., whilst it has an annual budget of £7,000.

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

CONTENTS OF NEW SERIES Vol. V., No. 2.

NOTICE.

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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.