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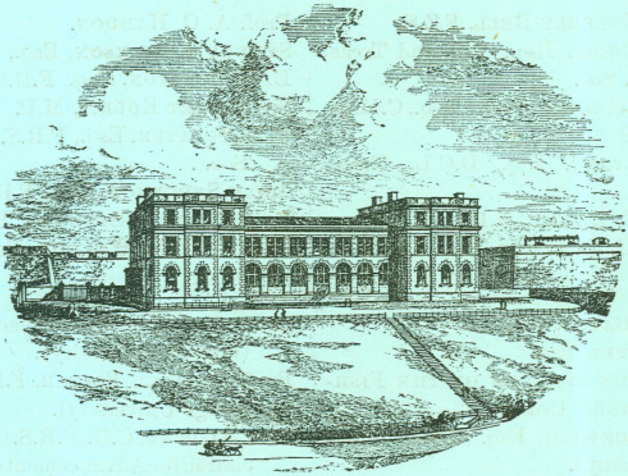
Journal

OF THE

MARINE BIOLOGICAL ASSOCIATION

OF

THE UNITED KINGDOM.



THE PLYMOUTH LABORATORY.

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Journal of the Marine Biological Association.

Report of the Council, 1890-1891.

During the past year the Council has met ten times for the conduct of the business of the Association.

In accordance with Bye-law 5, which provides for the election of officers, Prof. E. Ray Lankester was elected in the course of the year to the office of President in succession to Prof. Huxley, and Dr. G. H. Fowler to that of Honorary Secretary. No other changes have occurred in the Council.

The Council desire to express their indebtedness to the courtesy of the Royal Society in permitting the meetings of the Association to be held in their rooms.

Buildings, Fittings, Aquarium, &c.

The buildings at Plymouth are now in thorough repair. In the course of last summer the bottoms of the two largest tanks showed signs of weakness, the slate beams on which they rested being inadequate to support the enormous weight of water; the danger was fortunately discovered in time, and has been permanently averted by the building up of brick piers from below. A small shed has been erected at the back of the Laboratory for the reception of a forge and anvil, by the aid of which the engineer is now able to effect all minor repairs to the gas engines and steam-launch. Both gas engines have lately been thoroughly overhauled, and are working with little or none of the vibration which originally threatened danger to the vulcanite pipes. A twelfth compartment has recently been fitted up in the Laboratory for physical work.

The severe winter produced a noticeable effect on the animals in the aquarium as well as on those in the Sound, and the mortality has been considerable. The condition of the tanks is, however, annually improving, and a self-sown fauna, including Hydroids, Ascidians, and Chætopods, is slowly springing up. A small charge for admission to the aquarium, which is now open daily, has lately been instituted with satisfactory results.

Boats.

The only addition to the boats during the year is a small dinghey. The steam-launch "Firefly," purchased in July, 1889, while very economical when in working order, is a considerable source of expense for repairs, and great inconvenience was caused during the summer of 1890 by her breaking down when the Laboratory was full of workers. The terrible storm which swept over the west of England on March 9th last did extensive damage both to the "Firefly" and to the "Anton Dohrn," since repaired; the three-ton dandy "Mabel," which fortunately escaped injury on that occasion, is also in working order.

Library.

Considerable additions have been made to the Library during the year, the most important of which consists of the large and valuable collection of works on Crustacea belonging to the late C. Spence Bate, Esq., F.R.S., which have been presented by Captain McGuire Bate. Among other valuable donations are the following:

	Presented by
Bull. and Mem. Mus. Comp. Zool., Harvard College	Prof. Agassiz.
Proc. and Phil. Trans., Royal Society of London	The Society.
Mem. Roy. Acad. of Copenhagen	The Academy.
Bull. and Rep. United States Fish Commission	The Commission.
Journ. Royal Microscopical Society	The Society.
Results of the Norwegian North Atlantic Expedition	The Commission.
Quarterly Journal of Microscopical Science	Messrs. Churchill.
Mittheil. Zool. Station in Neapel	Dr. Anton Dohrn.
Bull. Scientifique de France et de la Belgique	Prof. Giard.
Mittheil. deutscher Fischerei-Verein	The Society.
Notarisia	Dr. Moreños.
Ber. Kommission wissensch. Untersuch. deutschen Meere	The Commission.
Proc. and Bull. United States National Museum	The Museum.
Tijdschrift Nederlandsche Dierkund. Vereeniging	The Society.
Journal of the Linnæan Society	The Society.
Bergens Museum Aarsberetning	The Museum.
Journal of the College of Science, Tokyo	The College.
Trans. Royal Society of Edinburgh	The Society.

The Council beg to tender the thanks of the Association to the donors of these and of many other publications.

The Staff.

At the end of July last Mr. G. C. Bourne tendered his resignation of the post of Director of the Laboratory to the Emergency Committee, and Dr. G. H. Fowler was appointed *ad interim* Director for the summer months. At a special meeting held on November 14th Mr. W. L. Calderwood was appointed to succeed Mr. Bourne, and entered on his duties on November 29th. The Director's Assistant, Mr. Walter Garstang, M.A., resigned in December last to take up a Research Fellowship at the Owens College, Manchester; and Mr. Calderwood has appointed Mr. H. N. Dickson, F.R.M.S., F.R.S.E., in his place. Mr. F. Hughes, of the Finsbury Technical College, has been recently appointed to carry out an inquiry from the chemical side into the possibility of manufacturing an artificial bait for long-line fishing. The funds for this purpose have been provided by the generosity of Mr. Robert Bayly, of Plymouth.

The following gentlemen have occupied tables in the Laboratory during the past year for the prosecution of their private researches, some of them on more than one occasion:— *Occupation of Tables for private research.*

Mr. W. B. Benham, D.Sc. (*Polychæta*).
Mr. Hans Driesch, Ph.D. (Heliotropism in *Hydroidea*).
Mr. G. H. Fowler, B.A., Ph.D. (Variation in *Isopoda*).
Mr. W. Garstang, M.A. (*Ascidiacea*).
Prof. T. Johnson, B.Sc. (*Algæ*).
Mr. E. A. Minchin, B.A. (*Porifera* and *Gregarinida*).
Mr. T. H. Riches, B.A. (*Pagurida*).
Mr. W. G. Ridewood (*Clupeidæ*).
Mr. W. W. Welch (General Zoology).
Prof. W. F. R. Weldon, M.A., F.R.S. (*Decapoda*).
Mr. M. F. Woodward (*Mollusca*).

The first volume of the new series of the Journal of the Association has been completed. The quarto Treatise on the Common Sole by Mr. Cunningham, the Naturalist of the Association, was published in October last. *Publication.*

Prof. E. Van Beneden, of Liège, has recently published a memoir on specimens of the interesting larval Anthozoan, *Arachnactis*, which had been collected at Plymouth by the Director, and forwarded to Prof. Van Beneden at his request (Archives de Biologie, xi, p. 115).

The most important investigations in connection with fisheries are those carried out by Mr. Cunningham. A point to which he has lately paid considerable attention is the rearing of post-larval forms in the aquarium. This research, when taken in conjunction with observations made by trawling, is yielding valuable information on the rate of growth and the age at which sexual maturity is attained. Information on these points is a necessary preliminary to the serious consideration of any such prohibitory legislation as has lately been demanded. Mr. Cunningham is also continuing his inquiries into the localities frequented by immature fish in the Plymouth area. *Fishery investigations.*

A series of careful experiments into the suitability of the river Yealm for purposes of oyster-farming were made during 1890 by Mr. Bourne and Dr. Fowler; and a report embodying their results and recommending its employment for such purposes has been furnished to Lord Revelstoke, the lessee of the river.

Further experiments on the rearing of larval lobsters, with the view of keeping them in safety through the first moults, instead of turning them free in the sea at what appears to be their most helpless phase, have been carried out under the superintendence of Prof. Weldon; the difficulties in the way being apparently the provision of adequate space and of an appropriate food. As regards the question of space, it is most desirable that, for the purposes of rearing both lobsters and fish, the Association should form an enclosed pond within reach of Plymouth; but the peculiar features of the coast render it extremely difficult to find a site which can be made available except at considerable cost.

Dr. Grenfell, the Medical Superintendent of the Mission to Deep Sea Fishermen, has consented to extend the observations which he has already taken in the North Sea so as to include points bearing on the proposed closure of certain extra-territorial waters to beam-trawlers, which was discussed at the International Conference of 1890; he has been furnished with thermometric and other apparatus, and with printed forms for the systematic record of the numbers and sizes of fish taken on the various grounds.

The same reasons which make it difficult to find a suitable site for a rearing pond for young fry in the neighbourhood of Plymouth have hitherto prevented the establishment of a pond for growing immature soles, &c., to a marketable size. The Director has lately paid attention to the matter, but no place combining the numerous requirements for success has been as yet found within an accessible distance of Plymouth.

So many anchovies were brought to the Laboratory in the course of last winter, in consequence of a price having been offered for them by the Association, that the Council has authorised the construction of an anchovy drift-net on the most approved model at a cost of about £60. The fish ordinarily caught appear to be exceptional specimens, large enough to be taken in a pilchard net, and it is expected that, by the use of the special net, the occurrence of anchovies in sufficient numbers to justify a regular fishery will be demonstrated.

Among other extensions of the work of the Association during 1891, it may be mentioned that a series of systematic physical observations will in future be carried out by Mr. Dickson, which may be brought to bear on various questions connected with fisheries.

The usual hatching and breeding experiments have been continued.

Finance. The receipts of the past year including the annual grants from H. M. Treasury (£500), and from the Worshipful Company of Fishmongers (£400) amount to £1925 5*s.*; the annual subscriptions and composition fees produced £273 9*s.*, the interest on investments £35, the rent of tables £85, the sale of specimens £148 17*s.* 11*d.*, the charge for admission to the aquarium (since February 11th, 1891) £30.

A comparison of the chief items with the corresponding amounts of last year

	1889–90.		1890–91.
Annual Subscriptions and Composition Fees	£143 13 0	...	£273 9 0
Founders' Subscriptions . . .	300 0 0	...	100 0 0
Rent of Tables and Sale of Specimens .	185 5 0	...	240 19 11

shows an increase in the subscriptions of Annual and Life Members, and also points to an increased use of the Laboratory by the public both for original investigation and for the obtaining of material for teaching purposes. On the other hand only one Founders' subscription has been received during the year.

The Council are glad to be able to announce that in addition to the £500 annually granted (during a period of five years) to the Association by H.M. Government, a further sum of £500 has been placed on the estimates for the current financial year.

Mr. J. P. Thomasson, M.P., has generously offered the sum of £250 for expenses incurred in carrying out observations bearing on the closure of certain extra-territorial waters to beam-trawlers by international convention. It is proposed to take advantage of his offer immediately.

The Council have recently taken steps to bring the claims of the Laboratory and its work under the notice of the Technical Education Committees of the County Councils of the South Coast of England.

The Officers and Vice-Presidents proposed by the Council for the year 1891–92 are:

PRESIDENT.

Prof. E. Ray Lankester, LL.D., F.R.S.

VICE-PRESIDENTS.

The Duke of Argyll, K.G., F.R.S.
The Duke of Sutherland, K.G.
The Duke of Abercorn, C.B.
The Earl of St. Germans.
The Earl of Morley.
The Earl of Ducie, F.R.S.
Lord Walsingham, F.R.S.
Lord Revelstoke.
The Right Hon. A. J. Balfour, M.P., F.R.S.
The Right Hon. Joseph Chamberlain, M.P.
Prof. G. J. Allman, F.R.S.
Sir Edward Birkbeck, Bart., M.P.
Prof. Flower, C.B., F.R.S.
Sir John Lubbock, Bart., M.P., F.R.S.
Prof. Alfred Newton, F.R.S.
Sir Henry Thompson.
Rev. Canon Norman, D.C.L., F.R.S.
Captain Wharton, R.N., F.R.S.

J. P. Thomasson, Esq.

COUNCIL.

Elected Members.

Prof. F. Jeffrey Bell, F.Z.S.
Frank Crisp, Esq., V.P. and Treas. Linn. Soc.
W. T. Thiselton Dyer, Esq., C.M.G., F.R.S.
John Evans, Esq., D.C.L., Treas. R.S.
Prof. J. C. Ewart, M.D.
A. C. L. G. Günther, Esq., F.R.S.
Prof. A. C. Haddon, M.A.
E. B. Poulton, Esq., F.R.S.
P. L. Sclater, Esq., F.R.S., Sec. Z.S.
Adam Sedgwick, Esq., F.R.S.
Prof. Charles Stewart, P.L.S.
Prof. W. F. R. Weldon, F.R.S.

Hon. Treasurer.

E. L. Beckwith, Esq.

Hon. Secretary.

G. Herbert Fowler, Esq., B.A., Ph.D.

June 24th, 1891.

Dr. *Statement of Receipts and Payments for Year ending* 31*st May*, 1891. Cr.

Receipts.	£	s.	d.	£	s.	d.
To Balance from last year, made up as follows:						
Special Fund, Bait Investigation	387	9	9			
„ Steam Launch	90	4	0			
	477	13	9			
Less Deficit on General Account	204	10	10			
				273	2	11
To H. M. Treasury				500	0	0
„ Fishmongers' Company				400	0	0
„ Donation, J. P. Thomasson, Esq.				250	0	0
„ Annual Subscriptions				211	4	0
„ Founders				100	0	0
„ Composition Fees..................................				62	5	0
„ Rent of Tables, Sales of Journal, Specimens, &c..	240	19	11			
„ Sales of Monograph on the Sole..............	96	1	6			
„ Admission to Tank Room	29	12	7			
„ Interest on Investment	35	2	0			
				401	16	0
				£2198	7	11

Payments.	£	s.	d.	£	s.	d.
By Salaries and Wages:						
Director	200	0	0			
Naturalist	250	0	0			
Wages and Salaries of Assistants, &c....	384	14	0			
				834	14	0
By Stationery, Office Printing, Postage, &c. ...				162	9	1
„ Printing and Illustrating Journal...........				114	4	3
„ Printing and Illustrating Monograph on the Sole				282	10	8
„ Gas, Water, Coal, Oil, &c.	116	6	5			
„ Stocking Tanks with Fish, Feeding and Maintenance	89	2	5			
„ Glass, Chemicals, Apparatus, &c.	135	3	5			
„ Maintenance and General Repairs...........	105	7	11			
„ Rates and Taxes	34	3	9			
„ Boat Hire	49	4	8			
„ Travelling Expenses	32	2	7			
„ Library	25	6	7			
„ Lecture Fund	7	5	5			
				594	13	2
By Balance forward, made up as follows:						
Special Fund, Bait Investigation	387	9	9			
„ Steam Launch	90	4	0			
	477	13	9			
Less Deficit on General Account	267	17	0			
				209	16	9
				£2198	7	11

Examined and found correct,

C. Stewart,
P. L. Sclater,
Edwin Waterhouse, } *Auditors.*

22nd June, 1891.

Investment held 31st May, 1891:
£900 Forth Bridge Railway 4% Debenture Stock at 125...£1125 0 0

Annual General Meeting, 1891.

The Annual General Meeting of the Association was held in the rooms of the Royal Society on Wednesday, June 24th, 1891, the President, Prof. E. Ray Lankester, LL.D., F.R.S., in the Chair.

The minutes of the last General Meeting having been read and confirmed, the Report of the Council was read, and was adopted on the proposal of Admiral Sir Erasmus Ommanney, C.B., F.R.S., seconded by Dr. S. J. Hickson.

The Report of the Hon. Treasurer, and the Balance Sheet were also adopted on the proposal of John Evans, Esq., D.C.L., Treas. R. S., seconded by Prof. Weldon, F.R.S.

The Hon. Treasurer then moved a vote of thanks to the Rt. Hon. Joseph Chamberlain, for his valuable services to the Association during the past year, which was seconded by Prof. McIntosh, F.R.S., and carried unanimously.

The list of the Officers and Council suggested by the Council for the year 1891–92 having been proposed by Dr. S. J. Hickson, and carried, Prof. Flower, C.B., F.R.S., moved a vote of thanks to Mr. J. P. Thomasson for his offer of £250 for expenses to be incurred in carrying out observations in the North Sea, which was seconded by the Hon. Treasurer, and carried unanimously.

The proceedings concluded with a vote of thanks to the Officers and Council, proposed by Prof. M'Intosh, and supported by Admiral Sir Erasmus Ommanney.

Director's Report.

During the summer months the tables of the Laboratory were well occupied; the following is a list of the workers, together with the subjects studied:

Garstang, W. . .	Tunicates.
Buchanan, Miss . .	Polychætes.
Stewart, A. H. . .	Holothurians.
Gamble, F. W. . .	Eyes of Mollusca.
Weldon, W. F. R. .	Crangon.
Robinson, Miss . .	Palæmon.
Ritches, J. H. . .	Pagurus and Hormiphora.
Willey, A. . .	Tunicates.
Hughes, W. J. . .	General Natural History.
Hamel, E. de . .	General Natural History.
Hickson, S. J. . .	Alcyonium.

The weather has been extremely unfavorable for carrying on continuous and systematic dredging; nevertheless the boats of the Laboratory have been constantly employed on every suitable day, and a considerable amount of material has been collected.

The preservation of specimens has been much more carefully attended to than formerly. One man now devotes almost his entire time to this work. This is necessary, since it is only by constant practice in the treating and handling of delicate specimens that really satisfactory results can be attained. Our trade in specimens is now becoming extensive, and it is therefore highly desirable, both for the credit of the establishment and for its purse, that the material supplied should be prepared with the utmost care.

Mr. Cunningham continues his valuable observations on the rate of growth of food fishes, also on their life histories and spawning periods. Papers by him will be found in the present number treating on these subjects.

Experiments on the production of artificial baits are also being continued by Mr. Hughes. He has also been making some interesting experiments as to the presence of fat in the flesh of fishes, particularly those fishes which are prepared for the market by drying.

A meteorological station of the second order has been established, where observations are taken twice daily. This, in addition to the ordinary physical work of the Laboratory, is under the supervision of Mr. Dickson.

The presence of anchovies in considerable numbers in the waters of the Channel has from time to time been taken notice of ;* and now, in order to demonstrate as far as possible the actual numbers, and the possibility or otherwise of instituting a regular anchovy fishery, a fleet of small-meshed nets has been specially constructed. Owing to the very boisterous weather we have only been able to shoot the nets three times, and as yet have not been successful in coming upon anchovies.

Arrangements for a still larger Fishery Investigation have been made. The Association has determined to make a thorough examination into the actual condition of the North Sea Trawling Grounds, the International Conference of July, 1890, having abundantly proved that reliable data were required before any legislation could, with confidence, be expected; and at the same time that international legislation was demanded on all sides, owing to the general outcry that the grounds are over-fished, and that large quantities of sexually immature fish are constantly being captured or destroyed. Mr. Holt, at present engaged in Irish Fishery duties, has been specially appointed to carry on this work during the ensuing year. I shall not at present enter into a detailed statement as to how it is proposed to investigate the question, but shall probably, in the next number of the Journal, give an account of the lines on which the work has actually been begun. I have already made the various headings in the scheme of work public, by including them in a general paper on the work of the Association read to the Biological Section of the British Association this year.

I need only add that the general work of the staff continues steadily ; that we have hatched both flat-fish and lobsters in considerable numbers in the Dannevig hatching-box, of which I spoke in my last report ; that many interesting animals have been obtained—some of which are described in this number of the Journal ; and that we hope to continue to increase our knowledge, both in regard to matters scientific, and in the more practical questions connected with the fishing industries of the United Kingdom.

W. L. Calderwood.

* Journal Marine Biological Assoc., vol. i (N.S.), p. 328.

The Egg and Larva of Callionymus lyra.

By

J. T. Cunningham, M.A.

With Plate V.

The egg of this species has been described and discussed by Professors McIntosh and Prince, by Mr. E. W. L. Holt, and by myself.* Raffaele, in his paper in the Mittheilungen of the Naples Station, vol. viii, described the yolk in the ovum of *Callionymus festivus* as having a peripheral layer of yolk-segments, but no reticulated marking on the surface of the vitelline membrane; while all we English observers have agreed in stating that the egg of *Callionymus lyra*, our common dragonet, has a reticulated marking on the vitelline membrane, but no yolk-segments. I was, therefore, very much surprised, in examining some eggs of this species from the tow-net this year, to find that there actually was a peripheral layer of yolk-segments, which had hitherto been overlooked.

Raffaele states that in *Callionymus festivus*, the Mediterranean species, the yolk-segments extend all round the yolk from the beginning, before it has been enveloped by the blastoderm. Whether this is correct in *C. festivus* or not, it does not apply to *C. lyra*. In the ovum shown in Pl. V, fig. 1, which was taken in the tow-net on May 14th, 1891, the blastoderm has spread over about one third of the circumference of the yolk, and the layer of yolk-segments extends beneath the blastoderm and somewhat beyond it, but is absent from the opposite pole of the yolk. An egg of the same species at a later stage, in which the yolk is completely enveloped, and Kupffer's vesicle has appeared beneath the posterior end of the embryo, is shown in fig. 2, and it will be seen that at this stage the external subdivided layer extends over the whole of the yolk. Thus the layer of yolk-segments in the egg of *C. lyra* is at first confined to

* See Ann. and Mag. Nat. Hist., Dec., 1885; Memoir by McIntosh and Prince in Trans. Roy. Soc. Edinb., vol. xxxv, pt. 3, 1890; my paper in this Journal, vol. i, p. 21; Mr. Holt's Memoir in Sci. Trans. Roy. Dublin Soc., vol. iv, ser. 2, No. 7.

the part of the yolk beneath the blastoderm, and accompanies the latter in its gradual extension, just as in the eggs of *Solea* and in other cases where the peripheral yolk-segments occur.

There can, I think, be no doubt about the identification of the eggs I refer to. I have never found in the egg of any other species anything resembling the hexagonal reticulation in the membrane of the egg of the dragonet. The size of the eggs described here was ·81 and ·83 mm. in diameter, while those described in my former paper measured ·90 and ·97, a variation not greater than that which occurs among the eggs of a given species.

Mr. Holt (loc. cit.) has given figures of the larval dragonet when just hatched, and about twelve hours after hatching. I am able now to give a figure of a later stage. The larva depicted in fig. 3 was drawn on May 14th, and hatched from an egg taken on May 6th, so that it was probably five or six days old. The yolk is entirely absorbed, but the larva retains some of the characteristics mentioned by Holt. There are marginal pigment spots on the embryonic fin-fold, but they are more numerous than in the stage figured by Holt; while there is no band across the tail, but pigment over nearly the whole of the post-anal portion of the body. The pectoral fin is large. The snout has still a somewhat pointed form, but the region of the mid-brain is much more prominent than in Holt's stage. Holt speaks of only one pigment, a bright orange, dark by transmitted light, and I gather from his description that in the stages he examined he saw no black chromatophores. I think this must be a mistake; in any case there are, as usual, both black and coloured chromatophores in the stage I am describing, the coloured cells being light yellow by reflected light and darker yellow by transmitted. The length of the larva was 4·7 mm.

DESCRIPTION OF PLATE V,

Illustrating Mr. Cunningham's paper on "The Egg and Larva of *Callionymus lyra*."

FIG. 1.—Egg of *Callionymus lyra*, taken May 14th, 1891. Zeiss A, Oc. 3. Under cover-glass, drawn with Abbé's camera lucida.

bl. **Blastoderm.**

y. s. **Yolk-segments.**

FIG. 2.—Another egg at a later stage of development. Drawn with the same combination, without cover-glass.

k. v. **Kupffer's vesicle.**

y. s. **Yolk-segments.**

FIG. 3.—Larva of same species some days after hatching. Drawn May 14th, 1891. iss a_2, Oc. 3, camera.

Plate V.

Fig. 1.

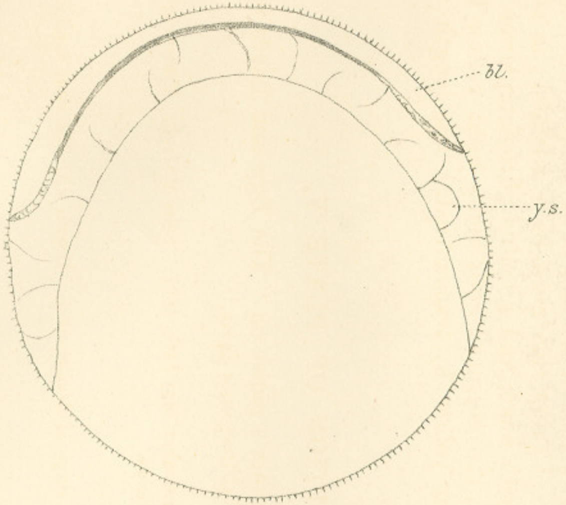


Fig. 2.

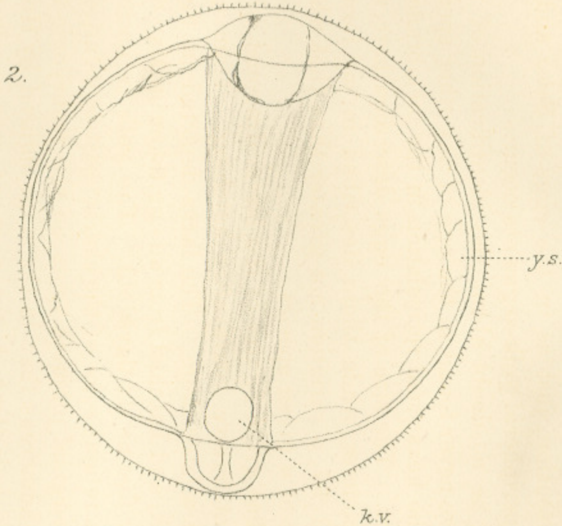
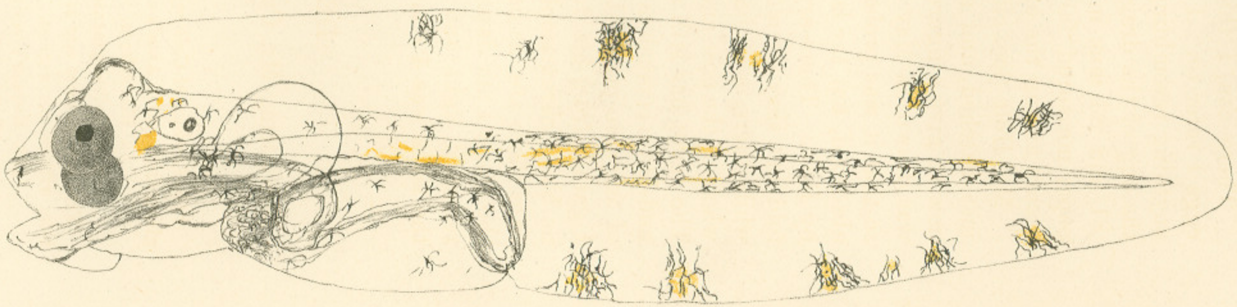


Fig. 3.



J. T. Cunningham del.

F. Huth, Lithr. Edinr.

Experiments on the Production of Artificial Baits.

By

Frank Hughes.

It may be well to preface the paper on the *Production of Artificial Baits* by a short statement as to the way in which the experiments were taken up by Mr. Hughes.

Members of the Association are of course aware that, through the kindness of Mr. Bayly, of Torr Grove, Plymouth, a special fund was instituted for the purpose of finding out, first of all, what it was in the bait that attracted fish, and, secondly, how the attracting matter could artificially be extracted, and applied to easily procured substances ; or manufactured altogether afresh.

The papers of Mr. Bateson, published in the Journal, vol. i, No. 3, discussed, at considerable length, the manner in which fish sought their food by the action of their various senses. This work formed a logical basis for the whole inquiry of artificial bait, besides proving of great scientific value.

The question has now been taken up from a chemical point of view, and practical results sought after. This preliminary paper by Mr. Hughes—a chemist from Prof. Meldola's Laboratory—shows generally the methods he has employed in trying to produce an artificial bait from natural sources.

When several preparations had been made, a long line was set somewhere in the neighbourhood of Plymouth, the hooks being baited, not only with the newly prepared substances, but with natural baits as well, so that a proper estimate might be formed by comparison.

Briefly, it may be said, that no bait has yet been discovered which appears to act as an irrestible lure to the fishes, but at the same time a considerable amount of success has been met with, and if the difficulty of finding a proper medium with which to convey the attracting smell could only be got over the problem would practically be solved.—W. L. CALDERWOOD, *Director*.

In a previous number of the Journal Mr. Bateson has shown that the majority of the fishes which are caught by the long lines are attracted to their food entirely by smell, and it has been suggested that if the odorous material could be extracted from the bait and preserved, it would be possible to keep a supply of such bait in hand, and so be more or less independent of the supply of natural bait, which is at all times very uncertain. My first experiments were mainly in this direction, to extract and preserve the odorous matter from the bait, and in this I have been to some extent successful.

Various solvents were employed for extracting. The volatile ones, such as ether and chloroform, were used in an extracting apparatus, while in other cases the bait, &c., was cut into small pieces and soaked in the liquid at as high a temperature as could be employed without destroying the scent. This temperature appears to be about 50° C. Ether extracts from almost all kinds of bait an oil, varying greatly in quantity; from squid and mollusca; generally this amount is extremely small and on this account quite useless, although it has in some cases attractive properties. Pilchards and mackerel give a relatively large amount of extract, owing to their oily nature; but although these are to some extent attractive, they do not appear to contain anything like the total amount of odorous matter present in the animal. *Nereis* and *Arenicola* (as worm baits) give ethereal extracts which are attractive to some fish—turbot, rockling, pouting, &c., but the conger is not attracted by them. Chloroform extracts nothing from mollusca, and in no case was an extract having attractive properties prepared with this solvent. Olive oil and fats do not take up the scent from any of the baits mentioned. Distillation of the baits in water, or in a current of steam, only gives a smell of cooked fish, which is utterly unattractive.

Besides extracts of the baits usually employed, I have also prepared some from coarse fish; from the intestines, livers &c., of ling, and hake, and from the hermit crabs; but have not succeeded in obtaining anything at all attractive, and I believe that, if any efficient extract is to be prepared, it must be from squid, mackerel, or pilchard. The most attractive extracts are those prepared with glycerine, but they have the disadvantage that the solvent cannot be recovered or got rid of; but, on the other hand, they can be kept for any length of time if some boracic or salicylic acid be dissolved in the glycerine.

When a sufficiently attractive extract is obtained, however, it does not necessarily follow that it is of any use as a bait, since there is a great difficulty in applying anything in a liquid form. To do this, some substance is needed which will soak up enough extract to retain its odour for a sufficient time in the water, and yet be soft enough to allow of the fish getting hooked. Various substances have been tried for this purpose. Pieces of flannel and bags of buttercloth filled with pulp or cotton-wool, were soaked in the extracts, but these do not retain their smell more than a few minutes. To obviate this, I tried to thicken the extracts with gelatine, but this appears to precipitate the odorous substances, and the smell is destroyed. Slices of turnip, filled with the extract under reduced pressure, were also tried; but in this case a strong vegetable odour was developed, which rendered the substance useless. Gelatine appears at first to be just the substance required, but in order to mix the extract with the gelatine heat must be applied, and this completely destroys the smell of the extracts.

Since liquid extracts appeared to be so difficult to use as bait, I tried making a kind of mash of the bait, adding small quantities of boracic acid and glycerine, to prevent decomposition. These mixtures remain unchanged for a considerable length of time, and retain their attractive properties.

Mackerel and squid treated in this manner were most attractive to the conger in the tanks of the Laboratory, but I have not caught any fish with them from the sea, although some of the bags containing the mixtures have been sucked off the hooks. Conger will also eat pastes made with flour and these mashes; but these are of no use for fishing, as they do not remain on the hooks for a sufficient length of time. If one may judge from experiments in the Aquarium, as soon as a bait reaches the bottom it is seized by the crabs, and if it is not sufficiently tough, is pulled off the hook before the fish have time to get the scent. For this reason the medium for applying an extract, or, in fact, almost any kind of preparation must be exceedingly strong, and not easily pulled to pieces. If anything of this nature can be prepared, the application of extracts will become easy, and the whole question will be very much simplified.

I have not made any experiments with essential oils, since Mr. Bourne, when at Plymouth, tried several of these, and found that none were in any way attractive; it seems improbable that fish would be attracted by anything of that nature, since, in the natural course of events, they would never meet with such bodies.

Preserving bait by freezing has also been tried, and was moderately successful. A number of squid were cleaned and placed in an air-tight jar, a small quantity of dry boracic acid, being sprinkled over them ; this jar was then surrounded with a mixture of ice and salt, so that the temperature did not rise above 28° F. At the end of about a fortnight the jar was opened, and the water which had accumulated at the bottom poured out ; the jar was again closed and kept for three weeks in ice ; the squid was then of a pink colour, but was quite fresh, and fifty hooks baited with it caught four conger, while fifty with natural bait caught only one conger and two pollack. This shows conclusively that squid can be kept for a considerable time in a frozen condition, and, if this process could be carried out on a larger scale, with refrigerating apparatus, the expense need not be very great. I intend to try if pilchards can be preserved in a similar way. This has been attempted, but the temperature was allowed to rise too high, and decomposition occurred.

The Rate of Growth of some Sea Fishes and their Distribution at Different Ages.

By

J. T. Cunningham, M.A.

Dr. Wemyss Fulton has made an extensive investigation of the distribution of immature sea fishes, and has published his results in the Report of the Scottish Fishery Board for the year 1889. He had at his disposal a sea-going vessel specially adapted to fishery investigations, and his data were obtained exclusively by means of this vessel. As scientific Secretary to the Board Dr. Fulton is attached to the Office in Edinburgh, and the observations he required were made and recorded according to his directions by the naturalists on the Board's steamer "Garland." The conception and the execution of this investigation are both admirable, and it has supplied a great deal of definite knowledge upon subjects of great importance on which previously we knew little or nothing. The enquiry consisted in determining firstly, from the examination of a large number of specimens, the minimum and maximum size of sexually ripe specimens of each species; and secondly, the relative abundance of specimens smaller than this minimum size at various depths and various distance from shore.

The enquiries described in the present paper are to some extent similar to Dr. Fulton's, but in the main they are different both in object and in method. My first object was as far as possible to ascertain something of the rate of growth of sea-fishes of various species. With this purpose, I have searched for young specimens in all possible ways, and have measured and preserved all I could meet with. Some have been taken with the shrimp-trawl worked from our little steam-launch in Plymouth Sound and the neighbouring bays, some in the tow-net. I have also collected specimens from the deep-sea trawl of the professional trawlers, and from the hauls of ground seines. During the summer of the present year, I have been authorised to hire steamers in order to collect in deep water at some distance from land, and have trawled at various depths with the shrimp-trawl and a small-meshed otter-trawl, and have also worked a large tow-net, 8 feet by 6 feet in area at the mouth, at various distances from the coast. Knowing the spawning time of each species I have been able to determine the age of the young specimens collected in a number of cases with more or less certainty. Often there is no doubt as to the age within a month or so of young specimens of the same year's brood, and it is often possible to say that small fish which are too large to be derived from the last spawning period, for instance those collected at the spawning period itself or a little later, must be a year old or a little over. But it is difficult in this way to ascertain the maximum growth for one year, since a number of specimens of one species often form a continuous series in size, and it becomes difficult or impossible to say where those of one year old end and those of two years begin.

In order to get more certainty on the question, I have been rearing specimens of known age of as many species as possible in the tanks of the aquarium. The first results of these experiments were published in this Journal, vol. i, p. 370. Many of the flounders and other fish mentioned there are still alive. It is, of course, a question in the case of each species how far the growth of specimens in captivity is normal, whether it exceeds or falls short of the growth of those living in the free state. This question can only be answered by comparing the size of captive specimens with that of young specimens collected from the sea at various times of the year.

I have recorded the place of capture as well as the size of the specimens collected, and am able therefore in some cases to confirm and in others to add to the results obtained by Dr. Fulton. In a few cases I have had opportunities of determining the minimum size of ripe specimens with results which sometimes differ from Dr. Fulton's, a difference doubtless due in part to the difference of the districts in which our observations have been made.

Another subject I have discussed is the relation between age and sexual maturity. It is not at present known whether flat fishes for instance begin to breed at one year of age or at two, or whether some breed at one year and others at two according to the size they reach in the time. Some species again may have a more uniform growth than others, and all breed at the end of their first year, while other species do not breed till a later age.

I have given below, in tabular form, the details I have collected up to the present time concerning the several species. The majority of the species considered, belong to the families Pleuronectidæ and Gadidæ, and I have more data referring to the flat fishes than to any other species. With the exception of *Caranx trachurus* all the species included in this paper are trawl-fishes. Each table is followed by a short commentary, and at the end of the paper I have summarised and compared together the results brought out by the tables.

Pleuronectes flesus, the Flounder. Specimens reared in the Aquarium.

Date.	Number of specimens.	Length in centimetres.	Length in inches.	Age.	Remarks.
May, 7, 1890	200—300	1·15—1·2	$\frac{1}{2}$	About 1 month to 2 months	Obtained in Mevagissey Harbour at low tide.
Aug. 19, 1890	2	6·7—8·0	2·6—3·2	4 to 5 months	Only two measured.
April 4, 1891	18	4·0—16·3	1·6—6·0	1 year	Kept in a tank 5 ft. by $2\frac{1}{2}$ ft. and 1 ft. 6 in. deep.
"	20	5·0—17·4	2·0—6·9	1 year	Kept in another tank of the same size.
"	13	5·5—19·0	2·2—$7\frac{1}{2}$	1 year	Kept the latter part of the time in a tank 18 ft. by $3\frac{1}{2}$ ft., by 2 ft. deep. The smallest weighed $\frac{1}{4}$ oz., the largest $3\frac{3}{8}$ oz.
Sept. 1, 1891	3	17·8—20·8	7·0—8·2	1 year 6 months	Kept in a tank 2 ft. by 1 ft. in area, and died from an accident to the water.

The above table gives the growth actually observed in a large number of specimens kept in captivity and abundantly supplied with food. The most striking feature of the result is the very great variation in growth among these individuals, spawned at the same season, and therefore not differing by more than a few weeks in age. Whether there is as much variation under natural conditions is a question that immediately suggests itself. It is evident there is considerable variation in the rate of growth in nature, from the difficulty of distinguishing in a large number of fish those of one year's, two years', and three years' growth. It is not difficult to recognise with certainty young fish only a few weeks or months old; but the individuals of a given species brought up in numbers at a single haul of the great beam-trawl form usually a regular series of sizes, so that it is difficult if not impossible to separate definitely those which are one year old from those which are two, and those which are two years from those which are three.

Another point of interest is the relation of age to sexual maturity. According to Dr. Fulton's investigations, the smallest ripe flounder is 7 inches long. Now some, namely two out of fifty-one specimens, of my captive flounders had reached and passed this limit of size in one year's growth. But these specimens were not ripe, and the proportion of specimens of this size is so small, that I think it may fairly be concluded that the flounder does not breed at the end of its first year. Of course, it is possible that the largest specimens one year old breed, while the smaller are still sexually immature; but the evidence of my captive specimens is against this. It seems probable, therefore, that the flounder does not begin to breed until it is two years old, when its length would probably be from 7 to 9 or 10 inches. The largest flounder observed by Dr. Fulton was 16½ inches long. The increase in length per annum must of course diminish with every year of age, even if the rate of increase in weight were to remain uniform, simply because the weight is proportional to the cubic dimensions of the fish, and probably the rate of increase in weight also diminishes with age. Therefore, a flounder from 12 to 16 inches in length is in all probability at least three years old and may be many more.

Pleuronectes flesus, the Flounder. Specimens obtained from the Sea.

Date.	Number of specimens.	Length in centimetres.	Length in inches.	Calculated age.	Locality and remarks.
May 7, 1890	200—300	1·15—1·2	½ inch	About 1 to 2 months	Mevagissey Harbour.
May 31, 1889	A number	1·1—1·9	½—¾	2 to 3 months	„ „
June 15, 1889	„	1·2—2·8	½—1·1	2½ to 3½ months	„ „
April 8, 1891	6	14·2—19·0	5·6—7·5	1 year	Taken by seine in Catwater.
Oct. 15, 1890	3	18·1—21·3	7·1—8·4	1 year 7 months	Taken by seine in Hamoaze.
	2	26·2—27·0	10·3—10·6	2 years 7 months	„ „

The data here are very insufficient, and I hope to add largely to their number in future. But I think it is evident that the flounders taken on April 8th, 1891, in the Cattewater, were just over one year old, and had grown to about the same size as the larger among the specimens kept in our tanks. It seems, therefore, that the growth of this species observed in captivity does not differ very much from that of specimens living in freedom. Whether in a state of nature specimens ever reach such a small size in one year as the smallest of my captive specimens I am as yet unable to say. But it must be remembered that the competition for food in a small tank containing a large number of specimens is very great, so that individuals which possess a little superiority in size and activity to start with, probably increase that superiority continually by seizing the greater part of the food before the smaller ones can get it. No doubt there is competition in the natural state, but at any rate the individuals on the sea bottom have a much greater area to wander over.

With regard to distribution it is noteworthy that I have taken no flounders under 7 inches long except in the estuaries of Cattewater and the Hamoaze, although I have seen numbers of ripe flounders brought up in the trawl on the ground inside the Eddystone from a depth of 25 to 28 fathoms. Dr. Fulton also failed to find any small flounders in the results of the Garland's fishing at various depths and distances from the shore with a small-meshed trawl. It seems pretty certain that the flounder in its immature state is confined to inlets and especially estuaries, where the water is more or less brackish. It certainly spawns in the open sea up to depths of 30 fathoms; but even adults are found far up such estuaries as the Firth of Forth, and the Cattewater at Plymouth.

Pleuronectes platessa, the Plaice.

Date of collection.	Number of specimens.	Length in centimetres.	Length in inches.	Calculated age.	Locality and remarks.
June 13, 1889	1	5·1	2·0	4 months	Whitsand Bay, 5 to 7 fathoms. Shrimp trawl.
June 17, 1889	39	3·5—5·9	1·4—2·3	3 or 4 months	" "
Sept. 28, 1889	1	6·3	2·5	6 months	Sutton Pool.
Feb. 13, 1889	2	8·0, 8·3	3·1, 3·3	1 year	Cattewater.
Feb. 26, 1889	1	9·4	3·7	1 year	Entrance of Cattewater.
Feb. 27, 1889	1	8·9	3·5	1 year	Cawsand Bay, 3 to 5 fathoms.
May 16, 1889	10	11·2—17·7	4·4—7·0	1 year and 3 months	Cattewater, in small seine.
May 24, 1889	1	15·5	6·1	"	Cattewater.
Sept. 18, 1891	1	20·7	8·2	1 year and 7 months	5 to 8 miles S. of Eddystone, 35 fathoms.
Oct. 15, 1890	7	19·5—24·8	7·7—9·8	1 year and 8 months	Hamoaze, in small seine.
Dec. 10, 1889	1	22·4	8·8	1 year and 10 months	Cattewater.
April 19, 1891	2	25	9·8	2 years	Professional trawler, E. of Eddystone, 30 fathoms.
Sept. 8, 1891	1	22·2	8·7	1 year and 7 months	S.W. of Rame Head, 25 fathoms, otter-trawl.
"	6	27·5—31·5	10·8—12·4	2 years and 7 months	S.W. of Rame Head, 25 fathoms, otter-trawl.

It may seem that I have estimated the age of the specimens in the last entry of the table too highly, but it must be remembered that the plaice reaches by no means so large a size on the south-west coast of England as it does on the east coast. In fact, in the neighbourhood of Plymouth the plaice is not very much larger than the flounder. Dr. Fulton gives the maximum size of the plaice as

28 inches, but I think 20 inches is about the maximum at Plymouth, and the usual size is 15 to 18 inches. I do not think, therefore, that this species could reach 12 inches in less than two years. My observations fully agree with those of Dr. Fulton in regard to the distribution of young plaice, all those I have obtained under 9 inches having come from Whitsand Bay, 3 to 7 fathoms, or from the estuaries opening into Plymouth Sound. The smallest ripe plaice I have seen was 25 c.m. or 9·8 inches long, and this was a male, while Dr. Fulton finds the lowest limit in size of mature individuals to be 12 inches. This again illustrates the difference with respect to this species between the south coast and the east coast.

From my results and Dr. Fulton's together I think there is very strong evidence that the plaice does not begin to breed till it is two years old (and over 8 inches long on the south coast), that for the first eighteen months of its life it resides in estuaries and inlets under 10 fathoms in depth, and that it only migrates to deeper water when it is nearly two years old, shortly before it begins to breed for the first time.

Pleuronectes limanda, the Dab.

Date.	Number of specimens.	Length in centimetres.	Length in inches.	Calculated age.	Locality and remarks.
June 14, 1890	1	1·05	0·4	About 3 months	Cawsand Bay, 3 to 5 fms.
June 17, 1889	11	3—3·4	1·2—1·4	,,	Whitsand Bay, 5 to 7 fms.
June 25, 1889	7	1·7—3·2	0·7—1·3	,,	Cawsand Bay.
July 9, 1891	2	1·6—1·7	0·6—0·7	,,	Two miles N. of Eddystone, fine meshed shrimp trawl.
Sept. 4, 1890	8	3·3—5·1	1·3—2	About 6 months	W. of Rame Head, 20 fms.
Oct. 3, 1889	1	3·6	1·4	About 7 months	Cawsand Bay.
Dec. 10, 1889	5	5·7—11	2·2—4·3	About 9 months	Cattewater.
Feb. 13, 1890	7	2·6—9·5	1—3·7	About 11 months	Cattewater.
Feb. 27, 1890	2	5·7, 6·1	2·2, 2·4	,,	Cawsand Bay.
Apr. 3, 1891	8	5·7—12·6	2·2—5	About 13 months	Cattewater. With these was 1 specimen 17·2 cm., probably 2 years old.
Apr. 30, 1891	5	5·0—6·0	2—2·4	,,	Plymouth Sound.
May 10, 1889	18	4·7—9·1	1·8—3·6	About 14 months	Cattewater.
May 8	2	7·9	3·1	,,	Cawsand Bay.
May 6, 1889	2	7·9	3·1	,,	Whitsand Bay.
Apr. 19, 1891	3	11·5—13·5	4·5—5·3	About 1 year	Large trawl, E. of Eddystone. Unripe males.
,,	6	14·4—18·3	5·7—7·2	Probably 2 years	Ripe Males.
,,	2	17·0—18·8	6·7, 7·4	,,	Females, 1 ripe, 1 nearly so.
Aug. 20, 1891	25	11·6—14	4·7—5·5	Probably 1 year and 5 months	Trawler, 5 miles S. of Eddystone
,,	22	14—16	5·5—6·3		
,,	30	16—18	6·3—7·1		
,,	36	18—20	7·1—7·9		
,,	5	20—22	7·9—8·7	Probably 2 years and 5 months	,, ,,
,,	2	22—24	8·7—9·5		
Dec. 10, 1889	5	14—18·5	5·5—7·3	1 year 9 months	Cattewater. Weight of the largest 2 oz. 6 drms.
Sept. 18, 1891	49	12·5—19·	4·9—7·5	1 year 6 mos.	From 2 trawlers working 5 to 8 miles S. of Eddystone.
,,	48	19—26	7·5—10·2	2 years 6 mos.	

According to Dr. Fulton the smallest ripe dab was 5½ inches long, and the maximum specimen observed 14 inches long. The smallest ripe specimen seen by me was a male 5·7 inches in length; the smallest ripe female I have seen was 6·7 inches. The dab spawns in March and April, and in reckoning the ages in the above table I have counted from the month of March. It is certain that the ages given in the above table up to the entry for May 6th, 1889, are correct, and we see, from the sizes of those taken in the summer and autumn, the growth of the fish spawned the same year, while those taken between Christmas and May must be derived from the brood of the previous year, even the smallest taken in May, 1·8 inches, being too large to be attributed to the spawning of the same spring. Thus we find that a dab just over a year old may be as small as 1·8 inches in length; a conclusion not surprising in view of the fact that some of the flounders reared in captivity were only 1·6 inches at the same age. The maximum growth exhibited by this species in a year is more difficult to determine, but considering the case of the flounder we need have no doubt that the specimens 5 inches long, taken on April 3rd, were only just over a year old. Some specimens may very likely reach a greater size than this in the same time. The maximum observed in the flounder was 7½ inches, and as the adult flounder is 2 inches longer than the adult dab, we may provisionally conclude that 5½ inches is about the maximum length reached by a dab in one year. Thus we see that the minimum size, compatible with reproduction, may be reached or slightly surpassed at the end of the first year, but it is certain that the great majority of dabs at one year old are below that size. And it is not certain that those which are large enough to breed at the end of one year, do actually breed then. On the other hand the great majority of even the smallest ripe specimens are of a size that in all probability is not reached by any individuals in less than two years.

If we examine the entries of specimens obtained from the professional trawlers, we get some interesting results. In the first place we find that the smallest specimens captured are about 4½ inches long. The breadth corresponding to this length is little over 1½ inches. The meshes of the great beam-trawl, as used at Plymouth, are 4 inches square at the mouth, diminishing to 1½ inches square at the cod end. Thus there is a close correspondence between the size of the mesh at the cod end and the smallest fish caught.

We may roughly estimate the growth of the dab in successive years as follows:

1st year	2 to 6 inches.
2nd "	5 to 8 "
3rd "	7 to 10 "
Maximum length	14 "

Distribution.—The above records show that although the young dabs under one year old, and 6 inches in length, are common everywhere in shallow water, penetrating even to the estuaries such as the Cattewater, where the greatest depths is only 3 fathoms, they are also taken out near the Eddystone at a depth of about 30 fathoms. In the latter region I took two specimens ·6 and ·7 inches long in July. These were taken in a shrimp trawl lined with mosquito-netting, having a mesh of about ¼ inch. The professional trawlers do not, however, catch specimens of the first year, because their mesh is too large. These conclusions as to the distribution are in complete agreement with those of Dr. Fulton.

Pleuronectes microcephalus, the Lemon Sole, or Merry Sole.

Date.	Number of specimens.	Length in centimetres.	Length in inches.	Calculated age.	Locality and remarks.
Nov. 4, 1890	4	15·5—17·5	6·1—6·9	1 year 5 months	Firth of Forth; sent me by Dr. Fulton.
Aug. 20, 1891	5	16·8—20·1	6·6—7·9	1 year 4 months	4 or 5 miles S. of Eddystone, from professional trawler.
April 19, 1891	5	16·3—23·6	6·4—9·3	2 years	East of Eddystone, professional trawler. All ripe males.

The above data are all I have hitherto been able to collect concerning this species. The lemon sole spawns in May and June off the Firth of Forth, and in April and May off Plymouth. It is manifestly impossible that the young should reach a length of over 6 inches between May and November, since the adult lemon sole is but little larger than the adult flounder, and its growth not likely to be more rapid. Therefore the specimens taken in the Firth of Forth in November, and at Plymouth in August, are probably in their second year. As to the age of those taken in April, they might have reached the size of 6 inches in a year, but could scarcely have reached 9·3 inches in that time. If the lemon sole can become mature in one year some of these may have been one year old, and the larger ones two years.

It is noticeable that lemon soles only 6·4 inches long are sexually mature at Plymouth, while the smallest observed by Dr. Fulton to be ripe were 8½ inches long.

Hitherto, lemon soles, less than one year old, have not been obtained by me either in shallow or in deep water. Dr. Fulton obtained three specimens 2 inches in length in March and May, in about 20 fathoms. This shows that the growth is not more rapid than that of the flounder, since these specimens were ten to twelve months old.

Solea vulgaris, the Sole.

Date of collection.	Number of specimens.	Length in centimetres.	Length in inches.	Calculated age.	Locality and remarks.
May 15, 1889	15	1·2—1·5	0·5—0·6	About 1 month	Mavagissey Harbour, between tide-marks.
„ 10, 1889	3	16·8—19·5	6·6—7·7	1 year	Cattewater, taken in shrimp trawl.
„ 9, 1889	1	17·6	6·9	„	Under Citadel, shrimp trawl
June 17, 1889	1	19·8	7·8	1 year and 2 or 3 months	Whitsand Bay, 3 to 5 fathoms.
July 27, 1889	4	13·1—19·7	5·2—7·8	1 year and 3 or 4 months	Malpas, Falmouth River.
Sept. 19, 1890	2	16·0, 16·2	6·3, 6·4	1 year and 6 mos.	Cattewater, seine.
April 19, 1891	1	24·0	9·5	2 years	Large trawl, E. of Eddystone.

Most of these data were given in my "Treatise on the Common Sole," but I have slightly modified my interpretation of them. The specimens taken in the Sound up to 19·7 cm. in length I formerly considered to be two years old, but my observations on the flounder in captivity show that some soles probably reach this length at the beginning of their second year.

Solea lascaris, the French Sole, or Sand Sole.

Date of collection.	Number of specimens.	Length in centimetres.	Length in inches.	Calculated age.	Locality and remarks.
Sept. 28, 1889	1	9·0	3·5	4 months	Whitsand Bay, about 5 fathoms.
March, 1890	1	5·0	2·0	10 months	Off Falmouth, collected by Mr. Vallentin.
June 17, 1889	3	17·2—19·2	6·8—7·6	1 year	Whitsand Bay, 5 to 7 fathoms.

This species is not common, and it is therefore difficult to get more than an occasional specimen; the size of the adult is about the same as that of the common sole, and the above estimated ages are based on comparison with that of my captive flounders.

Solea lutea, the Little Sole.

Date of collection.	Number of specimens.	Length in centimetres.	Length in inches.	Calculated age.	Locality and remarks.
June 25, 1890	1	5	2	1 year	Cawsand Bay, 3 to 5 fathoms, shrimp trawl.
Sept. 21, 1891	7	7·4—8·5	2·9—3·4	1 year 3 months	Cawsand Bay, shrimp trawl.
„ 8, 1891	1	11·5	4·5	2 years 3 months	S.W. of Rame Head, 20 fathoms.
„ 3, 1891	2	10·8, 11·6	4·3, 4·5	„	„
Nov. 26, 1889	1	11·9	4·7	2 years 5 months	Cawsand Bay.

According to Dr. Fulton, this species spawns when it is 3¾ inches long, a length which seems to me to be reached at the end of two years. The fish rarely exceeds 5 inches in length, and specimens nearly as large as this occur occasionally in the shallow water of Cawsand Bay. But the adults are more commonly found farther from shore at depths up to 30 fathoms.

Solea variegata, the Thickback.

Date of collection.	Number of specimens.	Length in centimetres.	Length in inches.	Calculated age.	Locality and remarks.
July 9, 1891	2	4·5, 4·6	1·8	3 months	2 miles N. of Eddystone. Trawl of mosquito-netting.
Sept. 8, 1891	1	12·7	5	1 year and 5 months	Off Whitsand Bay, 20 fathoms.
Dec. 9, 1889	1	10·1	4	1 year and 8 months	Near Eddystone, from trawler.
Aug. 20, 1891	2	14·5, 15·2	5·7, 6·3	2 years and 4 months	5 miles S. of Eddystone, from trawler.

As this is a small species the maximum length observed by me being 21.5 cm., or 8½ inches, its growth is probably proportional; the spawning takes place in April and May. It will be observed that the only specimens under 2 inches long were obtained in deep water six miles from land.

I will take this opportunity of recording some observations I made on the relations of the sexes to one another in size and number in this species. On April 19th, 1889, on board a Plymouth trawling smack, I examined a large number of thickbacks taken in two or three hauls of the trawl. The result was as follows:

Number of males 34.—Largest measured 19·2 cm. long. Middle-sized specimen 17·0 cm.

Number of females 179.—Largest measured 21·5 cm. long. Middle-sized specimen 19·3 cm.

Thus the females in this species are both larger and more numerous than the males, as was found to be the case by Dr. Fulton in many other species of flat fishes. The proportion between the sexes is 526 females to 100 males, or one male to five females nearly. The ratio of females to males is even higher than this, according to Dr. Fulton, in the long rough dab, *Hippoglossoides limandoides.*

Rhombus maximus, the Turbot.

Date of collection.	Number of specimens.	Length in centimetres.	Length in inches.	Calculated age.	Locality and remarks.
Aug., year ?	6	2·4—3·8	·95—1·5	About 1 month	Collected at surface in Mevagissey Harbour by Mr. Dunn.
Aug. 11, 1888	1	3·7	1·45	„	At surface in Plymouth Sound.
Sept. 1, 1891	3	1·5—2	·6—·8	About 3 weeks	Surface at wharf, Cattewater.
Sept. 4, 1891	9	1·5—2·5	·6—1·0	3 weeks to 1 month	Surface at West Hoe Pier, Plymouth Sound.
Sept. 8, 1891	1	2·5	1·0	About 1 month	Tow-net surface, S.W. of Mewstone, about 4 miles from Plymouth Breakwater.
June 17, 1889	3	23—34	9—12	11 months	Whitsand Bay, 3 to 5 fathoms.

It will be seen from the above that the young turbot in process of metamorphosis, and swimming horizontally at the surface, occur at Plymouth and the neighbourhood in August and the beginning of September, while the brill at the same stage occur in May and June. It is thus evident that the turbot spawns later than the brill. I have estimated the age of these specimens about an inch long at one month, though they may be a little more. The spawning period, therefore, occurs in June and July. Wenckebach, in Holland, found turbot ripe in July.

I have no stages between the pelagic stage just mentioned and the small turbot, of 9 to 12 inches, obtained in Whitsand Bay in June, 1889. This year, although I have several times trawled in Whitsand Bay, I have obtained no specimens of this species. At present I see no reason to suppose that the specimens of 9 to 12 inches were more than one year old; it is certain that they were not less, as the spawning takes place in June and July. The largest turbot recorded by Dr. Fulton was 28 inches long, and the smallest mature was 18 inches long. It is probable that a turbot 2 feet in length is at least four years old.

Rhombus lævis, the Brill.

Date of collection.	Number of specimens.	Length in centimetres.	Length in inches.	Calculated age.	Locality and remarks.
June 4, 1889	1	2·5	1·0	About 1 month	Surface off Lambhay Point, at entrance of Cattewater.
May 21, 1890	20	2·2—2·5	·85—1·0	3 wks. to 1 month	Sutton Pool, Plymouth.
June 11, 1890	14	"	"	"	Ditto.
Sept. 30, 1890	1	18·5	7·2	1 year 4 months	Seine at Cremyll, Plymouth Sound.
Specimens reared in the Aquarium.					
May 21, 1890 / June 11, 1890	34	2·2—2·5	·85—1·0	3 wks. to 1 month	
Oct. 4, 1890	1	8·5	3·45	6 months	
" 18, 1890	4	7·0—9·8	2·8—3·9	"	
April 3, 1891	2	8·4—8·8	3·3—3·7	11—12 months	

The young brill occur floating at the surface in May and June, at which stage they are in process of metamorphosis, swimming in a slanting or horizontal position, and provided with a large air bladder. They cannot well be less than three weeks old at this stage, and the eggs must, therefore, be shed in April and May. Raffaele believes that at Naples the eggs are shed in February and March, and one would naturally expect the spawning period to be earlier in the Mediterranean.

According to the results observed in the specimens reared in captivity, the growth would seem to be very slow, not exceeding 4 inches in twelve months; but it will be seen from the table that this length was almost reached in six months, so that scarcely any increase in size took place after the first six months. It is probable, therefore, that the growth of my captive specimens was abnormally checked. In nature, these fish feed chiefly on living fish of other species, and I was unable to provide such food for my captive specimens, but fed them on marine worms. On the other hand, I think it unlikely that the specimen obtained in the sea September 30th, 1890, could have reached its length of 7·2 inches in five months, and, therefore, I have considered it to be more than one year old. The adult brill is from 18 inches to 2 feet long, the latter being the maximum length observed. If 7 to 8 inches is the average growth in one year, the growth of the brill would appear to be slower in proportion to its size than that of the flounder, and it would probably take four years to reach a length of 18 inches. Additional data are needed, but I have found it difficult to find specimens of two to twelve months old in the sea. The species is much less common than the plaice, flounder, or dab, and even the adults are only taken sparingly by the professional trawlers.

Arnoglossus laterna, the Scald-back.

Date of collection.	Number of specimens.	Length in centimetres.	Length in inches.	Calculated age.	Locality and remarks.
Oct. 3, 1889	2	2·8—3·4	1·1—1·4	4 or 5 months	Cawsand Bay, shrimp trawl.
Feb. 9, 1888	11	4·5—6·3	1·8—2·5	8 or 9 months	Cawsand Bay, 3 to 5 fathoms.
May 8, 1889	1	4·7	1·9	11 months	Cawsand Bay.
Feb. 9, 1888	5	9·3—11·5	3·7—4·4	1 year and 8 months	Cawsand Bay.
Sept. 4, 1890	8	8·5—12	3·4—4·7	1 year and 3 months	W. of Rame Head, 20 fathoms.
Sept. 3, 1891	19	8·8—13·2	3·5—5·2	,,	3 miles N. of Eddystone, 25 to 30 fathoms.
,,	35	8·8—13·8	3·5—5·4	,,	Off Plymouth Sound, 20 fathoms.
Sept. 8, 1891	77	7·8—12·6	3·1—5	,,	Off Mewstone and Whitsand Bay, 23 to 27 fathoms.
Sept. 12, 1891	13	8—12	3·15—4·7	,,	8 to 10 miles S. of Eddystone, 36 to 38 fathoms.
Dec., 1889	43	14·7—20·4	5·8—8	Over 2 years, adult and sexually mature	10 to 20 miles from shore off Plymouth, from professional trawler.

I do not know exactly the spawning period of this species, but believe it occurs in summer, in May and June; the ages in the above table have been reckoned from June. I have only obtained the very small specimens, less than one year old, in Cawsand Bay, at 3 to 5 fathoms depth, in the small shrimp trawl. In September of the current year I obtained large numbers of the species, 7 to 14 cm. long, in an otter trawl, both inside and outside the Eddystone, at depths varying from 20 to 38 fathoms. I think it is impossible that these should be derived from this year's spawning, since small specimens, less than 4 cm. long, and evidently a few months old, were taken in Cawsand Bay in October. It follows, therefore, that the specimens taken in September, 7 to 14 cm. long, are in their second year. The adult condition in this species is distinctly marked in the male sex by the sudden elongation of the anterior dorsal fin-rays which occurs when sexual maturity is reached, and which I have observed only in specimens over 14 cm. in length. The largest specimens I have seen were 20·4 cm. long. I have only obtained the adults from the deep sea trawlers, and they were taken at some distance from the coast. There seems, therefore, to be a regular distribution of the different stages, those of the first year occurring in shallow sandy bays, of 3 to 5 fathoms in depth; those of the second year occurring from shallow water to a depth of 36 fathoms, but being especially abundant between 20 and 30 fathoms;

while the adults occur principally beyond the 30 fathoms line. The adult condition and sexual maturity is not reached till the end of the second year.

Gadus merlangus, the Whiting.

Date of collection.	Number of specimens.	Length in centimetres.	Length in inches.	Calculated age.	Locality and remarks.
June 13, 1889	2	5·7	2·2	3 or 4 months	Whitsand Bay, 3 to 5 fathoms; small meshed trawl.
July 16, 1891	13	5·4—9·0	2·1—3·5	4 or 5 months	2 miles S. of Eddystone; large tow net, 8 feet by 6 ft. at mouth; 11 specimens at 15 fathoms from surface, 2 at 6 fathoms. These were all the whiting caught.

The second entry shows that the young whiting, from eggs spawned the previous spring, occur not only in shallow bays close to the bottom, but also at some distance from land in mid-water. The whiting at Plymouth spawns in February and March. I think there can be no doubt that these whiting were under six months old, and were hatched in the previous March, and that they were not in their second year. Dr. Fulton describes the occurrence of a great shoal of young whitings, from 2 to 5 inches in length, in September; these young fish were so numerous that over 3000 were taken at a single haul of an 18 foot beam-trawl. Dr. Fulton seems unable to account for the origin of this shoal, apparently rejecting the obvious idea that the fish comprising it were hatched the previous spring. He says the whiting spawns in March, April, May, and June, and that a pelagic specimen, 1 inch long, has been captured by the tow-net in September, by Prof. McIntosh. Now, according to my own experience, the whiting spawns in the Firth of Forth and neighbouring sea, principally in April, and young fish hatched in April cannot be only 1 inch long in September, when five months old. I think the various observations I have here brought together with regard to other species show, conclusively, that the whiting mentioned by Dr. Fulton, from 2 to 5 inches in length in September, were hatched in the preceding April and May.

Gadus pollachius, the Pollack.

Date of collection.	Number of specimens.	Length in centimetres.	Length in inches.	Calculated age.	Locality and remarks.
Apr. 3, 1890	22	2—2·4	·8—·95	3 to 6 weeks	Taken with hand-net in Mevagissey Harbour.
Oct. 2, 1890	10	9·7—11·2	3·8—4·4	7 months	Taken in cheesecloth trawl, Cawsand Bay, 3 to 5 fathoms.
Dec. 4, 1889	4	9·3—11·8	3·7—4·7	9 months	Taken from the dry dock at Millbay when the dock was emptied.

I have not myself made any observations on the spawning of the pollack, but there can be no doubt that it spawns early in the year, in February and March. It may also be assumed that the ova are pelagic and buoyant. The few data given in the table are not sufficient to show the rate of growth with certainty, but I think they may be trusted as far as they go. It may be inferred that 7 inches is about the maximum growth for one year. The pollack caught in Plymouth Sound in June and July are 12 to 15 inches in length. These are, I believe, over two years old. The fish grows to more than 2 feet in length. I have no evidence to show whether it begins to breed when only one year old or not. The pollack is a coast fish, and its young seem always to be found in shallow water, in bays and inlets, and in the neighbourhood of rocks and piers. It is seldom, though occasionally, taken in the trawl, as it feeds mostly in mid-water, not on the bottom, and usually occurs in the neighbourhood of rocks and weeds.

Gadus luscus, the Pout or Bib.

Date of collection.	Number of specimens.	Length in centimetres.	Length in inches.	Calculated age.	Locality and remarks.
June 17, 1889	11	6·4—7·7	2·5—3·0	3 months	Whitsand Bay, 3 to 5 fathoms; small-meshed trawl at night.
Sept. 5, 1890	1	11·7	4·6	6 months	Cawsand Bay; shrimp trawl.
Oct. 2, 1890	2	10·7—13·0	4·2—5·1	7 months	Ditto.
June 17, 1889	1	12·5	4·9	1 year 2 months	Whitsand Bay; small-meshed trawl.

This species grows to about 1 foot in length, and we may judge from the last entry in the table that its size at the end of the first year is 5 to 6 inches. In June it is 2 to 3 inches in length, and at this stage I have taken it, though sparingly, in shallow water in Whitsand Bay. Specimens in their second summer, just over one year old, are abundant in June and July in Plymouth Sound and elsewhere along the coast in shallow water, and are taken in numbers by hook and line. Specimens of the same age and about 6 inches long are also taken by the deep-sea trawlers in depths up to 30 fathoms. I have as yet, however, made only the above records.

Gadus minutus, the Poor Cod.

Date of collection.	Number of specimens.	Length in centimetres.	Length in inches.	Calculated age.	Locality and remarks.
May 28, 1890	12	2·8—4·3	1·1—1·7	8—12 weeks	Shrimp trawl, in Catwater.
June 17, 1889	218	4·2—7·2	1·6—2·9	About 3 months	Small-meshed trawl, in Whitsand Bay, 5 to 7 fathoms, at night.
July 9, 1891	6	11·5—16·2	4·5—6·4	1 year 3 months	Taken in shrimp trawl, 2 miles north of Eddystone, 27 fathoms.
April 19, 1891	7	14·3—19·0	5·6—7·5	2 years	The smallest specimens taken by a professional trawler to the east of Eddystone, 30 fathoms.
June 17, 1889	2	13·7—15·0	5·4—5·8	1 year 2 months	Small meshed trawl, Whitsand Bay, 5 to 7 fathoms, at night.
	1	20·0	7·8	2 years 2 months	

The observations on this species are very inadequate, but they supply some definite facts. The occurrence of more than two hundred specimens less than 3 inches long in Whitsand Bay, undoubtedly from ova shed the preceding spring, shows that the young frequent shallow water and sandy ground. It is also clear that the specimens, 4·5 to 6·4 inches, obtained on July 9th, near the Eddystone, were in their second year. I have not ascertained at what size the species begins to breed. But specimens of 4 to 6 inches, and just over a year old, were caught in the Sound and placed in our tanks in the summer of 1889, and were breeding there in March, 1890. I am pretty sure this was their first time of breeding. I am not quite sure as to the size attained in two years, but as the rate of growth in length decreases gradually, I think those of April 19th, 1891, in the table, must have been two years old. The poor cod never exceeds 9 inches in length.

Zeus faber, the Dory.

Date of collection.	Number of specimens.	Length in centimetres.	Length in inches.	Calculated age.	Locality and remarks.
Oct. 3, 1889	1	4·3	1·7	About 3 months	Cawsand Bay, 3 to 5 fathoms; shrimp trawl.
June 3, 1889	3	12·5—14·1	4·9—5·5	11 months	3 miles from Rame Head, 20 fathoms; small-meshed trawl.
Aug. 20, 1891	7	13·5—15·6	5·3—6·1	1 year and 1 month	5 miles S. of Eddystone; professional trawler.
Sept. 8, 1891	2	17·2, 17·5	6·8, 6·9	1 year and 2 months	Whitsand Bay, 5 fathoms; otter trawl.
„	1	16·6	6·5	„	S.W. of Rame Head, 20 fathoms; otter trawl.
Sept. 18, 1891	5	14—18·5	5·5—7·3	„	5 to 8 miles S. of Eddystone; professional trawler.
Apr. 21, 1891	1	24·5	9·6	1 year and 10 months	S.E. of Eddystone, 35 fathoms; professional trawler.
Sept. 3, 1891	1	28·2	11·1	2 years and 2 months	S. of Rame Head, 25 fathoms; otter trawl.

Although the above table includes but a small number of specimens, I believe that it represents with considerable certainty the growth of the dory. I do not know exactly when the dory spawns, but I have examined the adults in spring and found the ovaries ripening, and in autumn have found them shotten, so that I conclude the spawning takes place about June and July. In the table I have reckoned the ages from July. It will be seen that specimens from 5 to a little over 7 inches in length are fairly common in August and September, and since young specimens of 1 to 2 inches in length occur in autumn, it is evident that the former are just over one year old, while the latter are derived from eggs shed in the preceding summer. The last specimen in the table is, I think, too large to be only one year old, and I therefore judge it to be in its third year. The largest dory mentioned by Day was 22½ inches long, but the usual size is from 15 to 18 inches, which is probably not reached in less than three years.

Motella mustela, the Five-bearded Rockling.

In this Journal, vol. i, p. 372, I mentioned some specimens of this species kept in the Aquarium from May to August, 1890. All except one of these were placed in a large tank and have not been seen again, but the remaining specimen was measured alive on May 19th, 1891, when just over a year old, and found to be 13·0 cm., or 5·1 inches long. Measured again on September 21st, it was exactly the same length. In the tank with it were several vigorous flounders, and probably this was the reason that it had not grown, the flounders having seized all the food put in the tank. But numbers of this species, 5 to 7 inches in length, occur under rocks, between tide-marks, in summer, which are obviously at the commencement of their second year. This species reaches 18 in. in length, and does not change colour when adult. My young specimen, like the adult, is a dark rich brown on the sides, black on the back, white on the ventral surface.

Motella tricirrata, the Three-bearded Rockling.

On June 20th of the present year I went out for a fishing trip in a mackerel boat, and when we got as far as the Mewstone it fell dead calm, and remained so for some hours. The surface of the sea was covered with great quantities of *Noctiluca miliaris,* here and there collected in patches and streaks into a thick scum of a salmon-pink colour. Darting about at the surface were numerous small active fishes, of which I secured a great number, and found on examining them ashore that they were the young of *Motella tricirrata,* the three-bearded rockling. These young fish were swimming at the very surface of the water, causing it to ripple by their motion. Fishermen at Plymouth call all such young fish "britt," not distinguishing one species from another. The older naturalists described this young form as a distinct species, and Couch calls it the mackerel-midge.

Among my specimens there are three stages to be distinguished, which pass gradually into one another. The oldest stage is from 2·5 to 3·2 cm. long (1 to 1·3 inch), and is closely similar to the adult, except that the sides are brilliantly silvery, which is not the case in the adult. In this stage the fins are all similar to those of the adult, the pelvic reaching only half way to the anus. The youngest stage is under 1 cm. in length, and the skin is almost transparent, the silvery opacity commencing to develop in the largest specimens. There are pigment cells, especially on the back. The fin-rays have only recently begun to develop and are not complete at their distal ends ; the anterior dorsal fin is not visible, but the principal peculiarity is the pelvic fins, which are comparatively long, extending beyond the anus, and having a dense black colour over their outer halves. The second stage is intermediate between these in all respects : it is from 1 to 2·5 cm. in length, and in the different specimens in this stage can be traced the development of the silvery layer in the skin, and of the anterior dorsal fin, and the gradual reduction of the pelvic fin. A specimen of the young

Motella in the second of the stages above mentioned, is described and figured in my paper in this Journal, vol. i, p. 47.

Caranx trachurus—the Scad, or Horse-mackerel.

This is a pelagic species frequently taken in mackerel nets. Its young are also pelagic, and I have taken them in the tow-net in August and September. In August, 1888, one 5·4 cm. (2·1 inches) was taken three or four miles off Loae. On September 8th this year I took two, 2·4 and 3·5 cm. long, to the south-west of the Mewstone; and on September 12th, one 2·5 cm. long, about five miles south of the Mewstone.

Comparisons and Conclusions.

1. *Flat fishes.*—If we consider first the species of the genus *Pleuronectes* alone we find some curious and interesting differences. We find that the flounder and plaice when immature, that is under 7 and 9 inches respectively in length, and less than two years old, are almost entirely absent beyond the 20 fathom line. The young of these two species are abundant in the estuaries of Cattewater and the Hamoaze. In June, 1889, I found plaice 1 to 3 inches long, spawned the previous spring, in abundance in Whitsand Bay, which is not an inlet, but a bay open to the sea; but during the present summer, I have trawled there several times in July and September and found no young plaice at all. On the other hand, the dab (*Pl. limanda*), even under one inch in length and only three months old, occurs, though not abundantly, near the 30 fathom line, a little inside the Eddystone. It is much more abundant at this age in Cawsand and Whitsand Bays, at depths of 3 to 7 fathoms. Up to 5 inches in length it is common in the Cattewater, where also larger specimens are not uncommon. The trawlers working off Plymouth between 20 and 40 fathoms bring up numbers of small flat fishes, but, with very few exceptions, these are all dabs or scald-backs, *Arnoglossus laterna.* The smallest dabs I have obtained from the trawlers were 4½ inches long, a length which may be reached by some individuals at one year of age. Thus, although specimens of less size and age than this are not uncommon at depths of 10 to 30 or 40 fathoms, the great beam trawl does not catch them because its meshes are too large. I have not kept records of the small scald-backs brought up by the great beam trawl, though when studying other subjects on board trawlers I have seen numbers of them brought up. During the present summer, however, when fishing

with an otter-trawl myself, on purpose to obtain young fish, I have obtained large numbers of this species from 3 to 5 inches in length. I find that specimens of this size are between one and two years in age, are not sexually mature, and are distributed at all depths from 3 to 40 fathoms.

Pleuronectes microcephalus, the merry-sole, is the only other species of the genus usually met with near Plymouth. There is no doubt that the young, under 6 inches long, and less than one year old, are entirely absent from shallow water, under 10 fathoms, and from inlets and estuaries. No destruction of the young of this species can be effected by shrimp, or seine, or bag-net fishing in territorial waters. As far as my observations go, the professional deep-sea trawler does not capture the young of this species under 6 inches, but on this point I have collected very few data up to the present time. It is, however, certain that the species belongs to rather deep water; it is scarce at less than 30 fathoms, and abundant at greater depths. I have not yet obtained any specimens under 6 inches long, but Dr. Fulton obtained three specimens, 2 inches long, at about 20 fathoms. I have not met with any such specimens in my numerous hauls with small-meshed trawls this summer inside the Eddystone. I am inclined to think that most of the young of this species, when they go to the bottom, remain in deep water beyond the 30 fathom line.

I have not yet found young soles between ½ inch and 6 inches in length, although I have specially searched for them at various depths up to 35 fathoms. My evidence concerning this species is similar to that concerning the brill and turbot; in all three cases I have found the very young forms only a few weeks old close to the shore in harbours and inlets, and have taken other specimens much larger and about one year old in territorial waters within the 10 fathom line.

With regard to the age of sexual maturity, I have proved that a large number of individuals do not reach the minimum size of mature specimens at the end of one year, and that it is quite probable that all flat fishes normally breed for the first time when two years old.

2. *Other species.*—It will be seen that the young of all the species of Gadus mentioned above, namely the whiting, pollack, pout, and poor-cod, for the first six months of their existence are found close to the shore, the fry of the pollack and poor-cod seeking harbours and estuaries, and being seen in numbers swimming about near piers and wharves. When about one year old, these kinds of fish are found in abundance at depths of 5 to 30 or more fathoms. The pollack haunts rocky shores all its life, and only very large

specimens, 12 inches to 2 feet long, are occasionally taken in the great trawls, but of the other species many one-year-old individuals are destroyed by them. It is remarkable also how commonly one-year-old dorys are taken in the deep-sea trawls.

Practical Considerations.

A great deal of work remains to be done before we obtain an adequate knowledge of the life-histories of our valuable sea fishes. I hope to continue my own observations in various directions, and in future to add largely to the data recorded above. But in the meantime the question of the harm done to our sea fisheries by the destruction of under-sized or immature fish is constantly being agitated, and cannot be too carefully considered. Our national statistics show that our best sea fish are getting scarcer. It seems at first sight the irony of fate that the finest fish such as sole, turbot, brill, and dory should be scarce, while inferior kinds such as dabs are plentiful, and worthless kinds such as scald-fish and dog-fish are still more abundant. The case of the sole is difficult to explain. It feeds on worms chiefly as do the plaice and flounder, yet it is by no means so plentiful as the plaice. One might be tempted to maintain that the sole is really no better intrinsically than the plaice, but only valued more because it is dearer. But a moment's consideration of the difference between the flesh of the two is enough to dispel such an idea. In the case of the turbot, brill, and dory, however, there is a reason why they are relatively scarce. These fishes, compared with many other kinds, are as the Carnivora to the Herbivora on land. They feed exclusively on other fishes. They are fishes of prey, and must, therefore, as in the case of other Carnivora, exist in smaller numbers than the fish they prey upon. Perhaps some day we shall also be able to understand why the sole is less abundant than the plaice.

But the practical question is how to prevent the decrease in the supply of fishes whatever their natural numerical proportions to one another, and one obvious precaution is to prevent as far as possible the destruction of the young. I will, therefore, here indicate the bearings which my observations at Plymouth have upon this practical question. Dr. Fulton, throughout the whole of his inquiry, has interpreted the term immature fish as meaning a fish not yet capable of reproduction. The fishermen of the east coast, who have been so strongly moved on the subject of immature fish, knew nothing and cared nothing about the size at which a fish of a certain kind began to breed. What they were thinking of was the fact that if all the small fish were caught there were none left to grow large, and consequently, as the large fish were more valuable per pound, their work became less remunerative. Dr. Fulton evidently thinks that a fish ought not to be destroyed before it has spawned at least once, and that if it is sexually mature there can be no harm in capturing it. Thus he would only preserve lemon soles (*Pl. microcephalus*) up to 8 inches, while the fishermen wanted to place the limit at 12 inches. Theoretically I am more in agreement with the fishermen on this point than with Dr. Fulton. It seems to me that the mere fact that a fish at a certain small size is capable of breeding, is not a reason for capturing it if its full-grown size is very much larger. Salmon parr in our rivers are sexually mature, at least the males are when only a few inches long, but their capture is prohibited nevertheless. If it were possible to limit the capture of each sea fish to those above a certain size, I think the limit should be determined by the size of the full-grown fish, and not by the size at which it begins to breed. At the same time the limit should not be fixed below the minimum size of sexually mature individuals.

However, it is not possible to fix a different limit of size for each species of fish captured by the deep-sea trawlers. The only differences in the smallest sizes caught with a given mesh will be due either to differences in the distribution of the young of the several species, or to differences in the shape of the fish. Thus a sole, 10 inches long, could escape through a mesh say 3 inches square, while a turbot, brill, or dory of the same length could not, because the latter three fish are so much broader than a sole in proportion to their length. All that is practically feasible in the case of the deep-sea trawl is to increase the size of the mesh so as to allow more small fish of whatever kind to escape.

The destruction of under-sized fish in the neighbourhood of Plymouth may be described under two heads : (1), that which is due to the deep-sea trawlers ; (2), that which is due to inshore fishing. The deep-sea trawlers capture large numbers of under-sized soles, lemon-soles, dorys, dabs, pout, whiting, and gurnard. The dabs are, perhaps, of no great importance, but the young pout and poor-cod (*G. luscus* and *G. minutus*) form an important part of the food of the turbot, as I know from examination of the stomachs of the latter. None of these young fish are of much value in the market. Some of them are sold separately, and the proceeds are by custom allowed to the crew as perquisites. If the mesh of the trawl were enlarged these small fish would not be caught. The mesh at the cod-end is now $1\frac{1}{2}$ inches square, and at the mouth, 4 inches. I believe that the mesh ought to be not less than 3 inches square at the cod-end, and I think that this change would have the additional advantage of allowing much of the useless material known here as "scruff" to escape. However, together with the scruff, on certain grounds large quantities of so-called queens (*Pecten opercularis*) are taken, and these are eaten to a considerable extent by the poorer people. These would probably not be caught by a 3-inch mesh, and their loss would have to be considered. I do not believe that it would be of much use to return to the sea the under-sized fish taken in the deep-sea trawl, leaving the mesh unaltered. It is true that most of the small fish are alive when brought on deck; they flap about and move when touched, but by the pressure of the great mass that the trawl contains, the violent concussions of this mass against the sides and bulwarks of the vessel, the sudden fall of the mass on deck when the end of the trawl is opened, and the trampling of the heavy boots of the crew as they handle the gear, the majority of the small fish are so much injured, especially in rough weather, that a great many of them would die sooner or later if thrown overboard.

The inshore fishing which destroys young fish consists principally of shrimp-trawling, fishing with small fish-trawls, and ground-seining. The shrimp trawls in Plymouth Sound take numerous small soles which ought not to be taken. This would be prevented if it were made illegal to keep them, because these fish are not in the least injured when brought up in the trawl. The ground-seines destroy large numbers of small plaice and flounders in the Cattewater and Hamoaze, but I have been informed by Mr. Henry Clark, who holds exclusive fishing rights in the upper part of the Cattewater, that fish of all kinds have grown very scarce there in recent years, probably, in his opinion, in consequence of the pollution of the estuary by manure and china-clay refuse. The ground-seines are used chiefly for the purpose of catching mullet and bass, and there would be no difficulty in compelling the fishermen who use them to return small flat fishes to the water, for these fishes are not injured in the process of capture by this method. The small fish trawls are worked by small sailing-boats in Whitsand Bay and Bigbury Bay. Their most valuable produce consists of small turbot and brill, and they take more under-sized fish of all kinds in proportion to the total catch than the deep-sea trawls. I think this kind of fishing should be prohibited altogether, at least in certain areas. The inshore bays should be strictly preserved as nurseries for young plaice, dorys, turbot, and other fish, which are at present captured in them. The Cornwall County Council has passed a bye-law prohibiting steam trawling in territorial waters within its district. It seems to me that this is a perfectly justifiable measure in relation to what it does, but not in relation to what it leaves undone. Small steamers, and tugs at times, when they are not employed in their proper work, are on many parts of the coast used for trawling in bays and inshore waters, and are very destructive on account of the ease with which they are handled. It is a good thing, therefore, that this kind of fishing should be prohibited, but it is inconsistent and unreasonable to allow sailing boats to do that which steamers are prohibited from doing.

On some Ascidians from the Isle of Wight:

A Study in Variation and Nomenclature.

By

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With Plates VI and VII.

Although the Isle of Wight has been a favourite haunt of the geologist and the palæontologist, references to its present marine fauna are exceedingly rare in zoological literature. Early in May of the present year, however, I had an opportunity, at the suggestion and through the kind hospitality of my friend Mr. Poulton, of examining the littoral fauna of the eastern shores of the island, and of making a considerable collection of zoological specimens. A list of the species which I obtained will be published as soon as I have had time to complete the examination of them; but several of the Ascidians throw so much light upon the brief and obscure descriptions of certain species, that I believe it will be serviceable to give a full account of them without further delay, especially since the pressure of other work may prevent an early appearance of the complete list.

I.

Ascidia mollis, *Alder and Hancock.*

Ascidia mollis, *Hancock.* Ann. Mag. Nat. Hist. (iv), vol. vi, 1870, pp. 358, 359.

I found eleven individuals of this species attached to rocks in the Zostera bed off Nodes Point, St. Helen's, at extreme low water, May 7th.

The short account of *A. mollis* given by Hancock is admirable as regards the description of the external features, but is insufficient in some points of internal structure. I am glad, therefore, to have an opportunity of re-describing this Ascidian. It appears to be a comparatively rare species, and I am not aware that it has been hitherto recorded from any other locality than the coast of Connemara, in the West of Ireland.

The *body* is ovate in form, thick, lobate, attached generally by the posterior half, sometimes by a larger area of the left side. When living, it is invariably of a rosy-flesh colour; and this colour, upon close examination, is seen to be due to a number of crimson dots (the culs-de-sac of the test-vessels) profusely scattered in the substance of the test.

The dimensions of the largest individual (Pl. VI, fig. 1) are as follows:

Maximum length (antero-posterior)	. .	$1\frac{1}{16}$ inch
,, breadth (dorso-ventral)	. .	$\frac{3}{4}$,,
,, thickness (right to left)	. .	$\frac{3}{8}$,,

The oral and cloacal *apertures* are on the right side of the body; the oral is sub-terminal, the cloacal half-way down and near the dorsal edge; both are small and inconspicuous. The position of the cloacal aperture varies very little in these specimens; in a few it is slightly posterior to the middle dorso-ventral line, but never so much so as to be two-thirds of the way down. No *ocelli* were observed around the apertures.

The *test* is, in Hancock's words, "firm, thick, semi-transparent, smooth and soft to the touch, rather shining, obtusely lobed, of a rosy flesh-colour, showing minute punctures and veinings of crimson." In its thick, smooth, firm, and shining character, the test of this species resembles that of *Phallusia mammillata*, a resemblance further borne out by the lobes of its surface, although these are much flatter and less protuberant in *Ascidia mollis*, than in the latter species. In its softness, however, the test of this species is very unlike that of *P. mammillata*.

Hancock states that the "terminal extremities" of the blood-vessels of the test are "more inflated and globular in this than in any other species." I have a distinct recollection of their pyriform character in the living animal, but their appearance in specimens after preservation in alcohol is very different; and they are seen to be elongated and finger-shaped, rather than inflated and globular (Pl. VI, fig. 2).

When the test has been removed from the rest of the body, the oral and cloacal *siphons* are seen to be short (Pl. VI, fig. 3). The *musculature* is, as usual, almost confined to the right side of the body; the fibres are long and delicate. Round each of the siphons a number of delicate fibres form a complete sphincter.

On the left side, the course of the intestine is visible through the body-wall. The *stomach* is rounded in form and is situated at some little distance (about one-fifth of the total body-length) from the posterior end of the body. The *intestine* is narrow and uniform; its first bend is well in front of the cloacal siphon, its anterior wall being on a level with the ganglion; the second bend of the intestine is behind the cloacal siphon, its posterior wall being on a level with the opening of the œsophagus into the pharynx; the rectum is directed obliquely forwards towards the cloaca.

Upon opening the pharynx from end to end, along the line of the endostyle, the remaining structures can be examined.

The *coronal tentacles* are forty or more in number. In an individual possessing forty tentacles, they were of three sizes and regularly arranged—ten long and slender primaries, ten intermediate secondaries, and twenty short tertiaries.

The *præbranchial zone* is studded with microscopic papillæ.

The aperture of the *dorsal tubercle* is crescentic in the smaller specimens, horse-shoe shaped in the individual represented in fig. 1, the horns not being incurved.

An *epipharyngeal groove* extends along one-third of the distance between the dorsal tubercle and the ganglion, which is situated half-way between the mouth and the cloacal aperture. The ganglion is small, three times as long as broad, and extends over three of the meshes of the pharyngeal wall, beginning at the fourteenth horizontal bar. The epipharyngeal groove becomes elevated towards it posterior end, and behind it commences the *dorsal lamina*, which is very narrow, strongly ribbed transversely, and pectinated at its margin. The ribs and teeth of the lamina correspond in number with the horizontal bars of the pharyngeal wall. Occasionally there are minute projections from the edge of the lamina which alternate with the teeth in position. The concave side of the lamina shows a series of weak ridges running towards its edge very obliquely from before backwards.

Branchial apparatus.—A portion of the inner face of the pharyngeal wall is shown on Pl. VI, fig. 4. The horizontal vessels form three complete series and a rudimentary growth. The primary vessels (*h. v.* 1), which give off branches* to the body-walls, are usually of greater diameter than those of the remaining series. Between each pair of primaries are situated one secondary vessel (*h. v.* 2), and two tertiary vessels (*h. v.* 3), at approximately equal distances.

Connecting ducts (*c. d.*) arise from all these vessels and support delicate internal longitudinal bars (*i. l. b.*) which are surmounted at the points of junction by moderately stout conical papillæ (*p.*) and at intermediate points by comparatively slender ones (*i. p.*). The

* The origin of these branches—the dermato-branchial connectives—is marked in some specimens by white spots upon the primary horizontal bars.

connecting ducts themselves are sub-triangular in shape when seen in profile. The horizontal and internal longitudinal vessels delimit meshes, which are sometimes almost twice as long as broad, and contain four or five stigmata each. The stigmata are elongated, with rounded ends; they are frequently double, and then consist of an anterior and a posterior portion of elliptical shape. The pharyngeal wall is minutely plicated in a longitudinal direction. The meshes almost invariably show some trace of a division into two equal portions by the formation of an incomplete quaternary series of horizontal vessels; the extent to which this process is carried out varies in different individuals and in different parts of the same pharynx. The process is interesting, and may be completely traced in fig. 4. A small projection arises from the internal face of an interstigmatic bar, at its middle point (see fig. 4, upper row, third mesh from the left), and is joined by a similar projection from the opposite wall of the stigma (see the mesh below). The concrescence of the two projections forms a horizontal bridge across the middle of the stigma. The formation of several such bridges across adjacent stigmata thus gives rise to a small horizontal vessel (see the mesh below), which may be said to form part of a quaternary series; these quaternary vessels (*h. v.* 4) may even form connections with the internal longitudinal bars beneath the intermediate papillæ (*i. p.*) of those structures. My figure represents the condition of the branchial apparatus in the individual shown in fig. 3; but in a somewhat larger individual (fig. 1) the intermediate or quaternary vessels are much more highly developed, and there is less difference between them and the other horizontal vessels. There is no pharyngo-cloacal slit.*

The *œsophagus* opens into the pharynx high up on its dorsal edge, halfway between the cloacal siphon and the posterior end of the body. In the largest specimen there are six primary horizontal bars between the œsophageal opening and the posterior end of the pharynx.

All my specimens are immature; in even the largest individual the development of the generative organs is still incomplete, and the ducts are very slender in form; while in smaller specimens the gonads are quite rudimentary.

In addition, however, to the specimens of which the above account has been given, I took another Ascidian which there is every reason to believe to be an adult individual of the same species, but which, from its exceptional shape, is at least an abnormal one, so that I have excluded it from the general description.

* See p. 132.

It is represented of the natural size on Pl. VI, figs. 5 *a* and 5 *b*, and deprived of the test, by fig. 6. The *body* is not compressed from side to side (right to left morphologically) like an ordinary Ascidian and like normal individuals of the same species, but dorso-ventrally; and thus it comes about that, although attached in the usual manner by its left side, its right side does not present a flattened surface, but is elevated so as to form a thickened longitudinal ridge of considerable height.

The dimensions are as follows:

Length (antero-posterior) . . .	2 inches.
Breadth (dorsal-ventral across the plane of attachment)	$\frac{5}{8}$,,
Thickness (morphological right to left) .	$\frac{7}{8}$,,

The breadth becomes considerably reduced towards the summit of the ridge which represents the right side of the body.

The *test* is very thick and presents all the characters of normal individuals of *Ascidia mollis,* except that it is much corrugated on that face of the body which contains the cloacal aperture (see fig. 5 *a*). The *oral aperture* is sub-terminal and on the same side as the cloacal aperture, which is slightly nearer the anterior than the posterior end of the body. The body is attached by almost the whole of the left side, which is deeply furrowed and irregularly pitted. The test is overgrown by extensive colonies of the Polyzoon *Cylindrœcium dilatatum.*

Upon removal of the test, the extent of the dorso-ventral compression is at once noticed. The *ganglion* and *cloacal siphon,* instead of occupying their usual position upon the apparent left of the body, are in the median line of the upper side; and the whole of the *viscera* appear to have suffered a similar rotation through 90 degrees. Strictly speaking, however, the viscera present exactly the same morphological relations to the rest of the body as in the normal individuals described above.

The *generative organs* are well developed, and the oviduct and vas deferens are remarkably dilated. The former contains numerous ripe ova, of small size; and the latter is filled with a mass of spermatozoa.

The only difference of any importance in the pharynx is the presence of a *pharyngo-cloacal slit,** $\frac{1}{8}$ inch in length, in the usual position opposite the cloacal aperture.

The *præbranchial zone* is closely studded with minute papillæ.

The growth of the aperture of the *dorsal tubercle* has progressed still further; both horns are now curved inwards.

Epipharyngeal groove and *dorsal lamina* as in younger specimens,

* See p. 132.

but the lamina is a little deeper; the ribs are very strong and regular, the teeth rather short, very regular, without intermediate smaller ones; the concave side of the lamina as described above.

Behind the œsophageal aperture is a long smooth area (the "post-buccal raphé" of Roule), bounded on the left by a continuation of the dorsal lamina, and on the right by a series of terminal elevations of the horizontal membranes of that side, as in *A. mentula*.

Branchial apparatus.—This is much as in younger specimens, but the arrangement of horizontal bars into primaries and secondaries, &c., is less obvious, owing to the increase of the quaternary vessels which are in many parts of the pharynx completely formed. Rudimentary quaternaries are rare.

The papillæ at the junctions are bluntly conical; the intermediate papillæ are well developed and slenderly conical. The meshes are slightly longer than broad, except where new quaternaries are forming, when they are twice as long. There are from five to seven stigmata in a mesh.

Between this Ascidian and the immature specimens of *A. mollis* described above, the only points of difference, which are not obviously the consequences of further growth, are the different plane of compression and the presence of a pharyngo-cloacal slit.

As to the former, it is a pure abnormality. By Professor Lankester's kindness I have had an opportunity this year of examining in detail the collections of Tunicates in the Oxford Museum, and I found there a specimen of *Phallusia mammillata* which exemplified precisely the same kind of variation. The broadly ovate test was compressed dorso-ventrally, the apertures and ganglion being in the middle line of the upper side, and the viscera and visceral septum of the test being correspondingly rotated. Yet there were no structural differences at all to warrant a division of the species.

As to the pharyngo-cloacal slit, its presence in the adult and not in the young may seem surprising, especially when its supposed morphological importance is taken into account; but I have found exactly the same phenomena in the species *Ascidiella aspersa*. The ordinary specimens of that species show no trace of this aperture, but I have seen a distinct pharyngo-cloacal slit in a particularly large individual, taken from a Falmouth trawler, which I examined this year at Plymouth; in it the slit* occupied its usual position

* The walls of the slit were definite, straight, and smooth, resembling in all respects those of the slit in *Ascidia mentula*. It must not be imagined that the slit, which I have mentioned, was an irregular abnormality of the kind described by Prof. Herdman in specimens of *Ascidiella aspersa* from the west coast of Ireland (Proc. Liv. Biol. Soc., v, 1891, p. 210, pl. x), an abnormality which may also occur in *Ascidia mentula*, as I have myself observed in a specimen from Loch Long.

opposite the cloacal aperture. It may therefore be admitted that the presence of this slit is in some way a consequence of increased size, and that its absence in young individuals is not a matter of specific value. An attempt to explain the meaning of this remarkable aperture is made below (see p. 132).

II.

Ascidia depressa, *Alder*.

ASCIDIA DEPRESSA, *Alder*. Cat. Moll. North. Durham, Trans. Tyneside Nat. Field Club, 1848, p. 107.

— — *non Heller*. Untersuch. über die Tunicaten d. Adriat. Meeres, Denks. d. Kais. Akad. Wiss. Wien., xxxiv, ii, 1875, p. 15, Taf. v, figs. 10—12.

— — *nec Herdman*. Notes on British Tunicata, Journ. Linn. Soc., xv, 1881, pp. 286, 287, pl. xviii, figs. 4, 5.

— — *nec Roule*. Rech. s. les Ascidies Simples d. Cotes de Provence, Ann. Mus. d'Hist. Nat. Marseille, tom. ii, 1884.

Under this name I describe a species of Ascidian of which I took four specimens on May 11th. They were attached to the under surface of a stone near the Zostera bed off Nodes Point.

SPECIFIC DIAGNOSIS.—*Body* oblong ovate, much depressed, greenish when alive, attached by the whole of the left side. *Oral aperture* subterminal; *cloacal* two thirds of the way down, on the right side, near the dorsal edge. *Test* rather thin, cartilaginous, provided with numerous minute tubercles on its free surface. *Oral* and *cloacal siphons*, especially the cloacal, rather long. *Stomach* rounded, at the posterior end of the body; first bend of intestine considerably anterior to the cloacal siphon; rectum directed obliquely forwards, sometimes almost horizontal. *Tentacles* 25 to 30, long and slender. *Præbranchial zone* studded with minute papillæ. Aperture of *dorsal tubercle* horse-shoe shaped, horns not incurved, concavity anterior. *Ganglion* much elongated, slightly dilated at each end. *Epipharyngeal groove* low, moderately long. *Dorsal lamina* continued behind the œsophageal opening, fairly deep, strongly ribbed on the convex side and regularly pectinated, with stout papillæ profusely scattered on the concave side. *Pharyngeal wall* minutely plicated; horizontal bars usually broad and narrow alternately, their breadth never exceeding half the length of the meshes; internal longitudinal bars slender; papillæ above the connecting ducts erect, discoid, provided with a supporting ridge in front and behind; no intermediate papillæ; meshes square, each containing four or five stigmata. *Œsophageal aperture* on dorsal side of pharynx, near its posterior end.

The *body* in all the specimens is much depressed, oblong in form, with sloping and expanded edges, and attachment is affected by the whole of the left side. The position of the oral and cloacal apertures is indicated in fig. 7 (Pl. VII), which represents the largest individual of twice the natural size. The cloacal aperture varies slightly in position, but it is always nearer the posterior than the anterior end of the body, between half and two thirds of the way down the dorsal edge. Both apertures are small and inconspicuous; no ocelli were observed in the living animal.

The dimensions of the largest specimen are as follows:

Maximum length	$\frac{15}{16}$	inch
„ breadth . . .	$\frac{5}{8}$	„
„ thickness . . .	$\frac{1}{4}$	„

The *test* is firm and cartilaginous, though rather thin; it is not rough to the touch, but its surface is in reality studded with minute tubercles of bluntly conical form. They are so small that they cannot be readily observed when the test is immersed in alcohol, but when removed for a moment from the fluid, the presence of minute projections is detected by the broken reflection of light from its upper surface. A portion of the surface of the test is shown on Pl. VII, fig. 9, considerably magnified. A series of vertical sections through the test shows that the tubercles are quite solid, and that the culs-de-sac of the test-vessels have no connection with them. The greater part of the test is composed of huge "bladder-cells," the largest of which are as large as many of the tubercles on the surface; they are of spherical or polyhedral form. The superficial tubercles are entirely destitute of bladder-cells.

The body when deprived of the test is at least twice as long as broad in the majority of the specimens, but in one individual the proportion between the two dimensions is slightly less than this. The oral and cloacal siphons are both rather long and tubular, and the cloacal siphon is particularly so (Pl. VII, fig. 8).

From the œsophageal opening being situated near the posterior corner of the pharynx, the viscera extend to the posterior end of the body. The *stomach* is rounded in form and considerably wider than the intestine. The course of the intestine has been sufficiently indicated above.

The *ganglion* is remarkably elongated, being six times as long as broad; it extends from the level of the fifteenth to that of the twenty-first horizontal bar in the specimen shown in figs. .

The *epipharyngeal groove* in the same individual is a low furrow, not elevated behind, extending from the dorsal tubercle as far as the ninth horizontal bar, but at the sixth bar its left lip suddenly thins out and bends over the right lip, concealing it from view, and continuing posteriorly as the *dorsal lamina*. This structure has a very characteristic form in this species (Pl. VII, fig. 10). It is moderately deep, provided with a regular succession of transverse ribs on its convex side and of well-marked teeth on its edge, the latter corresponding to the number of ribs. There are no intermediate pectinations of its edge; but the concave side, instead of being smooth, as is usually the case in Ascidians, is profusely studded with stout papillæ, as shown in the figure. There is a certain tendency of the papillæ to be arranged in rows directed obliquely from the summit to the free edge of the lamina, from before backwards; but this general tendency is frequently departed from. The dorsal lamina is continued for some distance behind the œsophageal aperture.

Branchial apparatus.—The horizontal vessels are often of two sizes,* broad and narrow, and these vessels alternate with one another in position; but the breadth of the larger vessels never exceeds half the antero-posterior diameter of the meshes—usually it is considerably less. The pharyngeal wall is minutely plicated. The internal longitudinal bars are slender in form. At their junctions with the connecting ducts are situated blunt papillæ of characteristic shape; they are of an erect discoid form, with a semi-circular edge, compressed from before backwards, and provided with a supporting ridge or buttress upon their anterior and posterior faces (fig. 11 *b*). Usually the meshes are square, and intermediate papillæ quite absent; but in some parts of the pharynx transverse rows of meshes may frequently be observed which are distinctly elongated in a longitudinal direction, and in such regions minute intermediate papillæ may be detected upon the internal longitudinal bars. The elongation of the meshes and appearance of intermediate papillæ is preparatory to the formation of a new series of horizontal vessels, in the manner which I have described above in *Ascidia mollis*. There are four or five stigmata in each mesh (fig. 11 *a*). There is no pharyngo-cloacal slit.

My largest specimen is mature, and minute white ova are present in the oviduct.

After much consideration I have arrived at the conclusion that the specimens whose structure I have just described represent the species *Ascidia depressa* of Alder, and that the Ascidians described under this name by Heller, Herdman, and Roule, are distinct from it.

A reference to Alder's original account will show how perfectly in every point my specimens agree with his description, with the exception that I can make no statement as to the presence of red ocelli around the apertures. I did not observe these spots in the living animals; but on the other hand I paid no attention to the point, and probably overlooked their existence. In every other respect the correspondence is complete, and I may draw especial attention to the following details—the shape and colour; the expanded edge; the position and form of the apertures; the granulations (minute tubercles) on the upper surface; the absence of inter-

* This distinction of size is much less apparent in mature than in young individuals.

mediate papillæ in the branchial sac (for it was Alder's habit to imply the absence of these structures when he made no direct reference to them); and the size.

If this be really so, it necessarily follows that Heller's specimen described under the same name is distinct. The structure of the test is alone sufficient to distinguish my specimens from his. The bladder-cells in the former are huge, of spherical or frequently polyhedral form, exactly as Heller has himself described and figured for his *Ascidia rudis* (l. c., p. 14, Taf. v, fig. 6); but for his *A. depressa* a very different condition was described by him (l. c., p. 15). Further, Heller's *A. depressa* was destitute of the superficial microscopic tubercles which are present in my specimens (and in Alder's), and which Heller himself also figured for another species (*A. rudis*, l. c.).

Secondly, the specimens which Prof. Herdman has referred to this species differ from Alder's in possessing intermediate papillæ on the internal longitudinal bars; Alder would certainly have noticed the existence of such papillæ as Herdman has figured (l. c., *supra*, pl. xviii, fig. 4), if they had existed in his specimens. Prof. Herdman's specimens cannot belong to the same species as these from the Isle of Wight, because in the latter the internal longitudinal bars rarely show a trace of intermediate papillæ, except when the meshes have grown to a size when they are almost twice as long as broad; in Prof. Herdman's species these papillæ are normally present, and the meshes are elongated transversely. Further, the structure of the dorsal lamina is very different in the two cases. Prof. Herdman in the same paper noticed the existence of tubercles on the dorsal lamina of *Ascidia plebeia*, so that there is no reason to suppose that he overlooked them in his *A. depressa*.

Lastly, M. Roule has described under the name *Ascidia depressa*, a species which, while probably identical with Heller's, is undoubtedly distinct from Alder's species. The mode of attachment, the shape of the body, and the structure of the branchial sac are very different in the two cases. The species described by Heller and by Roule presents a close affinity with *Ascidia mentula*, and still more, perhaps, with Alder's (not Heller's) *Ascidia rudis*; but there is nothing in Alder's description of *A. depressa* to indicate a similar relationship for that species, and my specimens are distinctly against it.

Ascidia depressa, as now re-described, is very closely related to Traustedt's *Ascidia* (*Phallusia*) *pusilla* (Mitt. Zool. Stat. Neap., iv, 1883, p. 465, Taf. xxxiv, figs. 16, 17; Taf. xxxv, fig. 26). The chief points of difference are found in the different proportions of the length to the breadth of the body, the length of the siphons, the breadth of the largest horizontal vessels of the pharynx, the number of stigmata in the meshes, the shape of the stomach, and especially the structure of the dorsal lamina. Some of these differences are trivial, and it is impossible at present to say whether Traustedt's single specimen of *A. pusilla* is, or is not, merely an abnormal individual of our species; but the constancy in the structure of the dorsal lamina in my specimens is, when associated with the other peculiarities, a strong piece of evidence in favour of the specific distinctness of the two types.

Ascidia depressa is also allied to *Ascidia marioni*, Roule, on account of the close agreement between the two species in the following points—the mode of fixation, the position of the apertures, the minute tuberculation of the surface, the absence of intermediate papillæ, the strong pectination of the dorsal lamina, the elongation and approximation of the stigmata; but the two species are of course quite distinct owing to the important difference between them in the structure of the subneural gland and its accessory organs.

I have already pointed out the curious resemblance between *Ascidia depressa* and Heller's *Ascidia rudis* in the histological and superficial structure of the test. Since Heller's specimen agrees with Roule's *Ascidia marioni* both in the position of the cloacal aperture and in the minute tuberculation of the surface, it is not improbable that the two are specifically identical; but whether Heller's individual was rightly referred to Alder's species or not is very doubtful. Alder's *rudis* possessed "small, *distant* tubercles" on the test, and was "sometimes nearly smooth,"—a condition very different from that in Heller's specimen, as well as in Roule's *A. marioni*.

If, as I believe it will now be generally admitted, the forms described by Heller, Roule, and Herdman under the name *Ascidia depressa* can no longer lay claim to that title, it will be necessary to refer to them under new designations. I would propose for the Mediterranean species described by Roule the name *Ascidia Roulei*. To the variety *petricola* of this species, Heller's specimen almost certainly belongs. I believe that *Ascidia Roulei* is closely related to, if not identical with Alder's *Ascidia rudis*: but it is impossible to give a final decision upon this question until our British Ascidians have been collected and re-examined in greater detail.*

The form described by Herdman as *Ascidia depressa*, in the paper to which reference has been made above, appears to be distinct from *Ascidia Roulei*, although it is impossible, from the want of correspondence between the descriptions, to speak decisively. But Prof. Herdman has himself thrown doubt upon their identity

* It is needless to say that we look forward with interest towards Prof. Herdman's promised re-description of some of Alder and Hancock's types.

in his recently published* Revised Classification of the Tunicata, so that a new name is, at least provisionally, desirable. I therefore propose for it the name *Ascidia Herdmani*.

The subjoined synonymic lists show briefly the conclusions to which I have been led by the study of this species from the Isle of Wight.

1. ASCIDIA DEPRESSA, *Alder*, 1848, loc. cit.

= ASCIDIA DEPRESSA, *Garstang*, 1891 (the present paper).
?? = PHALLUSIA PUSILLA, *Traustedt*, 1883, loc. cit.
non ASCIDIA DEPRESSA, *Heller*, 1875, loc. cit. (= *A. Roulei*, Garstang, 1891).
nec — — *Herdman*, 1881, loc. cit. (= *A. Herdmani*, Garstang, 1891).
nec — — *Roule*, 1884, loc. cit. (= *A. Roulei*, Garstang, 1891).

2. ASCIDIA RUDIS, *Alder*, 1863. Ann. Mag. Nat. Hist. (3), ii, p. 195.

? = ASCIDIA ROULEI, *Garstang*, 1891.
= A. DEPRESSA, *Roule*, 1884 (*non* Alder, 1863, *nec* Herdman, 1881).
= [VAR. PETRICOLA] A. DEPRESSA, *Heller*, 1875.
non — RUDIS, *Heller*, 1875.
? = A. MARIONI, *Roule*, 1884.

III.

Ascidia mentula, *O. F. Müller*.

ASCIDIA MENTULA, *Müller*. Zoologia Danica, 1788, vol. i, pp. 6, 7, pl. viii, figs. 1—4.
— RUBROTINCTA, *Hancock*. Ann. Mag. Nat. Hist., 1870.
— RUBICUNDA, *Hancock*. Ibid., 1870.
— ROBUSTA, *Hancock*. Ibid., 1870.
PHALLUSIA MENTULA, *Kupffer*. Jahresb. d. Komm. z. Unters. d. deutsch. Meere in Kiel, Berlin, 1874, p. 209, pl. iv, fig. 1.
ASCIDIA MENTULA, *Heller*. Untersuchungen, 1875, loc. cit., pp. 2—13, pls. i—iv.
— RUBESCENS, *Heller*. Ibid.
— LATA, *Herdman*. Journ. Linn. Soc., xv, 1881.
PHALLUSIA MENTULA, *Traustedt*. Die einfachen Ascidien, 1883, loc. cit., pp. 457—459.
ASCIDIA MENTULA, *Roule*. Recherches, 1884, loc. cit.

Several large Ascidians, which I refer to this species, were found attached to the sides of a rock, situated far out in the Zostera bed off Nodes Point, on May 7th, at extreme low water,

* Journ. Linn. Soc. Zool., vol. xxiii, 1891, p. 594.

spring-tides having then almost reached their height. The following descriptions refer to two individuals which I brought away with me for more detailed examination; they are given separately in order to indicate the degree of variation the more naturally.

A. *Body* oblong, elongated, attached by almost the whole of the left side. Dimensions—Length, 3 inches; breadth, $1\frac{1}{3}$ inches; thickness, $\frac{11}{12}$ inch. An idea of its external appearance may be gained from the figure which Heller gives (l. c. pl. v, fig. 5) to represent a supposed specimen of Alder's *Ascidia rudis,* but the position of the cloacal aperture is different.

Test thin, hard, cartilaginous, greatly wrinkled in a longitudinal direction on the right side, almost entirely overgrown by small algæ, and extensive colonies of the Polyzoon *Alcyonidium mytili* and some Didemnids. Here and there on the right surface a few minute tubercles may be detected. *Oral aperture* on the right side, sub-terminal, not prominent, bounded by nine lips; *cloacal aperture* on the right side near the dorsal edge, very slightly nearer the anterior than the posterior end of the body, bounded by six lips.

Upon removal of the test the rest of the body is seen to be of a yellowish colour, the musculature being of a rather deeper amber-colour. The *oral* and *cloacal siphons* are tubular but short. The oral siphon terminates in nine sub-triangular lips, which are rather prominent, with rounded apices and with a spoon-shaped concavity on their external surfaces. The edge of the siphon is bounded by a thin red line which is discontinuous towards the tips of most of the lips. A small red ocellus is found behind the red line between each pair of lobes, and the surface of the siphon is slightly sprinkled with red dots. The cloacal siphon terminates in six lobes, bounded similarly by a thin red line, but without ocelli. It is directed straight towards its external orifice.

Musculature coarse and strong, the fibres amber-coloured.

Viscera disposed as usual in the species, the posterior border of the stomach being nearly $\frac{1}{2}$ inch from the posterior end of the body; the anterior wall of the intestine at its first bend is on a level with the ganglion; the posterior wall at its second bend is on a level with the opening of the œsophagus into the pharynx.

Renal vesicles large, forming a soft yellowish coating over the stomach and intestine; concretions showing as a small brown spot in each vesicle, when looked at with a lens, but resolving themselves in each case into a compact mass of several concretions, of different sizes and of a yellowish-brown colour, when examined under a low power of the microscope (cf. Roule).

Tentacles about thirty in number, short, of unequal sizes, irregularly arranged.

Præbranchial zone studded with microscopic papillæ arranged more or less regularly in longitudinal rows.

Dorsal tubercle longer than broad, presenting two apertures, one behind the other. The anterior is crescentic, with the horns produced and curved inwards; the posterior is crescentic, with the left horn slightly produced and curved towards the mid-dorsal line, and with the right horn also curved round and produced a little beyond the mid-dorsal line (Pl. VII, fig. 12).

Epipharyngeal groove present for a short distance and then ceasing abruptly (fig. 12). The *dorsal lamina* is quite absent anteriorly, and does not appear until halfway between the position of the ganglion and the level of the pharyngo-cloacal slit, when it gradually rises up in the form of a narrow membrane and is continued to the posterior end of the pharynx. Dorsal lamina strongly ribbed transversely and minutely pectinated at the margin, the teeth corresponding to the ribs; no intermediate pectinations; concave side smooth.

A *pharyngo-cloacal slit** present on the right side of the dorsal

* I give this name to the curious aperture, so commonly found in the pharyngeal wall of *Ascidia mentula*, in which species it was first noticed by Kupffer (l. c.). It has been ingeniously suggested lately that it represents the persistent internal opening of the right primitive atrial canal, in spite of the fact that it is absent in the more primitive Ascidians, such as *Clavelina* and the *Distomidæ*. Now, as has been stated above (pp. 123 and 124), I have discovered this slit to be present in large individuals of two other species of Ascidians which are not closely allied to *Ascidia mentula* (*Ascidiella aspersa* and *Ascidia mollis*), although it does not exist in young specimens of those species. This fact is a sufficient disproof of the theory which gives to the slit the value of a phylogenetic remnant. My own theory is less attractive, but possibly more true. The slit is always situated opposite the cloacal orifice, and only occurs in large species (*Ascidia mentula* and its close allies, *e.g. Ascidia lata*, Herdman) and in large individuals of smaller species (*e.g.* of *A. mollis* and *Ascidiella aspersa*). May it not be a special adaptation for the prevention of the over-accumulation of fæces in the cloacas of large Ascidians, where the ordinary methods of ejection are insufficient? Ascidians, being sessile animals, are especially liable to danger from such over-accumulation, as Giard long ago stated in the case of the *Didemnidæ* and *Polyclinidæ* (Arch. Zool. Exp., i, p. 520); and special means are adopted in various sections of the group to ward off the danger. For instance, as Maurice has well suggested, the cloacal languettes of the *Polyclinidæ* serve the definite function of keeping open the cloacal canals in colonies of that family (Arch. de Biol., viii, 1888, p. 243); while in the *Botryllidæ* the end is achieved only by the united efforts of the zooids in a cœnobium: they simultaneously and suddenly contract their bodies, and so drive a strong current of water through their peribranchial cavities into the common cloaca, ejecting the fæces with such violence, as Gaertner observed, "ut ingenti saltu oppositum faveæ marginem transiliant" (see Giard, loc. cit.).

In the large Ascidians under discussion, the presence of this big oval slit—it is frequently over a centimetre in length—directly opposite the cloacal cavity, will enable the animal, by a strong contraction of the muscular tunic, to drive a considerable body of water from the pharynx into the cloaca, and thus to effect the desired object more thoroughly than is possible when stigmata exist alone.

Kupffer has also recorded the existence of paired pharyngo-atrial slits, symmetrically lamina, directly opposite the cloacal aperture; slit, $\frac{1}{4}$ inch long and smooth-edged.

Ganglion hour-glass shaped, midway between the slit and the dorsal tubercle.

Œsophageal opening high up in the pharynx, between the slit and the posterior third of the body. Behind it is a long smooth "post-buccal raphe" (see Heller's figure, l. c.).

Branchial apparatus.—Meshes elongated transversely; stout conical papillæ at the junctions, provided with supporting ridges in front and behind (fig. 13); intermediate papillæ equally long, but more slender than the primary papillæ; six or seven stigmata in a mesh; minute plications deep, the longitudinal furrows frequently bifurcating.

B.—The second individual differs from the one just described in the external form, and in the absence of any malformation of the dorsal tubercle and lamina; in other respects it is closely similar to the first specimen.

Body of a compressed pyriform shape, the narrow end anterior, attached by a circular area over the posterior half of the left side. Dimensions—Length, $2\frac{4}{5}$ inches; Maximum breadth across middle, $1\frac{3}{8}$ inches; Thickness, $\frac{3}{4}$ inch.

Test very slightly furrowed, overgrown with algæ and Polyzoa.

Oral aperture terminal; *cloacal* on the dorsal edge, slightly nearer the posterior than the anterior end of the body.

Oral siphon with very short and obtuse lips; no red pigment upon either of the siphons.

Tentacles forty in number, considerably longer than in the preceding specimen, irregularly arranged.

Dorsal tubercle circular in shape; aperture horse shoe-shaped, the right horn curved inwards.

Epipharyngeal groove considerably longer, its lips gradually narrowing and becoming continuous with the dorsal lamina.

In all other respects this individual agrees with the former.

Both individuals are mature and have ova and spermatozoa in their generative ducts.

I believe that in point of size these specimens have undergone a

placed in the posterior region of the pharynx, in *Ascidia conchilega* and *Ciona* [*canina*] *intestinalis*. The former species I have been unable to examine, but in *C. intestinalis* (preserved material) some individuals possess huge slits, through which the intestine conspicuously projects into the pharynx, while in other individuals no unusual apertures can be made out at all. (Cf. Traustedt, loc. cit., p. 455. Heller, loc. cit., ii, p. 118, seems merely to repeat Kupffer's statement. Roule, loc. cit., makes no reference to any exceptional openings.) I am inclined, therefore, to believe that in both these species Kupffer's apertures are accidental or artificial rather than natural.

considerable reduction since their capture. In the rough notes which I then made, I put down the length as "about 5 inches," while actual measurement now shows that the largest of the two brought away does not exceed 3 inches. Allowing for a possible degree of error in my original estimate of their size, there must still, I think, have taken place some contraction of their test and body in the four months during which they have been in alcohol. It is, I admit, unsafe to argue upon these grounds, for the larger ones may have been just those which I dissected at the time of capture and did not retain. I will, therefore, merely state that the size of some of the specimens which I found was fully 4 inches.

The *colour* of the individuals when alive was hardly different from that which these spirit specimens now exhibit. It is sufficient to say that there was an almost total absence of red pigment in their bodies, and what did exist was confined to the region of the siphons, particularly the oral siphon. The test-vessels, also, with their terminal dilatations, were destitute of red and of all conspicuous colouration.

The species *Ascidia mentula* has been described in greatest detail upon Mediterranean specimens, although it is widely distributed round all the coasts of Europe, and has been called the commonest of the British deep-water Ascidians. Off the south-western shores of England, however, it is certainly not common within the 40 fathom line; I have only taken it once or twice there, and its place seems to be occupied by two other large Ascidians, *Phallusia mammillata* and a coarse variety of *Ascidiella aspersa*. Indeed, the fact that there is extant no anatomical description of British specimens referred to Müller's species, seems at first to be strange, if they are really so abundant.

A comparison of my specimens with Müller's original description revealed some distinctions which at the outset seemed to be of some importance. Both of Müller's specimens were brilliantly pigmented, the whole of the body within the test being of a bright crimson colour, except over the area occupied by the viscera on the left side, which was whitish, the intestine being of a livid green colour ("colorem luridum exhibens").

But in Traustedt's specimens from Naples the red pigment was found to be a very variable and unreliable characteristic; sometimes the stomach only was so coloured, sometimes this pigment was spread over the entire area of the branchial sac (as in Müller's specimens), whilst sometimes individuals were taken which were quite destitute of red colouration.

Roule, at Marseille, has observed that the test is almost always rose or red in colour, and he gives some beautiful figures in illustration of this condition, but he also admits a considerable degree of colour-variation in the species, which he attributes to local influences.

Heller's specimens from the Adriatic seem to have been much more subdued in colour than those from the neighbourhood of Naples and Marseille. He describes the colour as "greenish or yellowish-white, seldom brownish, the oral siphon usually edged with red (*rothgesäumt*);" further on he adds that the blood-corpuscles are brownish. My specimens, therefore, approach Heller's very closely in this respect.

Now a perusal of Hancock's paper on *Several New Species of Simple Ascidians* (1870, l. c.) shows that he attached a considerable importance to distinctions of colour in his definitions of species, an importance which can no longer be admitted for *mentuloid* forms at any rate; and Roule has quite rightly, in my opinion, merged Hancock's *A. rubro-tincta* into the species *A. mentula*. *Ascidia rubicunda* of Hancock agrees perfectly with the typical *mentula* of Müller in its brilliant colouration, and I shall show below how unimportant is the only other character which distinguishes it from the general form of that species. *Ascidia robusta* of Hancock is distinguished from the specimens which I have described from the Isle of Wight by hardly any other point than the prolongation of the oral and cloacal siphons.

It may be observed that in all the *mentuloid* forms there is a distinct correlation between the position and extent of the area of attachment and the zone of the sea-bed from which individuals have been taken. The *Ascidia mentula* of authors is an inhabitant of the deeper waters, and is found attached usually to stones and shells by its base and a very little of the left side. Adhering in this way, it is obvious that it has an erect position upon the sea-bottom. Now the three species named above were distinguished by Hancock from *Ascidia mentula* partly on account of the mode of their attachment; *A. rubrotincta* adhered "by the middle portion of the side," *A. rubicunda* "by the whole side with imperfect marginal expansions," *A. robusta* "by the whole side, but [was] sometimes much distorted, and with adherent root-like prolongations."

These three "species" were all taken from between tide-marks, the first at Guernsey, the second at Tobermory (Isle of Mull), Portaferry (Strangford Lough), and Bertraghbuy Bay (Connemara), the third at Herm.

The Isle of Wight specimens also were attached by the whole or the greater part of the left side, and they also were taken from a rock at low water.

Now no one can have much attended to the conditions of existence in the littoral zone without having been impressed by the extent of the disturbing forces which littoral animals have to resist, if they are to survive in that locality. They are battered by the waves almost incessantly, and cannot exist without special means of defence. This defence in many groups is ensured by the development of strong adhesive or clinging organs, the prevalence of which among littoral animals shows, by a reversal of the argument, the extent of the disturbing forces that play around them.

Tunicates are essentially plastic creatures, for the structure and mode of development of their tests renders their external form easily modifiable. It would, therefore, be extremely improbable to find that the larvæ of *Ascidia mentula*, when carried by in-flowing tidal currents from deeper water into the littoral zone, would grow in quite the same way in one place as in the other. The incessant motion of the water would necessitate, and indeed frequently bring about, as growth proceeded, a larger area of attachment than would suffice to resist the comparatively feeble currents of deeper water.

The results of such a process would be (1) Hancock's *Ascidia rubicunda*, which is merely the red-coloured variety of *A. mentula* adapted to a littoral existence ; (2) my specimens from the Isle of Wight, which are merely the pale variety of *A. mentula* adapted to a littoral existence upon a comparatively smooth surface of rock ; (3) Hancock's *A. robusta*, which is a pale reddish variety modified in its mode of attachment by tidal influences, and in its general shape by the irregularity of the surrounding objects ('roots' of *Laminaria digitata*).

Even Müller a hundred years ago recognised the plasticity of form in his species, for, referring to the oral and cloacal apertures, he says :—" Pro figura massae, quae ab adjacentibus corporibus determinatur, vel utraque lateralis, vel altera plerumque terminalis."

If it should be objected that the Mediterranean zoologists can supply little or no evidence of variability in the extent and mode of attachment in their specimens, the fact is rather in favour of my contention than against it ; for the causes to which the variation has been here attributed are absent in the Mediterranean, where the tidal oscillation, with its accompanying disturbance of the sea-bottom, is so small that it may practically be neglected.

With regard to internal structure, the differences between the Isle of Wight specimens and those described by the Mediterranean zoologists are very slight and unimportant.

For a comparison of the descriptions of Mediterranean forms shows that variability is not confined to points of colour and external form. Traustedt gives the number of tentacles as from

78 to 85 in Neapolitan specimens, while Heller, who also examined the species in great detail, ascribes from 30 to 35 to Adriatic examples. There are 30 in one of mine, 40 in the other. Herdman's *Ascidia lata* ($3\frac{1}{2}$ inches long; one specimen) possessed from 16 to 20, and the species was defined upon the ground of this difference* and of a peculiarity in the aperture of the dorsal tubercle.

Take again the dorsal lamina. Heller unfortunately gives no details upon this point, but Traustedt and Roule agree that the lamina is strongly pectinated. In Roule's specimens the right face of the lamina is also provided with a few smaller "languettes." On the other hand, Hancock's *A. rubicunda,* Herdman's *A. lata* (from Loch Long), and my specimens agree in being merely minutely denticulated along the edge of the lamina.

It is true, therefore, that we have at last arrived at a point wherein some of the north Atlantic forms agree to differ from their Mediterranean relatives; but he would be rash who would distinguish the species upon this ground alone, in view of the numerous cross-resemblances in other respects.

The præbranchial zone is minutely tuberculated in my specimens just as in Traustedt's.

Altogether, therefore, there appears to be no sound reason why the numerous *mentuloid* forms mentioned in this paper should not be grouped together into one species and entitled *Ascidia mentula.* Some other "species" might even be added to the list. Heller's *A. rubescens* has rightly been included by Roule as a young individual of the species, and it is just possible that Herdman's *A. fusiformis* ($1\frac{3}{8}$ inches long; three specimens) is merely a young condition also.

It is difficult to form an opinion upon Hancock's *A. plana* and *A. alderi*; but they appear to belong to this species also.

I cannot hope to have altogether avoided error in the course of this paper, but I have certainly endeavoured to do so; and I trust that, as an attempt to throw a little light upon some of our British Tunicates, my essay will not be without useful results.

Moreover, it would seem to be serviceable if a word or two should be said upon the desirability of keeping in mind the facts of variation, and of adopting some method by which the broad phenomena of variability within the limits of a species can be properly and systematically recorded.

* Since the above was put in type, I have been enabled to examine some specimens of *A. mentula,* which were dredged in Loch Long and are now under Mr. Hoyle's charge in the Manchester Museum. The number of tentacles is so variable as to be only 18 in an individual $4\frac{3}{4}$ inches long, while it is nearly 40 in an individual 3 inches long.

It is now a truism that variation does not only consist in the manifestation of irregular abnormalities. The commonest Anemone of our sea-coasts, *Actinia equina*, Linn., sufficiently testifies to the existence of a fixity and a stability even in variation. Yet it would be a strange misconception of the species-idea that would lead anyone to specifically separate the more constant varieties of *Actinia equina* or of *Cylista undata* from one another simply on the ground of that constancy.

The *nomen triviale* of taxonomy is a great boon to the investigator in biology, but it becomes a burden when it is applied with random pen to every little group of forms, distinguished though they may be, under their particular conditions, by the constant possession of some minute peculiarity. Minute and constant peculiarities are of the greatest interest and importance, and nothing could be, for some time to come, of higher value to the student of organic evolution than their careful recognition and classification, involving also a similar record of the bionomical conditions under which those peculiarities are found to be manifested.

But there is no reason why the specific name should be bestowed upon these minutely isolated groups. They had much rather have a nomenclature of their own within the limits of the species embracing them; and that such a nomenclature can be adopted with success is sufficiently established by a perusal of Mr. Gosse's admirable monograph of the British Actinians,—to go no further.

I will conclude with an attempt, by way of illustration, to record what seem to be the main outlines of variability in the species which has just been discussed.

Ascidia mentula, *O. F. Müller*.

Var. 1.—Ruberrima. Body-walls beneath the test of a brilliant red or rose-colour; tentacles (always ?) numerous (60 to 80).

Form *α.—Erecta*. Area of attachment small, usually posterior and basal; infra-littoral.

Distribution.—Off the south coast of Norway; Mediterranean, off Marseille and Naples, rare in Adriatic (= *A. rubescens*, Heller).

Form *β.—Depressa*. Area of attachment large, extending over the whole or the greater part of the left side; littoral.

Distribution.—West coast of Scotland, west and north-east coasts of Ireland (= *A. rubicunda*, Hancock).

Var. 2.—Rubrotincta. Body-walls tinged with reddish flesh-colour.

Form *α.—Erecta*. Attached as described above; infra-littoral. Naples, Marseille, British seas ?

Form β.—*Depressa*. Attached as described above; littoral.
Channel Isles (= *A. rubrotincta* and *A. robusta*, Hancock).

Var. 3.—RAVA. Body-walls yellowish, with little or no trace of red; tentacles rarely exceeding 40 in number.

Form α.—*Erecta*. As above; infra-littoral.
Adriatic. [West coast of Scotland (= *A. lata*, Herdman; but the colour of this race is only known from spirit specimens).]

Form β.—*Depressa*. As above; littoral.
Isle of Wight.

DESCRIPTION OF PLATES VI AND VII,

Illustrating Mr. W. Garstang's paper "On some Ascidians from the Isle of Wight."

N.B.—All the figures were drawn from preserved material.

PLATE VI.

FIG. 1.—*Ascidia mollis*, Ald. and Hanc. The largest normal individual, nat. size.

FIG. 2.—*A. mollis*. Culs-de-sac of the test-vessels, magnified.

FIG. 3.—*A. mollis*. Another individual of smaller size, as seen after removal of the test; twice the natural size.

a. = View of the right side, showing the musculature.
b. = View of the left side, showing the disposition of stomach and intestine.

FIG. 4.—*A. mollis*. Portion of the pharyngeal wall of the same individual; much enlarged. Zeiss, Obj. A. Oc. 2, Cam. luc. The dark portions represent the longitudinal furrows, the light portions the elevations which are caused by the "minute plication" of the wall.

c.d. = Connecting ducts between the horizontal and the internal longitudinal vessels.
h.v. = Horizontal vessels, forming three complete series and a rudimentary fourth.
i.l.b. = Internal longitudinal bars or vessels.
i.p. = Intermediate papillæ.
p. = Papillæ on the int. long. bars above the connecting ducts.

FIG. 5.—*A. mollis*. The large abnormal individual, nat. size.

a. = View from above the dorsal surface. The left side consists entirely of the area of attachment; the right side forms an elevated ridge. The inconspicuous slit-like oral and cloacal apertures are indicated.
b. = View of the opposite surface.

FIG. 6.—*A. mollis.* The same with the test removed, in the same position as in fig. 5 *a.* Nat. size.

an. = Anus.
c.s. = Cloacal siphon.
gn. = Ganglion.
int. = Intestine—the descending portion.
œs. = Œsophagus.
o.s. = Oral siphon.
ov. = Oviduct.
pc. = Pericardium.
st. = Stomach, covered with renal vesicles.
v.d. = Vas deferens.

PLATE VII.

FIG. 7.—*Ascidia depressa,* Alder. The largest individual, twice the natural size.

FIG. 8.—*A. depressa.* The same, with the test removed, viewed from the left side, showing the course of the viscera, and the rather elongated siphons.

FIG. 9.—*A. depressa.* A portion of the test, magnified, showing the papillæ on its surface.

FIG. 10.—*A. depressa.* A portion of the dorsal lamina, magnified, showing the marginal teeth (*m.t.*) and the lateral papillæ which project from its concave surface. Camera lucida.

FIG. 11 *a.*—*A. depressa.* A portion of the pharyngeal wall, magnified. Camera lucida.

h.v. = Horizontal vessels.
i.l.b. = Internal longitudinal bars or vessels.
p. = Papillæ above the connecting ducts.
r.i.p. = Extremely rudimentary intermediate papillæ, here and there present where the meshes are elongated.

FIG. 11 *b.*—*A. depressa.* An enlarged view of the junction between an internal longitudinal bar (*i.l.b.*) and a horizontal vessel (*h.v.*), showing the form of the disc-shaped papilla (*p.*), with its anterior (*a.b.*) and posterior buttresses.

FIG. 12.—*Ascidia mentula,* O. F. Müller. The peritubercular area in the individual A., showing the double aperture of the dorsal tubercle.

ep.gr. = Epibranchial groove.
p.gr. = Pericoronal groove.
p.z. = Præbranchial zone, studded with minute papillæ.

FIG. 13.—*A. mentula.* Portion of an internal longitudinal bar (*i.l.b.*), seen obliquely from the side, showing the form of the papillæ on its surface; magnified. Camera lucida.

c.d. = Connecting duct.
h.v. = Horizontal vessel.
i.p. = Intermediate papillæ.
p. = Papillæ.

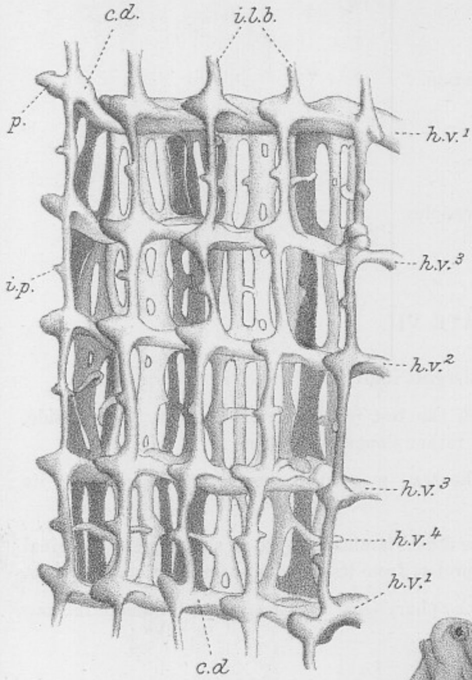


Fig. 4.

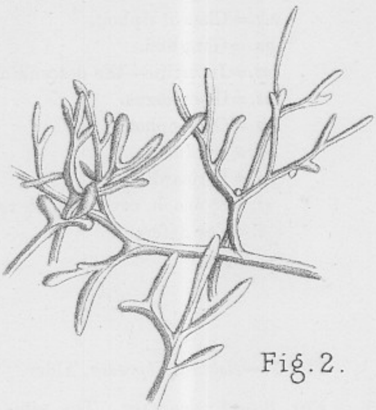
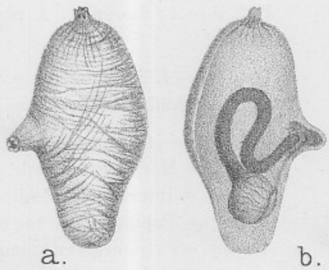


Fig. 2.



a. b.

Fig. 3.

Fig. 1.

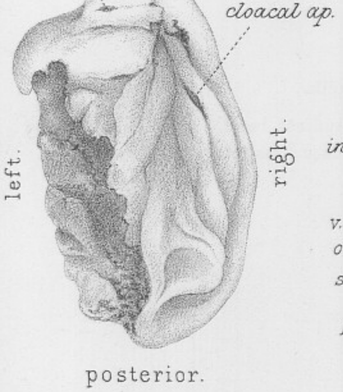


Fig. 5. a.

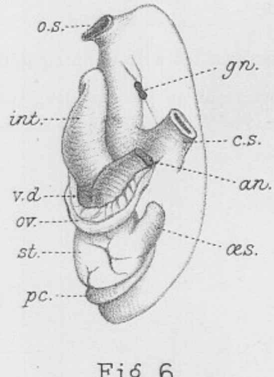


Fig. 6.

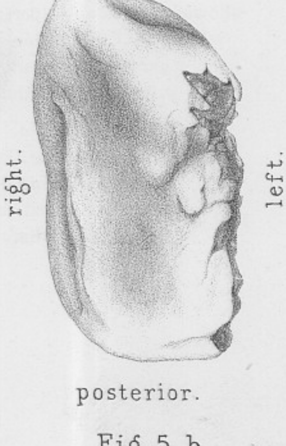


Fig. 5. b.

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Fig. 7.

$\frac{2}{1}$

Fig. 8.

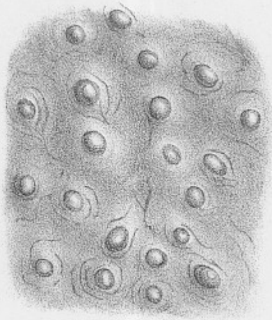


Fig. 9.

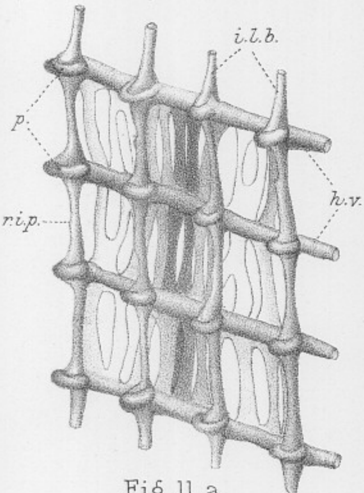


Fig. 11. a.

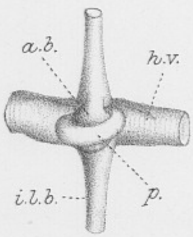


Fig. 11. b.

Fig. 10.

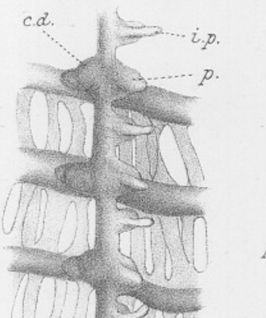


Fig. 13.

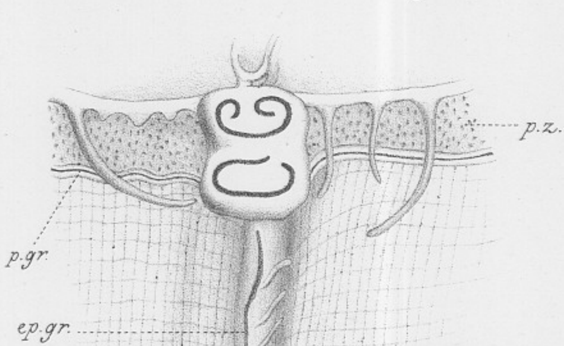


Fig. 12.

W. Garstang del. F. Huth, Lithr. Edinr.

On the Development of Palinurus vulgaris, the Rock Lobster or Sea Crayfish.

By

J. T. Cunningham, M.A.

With Plates VIII and IX.

1. *Historical Review.*

The history of our knowledge of this subject is complicated and curious, and is not quite correctly narrated in any English publication, not even by Balfour in his account of the development of Crustacea (Comparative Embryology, vol. i). The story begins with the establishment and definition of the genus *Phyllosoma* by Leach in 1818. Various succeeding zoologists included descriptions of species of *Phyllosoma* in their works, but the result of all previous investigations are included by Milne Edwards in the comprehensive account of the genus given in his Hist. Nat. des Crustacés, vol. ii, 1837. The state of knowledge at that time may be briefly summarised as follows :—The Crustaceans known by the name *Phyllosoma* had been found near the surface of the ocean in various parts of the world. They varied in size from less than half an inch to two inches. They were, when alive, of glassy transparency ; the body was remarkably flat, and expanded horizontally, while the limbs were long, slender, and biramous. The body consisted of three parts ; firstly, a head having the form of an oval leaf, bearing at its anterior extremity a pair of eyes on long stalks and two pairs of simple antennæ. The mouth was situated beneath the middle or posterior third of the head, and surrounded by an upper and lower lip, a pair of mandibles, and the first pair of maxillæ. The second pair of maxillæ and the first pair of maxillipeds were rudimentary and situated behind the mouth. The second part of the body was the thorax, quite as flat but not so large as the head; it was usually broader than long. It presented no trace of a division into segments, but on its lateral edges carried four to six pairs of long, delicate, articulated limbs, each of which was provided with a secondary shorter branch fringed with hairs on each side. The disposition of the abdomen varied; in some species it was distinctly marked off from the thorax and much narrower, sometimes situated in an emargination of the posterior edge of the thorax, and sometimes again it was at its base as broad as the thorax, of which it formed a direct continuation. Usually six or seven segments were visible in the abdomen, the last of which bore biramous flat appendages, like those of the lobster, on each side of the telson. According to these differences in the abdomen, Milne Edwards divided the species of *Phyllosoma* into three groups: (1) those which had a distinct well-developed abdomen, narrower than the thorax, *Phyllosomes ordinaires;* (2) those in which the abdomen was rudimentary, and situated in an emargination of the thorax, *Phyllosomes brevicaudes;* (3) those in which the abdomen was broad and continuous with the thorax, *Phyllosomes laticaudes.*

Since the date of Milne Edwards' work, various more or less incomplete researches have proved that the forms belonging to the genus *Phyllosoma,* as defined by the characteristics just described, are the early stages or larvæ of *Palinurus* and its allies, that is, of the Decapod Crustaceans of the family Palinuridæ or Loricata. Balfour, in his Comp. Embryology, vol. i, p. 477, states that the true nature of *Phyllosoma* was first shown by R. Q. Couch in a paper on *The Metamorphosis of Decapod Crustacea* in the Report of the Cornwall Polytechnic Society of 1848, but that Couch did not recognise the identity of his larva with *Phyllosoma,* which was first done by Gerstäcker. This statement is incorrect, probably because Balfour was unable to refer directly to the Reports of the Cornwall Polytechnic Society, to which I have access in the library of the Plymouth Institution. R. Q. Couch's first paper on *The Metamorphosis of Decapod Crustaceans* is in the Report of the said Society for 1843. The description of the newly hatched *Palinurus* there given is quite erroneous. Couch states that he obtained gravid specimens of *Palinurus* from the fishermen, and kept them in crab-pots until the eggs hatched. His description of the hatched larva is as follows:—" The whole animal is smaller and more slender than the young of the lobster. The body is oval, slightly depressed; eyes rather small compared with other species, sessile, marked at its circumference with radiating lines, and situated on a festoon of the dorsal shield. The claws are in four pairs, similar to those of the adult, and rather long. The tail is long, extended, and composed of five unequal annulations; it is generally semi-flexed on the abdomen and hid among the claws. On the four superior rings of the tail are situated four pairs of long slender appendages. They are attached to the rings by joints, similar to those of the true claws. At a short distance from the basal joint these organs branch into two long slender branches, which extend nearly one third as long again as the tail; hence the posterior part of the body has a very bushy appearance. The termination of the tail is formed of two small fan-shaped expansions, separated by a shallow notch."

Couch gives a figure of the larval Palinurus in profile, which is as fictitious as his description. It is evident from the description, that he mistook the thorax of the larva for the abdomen, and regarded the true rudimentary abdomen as the last joint of the "tail." In his figure the thorax appears cylindrical instead of flat, and the four long characteristic thoracic limbs of the *Phyllosoma* are represented by four biramous appendages having a filamentous appearance. But the extraordinary thing is that in the figure, as in the description, there are four unbranched appendages in front of the four biramous, attached to the cephalic portion of the larva which Couch mistook for the cephalothorax. Since, in reality, there is only one elongated articulated appendage in front of the four biramous, namely, the second maxilliped, and as the rest of the oral appendages are quite small and visible only under a lens, it is extremely difficult to understand how Couch invented his figure. It is possible that he supposed all the long appendages that he saw, four pairs, to be on one side, those of the other side being invisible; in this way he may have reached his conclusion that there were eight pairs of limbs in all, four claws on the "body" and four slender appendages on the tail. However this may be, this first description is quite worthless, and there is no reference in it to *Phyllosoma.*

In the Report of the same Society for the following year, 1844, there is a second paper on the *Metamorphosis of Decapod Crustacea,* but all that it contains concerning *Palinurus* is that the young had been examined again with the same results as before.

In the Report of the Meeting of the British Association in 1857 there is a short paper by R. Q. Couch, entitled *On the Embryo State of Palinurus vulgaris.* The description of the larva there given is much more correct than that previously published by the same observer. It runs thus :—"The carapace is globular, oval, slightly pointed or produced both at the anterior and posterior margin, and also slightly contracted anteriorly, so as to give the appearance of a rostrum. The abdomen is moderately long, and from four of the six annulations of which it is composed arise eight pairs of tendril-like appendages. These tendrils are long, slender, and dichotomous. Their double character commences at the third joint; for the remainder of their length they are nearly equal, and are covered with strongly marked spines; their termination is pointed. The caudal extremity is simple, contracted, pointed, and somewhat oval; on the centre of the rostrum is a dark spot; the eyes are placed on enormously long and stoutly club-shaped peduncles, which are attached by very narrow and slender points. The pedunculated eyes are about two-thirds as long as the carapace. The contrast between the young of the present species and others is very great. In them the eyes are sessile; in this enormously pedunculated. In them the limbs are beneath the carapace; in this they are attached to what, for clearness, I have called the abdominal rings. Instead, therefore, of belonging to the genus *Zoe*, this would be placed in *Phyllosoma* of Milne Edwards, as belonging to the Stomapodes."

Here, then, although it is evident Couch did not know much of the morphology of Crustacea, we have a great improvement on his former description. He evidently means to describe four pairs of biramous appendages; he mentions the long peduncles of the eyes, and the median eye (dark spot he calls it) on the rostrum. In this paper the comparison of the larva of *Palinurus* with *Phyllosoma* is made for the first time, although the importance of the comparison remained to be developed by men who understood the structure of Crustaceans better than Couch. In the British Association Report no figures accompany Couch's paper, but it is reprinted in the Natural History Review, vol. iv, 1857, with a plate (pl. xvii). On this plate is given a figure of the *Palinurus* larva from the ventral aspect. The figure is recognisable, though not very accurate. It gives fairly well the general shape of the body, the eyes, antennæ, and four pairs of long thoracic appendages. But the shape of the thorax is incorrect, as also that of the appendages, especially of the exopodites, while the appendages in front of the third maxilliped are entirely wanting from this figure and the rest of the plate.

In a *Report on the Progress of Entomology* in the Archiv f. Naturgeschichte, 1858, Gerstäcker speaks of the similarity of Couch's figure of the *Palinurus* larva with *Phyllosoma*, but does not mention that Couch made the comparison himself.

Independently of Couch, Gerbe in 1858 made the observation that the newly hatched larva of *Palinurus* had the characters of the genus *Phyllosoma*. Gerbe's studies were made at the Laboratory of Concarneau in Brittany, and were briefly described by Coste in the Comptes Rendus of 1858. Coste's publication was not accompanied by figures, but stated that Gerbe would be able, from material supplied by the aquaria of Concarneau, to publish at a future time a full account of the metamorphoses of *Palinurus,* an object which has never yet been realised either by Gerbe or anyone else.

In 1863 Claus, in an account of observations made at Messina (Zeit. f. wiss. Zool.), described the embryo of *Palinurus* before hatching, and compared it with young *Phyllosomata* captured in the sea. He found differences in this comparison which appeared to him inexplicable on the view that *Phyllosoma* was the larva of the *Palinuridæ.* Spence Bate also came forward to oppose the correctness of the conclusions of Couch and Gerbe, in a paper in the Ann. and Mag. Nat. Hist., ser. 4, vol. ii.

Dohrn, however, in 1870 (Zeit. f. wiss. Zool.) published an important confirmation of the identity suggested by Couch and Gerbe. He gives a description of the development of *Scyllarus* in the egg, and of the newly hatched larva, which he shows to be identical with the smallest *Phyllosoma* obtained by Claus from the sea. He shows that the second maxilla gets smaller during the end of the embryonic period, while the first maxilliped disappears altogether before hatching. The second antenna is much shorter than the first. In the embryo of *Palinurus,* at an early stage, the second antenna is longer than the first; the second maxilla is biramous, the inner branch smaller than the outer. The first maxilliped is at first distinctly biramous, but the branching disappears; the appendage becomes simple, but does not disappear as in *Scyllarus.* The abdomen is rounded at the end, and the last pair of appendages is indicated. In the embryo, when ready to hatch, Dohrn states that the first maxilliped is quite short and thick, and appears to have a prominence near the base, which probably developes later into a branchial plate. Dohrn gives no figure nor further description of the hatched larva.

In 1873 Ferd. Richters published in the same Zeitschrift a paper containing the results of a critical examination of a large collection of specimens of *Phyllosoma* from the Hamburg Museum. Richters has shown by tracing successive stages in his specimens, and comparing them with the observations of Claus and Dohrn, that all those Phyllosomes which possess the following three characters belong to the genus *Palinurus,* which is distinguished from the other genera of its family, such as *Scyllarus,* by having long, cylindrical, multiarticulate second antennæ, whereas the others have short, flat, broad second antennæ with few segments. The three distinguishing characters of the *Palinurus* Phyllosomes are—

(1) The second antennæ are longer than the first in the earliest stages, and later on always remain cylindrical; while in the *Scyllarus* Phyllosomes the second antennæ are in the earliest stages much shorter than the first, and soon become broad and flat.

(2) The abdomen is sharply marked off from the thorax, being much narrower at its base than the latter.

(3) The articulation of the thorax with the abdomen is on the same level with the origin of the last pair of thoracic limbs.

Thus Richters shows that the forms which Milne Edwards distinguished as *Phyllosomes ordinaires* are the larvæ of *Palinurus,* or genera belonging to the *Palinurus* division of the *Loricata.*

But here we come upon a point which requires elucidation. Richters states that the first maxilliped is completely wanting in the youngest larvæ of the *Palinurus* series; he points out that Dohrn himself describes a reduction of the first maxilliped as having taken place in the embryo almost ready to hatch, and then says that this last stump also, without doubt, disappears, since in the youngest *Palinurus* Phyllosomes which he examined no trace of this appendage was to be discovered.

The last publication I have to refer to is Spence Bate's Report on the Decapoda macrura collected by the "Challenger." That author says concerning the larvæ of *Palinurus,* that it has been found impossible to keep them alive in aquaria any time after hatching, and that although, no doubt, there are large numbers of these larvæ in the sea off our south-west coast, only solitary specimens of the *Phyllosoma* form have been occasionally taken. Spence Bate does not figure the hatched larva of our common *Palinurus,* the true *Phyllosoma,* but gives instead a figure of the nearly ripe embryo taken from the egg, and this is by no means perfectly similar to the free larva. With regard to the question of the first maxilliped Spence Bates' descriptions throw no light upon it, as he does not go into the details of the oral appendages in his specimens. He was not apparently acquainted with Richters' paper, for he attributes to *Palinurus,* a specimen of *Phyllosoma* having the characteristics of those larvæ which Richters has shown to belong in all probability to *Ibacus* or *Paribacus,* or, at all events, to develop into forms with short, flat antennæ.

We find then, from the above survey of the literature that although it is clear that *Palinurus vulgaris* is developed from a *Phyllosoma,* no single figure or detailed description of any larval stage, known certainly to belong to this species, has been published except those of Couch, which are unsatisfactory. Claus has published figures of Phyllosomes taken at Messina, the smallest of which Dohrn proved afterwards to be identical with the larva of *Scyllarus arctus,* now called *Arctus ursus,* which also occurs, though rarely, in the neighbourhood of Plymouth. The newly hatched larva of *Palinurus* has been obtained in aquaria several times, *e. g.* by Gerbe at Concarneau, by Dohrn at Messina, and by Alfred Lloyd at the Crystal Palace. But no correct figure of it is in existence, nor have its later stages been described. I now proceed to the description of my own observations.

2. *Observations on the Larva of Palinurus vulgaris.*

In July, 1889, a large number of larvæ were hatched from a berried crayfish in one of our tanks at the Plymouth Laboratory, and I preserved some hundreds of these, but did not then study them. This year, on the 9th July, when I was working a large net made of mosquito netting at the surface, a little to the north of the Eddystone, I obtained a number of Phyllosomes of different sizes and stages. On the 16th I obtained a still larger number in the same net to the south of the Eddystone. Hitherto they have only been very rarely taken on the south coast of England, and then, according to Spence Bate, only solitary specimens. The reason of this seems to be merely that suitable nets have not been used in the right place at the right time of year. These larvæ apparently do not occur near shore, for we have never taken them before in our ordinary tow-nets worked within a mile or two of the coast. At any rate it is interesting to find that some hundreds may be taken in about an hour in the neighbourhood of the Eddystone in July, with a net whose meshes are about 2 mm. in diameter, and whose mouth is 8 feet by 6 feet in area. On the two occasions on which I obtained the larvæ, I captured them only when towing the net at the surface, not when it was sunk to some depth.

The newly hatched larva of *Palinurus* is 3·1 mm. in length from the anterior border of the cephalon to the posterior extremity of the abdomen. The second antenna is almost, but not quite, as long as the first, and neither of them is divided into joints. The thorax is provided with four pairs of very much elongated appendages, namely, the third maxilliped and the first, second, and third ambulatory limbs or pereiopods. These appendages all have six joints, and from the end of the second joint springs an exopodite consisting of a larger number of short joints, and fringed with long feather-like bristles. The exopodite of the third pereiopod is not completely developed, having slight indications of one or two joints and no bristles. Of the oral appendages, the mandibles and first maxillæ are fully developed and functional; the second maxilla is rather large and foliaceous, and extends away from the median line; the first maxilliped is not wanting, but rudimentary, being represented by a simple, small, but distinct conical stump. The second maxilliped is a slender six-jointed appendage, not extending beyond the cephalon, and destitute of even the rudiment of an exopodite. The fourth and fifth pereiopoda are not yet developed, but represented by two minute rounded buds on either side of the root of the abdomen. The abdomen is without developed appendages, but the sixth pair of pleopods is indicated already by a slight rounded outgrowth on each side of the telson. The termination of the telson is truncated, without the slightest trace of bifurcation (Pl. VIII).

Among the Phyllosomes I obtained from the sea there are all sizes and stages, from the newly-hatched stage just described, up to one 7 mm. long, which is the largest and most developed I have yet obtained. The developments that have taken place at this stage are as follows :—The second antenna is now a little, but not much longer than the first. Two basal joints have been differentiated in the first antenna, and from the end of the second has grown out a simple process, the commencement of the internal filament. One nodal division is also visible in the basal portion of the second antenna. The exopodite has began to sprout out from the second joint of the second maxilliped, but the rudimentary stump of the first maxilliped, and the rest of the oral appendages, are quite unchanged. The exopodite of the third pereiopod is fully developed, and the fourth and fifth pairs of pereiopoda have developed considerably, the fourth being biramous and almost as long as the abdomen, the fifth still simple and somewhat shorter. The pleopods of the abdomen are considerably developed. The sixth pair or swimmerets are of some length and distinctly biramous, while the four preceding pairs are also visible, and each commencing to divide into exopodite and endopodite. No appendage is developed at all on the first abdominal segment. The cephalic shield which, in the newly-hatched stage, covered only the second maxilliped, leaving all the rest of the thorax with its appendages free, now extends back so as to cover the origin and base of the third maxilliped (Pl. IX).

There can be no doubt at all that the Phyllosomes I have obtained belong to *Palinurus vulgaris ;* Dohrn's and Richters' investigations have shown clearly that the larvæ of *Scyllarus* can be distinguished from those of *Palinurus* at all stages, and *Scyllarus arctus* (*Arctus ursus*) is the only other species of the family which occurs near Plymouth, and this form is very rare. It becomes possible, therefore, to identify the *Phyllosoma* larvæ of *Palinurus vulgaris* if they have been sufficiently described or figured in previous literature. It is not possible to identify satisfactorily the forms described by Milne Edwards and Richters ; they come from distant coasts, such as those of Africa, Asia, and New Guinea. However, it may be mentioned that Richters is very possibly wrong in stating that the first maxilliped was wanting in his youngest Palinurine form, 7 mm.

in length, since his figure of the appendages in this form is not conclusive, but suggests the idea that he has figured the rudimentary first maxilliped and mistaken it for the second maxilla.

It is more interesting to note that of the stages obtained and figured by Claus at Messina, while the oldest and youngest belong to *Scyllarus*, all the others, that is all those figured on Z. f. w. Z., Bd. xiii, pl. xxvi, are stages in the development of *Palinurus vulgaris*. The youngest of these stages is described as 4 mm. long, and therefore has not long been hatched. It agrees, except in one or two very minute details, due, I think, to slight mistakes in drawing, with the newly hatched larva I have described, and, above all, both in the description and figure of Claus, the first maxilliped is represented as a short papilla-like process, exactly similar to that in my specimens. Claus figures and describes two other stages, which also I identify as belonging to *Palinurus vulgaris;* one of these is 14 mm. long, the other 21 mm.; both, therefore, older than the oldest of my specimens. In the former, the thorax extends back over the third maxilliped in the older stage (21 mm.), still further, covering the base of the first pereiopod. In this oldest stage of Claus the antennæ have almost acquired the adult form, and the fourth and fifth pereiopoda are longer than the abdomen, although the fifth is still destitute of exopodite. In both these older stages the first maxilliped has considerably developed, consisting of a long cylindrical appendage borne on a short stump.

Thus it is evident that the *Phyllosoma* of *Palinurus vulgaris* reaches a length of more than 21 mm. before it begins to lose the characteristic flattened form of the larva. The smallest *Palinurus* observed by Richters was 25 mm., or 1 inch in length, and had all the characters of the adult. The later stages of transition between the *Phyllosoma* and the young *Palinurus* have still to be discovered.

I hoped to obtain stages later than those I have here described, but unfortunately the weather during the latter half of July and the whole of August was persistently stormy, and it was impossible to collect in the open sea. In September I resumed my expeditions, but obtained no more Phyllosomes.

DESCRIPTION OF PLATES VIII AND IX,

Illustrating Mr. Cunningham's paper "On the Development of *Palinurus vulgaris,* the Rock Lobster or Sea Crayfish."

PLATE VIII.

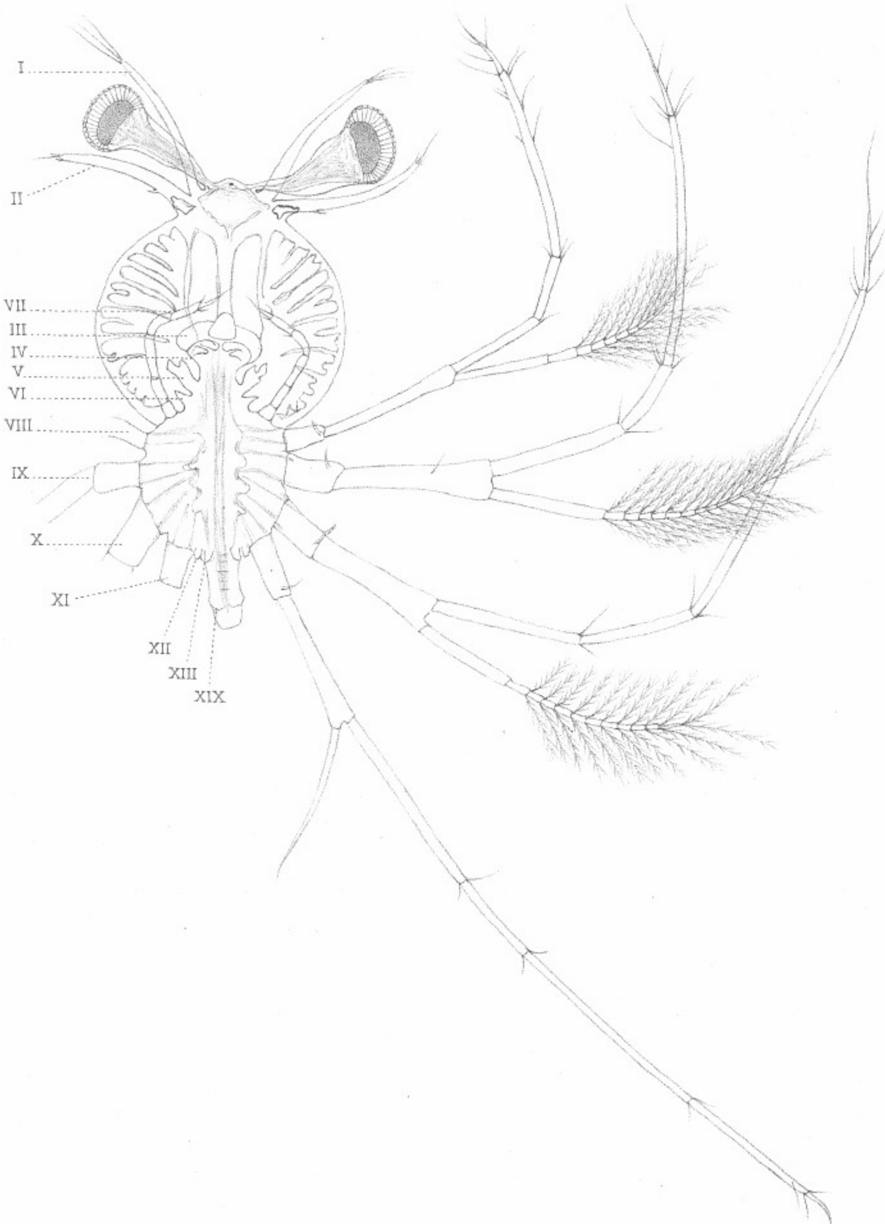
FIG. 1.—Newly hatched larva of *Palinurus vulgaris*; ventral surface, magnified 19 diameters. From a specimen hatched in the Aquarium, July, 1889.

PLATE IX.

FIG. 2.—*Phyllosoma* stage of *Palinurus vulgaris,* 7 mm. long, taken in large tow-net south of Eddystone, July 16th, 1891. The Roman figures in this and the preceding figure indicate the appendages (excluding the eye-stalks), numbered from the first antenna backwards.

FIG. 3.—The oral appendages of a larva 4·5 mm. long. *u. l.* Upper labium. *l. l.* Left half of lower labium. *md.* Mandible. 1 *mx.* First maxilla. 2 *mx.* Second maxilla. 1 *mxp.* First maxilliped.

Fig. 1.



J.T. Cunningham del. F. Huth Lith.r Edin.r

Fig. 2.

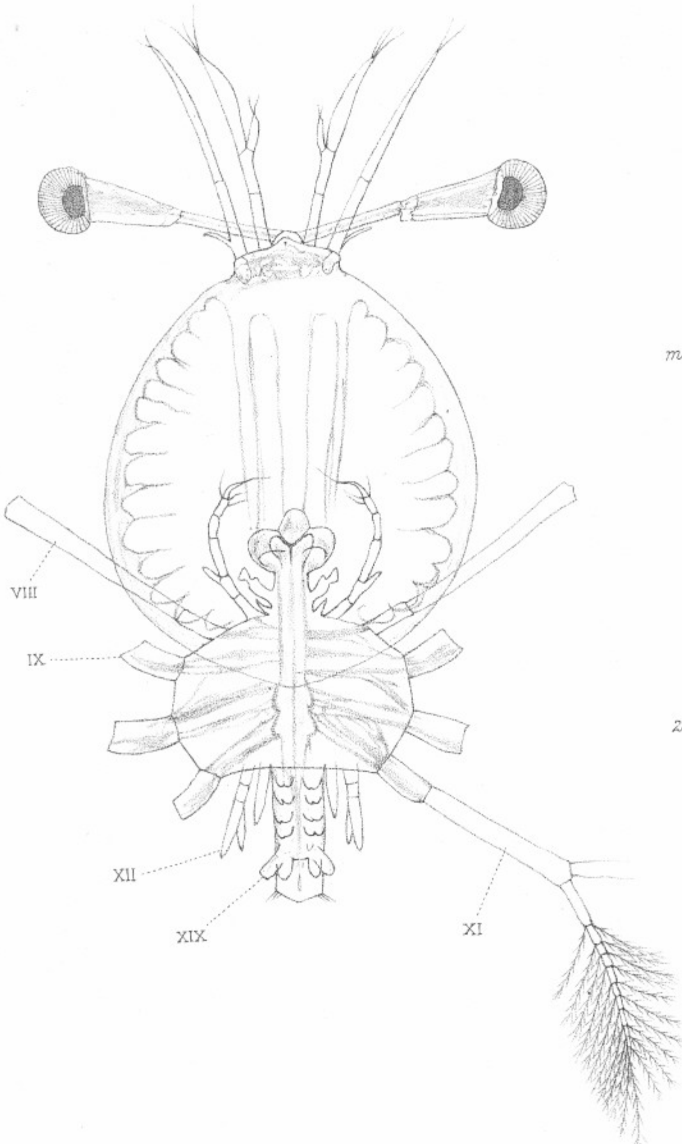


Fig. 3.

J. T. Cunningham del. F. Huth, Lithr. Edinr.

The Reproduction and Growth of the Pilchard.

By

J. T. Cunningham, M.A.

With Plate X.

In my paper on the *Reproduction of Fishes occurring at Plymouth*, published in this Journal, vol. i, p. 10, 1889, I identified as the egg of the pilchard, a pelagic egg commonly found in the tow-net in summer, and distinguished by three obvious characters, namely: (1) an unusually large perivitelline space; (2) a single large oil-globule in the vitellus; (3) a completely subdivided yolk. I also stated that ripe spawning pilchards occurred off Plymouth between June and October, but always at some distance from land, being usually taken in mackerel nets worked to the south of the Eddystone. My identification of the egg, taken in the sea, was founded upon a comparison between it and the eggs pressed from the ripe but dead female pilchards obtained from mackerel fishermen. The latter eggs were already dead, and did not float, but sank in sea water, but they possessed a single oil-globule, and the yolk in them consisted of a number of yolk-spheres. The large perivitelline space was absent, because it is only formed when living eggs are extruded into sea water.

Raffaele had previously described two kinds of pelagic eggs found at Naples, which he recognised, from their divided yolk and the characters of the larvæ hatched from them, as belonging to some species of Clupeoid. The larger of these eggs he attributed to *Clupea pilchardus*, but did not give his reasons. This egg is in all respects similar to that identified as belonging to the pilchard by myself at Plymouth. It is well known that the sardine of the French coast and of the Mediterranean is the same species of fish as the pilchard of Devon and Cornwall.

The natural history of the sardine has been investigated in recent years by two distinguished zoologists in France, namely, by Professor

G. Pouchet, who is Director of a marine laboratory at Concarneau, on the coast of Brittany, and by Professor Marion, who has a similar laboratory at Marseilles.

The first publication in which Pouchet mentions the mature egg of the sardine is a note in the *Comptes Rendus* of the French *Académie des Sciences,* tome cix, No. 3 (July 15th, 1889). He states there that the *sardine de rogue* is a young sardine which is not yet full grown, and which has not yet spawned; while the *sardine de dérive* is alone adult, and alone sometimes contains mature ova. The explanation of these French terms, applied to sardines of different sizes on the French coast, is as follows:—*Rogue* is the name given by the French fishermen to a preparation of cods' roe which they throw into the water as a bait to attract the sardines. After the bait is thrown overboard a seine is shot round the place, and the sardines thus enclosed. *Sardines de rogue* are thus sardines caught by means of rogue and seine. *Dérive,* on the other hand, means drift, and *sardines de dérive* are those caught in drift-nets.

Pouchet proceeds to briefly describe the ripe ova taken from large sardines. He says they measure 1·20 to 1·30 mm. in diameter; that they are transparent, heavier than sea water, and in the latter fall rapidly to the bottom. He says that there is little probability that the fertilized egg would behave differently, although some have supposed that it does. In any case, he says, he and his colleagues have never found this egg at the surface of the sea in the Bay of Concarneau. According to the same paper the vitelline membrane of the sardine's egg is smooth at its outer surface, but on its inner surface presents a reticulation of projecting ridges. The membrane consists of two layers, an external very thin and very refringent, and an internal thicker layer. The vitellus is granular and filled entirely with clear spheres, and with a single oil-globule of a pinkish colour. The paper concludes by insisting that the irregularity in the condition of the ovaries in the *sardines de rogue* indicates that the reproduction of the species is not subject to the influence of the seasons, but, like the greater part of the existence of the species, is carried in waters whose temperatures are nearly constant, that is in regions beyond the reach of man.

It is evident that, apart from the vitelline membrane, Pouchet does not differ from me as to the structure of the ripe egg of the pilchard; and as he has never seen the fertilized egg, it is somewhat hazardous on his part to argue that it does not float. The note above cited was published subsequently both to my paper and Raffaele's, so that it must be presumed that Pouchet attaches little weight to our evidence.

In his Report on the Concarneau Laboratory for 1889 presented to the French Minister of Public Instruction, and reprinted in the

Journal d'Anatomie et de Physiologie, December, 1890, Pouchet again discusses the history of the sardine. He refers to the note I have criticised above, saying that in it he made known for the first time the ripe egg of the sardine. The assertion is the more surprising because in a note on the same page he refers to my paper published in this Journal in March, 1889, four months before his own, and containing both a description and figure of the ripe ovum taken from the fish. In this foot-note Pouchet remarks that I made no reference to the structure of the vitelline membrane, which alone could justify an identification of the egg. He refers to a detailed description of the ripe ovarian egg by M. Biétrix, one of his assistants, printed as an appendix to the Report. But strange to say M. Biétrix does not confirm Pouchet's results as to the peculiarities of the vitelline membrane. He finds, it is true, that the membrane consists of two layers, but he states that the ridges on the internal face of the membrane are not always present, and when present are very variable in appearance; they are generally present when the egg is taken from the ovary and disappear a few minutes afterwards. M. Biétrix thinks that these markings are perhaps due to an alteration of the membrane, the eggs having only been examined in sardines captured several hours before, and in a bad state of preservation. It is evident, therefore, that no importance in respect to identification is to be attributed to the vitelline membrane of the egg of the sardine. On the other hand, M. Biétrix, like Pouchet himself, fully confirms my description of the yolk and the single oil-globule.

Pouchet's most recent utterance on this subject is a note in the Comptes Rendus, dated April 6th, 1891. He tells us there that he has only twice in three years been able to observe ripe female sardines ready to spawn, namely May 29th, 1888, and April 3rd, 1890. It is evident, therefore, that Pouchet has not had many opportunities for studying the subject, the reason probably being that there is no fishing at Concarneau capable of capturing adult sardines, and carried on at a sufficient distance from the shore.

Professor Marion, at Marseilles, has published his observations on the sardine in the Annales du Musée de Marseille, 1890 and 1891. He finds that adult sardines are present in the Gulf of Marseilles all the year round. The sexual organs show no signs of enlargement till the beginning of October, and ripe specimens are seen from December till March, while some shoals have not spawned till the beginning of May. This result is in harmony with mine, for it is not surprising that the sardine should spawn in winter and spring in the warm waters of the Mediterranean, while it spawns in summer at Plymouth, and in both regions it appears that the spawning period is prolonged over five or six months, though the majority of the fish spawn within two months. Marion squeezed the ripe eggs from the fish into sea-water; the eggs on leaving the ovary were 1·3 to 1·4 mm. in diameter, but after being in the water some hours the great perivitelline space had been formed, and the eggs were 1·7 to 1·8 mm. in diameter, although they did not float. He remarks that this is no proof that eggs perfectly healthy, living and fertilized, do not float, while the vast perivitelline space establishes a great resemblance with the eggs attributed to the sardine, being a rare character in buoyant eggs. Marion also obtained in the Gulf floating eggs of the kind assigned by Raffaele and myself to the sardine, and found them only at the time of year when the sardines were ripe. Marion figures the egg and the larva hatched from it, pointing out that the latter is undoubtedly a clupeoid larva.

In the course of the past summer I made an attempt to finally set at rest the question of the pilchard egg by obtaining healthy fertilised ova from the parent fish by artificial fertilization. With this object I went out in a mackerel boat on June 21st, and on June 22nd the nets were shot about twenty miles to the south of the Eddystone, that is nearly thirty miles from the coast. When the nets were hauled I obtained in all about fifty ripe pilchards from them, but to my disappointment found there was not a single male among them. Probably the explanation of this is that the meshes of the net were rather large, and that the males are not quite so swollen when ripe as the females, and were, therefore, not retained. It must be pointed out that these ripe pilchards are not meshed by the gills in a mackerel net as the mackerels are, but are meshed round the abdomen, which is greatly distended by the swollen ovaries. Pilchard nets are never, so far as I know, used off Plymouth so far out at sea as spawning pilchards are found. In fact, very little pilchard fishing is carried on in June and July, and when it is recommenced in August and September it is carried on almost exclusively inside the Eddystone. (See Mr. Roach's records of pilchard fishing, this Journal, vol. i, p. 388.)

However, I squeezed some ripe eggs from the living female fish I obtained into a bottle of clean sea-water without delay, and when I examined them in the Laboratory a few hours afterwards I had the satisfaction of finding nearly all of them floating at the surface. These floating eggs were in all respects similar to the eggs identified as pilchard eggs obtained in the tow-net from the sea; they were perfectly transparent, the yolk in them consisted, not of yolk-spheres as in the dead ova from the ovary, but of polygonal masses, that is of yolk-spheres made polygonal by mutual pressure, as in the eggs obtained from the sea, the large oil-globule was present and the great perivitelline space was formed. These eggs measured 1·2, 1·36, 1·45 mm. in diameter, that is, the perivitelline space was not quite so large as in fertilised eggs, but this is not surprising. The experiment proves conclusively that the ripe eggs of the pilchard, when pressed from the parent fish immediately it is captured, do actually float in sea water, become transparent, and develop a large perivitelline space.

Professor Pouchet makes an appeal to his Government to provide a suitable ship in order to discover where the sardine passes its existence when away from the coast, and reproduces its kind. He thinks the objects of the search would be found within 200 or 300 miles from the shore. He rejects the results of Marion's observations at Marseilles, because what is true for the sardine of the Mediterranean does not apply to the oceanic sardine. But, as Marion points out, the mode of reproduction of the sardine has been made known at Plymouth, and the conditions cannot be so very different a few miles off at Concarneau.

2. *Growth.*—The sardine of the Mediterranean is not so large as our pilchard or the sardine of the west coast of France—the oceanic sardine, as Pouchet aptly calls it. At Marseilles the adult sardines are 15 cm. to 18 cm. in length, or 6 to 7¼ inches. Pouchet finds that the *sardines de dérive* attain a maximum of 25 cm. or even a little more, that is they are from 9½ to 10 inches long. The ripe spawning pilchards which I obtained this summer did not vary much from 24 cm. or 9½ inches.

At Marseilles and Nice the alevins or fry of the sardine are captured for the market, as whitebait, the fry of the herring and sprat, are in England. The sardines remain and are captured in the Gulf of Marseilles during the whole of the first year of their life, and Marion finds from examination of specimens at various times of the year that they increase in length 1 cm. per month. The fishermen of Nice give special names to the successive stages in the development of the sardine, thus the young fish from 2 to 4 centimetres long without the silvery layer in the skin are called *poutino nudo*, while at a little larger size, 4 to 5 centimetres, when they have acquired the silvery livery they are called *poutino vestido*. When still larger they are called *Palailla* and *Sardinettes*. Marion concludes that poutines which are 3 or 4 cm. long (1·2—1·6 in.) in March grow to a length of 12 or 13 cm. (4·7—5·1 in.) by the following December. These fish were spawned in February, and by the following February according to Marion they are 14 or 15 cm. long, and therefore, it would be supposed, ready to spawn themselves. Professor Marion does not express any opinion on this point, but it would certainly appear from his conclusions as to the rate of growth that the sardine at Marseilles begins to spawn when it is one year old, although it probably does not reach the maximum size of 18 cm. ($7\frac{1}{4}$ in.) till it is at least two years old.

At present we have scarcely any evidence as to the growth of the pilchard or oceanic sardine. Pouchet tells us that the smallest sardine he has hitherto obtained was 9·8 cm. in length or 3·9 inches, and he thinks this was about six months old. At Plymouth I have not yet obtained the young of the pilchard at various successive stages. Our fishermen never seem to catch pilchards so small, and, therefore, presumably, so young as the fish taken for the sardine industry on the French coast. I believe this difference is due chiefly to the character of the nets used, the drift-nets at Plymouth having too large a mesh to retain the young fish. However I believe I have obtained some of the very early stages of the young pilchard. The specimens I refer to were taken in the same hauls of the large tow-net as the Phyllosoma I have described in another paper, that is to say they were obtained at the surface on July 9th and July 16th, about two miles north and south of the Eddystone. I have figured three of these specimens illustrating different stages of development. The smallest and youngest stage represented in fig. 1 is 8·5 mm. in length; the larval membranous fin is still present along the dorsal edge and behind the anus ventrally, the permanent dorsal fin is beginning to develope and a symmetrical larval tail fin is present supported by slender rays. All the figures have been drawn from preserved specimens mounted in Canada balsam, and this is the reason of their somewhat rough character, the mounted specimens having lost the transparency and sharpness of detail seen in living fish-larvæ. The notochord in the stage shown in fig. 1 is a large and conspicuous structure. Fig. 2 represents a slightly more advanced stage in which the development of the fin-rays of the dorsal fin is more pronounced, and there is an indication of the permanent caudal fin-rays on the ventral side of the notochord in the tail. The actual size of the specimen from which this figure was drawn is 11·5 mm. The specimen represented in fig. 3 is 2·4 cm. long, and is in the same stage as the fish called at Nice *poutino nudo*. All trace of the primordial fin-membrane has disappeared, and the permanent fin-rays are almost completely developed in the dorsal fin, ventral fin, and caudal fin. The pelvic fins have also appeared; the pectorals are present in the earlier stages, but in this stage are larger, and their fin-rays are beginning to develop. The dorsal fin at this stage is some distance behind the pelvic, while in the adult its anterior extremity is in front of the pelvic.

That these young clupeoids are not herring larvæ is proved by

Fig. 1.

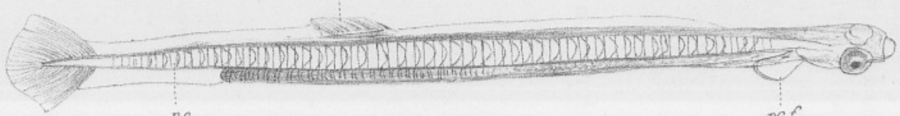


Fig. 3.

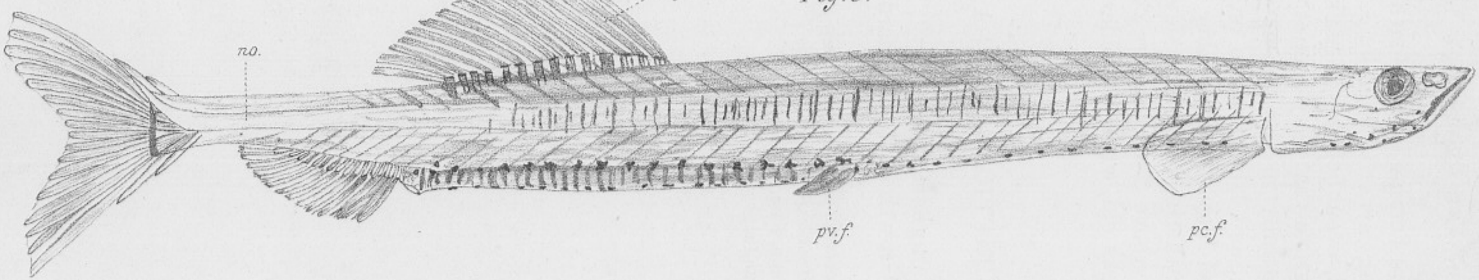
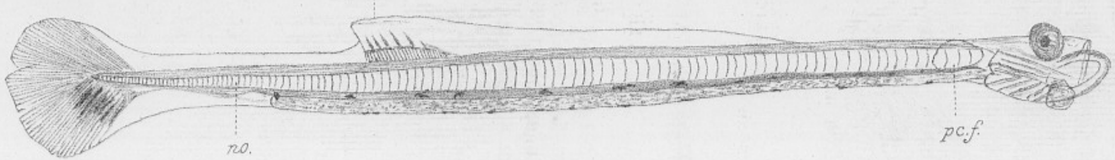


Fig. 2.



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two facts, first that the herring at Plymouth spawns in January, and second that the herring larva is 9 mm. long, larger than the earliest stage above described, even before the yolk-sac is absorbed. But it is more difficult to prove that they cannot be sprat larvæ. Sprat eggs occur most plentifully in the tow-net gatherings in January, February, and March, and I have taken only solitary specimens as late as the beginning of May. On the other hand pilchard ova were plentiful in tow-net gatherings taken outside the Eddystone in June, and the earlier stages above described are certainly not more than a fortnight or three weeks old, while the oldest stage is probably four or five weeks.

DESCRIPTION OF PLATE X,

Illustrating Mr. Cunningham's paper on "The Reproduction and Growth of the Pilchard."

d.f. Dorsal fin. *no.* Notochord. *pc.f.* Pectoral fin. *pv.f.* Pelvic fin.

FIG. 1.—Larva, probably of pilchard, 8·5 mm. long.

FIG. 2.—Older larva, 11·5 mm. long.

FIG. 3.—Later stage, 2·4 cm. long.

The Distribution of Crystallogobius Nilssonii.

By

J. T. Cunningham, M.A.

When trawling with a small beam trawl on July 9th last, a couple of miles north of the Eddystone, I obtained a large number of specimens of a fish which was quite unfamiliar to me. I found it was *Crystallogobius Nilssonii*. The chief characters distinguishing the species are the presence of only two rays in the anterior dorsal fin of the male, and the almost complete absence of this fin and of the pelvic fins in the female. The adult male is 4·4 cm. long, the female about 3 cm. When alive the fish is very translucent, and it is entirely destitute of scales. The species was first described by Düben and Koren in 1844 from half a dozen specimens taken near Bergen. Robert Collett has well described it in the Proceedings of the Zoological Society for 1878, having taken twenty-eight specimens at about 30 fathoms in the Christiania Fjord in the years 1875—1877. Only forty-five specimens altogether had been taken off the south and west coast of Norway at the time when Collett wrote. I captured 201 specimens in a single haul of the trawl, 188 of which were female and 13 male. Nearly all were adult, the eggs being visible through the integuments in the female. A few not quite full grown are included among the 188 reckoned as female, and some of these may prove on closer examination to be young males. In any case the excess of females is very great.

The species has already been included in the British fauna by Day, a single specimen having been taken by Edward in a rock pool at Banff. After I had identified my specimens, I received a copy of a paper by Mr. E. W. L. Holt (Proc. Roy. Dublin Soc., February, 1891), announcing that he obtained many specimens of the same species in Ballinskelligs Bay at a depth of 30 fathoms on the 21st August, 1890. It is evident, therefore, that the species, hitherto supposed to belong chiefly to Scandinavia, is common enough in certain localities on the British and Irish coast. The depth where my specimens were obtained was about 28 fathoms, the bottom, sand. The shrimp-trawl I was using was lined with mosquito-netting for the express purpose of catching small and young fish.

Physical Investigations.

Preliminary Paper.

By

H. N. Dickson, F.R.S.E.

With Plate XI.

It may be taken for granted that, apart from its purely scientific value, a knowledge of the physical conditions affecting the waters of the sea has been shown to throw considerable light on many important economical questions. In its bearing on fish and fisheries, the inquiry may be said to have reached a point where it is conclusively shown that there is a problem to solve.

In a report of the Herring Committee of the Scottish Meteorological Society we find the following stated as preliminary results:—"If, during the herring season, there be a district where, from any cause, the temperature of the sea is lower than in surrounding districts, the catch of herrings is heavier in that district; and conversely if there be a district where, from any cause, the temperature of the sea is higher than in surrounding districts, in that district the catch of herrings is less. Among the causes which bring about a local increase or decrease of sea temperature, the chief are clouded or clear skies in respective districts, according as these occur during the day or during the night. . . .

"The above refers to local fluctuations of temperature during the fishing season, when the temperature of the sea is high. It appears from the observations of past years that the herring seasons have closed about the time when the temperature of the sea in its annual fall has fallen generally to 54·5° F. It is of importance to ascertain how far this relation exists from year to year and in different districts.

"Another important point is the relation of surface temperature to bottom temperature, and the relations of the deepest parts of the sea to the positions of the fishing-grounds. It is found, for instance, that when the surface temperature is high—higher than lower down—the fish, if any can be caught, strike the nets far down in such a way as to lead to the supposition that a good deal of failure may often arise from the nets not going deep enough. The fish prefer, apparently, so far as the inquiry has gone, the lower to the higher temperature."*

Again, in summarising the results of physical investigations carried out for the Fishery Board for Scotland, Dr. John Gibson says, "I am not sure that the observations already made do not even now point to a connection between the presence of Atlantic water in the Moray Firth as a condition of successful inshore herring fishing. In the summer of 1883, when surface Atlantic water filled the Moray Firth, the inshore herring fishings in this firth are reported to have been unusually productive; while, on the other hand, in the summer of 1886, when water from the bottom of the North Sea filled the firth, during the month of August at any rate, it is reported that more than one half of the entire season's catch in the inshore waters was made during one single week, and that all the rest of the season these inshore waters were comparatively unproductive."†

That this opinion is general is shown by the extensive physical investigations carried on by the German Government, both by means of coast stations and exploring expeditions, such as those of the "Pommerania"‡ and the "Drache,"§ by the Norwegian Government, and by the U.S. Commission of Fish and Fisheries, the last named being about to publish an extensive series of observations of temperature and density on the Atlantic seaboard.

So far, however, the problem has only been stated; it has been shown that a more or less indirect relation exists between the physical and meteorological conditions affecting any particular region of the sea, and the quantity and quality of the fish to be caught in that region. Further, it has been shown that two methods of investigation give the most promising results:—(1) Continuous observations of temperature at fixed stations extending over a considerable period of time; and (2) Expeditions making a rapid survey of a certain area at intervals; the distribution of temperature being observed, and samples of water collected for subsequent examination.

These facts ascertained and defined, it remains at present to increase as far as possible, in either or both of the above-mentioned directions, the material for discussion.

In organising, at the request of the Director, a section for physical

* Journ. Scott. Met. Soc., 1876, vol. v, p. 30.

† Report of the Fishery Board for Scotland, 1888, p. 471.

‡ Jahresbericht der Commission zu Wissenschaftlichen Untersuchung der deutschen Meere in Kiel, 1872–3, Berlin, 1875.

§ Ergebnisse der Untersuchungsfahrten der Drache, Berlin, 1886.

work under the auspices of the Association, I have been chiefly guided by these considerations, and the work has divided itself into two separate investigations:—(1) The collection and discussion of existing observations, especially those of surface temperature; and (2) An inquiry into the physical conditions obtaining in the English Channel generally, and specially in the local fishing-grounds, by observations of temperature, examination of water samples, &c.

Through the kindness of the Meteorological Council, access has been obtained to all the records of surface temperature stored in the Meteorological Office. Part of the material has already been handed over to me, and a beginning has been made with its reduction and discussion. This work is necessarily laborious, and some time must elapse before any results can be presented for publication.

The difficulties in the way of commencing practical work were considerable. The steam launch belonging to the Association is useless for sounding outside the harbour except under unusually favourable conditions. I accordingly made an application to the Government Grant Committee of the Royal Society for the sum of £100, to pay hires of steam tugs for trips across the Channel at intervals. This application was granted. The unusually bad weather of the past summer, and the comparatively small amount of time at my disposal for research, have unfortunately prevented more than one trip being made, the results of which are given below.

The methods of marine physical investigation are now sufficiently well known to make it unnecessary to describe in detail the instruments and apparatus used. Temperature observations are made with Negretti and Zambra's reversing thermometer, in the Scottish frame,* and samples collected by Mill's self-locking water-bottle.† Where surface observations only are made, a sample of water is obtained in a wooden bucket, the temperature being taken by means of an ordinary thermometer, and the sample transferred to a glass bottle. All thermometers used have been verified by repeated comparison with a Kew standard belonging to the Association, and in most cases the instruments have Kew certificates in addition. Every care has been taken throughout to keep the errors of temperature observations within 0·1° F.

As the samples collected are at once brought to the Laboratory and their examination proceeded with, it has not been thought necessary to take special precautions in sealing the bottles. Winchester quarts of the ordinary type are used, note being made that the stoppers are well ground in each case.

Determinations of density have been made in the first place with

* Proc. Roy. Soc. Edin., xii, p. 928.

† Mill, ibid., 1886, vol. xiii, pp. 539—546.

an hydrometer of the "Challenger"* type, kindly presented to the Association by J. Y. Buchanan, Esq., F.R.S. This instrument weighs *in vacuo* 150·6897 grammes, and is furnished with seven brass weights varying from 0·3102 gr. to 4·0100 gr., giving for each sample of water at any temperature at least two distinct determinations. The constants of the instrument have been carefully determined twice at temperatures varying from 5° C. to 30° C., and the maximum probable error has been found to be 0·00005, a result agreeing with that arrived at by Mill.†

The want of a sufficiently delicate and reliable balance made the further examination of samples at first almost impossible. Through the kindness of Messrs. Balkwill, chemists, Plymouth, we now have access to an instrument giving results reliable to 0·1 mgrm.; and recently Prof. A. M. Worthington, of the Naval Engineering College, Devonport, has lent to the Laboratory a balance capable of weighing 100 gr. to within 1·0 mgrm. While we are unable to carry out analyses with the high precision reached, for example, in Dr. Gibson's work for the Scottish Fishery Board, we may now hope to make determinations sufficiently accurate to be of considerable value. The first object aimed at is to obtain determinations of density by means of the modified form of Sprengel's pyknometer.‡ In the hydrometer determinations given, the densities are reduced to 15·56° C. compared with distilled water at its maximum density point by Dittmar's tables.§ These tables, however, can only be safely used where the sample approaches the standard density of 1·02600 at 15·56° C. In all other cases determinations made with Sprengel tubes filled in melting ice are much to be preferred.

In the more strictly chemical work I have had the advantage of the co-operation of Mr. F. Hughes, the Chemist of the Association. The alkalinities of all the samples already collected have been determined by the usual methods with a fair degree of accuracy, and considerable progress has been made with estimation of the amounts of chlorine. I have thought it best to defer publication of the chlorine results until more progress has been made with the densities.

Table I gives the results of observations made in a trip on ss. "Deerhound" in the Channel in June last. On June 15th a line was taken from Bolt Head to a point west of Hanois Light, and thence to St. Peter's Port, Guernsey; on June 16th from Guernsey to St. Catherine's in the Isle of Wight; and on June 17th

* Challenger Reports, Narrative, vol. ii, pt. 2.

† Proc. Roy. Soc. Edin., xiii, p. 35.

‡ Report of the Fishery Board for Scotland, 1887, p. 336.

§ Challenger Reports, Physics and Chemistry, vol. i, p. 70.

from Anvil Point back to Bolt Head (see Plate XI). Column 1 gives the laboratory number of each sample of water; columns 2 and 3, the date and hour; columns 4 and 5, the position and depth of the sounding; column 6, state of the tide; 7 and 8, direction and force of the wind; 9, weather at the time of observation; 10, temperature of the air as ascertained by a sling thermometer; 11, depth of observation; 12, the temperature (corrected) at that depth; 13 and 14, the densities, referred to 4° C., at 15·56° C., and *in situ*. Column 15 shows the density at 0° C. referred to distilled water at 0° C., as determined by the Sprengel tubes; and column 16 the alkalinity.

The values given in column 13 are the means of at least three double determinations, and may be taken as accurate to ± 3 in the fifth place of decimals. The reductions, as before stated, have all been effected by means of Dittmar's tables; and as the deviations from standard water are in most cases very small, it is improbable that additional error has been introduced.

The numbers in column 15 are the means of at least two determinations in each case, and may be taken as correct within ± 2 in the fifth place.

The alkalinities have in great part been estimated twice, and are subject to an actual error not exceeding unity, the relative error being probably considerably less.

Table II gives extra observations of surface temperature, taken at intervals of about half an hour. The positions are given with reference to the sounding stations I, II, III, &c., as in Table I.

The route followed in the trips under consideration was chosen simply with the view of finding the most promising fields of investigation. I hope under more favourable conditions to repeat the observations in various parts of the Channel at intervals of two or three months. If this could be done regularly for several seasons we cannot doubt that a good deal of light would be thrown on variations of climate on different parts of our coasts, as well as on the distribution of fish at different periods.

Any general discussion of the observations made in June last is of course useless until material for comparison has been obtained, but a few noticeable features may be pointed out. It appears in the first place that the water in the area surveyed is extremely uniform. The densities at 15·56° C. show but little variation, the highest values, 1·02618 and 1·02612 at surface, and 1·02625 and 1·02612 at bottom, occurring at stations IIa and VIII; and the lowest, 1·02588 at surface and 1·02582 at bottom, at station X, off St. Catherine's. The mean density is practically that of normal sea water, both at surface and bottom, except off St. Catherine's.

The alkalinities also show great uniformity, varying only between

51 and 53, and the surface and bottom samples for each station showing no marked differences. The highest values are found for samples taken down Channel and on the southern side, a decrease being observed in Start Bay and along the coast to the eastwards.

At a depth of 10 fathoms a distribution of temperature is found which remains practically unaltered at all stations until the bottom is reached; even in the case of station VII the temperature at 73 fathoms is only 0·2° F. lower than that at 10 fathoms. At these depths the highest temperatures are found off the English coast east of the Bill of Portland, and again in the neighbourhood of the Channel Islands, colder water occurring in mid-Channel at stations II, IIa, and III, and VII and VIII, and between Start Point and the Bill of Portland, where the minimum of 50·6° F. is reached, the isothermals curving into Start Bay and turning south again.

On the surface the distribution of temperature is peculiar; and although the observations here are very much more numerous, less weight can be attached to their results on account of the action of wind. It is to be noted that on the first day of the cruise the wind was south-westerly, light, freshening, and veering a little towards evening, till at 2 a.m. next morning it was blowing hard from about west. After daybreak the force greatly diminished, and the wind gradually veered to north-west and died away altogether. On the third day the wind was westerly and extremely light, dying away to a calm at times.

Wherever undisturbed by land influences, the line between stations I and IV may be said to show a uniform temperature at the surface of 53·7° F. Further up Channel, *i. e.* between stations VI, VII, VIII, and IX, a lower temperature is found, varying irregularly at the time of observation between 52° F. and 53° F.; and this colder surface water seems to extend at any rate round the island of Guernsey. In the area covered by stations IX, X, XI, and XII a temperature between 53° F. and 54° F. is found, rising as we approach Poole Bay to about 55° F.

In the region between Start Point and the Bill of Portland a totally different distribution occurs. We find here the highest temperatures of the whole cruise, rising suddenly 2° as the Bill of Portland is passed, and slowly increasing thereafter till the maximum of 57° F. is reached off Beer Head. A sudden drop to below 52° is observed over the Skerries off Dartmouth Harbour. Soundings XIII and XIV show that the layer of warmer water is quite superficial, the temperature falling to 51·9° F. at 6 fathoms in XIII, and to 50·9° F. at 8 fathoms in XIV. It may be noted that extra samples, No. 42 and No. 45, show no change in the density at 15·56°. With regard to column 14, densities *in situ*, we have of course simply the results of the distribution of temperature, with the small variations of column 13. On the bottom the highest values are obtained in mid-Channel and in Start Bay, decreasing slightly on the southern coast, and more markedly to the east of the Bill of Portland. On the surface, again, the highest values are found at stations IIa and VIII, and on the southern side; and the lowest off the English coast, those to the east of the Bill of Portland being due to differences in the water, those to the west to differences of temperature.

The results suggested by these observations may be summarised as follows :

(1) The waters of the Channel are subject to a peculiar circulation, the nature of which cannot be determined without more extended investigation.

(2) The distribution of temperature in Start Bay demands special investigation. In this area we find the highest surface temperatures and the lowest bottom temperatures, the warm surface layer being about 6 fathoms in thickness, while at the same time there is no change in the composition of the water. In Start Bay we have a notedly good trawling-ground, and this confirms the result obtained off the east coast of Scotland by Dr. Gibson as already quoted, and again by myself,* viz. that where we have true oceanic waters, unmixed with estuarine or river waters, subject to special temperature conditions due to the presence of land or other causes, we find favourable conditions for successful fishing. This result seems to be to some extent borne out by observations on the Dogger Bank fishing-grounds.

What these temperature conditions actually are must be shown by investigation. The preliminary trip in the Channel indicates that more numerous and detailed temperature observations must be made over a large area, and that the samples collected need not be so numerous, but must in all cases be subjected to a rigorous examination of the greatest attainable accuracy.

In conclusion, I may say that the material discussed in my paper already quoted seems to me exceptionally valuable in the inquiry in hand. Observations of surface temperature taken regularly *on the fishing-grounds* by fishermen afford data of extreme interest even when great accuracy is not attempted. I have tried to initiate such observations amongst the local fishermen on these coasts, so far, unfortunately, without much success. The Association will be glad to supply instruments and books to any fisherman or seaman on any part of the coast who will take such observations.

During the winter months I hope also to investigate the conditions of local estuarine waters in relation to fisheries.

* Journ. Scott. Met. Soc.,' 1889, vol. viii, No. 6, p. 332.

TABLE I.

No. of sample.	Date.	Hour.	Position.	Depth. Fath.	Tide.	Wind. Direction.	Wind. Force.	Weather	Temp. of air.	Depth of observation	Temp. of sea. T.	$S\frac{15{\cdot}56}{4}$	$S\frac{T}{4}$	$S\frac{0}{0}$	Alkalinity.
13	12/6/91	Noon	Eddystone, S.W. 7 miles	28	½ ebb	S.W.	0	*b*	...	0	53·8	1·02607	1·02679	...	53·4
										1½	52·0				
										5	51·1				
										10	51·0				
										15	50·7				
										20	50·7				
14	...	...	...	...	...	...	...	...	...	27	50·6	1·02620	1·02725	...	53·1
15	12/6/91	1.30 p.m.	Between Penlee Point and Mewstone	10	½ ebb	...	...	...	...	0	54·0	1·02551	1·02621	...	52·0
										5	51·5				
16	...	...	...	...	...	...	...	...	...	9	50·9	1·02599	1·02700	1.02829	52·2
17	15/6/91	9 a.m.	I. Bolt Head, N.E. × E. 1½ miles	20	½ fl.	W.S.W.	0—1	*f°*	55	0	52·6	1·02601	1·02686	1·02820	52·8
										5	51·8				
										8	51·5				
										10	51·8				
										13	51·6				
										15	51·4				
										17	51·6				
18	...	...	...	...	...	...	...	...	...	19	51·4	1·02599	1·02695	...	52·2
19	15/6/91	12.30 p.m.	II. S.E. × S. ¼ S., 20 miles from I	40	H. W.	W.S.W.	1	o	56	0	53·9	1·02606	1·02676	...	53·0
										5	53·4				
										7	52·9				
										10	51·1				
										15	50·9				
										20	51·0				
20	...	...	...	...	...	...	...	...	...	39	50·9	1·02616	1·02717	...	52·8
21	15/6/91	2.30 p.m.	IIa. S.E. × S. ¼ S., 16 miles from II	42	½ ebb	...	...	...	56	0	53·8	1·02618	1·02690	1·02856	51·6
										22	51·4				

22	...	...	...	...	...	...	...	...	...	41	51·2	1·02625	1·02723	...	52·4
	15/6/91	3 p.m.	III. S.E. × S. ¼ S., 18 miles from II	40	...	...	...	...	55	0	53·8				
										5	53·1				
										10	51·5				
										12	51·4				
										15	51·3				
										20	51·3				
										39	51·2				
23	15/6/91	6 p.m.	IV. S.S.E. ½ S., 23½ miles from III. Hanois E.N.E. 3 miles	32	L.W.	W.S.W.	0–1	∞	55	0	52·6	1·02603	1·02688	...	52·2
										5	52·2				
										10	52·0				
										15	51·9				
										22	51·9				
24	...	...	...	...	...	...	...	...	...	31	51·9	1·02611	1·02702	...	52·5
25	15/6/91	7.25 p.m.	V. St. Martin's Point N.E. 2 miles	30	½ fl.	W.S.W.	0–1	f^{∞}	...	0	52·2	1·02608	1·02697	...	52·4
										10	52·0				
										15	51·9				
										20	51·9				
26	...	...	...	...	...	...	...	...	...	29	51·8	1·02601	1·02693	...	52·0
27	16/6/91	8.30 a.m.	VI. Caskets N.W. ½ N. 9 miles	28	1 hr. fl.	N.N.W.	1	∞	...	0	53·2	1·02604	1·02682	...	52·1
										5	53·0				
										10	52·8				
										15	52·7				
										20	52·4				
										23	52·4				
28	...	...	...	...	...	...	...	...	...	27	52·2	1·02606	1·02695	...	52·2
29	16/6/91	12.30 p.m.	VII. Caskets S.W. × S. 9 miles	73	H. W.	N.W.	1	Cloudless	...	0	53·6	1·02607	1·02681	...	52·2
										5	51·9				
										10	51·6				
										20	51·4				
										30	51·3				
										40	51·3				
										53	52·0				
										60	51·9				
30	...	...	...	...	...	...	...	...	...	72	51·4	1·02609	1·02705	...	52·6

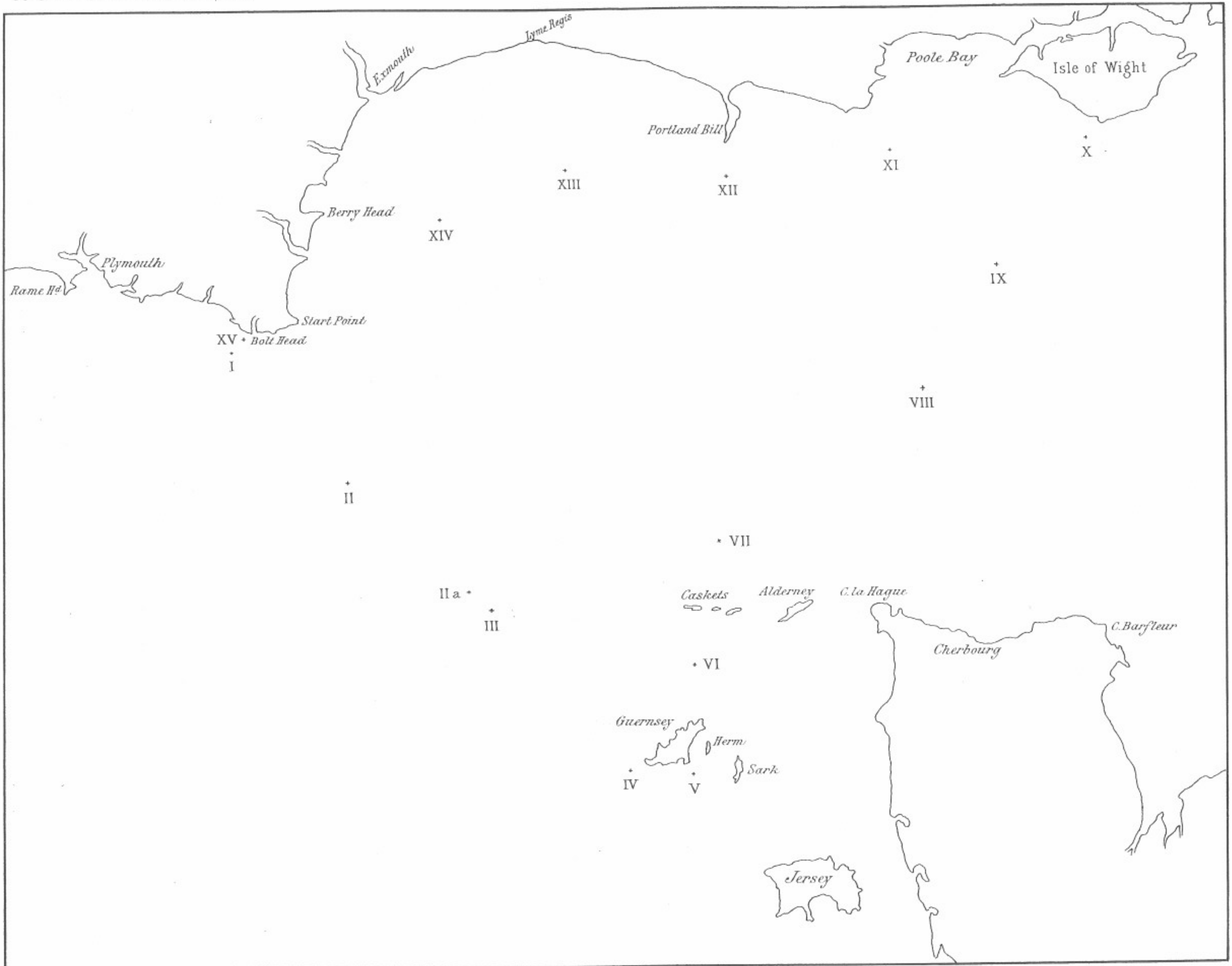
TABLE I (*continued*).

No. of sample.	Date.	Hour.	Position.	Depth. Fath.	Tide.	Wind. Direction.	Wind. Force.	Weather	Temp. of air.	Depth of observation	Temp. of sea. T.	S. 4. 15·56.	S. 4. T.	S. o. o.	Alkalinity.
31	16/6/91	4.15 p.m.	VIII. E. × N., 29 miles from VII	40	1 hr. ebb	N.W.	1	∞	...	0	52·0	1·02612	1·02703	...	52·2
										5	51·8				
										10	51·6				
										20	51·4				
										30	51·4				
32	...	...	...	...	...	...	...	...	...	39	51·3	1·02612	1·02710	...	51·5
33	16/6/91	6.15 p.m.	IX. N.E. × E., 15 miles from VIII	29	2 hr. ebb	N.W.	1	*b*	...	0	53·0	1·02604	1·02684	...	50·8
										5	52·9				
										10	52·8				
										19	52·8				
34	...	...	...	...	...	...	...	...	...	28	52·7	1·02599	1·02682	...	50·8
35	16/6/91	8.15 p.m.	X. St. Catherine's N.E. ¼ E. 2 miles	30	½ ebb	W.N.W.	1	*b*	...	0	54·6	1·02588	1·02650	...	51·1
										5	54·5				
										10	54·3				
										20	54·4				
36	...	...	...	...	...	...	...	...	...	29	54·3	1·02582	1·02648	...	51·1
37	17/6/91	6.45 a.m.	XI. Anvil Point N. × W. 10 miles	22	¾ ebb	Var.	0	*b*	...	0	53·7	1·02604	1·02676	...	51·1
										5	53·3				
										12	53·4				
38	...	...	...	...	...	...	...	...	...	21	53·3	1·02602	1·02680	...	51·9
39	17/6/91	10 a.m.	XII. Portland Low Light N.N.E.	29	¼ fl.	Westerly	0	*b*	56	0	54·3	1·02606	1·02672	...	52·0
										2	53·2				
										5	53·5				
										10	53·1				
										19	53·1				
40	...	...	...	...	...	...	...	...	...	28	53·0	1·02602	1·02682	...	51·2

41	17/6/91	Noon	XIII. Beer Head N. × E. 18 miles	28	¾ fl.	W.S.W.	0—1	o	57	0	55·9	1·02611	1·02659	...	51·9
										2½	55·0				
										5	52·9				
										6	51·9				
42	...	...	...	...	...	...	...	...	...	8	51·5	1·02608	1·02704	...	51·1
										10	51·4				
										20	51·0				
43	...	...	...	...	...	...	...	...	...	27	51·0	1·02611	1·02710	...	51·0
44	17/6/91	2.15 p.m.	XIV. W.S.W. 14 miles from XIII	26	H. W.	W.S.W.	0—1	o	...	0	56·6	1·02608	1·02648	...	52·1
										3	56·3				
										5	55·2				
										6	51·9				
45	...	...	...	...	...	...	...	...	...	7	...	1·02608	1·02709	...	52·0
										8	50·9				
										10	50·9				
										15	50·6				
										20	50·6				
46	...	...	...	...	...	...	...	...	...	25	50·6	1·02608	1·02713	...	51·7
47	17/6/91	6.10 p.m.	XV. Bolt Head N.N.E. 1½ miles	20	¾ ebb	Calm	0	o	...	0	53·5	1·02598	1·02674	...	52·3
										1	52·5				
										2	52·5				
										5	52·2				
										10	52·0				
48	...	...	...	...	...	...	...	...	...	19	51·9	1·02602	1·02693	...	52·7

TABLE II.—*Surface Temperatures.*

Date.	Hour.	Position.	Temperature.
15/6/91	9 a.m.	I. Bolt Head N.E. × E. ....1½ miles	52·6°
	10	*a.* S.E. × S. ¼ S. from I......... 4 ,,	54·2
	10.30	*b.* ,, ,, ... 9 ,,	54·1
	11	*c.* ,, ,, ...13 ,,	53·5
	11.30	*d.* ,, ,, ...18 ,,	53·0
	12.30 p.m.	II. ,, ,, ...20 ,,	53·9
	1.20	*a.* S.E. × S. ¼ S. from II ...... 5 ,,	53·6
	1.50	*b.* ,, ,, ... 9 ,,	53·6
	2.20	*c.* ,, ,, ...14 ,,	53·7
	2.30	II. *a.* ,, ,, ...16 ,,	53·8
	3	III. ,, ,, ...18 ,,	53·8
	4	*a.* S.S.E. ½ S. from III......... 4 ,,	53·4
	4.30	*b.* ,, ,, ... 9 ,,	53·7
	5	*c.* ,, ,, ...14 ,,	53·7
	5.30	*d.* ,, ,, ...18 ,,	53·1
	6	IV. ,, ,, ...23½ ,,	52·6
	7	Pleinmont Point N.W. × N. ...... 4 ,,	52·2
	7.25	V. St. Martin's Point N.E............ 2 ,,	52·2
16/6/91	8.30 a.m.	VI. Caskets N.W. ½ N.................. 9 ,,	53·2
	9.30	*a.* ,, ,, ... 6 ,,	53·0
	10	*b.* ,, ,, ... 3 ,,	52·1
	10.30	Off the Caskets	52·2
	11	Caskets S.W. × S. .... 4 ,,	52·0
	12.30 p.m.	VII. ,, ,, ... 9 ,,	53·6
	1.50	*a.* E. × N. from VII .... 4 ,,	53·1
	2.20	*b.* ,, ,, ... 9 ,,	52.6
	2.50	*c.* ,, ,, ...14 ,,	52·6
	3.20	*d.* ,, ,, ...19 ,,	52·3
	3.50	*e.* ,, ,, ...24 ,,	52·3
	4.15	VIII. ,, ,, ...29 ,,	52·0
	5.50	*a.* N.E. × E. from VIII......... 9 ,,	52·2
	6.15	IX. ,, ,, ...15 ,,	53·0
	7.15	*a.* ,, from IX........... 4 ,,	53·9
	7.45	*b.* ,, ,, ... 9 ,,	54·5
	8.15	X. St. Catherine's Light N.E. ¼ E... 2 ,,	54·6
	9	S.W. off Brixton...................... 4 ,,	54·8
17/6/91	6.15 a.m.	Anvil Point N. × W. .... 6 ,,	55·6
	6.45	XI. ,, ,, ...10 ,,	53·7
	7.30	*a.* W. ½ N. from XI .... 4 ,,	53·9
	8	*b.* ,, ,, ... 9 ,,	53·7
	8.30	*c.* ,, ,, ...14 ,,	53·8
	9	*d.* ,, ,, ...18 ,,	54·1
	9.20	*e.* ,, ,, ...20 ,,	53·9
	10	XII. Portland Light N.N.E. .... 9 ,,	54·3
	10.30	*a.* N.W. × W. from XII......... 5 ,,	54·0
	11	*b.* ,, ,, ... 9 ,,	55·8
	11.30	*c.* ,, ,, ...13 ,,	55·5
	12 noon	XIII. Beer Head N. × E. ....18 ,,	55·9
	1 p.m.	*a.* W. ½ N. from XIII .... 4 ,,	56·3
	1.30	*b.* ,, ,, ... 9 ,,	56·2
	2.15	XIV. Berry Head W.N.W. ½ N..........11 ,,	56·6
	3.15	*a.* W.N.W. ½ W. from XIV... 5 ,,	57·4
	3.50	*b.* Off Berry Head..............	57·1
	4.20	*c.* Off Dartmouth	54·1
	4.50	*d.* Off Beeson.....................	52·6
	5	*e.* Start Point W. ¾ S. .... ¼ mile	54·0
	5.10	*f.* ,, N.E. × E. ...... ¼ ,,	52·4
	6.10	XV. Bolt Head N.N.E. ....1½ miles	53·5



F. Huth, Lithr. Edinr.

Notes on Meteorological Observations at Plymouth.

By

H. N. Dickson, F.R.S.E.

The meteorological observations at Plymouth Navigation School, carried on for a period of more than twenty-six years by Dr. J. Merrifield, ceased on his death in June last. It seemed desirable that Plymouth should not be without an observing station, and as the Association was undertaking other work of a similar nature it was decided to begin observations on the scale of a station of the second order.

Mr. W. V. Merrifield, into whose hands the instruments passed on his father's death, kindly offered to lend a set of thermometers and sunshine recorder. The barometer used by Dr. Merrifield is the property of the Meteorological Council, who have transferred the instrument temporarily to the hands of the Association until another instrument can be acquired.

The ground behind the Laboratory, being almost enclosed by the walls of the Citadel, was obviously unsuitable for the exposure of meteorological instruments. Application was accordingly made to the municipal authorities of Plymouth for permission to erect a thermometer screen and to expose a rain gauge on the enclosed ground behind the public lavatory on the Hoe. This permission was granted by the Hoe Committee, and an exceptionally good exposure has been obtained close to the Laboratory.

In order to make the observations as generally useful as possible, copies are regularly supplied to the following:—(1) The Meteorological Office, weekly and monthly Reports. (2) The Royal Meteorological Society, monthly Reports. (3) The Medical Officer of Health, fortnightly Reports. (4) Western Morning News, daily Report and monthly Summary.

The sheets are issued from the Laboratory with all corrections made, and summed and averaged. The following is a list of the elements observed and calculated:—Atmospheric pressure. Temperature: Dry bulb, Wet bulb, Maximum, Minimum, Dew-point. —Pressure of vapour—Relative humidity. Wind: Direction, Force

(Beaufort Scale). Cloud: Form, Amount (0—10). Rainfall. Sunshine. Ozone (0—10).

The barometer is of marine pattern (B. T. 59), reading to ·002 in., and hangs in an unused room with a north light. The height of the cistern above mean sea level at Devonport Dockyard is 125·9 feet, as ascertained by levels from Ordnance datum mark, executed by Plymouth Borough Engineer. The reduction of observations to sea level is effected by tables specially supplied by the Meteorological Office.

The thermometers are exposed in a Stevenson screen of the usual pattern, open below. A complete duplicate set of thermometers is kept in readiness in case of accident. Observations are made with Negretti and Zambra's ozone tests, the papers being hung in the Stevenson screen.

The rain gauge is of Meteorological Office pattern, with circular rim 8 inches in diameter. Height of rim above ground 0·62 foot, above mean sea level 117·7 feet.

The Campbell-Stokes sunshine recorder is placed on the roof of the Laboratory, at the point where the eye observations of wind, cloud, and weather are made. The instrument fits into a frame mounted on an adjustable stage, so that it can be removed and replaced without further adjustment. The place of observation is in lat. 50° 21′ 49″ N., long. 4° 8′ 21″ W., as determined by measurements from the dial on the Breakwater, of which the position is accurately laid down on the chart.

The hours of observation are 9 a.m. and 9 p.m. local time, or 9 h. 16·5 m. Greenwich time. It was found impossible to take regular daily observations with greater frequency.

The ordinary routine work was begun on September 1st, and a table showing the means for the month is appended to these notes.

Mr. Merrifield has been kind enough to give me access to his father's meteorological records, and I hope to be able to discuss them fully in a future number of the Journal. In the meantime a few of the more obvious results may be of interest.

The position of the observing station was in lat. 50° 22′ 25″ N., long. 4° 7′ 16·5″ W. From the commencement of the observations the instruments were 90 feet above mean sea level up to July, 1873. They were then removed to a new position, cistern of barometer 69 feet above mean sea level; rain gauge 9 feet 2 inches above the ground. The hour of observation was 8 a.m. till 1887, when it was changed to 9 a.m.

Atmospheric Pressure.

The mean pressures, reduced to 32° F. and sea level (for the twenty-six years, 1865—1890), are as follows:

	Mean pressure, 8 a.m.		Monthly range.
January	29·956 inches	...	1·455 inch.
February	29·980 „	...	1·277 „
March	29·941 „	...	1·258 „
April	29·898 „	...	1·094 „
May	29·968 „	...	0·898 „
June	30·024 „	...	0·778 „
July	29·979 „	...	0·762 „
August	29·965 „	...	0·761 „
September	29·975 „	...	0·927 „
October	29·924 „	...	1·171 „
November	29·925 „	...	1·257 „
December	29·952 „	...	1·277 „
Means	29·957 „		1·076 „

The maximum pressure thus occurs in June, and the minimum in October and November. The month of greatest range is January; that of least, August. The highest recorded reading, 30·952 inches, occurs in January, 1882; and the lowest, 28·418 inches, in December, 1876. The highest monthly mean, 30·347 inches, is that for January, 1880; and the lowest, 29·422 inches that for December, 1876. It should be noted that for the reductions to sea level the tables supplied by the Meteorological Office have been employed.

For purposes of comparison I have taken the means for the fifteen years, 1870—1884, and beside these are placed means for the same years from Falmouth Observatory, the last named being extracted from the "Challenger" Report on Atmospheric Circulation,* and reduced to sea level by means of the table given in 'Instructions in the Use of Meteorological Instruments,' issued by the Meteorological Office.

	Plymouth.		Falmouth.		Differences.
January	29·991	...	30·003	...	−·012
February	29·944	...	29·946	...	−·002
March	29·970	...	29·979	...	−·009
April	29·880	...	29·896	...	−·016
May	30·013	...	30·025	...	−·012
June	29·986	...	30·002	...	−·016
July	29·968	...	29·983	...	−·017
August	29·962	...	29·977	...	−·015
September	29·961	...	29·962	...	−·001
October	29·899	...	29·915	...	−·016
November	29·897	...	29·908	...	−·011
December	29·943	...	29·959	...	−·016
Means	29·951		29·963		−·012

* Voyage of H.M.S. "Challenger," Physics and Chemistry, ii, pt. 5.

The correction for daily range in the above means for Plymouth is small, that derived from the Falmouth observations amounting to +0·003 inch during the month of June. I hope to determine its amount accurately by a full discussion of Dr. Merrifield's observations, supplemented by the readings of a Richard barograph now recording in the Laboratory.

Temperature.

The mean temperatures given below are calculated from the readings of maximum and minimum self-registering thermometers by the formula T. = Min. + K (Max. − Min.), where K has the following values :

Months	K.	Months	K.
January, December	0·520	April, September	0·476
February, November	0·500	May, August	0·470
March, October	0·485	June, July	0·465

(See title-page of Weekly Weather Report, 1884, Meteorological Office.)

Mean for Twenty-six Years, 1865—1890.

January	41·9	June	59·7	November	46·4
February	43·1	July	62·6	December	42·3
March	43·9	August	62·0		
April	49·2	September	58·2	Mean	51·2
May	53·8	October	51·5		

Taking the fifteen years 1870—1884 for Plymouth, we may compare with the same period for Exeter, Babbacombe, Prawle Point, Dartmoor (Princetown ?), and Bude as give in "Challenger" Report before quoted, reducing each to sea level by means of the correction 1° F. for 270 feet.

Stations.	Height in feet.	Jan.	Feb.	Mar.	Apr.	May.	June	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
Plymouth	90	42·9	43·9	45·0	48·8	53·3	58·8	61·8	62·1	57·6	51·7	46·4	42·6	51·2
Exeter	164	41·1	43·2	44·9	48·8	53·9	59·5	63·4	63·1	58·1	51·4	44·4	41·2	51·1
Babbacombe	293	42·9	44·1	45·0	48·3	52·9	58·5	62·0	62·3	58·3	52·4	46·8	42·8	51·4
Prawle Point	350	43·4	44·3	45·0	48·1	52·3	57·3	61·1	61·6	58·5	52·8	47·5	43·9	51·3
Dartmoor	1372	42·1	43·1	44·6	48·9	52·3	58·0	61·0	61·1	57·5	51·4	45·9	42·4	50·7
Bude	16	42·1	43·4	44·6	48·3	52·6	57·8	60·6	61·3	57·7	52·4	45·9	42·6	50·8
Falmouth	211	45·2	45·5	45·8	48·8	52·9	58·1	61·1	61·7	58·4	53·4	48·4	45·2	52·0

From this table it appears that the curve of temperature at Plymouth is of a form intermediate between stations wholly exposed to the influence of the sea, and stations more inland. Thus on an average Plymouth is about 1° F. colder than Prawle Point during the winter months, and during the summer months about 1° F. warmer. On the other hand, Plymouth is 1·5° F. warmer than Exeter in winter, and in summer 1·5° colder. In spring and autumn the temperatures of these stations are almost identical, although it may be observed that in September the temperature of Plymouth shows a somewhat greater fall than occurs, *e. g.*, at Babbacombe, a a phenomenon which, although not fully confirmed by the mean of the longer period, suggests the influence of the high plateau of Dartmoor in some peculiar seasons.

Humidity.

The hygrometric conditions are shown by the following readings of dry and wet bulb thermometers, the values being means for twenty-six years as before.

	Dry.	Wet.	Dew-point.	Pressure of vapour. Inches.	Relative humidity. Per cent.
January	41·4	40·4	39·1	·238	92
February	41·8	40·8	39·5	·242	92
March	42·3	40·6	38·6	·234	87
April	48·2	45·8	43·2	·279	84
May	53·8	50·6	47·5	·329	79
June	59·9	56·3	53·2	·406	79
July	62·3	59·1	56·4	·456	82
August	61·3	58·7	56·5	·457	85
September	57·2	55·5	54·0	·418	89
October	50·4	49·1	47·7	·331	91
November	45·1	44·0	42·7	·274	91
December	41·3	40·5	39·5	·242	94
Means	50·4	48·5	46·5	·317	87

Winds.

The following table gives the twenty-six years' average of the number of days in each month on which the wind blew from a point in each quadrant.

Month.	N. by E. to E.	E. by S. to S.	S. by W. to W.	W. by N. to N.	Calm.
January	6	6	10	5	4
February	6	5	8	6	3
March	9	4	7	8	3
April	9	6	6	6	3
May	8	8	7	6	2
June	5	7	7	8	3
July	4	5	10	9	3
August	5	5	9	8	4
September	6	5	8	6	5
October	7	5	7	7	5
November	7	4	8	7	4
December	6	5	9	6	5
Sums	78	65	96	82	44

Taking the fifteen years 1870—1884 as before, and summing the values N.E. and E., S.E. and S., S.W. and W., N.W. and N., given in the "Challenger" Reports, for Falmouth at 8 a.m., we get the following:

Month.	Plymouth.					Falmouth.				
	N. by E. to E.	E. by S. to S.	S. by W. to W.	W. by N. to N.	Calm.	N. by E. to E.	E. by S. to S.	S. by W. to W.	W. by N. to N.	Calm.
January	7	6	10	4	4	4	9	11	7	—
February	6	6	8	5	3	4	8	11	5	—
March	9	4	7	8	3	6	6	9	10	—
April	9	6	6	6	3	9	5	8	8	—
May	9	5	7	8	2	9	6	7	9	—
June	4	6	8	9	3	3	7	10	10	—
July	3	5	11	9	3	3	6	14	8	—
August	6	5	10	6	4	5	5	12	9	—
September	6	4	8	7	5	4	6	11	9	—
October	8	5	7	6	5	4	8	10	9	—
November	8	4	8	7	3	4	6	11	9	—
December	6	5	8	7	5	3	6	12	10	—
Sums	80	60	100	82	43	58	78	126	103	—

These sums for the year for Plymouth are in close agreement with those for the longer period, and we observe, as compared with Falmouth, a considerable average of calms, and excess of north-easterly winds, which again point to the influence of high land as hinted in the temperature curve.

Rainfall.

The rainfall of Plymouth is an element the discussion of which raises many problems of the greatest interest, on account of its peculiar position with respect to the entrance to the English Channel and to the high plateau of Dartmoor. The whole question is well worthy of full investigation. In the meantime one may give Dr. Merrifield's observations as they stand.

Averages for Twenty-six Years ending December, 1890.

	Rainy days.		Amount in inches.
January	19·4	...	3·965
February . . .	16·4	...	2·960
March	14·0	...	2·615
April	13·5	...	2·252
May	12·1	...	2·140
June	12·0	...	1·892
July	14·5	...	2·839
August . . .	14·2	...	2·680
September . . .	14·3	...	3·692
October	18·4	...	3·660
November . . .	17·3	...	3·557
December . . .	18·4	...	3·775
Totals . . .	184·5		36·027

The following notes are given by Dr. Merrifield :—"The average for five years is taken from the Quarterly Weather Report, Meteorological Office, January to March, 1870; rain gauge not used until January, 1869. In ten years from 1869 to 1878, Mr. Balkwill, Old Town Street (Plymouth), had 412·05 inches; Navigation School, 363·19 inches. Hence 13·45 per cent. should be added to Navigation School amounts. In five years from 1870 to 1874 Mr. Balkwill had 196·94 inches; Navigation School, 171·09, or add 15·11 per cent. to Navigation School; Drake's reservoir, 201·43 inches and 895 rainy days; Navigation School, 171·09 inches and 865 rainy days. Hence add 17·73 per cent. rain and 3·47 per cent. number of rainy days to Navigation School."

Sunshine.

Dr. Merrifield's records of the duration of sunshine begin with the year 1882. We have accordingly nine complete years, with the following results:

	Total sunshine. Hrs.	Min.		Percentage of possible.
January	41	33	...	16
February . . .	76	48	...	27
March	130	27	...	36
April	171	53	...	42
May	198	25	...	40
June	202	59	...	42
July	187	17	...	38
August	197	52	...	45
September . . .	146	56	...	39
October	98	25	...	30
November . . .	57	57	...	22
December . . .	49	56	...	20
Total . .	1560	28		33

Whence it appears that on the whole Plymouth enjoys one third of the possible bright sunshine, the proportion rising to nearly one half in August, and falling to one sixth in January.

The foregoing results are deduced from the averages computed by Dr. Merrifield, and comparisons have been made only with the material immediately to hand. They are, however, sufficient to show the great value of Dr. Merrifield's records, and of what may be expected from a full discussion.

Meteorological Observations at M.B.A. Laboratory, Plymouth, September, 1891, *9 a.m. and 9 p.m.*

{ Lat. 50° 21′ 49″ N. }
{ Long. 4° 8′ 21″ W. }

Height of cistern of barometer above mean sea level 125·93 feet.
" rain gauge " " 117·67 "
" " .. ground 0·62 foot.

Day of month.	Mean barometer red. to 32° and sea level.	Temperature. Dry bulb.	Wet bulb.	Max.	Min.	Dew-point.	Elastic force.	Relative humidity. Sat.=100.	Wind. Direction. 9 a.m.	9 p.m.	Mean force, 0—12	Cloud amount, 0—10. 9 a.m.	9 p.m.	Sunshine, hours.	Ozone, 0—10.	Rain.	Remarks.
1	29·627	57·7	55·3	62·4	56·0	53·1	·405	84	S.S.W.	S.S.W.	2	10	0	—	4	·000	Gale in forenoon.
2	29·872	56·2	55·0	60·2	54·7	54·0	·418	92	S.S.W.	Calm	1	10	0	1·70	1	·000	
3	29·979	57·7	55·2	61·6	53·8	52·9	·402	83	S.E.	S.W.	1	2	1	10·27	6	·000	Lightning at midnight.
4	30·102	56·7	54·8	62·8	54·7	53·1	·405	84	S.W.	S.W.	2	7	0	9·34	4	·000	
5	30·198	57·1	53·3	61·2	53·8	49·9	·360	77	S.W.	S.W.	3	7	0	4·61	5	·000	
6	30·015	57·3	56·2	61·5	55·6	55·2	·432	93	S.W. × W.	S.W. × S.	4	10	10	2·73	6	·275	
7	30·027	58·2	58·1	62·1	56·4	58·0	·482	100	S.S.W.	S.S.W.	1	10	10	0·71	7	·025	
8	30·114	60·6	58·1	64·0	57·1	55·9	·449	85	S.	N.E.	2	0	9	5·10	6	·010	
9	30·092	64·6	60·7	73·4	55 8	57·5	·474	79	E.S.E.	N.E. × N.	1	1	0	11·05	4	·000	
10	30·093	65·6	59·9	73·6	59·8	55·4	·439	70	E.N.E.	Calm	1	0	0	11·51	2	·000	
11	30·097	66·6	60·3	75·2	53·9	55·4	·440	68	E.N.E.	E. × N.	1	0	0	11·10	1	·000	
12	30·004	69·0	62·0	76·3	54·8	56·5	·459	65	E. × N.	N.E.	1	0	0	11·17	4	·000	Faint lunar halo p.m.
13	29·812	63·5	60·9	70·6	60·9	58·6	·494	85	E.S.E.	E.N.E.	1	7	4	1·04	6	·004	
14	29·950	57·4	55·2	62·6	53·1	53·2	·414	86	E.S.E.	W.	1	10	0	2·17	7	·040	Wind force 7 in afternoon.
15	30·269	56·0	53·4	61·3	47·8	51·0	·376	84	W.	Calm	1	8	9	3·37	1	·002	
16	30·351	57·1	55·6	60·5	48·8	54·3	·422	90	S.	W.S.W.	1	10	8	0·00	7	·000	Lunar halo p.m.
17	30·166	59·6	58·6	62·6	55·2	57·7	·478	94	W.	S.W.	4	7	10	2·97	5	·147	
18	30·034	60·3	60·3	62·3	59·0	60·3	·523	100	W.	Calm	1	10	10	0·00	6	·470	
19	29·995	59·4	59·4	61·8	58·4	59·4	·507	100	S.W.	S. × E.	2	10	10	0·00	6	·270	
20	29·823	55·0	52·4	59·8	52·5	50·0	·361	83	W. × N.	W.N.W.	2	9	9	3·12	6	·194	Wind force 7 at 2 a.m. Bar. min. 5 a.m.
21	29·834	51·6	50·1	58·2	48·9	48·5	·342	89	W.S.W.	N.	2	10	10	4·18	4	·039	Wind N.W., force 8, at 2.30 p.m.
22	29 935	54·5	51·4	61·4	50·9	48·5	·343	80	N.	N.E.	2	7	0	8·00	3	·000	
23	30·160	54·0	52·5	62·1	44·6	51·2	·378	90	E.N.E.	N.N.E.	0	0	0	9·12	7	·378	Lunar halo at midnight.
24	30·166	57·0	57·0	59·2	50·8	57·0	·466	100	S.	Calm	3	10	10	0·08	7	·100	
25	30·115	57·9	57·4	59·4	56·9	56·9	·465	97	S.	S.	1	10	0	0·02	6	·030	
26	29·931	57·4	55·5	62·2	55·6	53·7	·415	88	S.W.	W.	3	10	10	1·20	4	·000	Wind S.W., force 8, from 4 to 6 a.m.
27	30·140	54·9	52·0	61·9	52·0	49·3	·352	82	W.S.W.	W.S.W.	2	8	0	8·06	7	·000	
28	30·156	58·1	56·7	61·1	45·0	55·3	·437	90	S.S.W.	S.	2	8	0	8·50	6	·000	
29	29·950	56·6	56·0	59·2	55·4	55·6	·442	96	S.S.W.	S.W.	3	10	3	0·00	8	·102	Wind S., force 7 at 6 a.m.; wind force 7 at 4 p.m.
30	29·814	57·7	55·9	61·2	47·7	54·4	·424	89	S. × W.	S.S.W.	5	8	0	8·17	4	·447	Gale from midnight till 5 a.m. on 1st.
Means	30·027	58·5	56·3	63·4	53·7	54·4	·427	86·8			1·9	7	4	5·01	5	·084	

Rain on 14 days.
Gales on 7 days.
Fog on 9 days.

Wind.								
N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	Calm.
3 ...	6 ...	5 ...	3 ...	11 ...	17 ...	10 ...	0 ...	5 days.

Notes on the Herring, Long-Line, and Pilchard Fisheries of Plymouth (continued).

By William Roach.
Associate Member.

I.—*Herring.*

Date.	Tide.	Wind.	Weather.	No. of boats.	Catch per boat.	Price per 100.	Locality.	Remarks.
1890 Nov.								
7	Flood	N.W.	Squally	—	300 and under	8/0	Cawsand Bay	A few nets were put down in Cawsand Bay on the 4th inst. and overhauled on the 5th inst., and it was found that a few herrings had arrived. A great many are getting their boats and nets in readiness for the approaching season.
14	—	—	—	4	100—200	4/0	Duke Rock	If the weather continues fine, with not much rain, there will soon be an increase in the fishing.
18	Spring	S.W.	Dull	1 9	300 Very few	4/6 —	Rum Bay to E. end of Breakwater	—
19	Ebb	S.W.	Mild	16	2000 dn.	4/5–4/9	Rum Bay to Duke Rock	Large fish.
20	,,	W.S.W.	Threatening	25	2000	3/1–3/5	Ditto	—
21	Neap	S.W.	Fine	80	500	3/4–3/8	E. end of Breakwater to the Cobbler Buoy	—
25	Ebb in Sound, flood outside	N. by E.	Moderate	8	800	3/4–3/6	N.W. of Staddon Heights, East Channel	Twelve boats with no fish.
26	Ebb in Sound, flood at sea	E. by N.	Stormy	2	200	—	—	Sixty boats went to sea, but owing to the bright moon only two boats took fish.
28	Flood	S.E.	Wet	10	100	3/6–3/8	Taken W. of Staddon Heights	Herrings fallen off considerably.
Dec.								
2	Ebb	E.	Gloomy	30	500	3/0–3/6	In East Channel and the Sound	—
3	Ebb at sea, slack water in Sound	N.	,,	30	800	2/9–3/0	Different stations in Sound	—
4	Ebb outside, slack water in Sound	N. Fresh	,,	40	600	2/5	Outside Breakwater	—
5	Ebb	—	—	20 Sound boats	700	—	Melampus Buoy and Breakwater Fort	Cawsand boats only taking a few hundred in their moored nets in Cawsand Bay, took them up and put

								them in Whitsand Bay, and hauled them next day, taking from 10,000 to 12,000.
6	,,	E. by S.	Wet	—	12,000	2/8–2/10	—	Small boats took their nets and moored them in Whitsand Bay, taking from 13,000 to 14,000 per boat.
8	—	—	—	3	10,000	3/0	Whitsand Bay	—
9	Flood	E.	Gloomy	16 Drift,	10,000	1/8–2/0	S. of Mothecombe	—
				9 Looe,	30,000	1/3	Whitsand Bay	—
				20 Sound	8000	3/0–3/9	Between Melampus and Drake's Island	Fifty boats with only a few fish.
10	,,	E.	Fresh	20	10,000	1/6	East Bay	—
				18	30,000	1/3	West Bay	This lot of herrings in the Sound was taken at 8 o'clock, during low water. Little boats almost sinking with fish.
				—	8000	2/0	Sound	
11	,,	E.	,,	20	20,000	1/3–1/9	5 to 6 miles S.W. of Bolt Head	Sound fishery fallen off considerably. Boats still working, but taking no fish.
12	,,	E.	Gloomy	3 Drift	30,000	1/3	S. of Mothecombe, 5 to 6 miles	—
13	,,	E.	Fine	15 ,,	40,000 down	10/0 per 1000	Ditto	—
15	—	—	—	6 ,,	10,000	1/6–2/3	S.W. of Bolt Head, from there up and down	—
16	Flood	N.	Wet	12 ,,		2/0–2/4	5 to 6 miles S.W. of Bolt Head	—
17	Ebb	E.	Gloomy	20 ,,	20,000	1/6–3/0	Various stations	—
18	—	E.	Threatening	30 ,,	30,000	1/1–1/4	Between Mothecombe and the Bolt Head, 4 to 5 miles off land	—
20	Ebb	E.	Gloomy	25 ,,	20,000	1/0	Off Stoke Point	—
22	Slack water outside	E.	,,	10 ,,	15,000	1/3	Off Stoke Point, Breakwater Light, S. of Mewstone	—
23	Ebb	E.	Fine	40 ,,	10,000	0/8–1/0	Various localities	—
24	,,	E.	Gloomy	8 ,,	5000	0/8	Off Stoke Point	—
25	,,	E.	,,	5	2000	1/0	Ditto	—
26	Flood	E.	,,	10	10,000	£2 10s. to £3 per last	6 miles S.E. of Stoke Point	—
27	,,	E.	Very cold	8	5000	3/0	4 to 5 miles S. of Stoke Point	70 per cent. shotten (spent).
29	—	—	—	6	3000	2/10	2 to 3 miles off Stoke Point	The herrings have made no appearance in Sound this year.
30	Ebb	E.	Very cold	50	20,000	2/0–3/0	2 to 3 miles S. of Salcombe	—
31	,,	E., blowing half a gale	Threatening for snow	80	30,000	2/8–2/10	Ditto	Two boats lost half their fleet of nets on account of heavy takes.

Date.	Tide.	Wind.	Weather.	No. of boats.	Catch per boat.	Price per 100.	Locality.	Remarks.
1891 Jan.								
1	Ebb	E.	Threatening	5	12,000	Full 3/0, shotten 1/1–2/0	Off Mothecombe	60 per cent. shotten.
2	,,	E.	Fine	30	20,000	2/6–3/6	Off Mothecombe, Breakwater Light, between the Mewstone and land	—
3	,,	E.	Gloomy	10	10,000	Full 3/1, shotten 2/0	Same as 2nd inst.	—
6	Slack water outside, 3 hours ebb in Sound	E.	Moderate	40	40,000	Full 3/0–3/6, shotten 1/6–2/0	Between Stoke Point and Bolt Head, 4 to 8 miles off land	—
7	1st hour flood	N.E.	Cold	30	25,000	1/8–2/3	Ditto	70 to 80 per cent. shotten.
8	2nd hour flood	S.	Threatening	20	15,000	Full 2/0, shotten 1/6	From Whitsand Bay to Bolt Head	One or two shoals travelling west.
10	Flood	N.E.	Fine	20	20,000	1/8–2/3	Between Stoke Point and Bolt Head, 1 to 2 miles off land	—
12	,,	N.	Gloomy	10	20,000dn.	1/6–2/4	Ditto	—
13	,,	N.	,,	30	15,000	1/4–2/2	Same as 12th inst.	—
14	,,	N.	Bright	10	20,000	1/5–1/11	1½ miles E. of Stoke Point	It is many years ago since such numbers of herrings have appeared in the East Bay.
15	Slack water	E.	,,	30	30,000	1/5–2/0	1 to 3 miles S. of Stoke Point, from there to Bolt Head	—
16	Ebb	E.	,,	15	10,000	1/8–2/0	1 to 3 miles S. of Stoke Point	—
17	,,	E.	,,	10	10,000	2/0–3/0	Ditto	—
20	,,	S.W.	Stormy	6	1000	2/0	8 to 9 miles outside the Eddystone	—
26	—	—	—	20	400	1/6	In East Bay	—

II.—*Long-Line.*

The "Remarks" show very clearly how much difficulty is experienced in procuring suitable bait, and how this branch of the fishing industry is paralysed for want of it. The conclusion might also be drawn that salted pilchard makes but an indifferent bait.

Date.	Tide.	Wind.	Weather.	Bait.	Locality.	No. of boats.	Conger.	Ling.	Rays and skates.	Cod.	Pollack.	Other fish.	Remarks.
1890 Oct. 21	Ebb	N.W.	Fine	Squid	¾ mile W. of the Eddystone	1	cwt. 3	12	Dozen. 3	—	1 doz.	3 doz. bream	—
22	,,	E.	,,	,,	6 miles S.E. of the Mewstone	1	,,	6	3	2	,,	—	—
,,	—	—	—	Pilchard	6 miles outside the Eddystone	1	—	700–800 spur dog-fish			—	—	Nothing but spur dogs (*Acanthias*) taken.
29	Flood	W.	Wet	Squid	1 mile N.W. of the Eddystone	1	5	12	1 doz.	2	2 doz.	2 doz. bream	—
31	,,	W.	Squally	,,	3 to 4 miles S.W. of the Bolt Head	3	5	5 to 6	1 to 2	2 to 3	1 to 2 doz.	1 doz. bream	Weather extremely bad for long-line fishing.
Nov. 5	—	—	—	Squid	¾ to 1½ miles S.E. of the Eddystone	3	4	10 to 12	2 to 3	3 to 4	1 doz.	—	—
14	Flood	S.	Wet	—	—	—	—	—	—	—	—	—	—
17	,,	S., moderate	Dull	Squid	5 to 6 miles S.E. of Stoke Point	3	3	7 to 8	2 to 4	3 to 4	5 to 6	—	—
19	Ebb	S.W.	Mild	—	On East Reites	1	2	12	2	—	—	—	
21	—	—	—	—	Outside the Eddystone	2	—		3 to 4	—	—	—	Caught 100 spur dog-fish. There are a great number on the coast just now.
28	Flood	N.E.	Very cold	—	—	3	3	6	1 to 2	6	—	—	These boats only shot half their gear owing to strong wind.
Dec. 1	—	—	—	Squid	7 to 8 miles S. of Bolt Head	2	14 to 15	—	—	—	—	—	—
						1	5	6	2 to 3	6	—	—	4 to 5 hand-liners, which use 4 lines, landed 4 cwt. each.
						1	4						
3	Ebb	N.	Gloomy	,,	7 to 8 miles off the Bolt Head	4	8	12	2 to 4	12	—	—	—
4	,,	N.	,,	,,	,,	2	4 to 6	2	2 to 4	12	—	—	—

Date.	Tide.	Wind.	Weather.	Bait.	Locality.	No. of boats.	Conger.	Ling.	Rays and skates.	Cod.	Pollack.	Other fish.	Remarks.
							cwt.	Dozen.					
Dec. 16	—	—	—	—	8 to 10 miles S.W. of Falmouth	1	9	9	4	12	—	—	—
					Outside the Eddystone	1	5	—	2	—	—	—	Lost half their gear.
					Off Bolt Head	1	2	—	—	—	—	—	—
29	Flood	E.	Gloomy	Squid	4 to 5 miles S. of Stoke Point	2	4 to 5	3 to 4 1/6 ach	—	—	—	—	Owing to the strong east wind and strong tides, these boats had to shoot their long lines near home. All the conger run from only 4 to 12 lbs. in weight.
1891 Jan. 5	Ebb	E.	Fine	Squid and pilchard	6 to 8 miles S. of the Bolt Head	6	10½ down	12	7 to 8	—	—	—	The boat which had the largest catch had 900 hooks baited with squid and 500 with pilchard. It is very difficult for long-liners to shoot now, owing to the drift-net fishery, which is carried on all the week excepting Saturday night.
12	Flood	N.	Gloomy	—	15 miles S.W. of Eddystone	1	1½	—	4	—	—	—	1000 dog-fish.
					Between Start Point and Bolt Head, 6 to 7 miles off land	5			Taken no fish				The men say the reason why they took no fish was owing to the extreme cold and the strong tides. One boat lost all its long line. This is owing to the drift-nets becoming entangled in the buoys attached to the long lines.
Feb. 4	—	—	—	Half squid half pilchard	8 to 10 miles S.W. of Bolt Head	2	5	6	5 to 6	3	—	—	
					1½ miles E., W., and S. of the Eddystone	5	3	£2 worth of rays, skates, ling, and cod			—	—	—
					14 miles S.W. of Eddystone	1	2½	—	Rays £1	—	—	—	—

				Pilchard	Off Falmouth, 7 miles S. of Mewstone	1	No conger	—	5	—	—	—	—
9	—	—	—	—	—	7	3	12	3 to 5	—	—	—	—
10	—	—	—	Pilchard	½ mile N.W. of Eddystone	5	2	—	3 to 4	—	—	—	—
11	—	—	—	,,	4 miles S.W. of Bolt Head	5	5	12 to 24	5 to 6	—	—	—	These boats have been successful in obtaining plenty of pilchard bait (which realised 18/0 per 1000).
14	Ebb	S., light	Bright	Squid	5 miles S.W. of Bolt Head	10	5	12	6	—	—	—	—
16	,,	S. by W.	Fine	,,	5 to 6 miles S.W. of Bolt Head	4	10	12	3 to 4	5 to 6	—	—	Each boat spent 10/0 for bait.
19	,,	E., strong	Gloomy	Pilchard	,,	15	3	—	3 to 4	6 to 7	6 to 7	—	Pilchard sold this day for bait by auction realised 35/0 per 1000, then there was not enough for all the boats, weather being so fine and fish making good prices.
26	Flood	E.	Bright	Squid	25 miles S.W. of Eddystone	1	1½	12	9	—	—	—	The bait used had been salted a week. All other long-liners been in harbour for want of bait.
Mar. 7	—	—	—	—	—	—	—	—	—	—	—	—	Long-liners received pilchard bait from Falmouth this evening at 6 o'clock at a cost of from 25/0 to 30/0 per 1000, caught in moored nets. These boats have been in harbour for a week waiting for bait, and now they have it the weather is setting in stormy. The bait was salted.
23	—	—	—	Pilchard and squid	12 to 15 miles S.W. of Start Point	6	1	5 to 6	7	—	—	—	Bait been in salt for a fortnight.
24	—	—	—	Salt pilchard and squid	10 miles S. of the Deadman	3	1 conger	24	8	—	—	—	Other boats never saw a conger, only having a few rays.
25	—	—	—	Fresh squid	E. side of the Eddystone	1	5	—	—	—	—	—	—
				,,	—	1	2¼	—	2	—	—	—	—
				Salt squid 14 days old	—	1	—	—	—	—	—	—	—

III.—*Pilchards.*

If, from the data supplied by Mr. Roach, we make an estimate of the fish landed in each of the four months, the totals come to be—In Oct. 322,750; in Nov. 923,500; in Dec. 4,128,500; in Jan. 2,795,000. These figures give a total for the season of 8,169,750 pilchards.

Date.	Tide.	Wind.	Weather.	No. of boats.	Catch per boat.	Price per 1000.	Locality.	Remarks.
1890 Oct.								
8	—	S.W.	—	30	4000 to 5000	11/0	—	—
15	—	S.	Foggy	12	10,000	11/0	—	—
16	—	N.W., strong	—	—	No pilchards	—	—	Too much wind for net-fishing.
20	—	—	—	—	—	—	—	—
21	Ebb	N.W.	Fine	15	2000 to 3000	13/0–15/0	6 to 8 miles W. of the Eddystone	—
22	„	E.	„	20	1000 and under	19/0	6 to 8 miles S.W. of Rame Head	—
23	„	E.	„	—	500	/0 per 100	Ditto	—
24	„	W.	„	20	2000	16/0	6 to 12 miles W. of the Eddystone	—
31	Flood	W.	Squally	12	1000	15/0	10 to 15 miles W. of the Eddystone	—
Nov.								
10	„	S.W.	Bright	3	15,000	21/0	5 to 6 miles S.S.W. of the Rame Head	Very large fish.
14	„	S.	Wet	50	4000	20/0	4 to 6 miles S. and S.W. of Penlee Point	Each boat had a few herrings; also several hundred of half-grown mackerel.
17	Strong	S.E., moderate	Dull	20	2000	14/0	3 to 4 miles S.S.W. of the Eddystone	—
19	Ebb	S.W.	Mild	10	10,000	13/0	1½ miles N.W. of Eddystone, from there up and down	—
20	Ebb	W.S.W.	Threatening	20	20,000	11/0–11/6	5 miles S.W. of Rame Head, from there inside the Eddystone	—

21	Neap	S.W.	Fine	20	10,000	11/0–12/0	2 miles inside the Eddystone	—
22	Flood	W.	Moderate	5	50,000	11/0–12/0	3 miles S.S.W. of Rame Head	Taken at 1 o'clock in the morning, after the moon went down.
25	Ebb in Sound, flood outside	N. by E.	,,	15	10,000	13/0	Between Rame Head and Eddystone	—
26	Ebb in Sound, flood at sea	E. by N.	Stormy	10	5000	12/6–13/0	Ditto	Fifty boats without fish.
28	Flood for a short time	N.E.	Very cold	20	5000 and under	13/0	Between Penlee and Eddystone	Large quantity of boats only a few hundred fish. They were sold to the pilchard curers, and sent by vessels to Cornwall.
29	Flood	E., showers of small sleet	,,	10	2000 to 3000	13/0	Ditto	Several boats came back again owing to the strong wind.
Dec. 1	—	E.	—	5	5000 to 6000	12/0	Ditto	The west country buyers will not take these fish because they were caught on Sunday.
5	—	—	—	60	—	13/0–14/0	Ditto	Owing to there being no seine pilchards in the west, there is a good demand for the drift pilchards here at present. All large boats came back again.
9	Flood	E.	Gloomy	7	30,000	14/0–15/0	10 miles outside the Eddystone	—
10	,,	E.	,,	20	10,000	16/0	8 to 10 miles S. of Plymouth	Owing to the strong east wind fish going to deeper water; largest catches outside the Eddystone.
11	,,	E.	,,	20	20,000	12/0	5 to 6 miles S.E. of Eddystone	—
12	,,	E.	,,	30	10,000	11/6–12/0	7 to 8 miles S. of Mewstone, from there in and outside the Eddystone	—
13	,,	E.	Fine	20	10,000	11/0	7 to 8 miles S. of Mewstone	These boats have taken 60,000 to 70,000 small mackerel in their pilchard and herring nets.
16	,,	N.W.	Wet	40	20,000	10/0–12/0	N.W. of the Eddystone	—
17	Ebb	E.	Threatening	12	20,000	12/0	Various localities	4000 to 5000 small mackerel in their pilchard-nets.
18	,,	E.	Gloomy	40	30,000	—	7 to 8 miles S. of Mewstone, from there S. and W.	—
23	Slack water outside	E.	Fine	10	10,000	12/0	N.E. of Eddystone	—

Date.	Tide.	Wind.	Weather.	No. of boats.	Catch per boat.	Price per 1000.	Locality.	Remarks.
Dec. 24	Ebb	E.	Gloomy	6	2000 to 3000	12/0	2 to 3 miles inside the Eddystone	—
29	—	—	—	—	—	—	—	Owing to the prevailing east wind, the pilchards have fallen off considerably during the last few months.
1891 Jan. 2	Ebb	E.	Fine	20	25,000	10/0–12/0	4 to 8 miles S.E. of Eddystone	—
3	,,	E.	Gloomy	15	25,000	6/0–8/0	Ditto	—
6	Slack water outside, 3 hours ebb in Sound	E.	Moderate	20	70,000	6/0–10/0	6 to 10 miles S.E. of Eddystone	—
7	1st hour flood	N.E.	Cold	7	20,000	10/0	Ditto	A large quantity of small mackerel taken in the pilchard-nets (but none in herring-nets), 4000 to 5000 down; sold at 2/0 to 3/0 per 100.
8	2nd hour flood	S.	Threatening	8	20,000	10/0	15 to 20 miles S. of P. H. Harbour	Almost all boats in harbour.
10	Flood	N.E.	Fine	10	10,000	8/0–10/0	8 to 10 miles S.E. of Eddystone	Some of these boats, having 2000 to 6000 small mackerel, sold at 2/0 to 2/6 per 100.
13	—	N.	Gloomy	5	6000	12/0	Ditto	2000 to 4000 small mackerel, sold at 3/0 per 100. There were never so many small mackerel taken before in this locality.
14	Flood	N.	Bright	5	6000	11/0	8 to 10 miles S.S.E. of Eddystone	One boat, 10,000 small mackerel, sold at 3/0 to 5/0 per 100.
15	Slack water	E.	,,	8	5000	12/0	8 to 9 miles S.S.E. of Eddystone	Several thousands of small mackerel, sold at 2/0 per 100.
16	Ebb	E.	,,	5	4000	12/6	Ditto	—
26							—	Pilchard season is now finished, and the buyers have stopped curing. There are two or three boats trying still. They catch bait for long-liners. Not nearly so many pilchards taken this year as last.
28	—	—	—	—	—	—	—	Both pilchard and herring boats now commence fishing mackerel.

Note on a British Cephalopod—Illex eblanæ (Ball).

By

William E. Hoyle,
Keeper of the Manchester Museum.

A SHORT time ago I received from my friend Mr. J. T. Cunningham a Cephalopod which had been taken by a trawler in the neighbourhood of Plymouth, with the remark that it appeared to fit well with the description of *Ommastrephes eblanæ* (Ball) as given by Forbes and Hanley,* and that it undoubtedly belonged to the genus *Illex* of Steenstrup.

I have compared the specimen with all the examples of the genus *Illex* at my disposal, and satisfied myself that Mr. Cunningham's surmise was correct; and since this species has generally been referred to the category of forms inadequately described,† I have much pleasure in acceding to the suggestion that I should contribute a few notes upon it to this Journal.

That the Cephalopod belongs to the genus *Illex* was at once obvious from (1) the smooth siphuncular recess, (2) the absence of fixing pads and cushions at the base of the tentacular club, and (3) the absence of a membranous wing on the third pair of arms. Two species of this genus have been hitherto described, *Illex coindeti* (= *Ommastrephes sagittatus, auctorum plurimorum*) from the Mediterranean, and *Illex illecebrosus* from the American coast. Both these have the horny ring of the large tentacular suckers either smooth or with broad truncated teeth, and the small suckers at the end of the tentacular club arranged in eight rows.‡ In the example from Plymouth the horny ring of the large tentacular suckers is armed with acute teeth, separated by interspaces broader than the bases of the teeth themselves, and the terminal tentacular suckers are in four (rather irregular) rows.

On referring to the definition of *Ommastrephes eblanæ* as given

* Brit. Moll., iv, p. 235, 1853.

† Steenstrup, Ommatostrephagtige Blæksprutter, p. 97 (27); Hoyle, "Challenger" Cephalopoda, p. 33.

‡ Steenstrup, loc. cit., p. 91 (21).

by Forbes and Hanley, we find it distinguished from *O. sagittatus* (*Illex coindeti*) by two characters : (1) body elongated in the latter, proportionately short in the former ; (2) terminal tentacular suckers in many (about eight) rows in the latter, in four rows in the former ; (3) the fin of *O. sagittatus* is rhomboidal, of *O. eblanæ* more elliptical. The character first mentioned is not specific but sexual, as may be seen from Verany's beautiful figures of the Mediterranean form ; * whilst as regards the two latter, the Plymouth specimen agrees with the description of *O. eblanæ*.

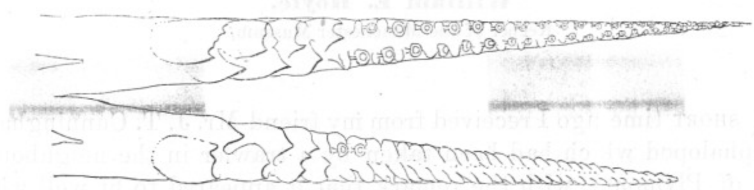


FIG. 1.—Ventral arms of *Illex eblanæ*, to show the hectocotylisation.

Among the specimens with which I have been able to compare it are two Irish examples, labelled *Ommastrephes eblanæ*, and presumably named by comparison with Ball's type, which I understand still exists in the museum of Trinity College, Dublin.†

It resembles these in all essential characters, and hence there can be no doubt that it belongs to the species which we must now call *Illex eblanæ* (Ball), whose synonymy and definition will be as follows :—

ILLEX EBLANÆ (*Ball*).

1841. LOLIGO EBLANÆ, *Ball*. Proc. Roy. Irish Acad., vol. i, p. 363, figs. 1—7.
1849. — — *Gray*. Brit. Mus. Cat., p. 65.
1853. AMMASTREPHES EBLANÆ, *Forbes and Hanley*. Brit. Moll., vol. iv, p. 235, pl. sss, fig. 2.
1856. LOLIGO EBLANÆ, *Thompson*. Nat. Hist. Ireland, vol. iv, p. 270.
1880. AMMASTREPHES EBLANÆ, *Steenstrup*. Ommatostrephagtige Blæksprutter, Oversigt k. Dansk. Vid. Selsk. Forhandl., p. 97 (27).

Fin very broadly rounded, sub-elliptical (see figs. 2, 3) ; *tentacular*

* Moll. médit., Céph., pls. xxxi, xxxii, 1851.

† Since the above was in type my friend Dr. Scharff, to whom I am indebted for much help regarding the Irish specimens, informs me that he has compared my description of the Plymouth specimen sent to him for the purpose with Ball's type. "This has," he says, "been very much knocked about, and could not be taken out of the bottle. It is a much smaller specimen, . . . and . . . the fin was more elongated in the type," but that otherwise the description fitted.

club with the central suckers about four times as great in diameter as the laterals, and provided with very acute teeth, separated by interspaces somewhat larger than the breadth of the tooth at its base; terminal suckers in four rows.

Habitat.—Britain: Dublin Bay (Ball), Antrim (Museum of Science and Art, Dublin, *fide* Scharff); North Sea (Captain Gray); Plymouth (Marine Biological Laboratory); Mediterranean: Naples (Zoological Station).

Among the material examined were four males, which exhibited the interesting form of hectocotylisation I now propose to describe

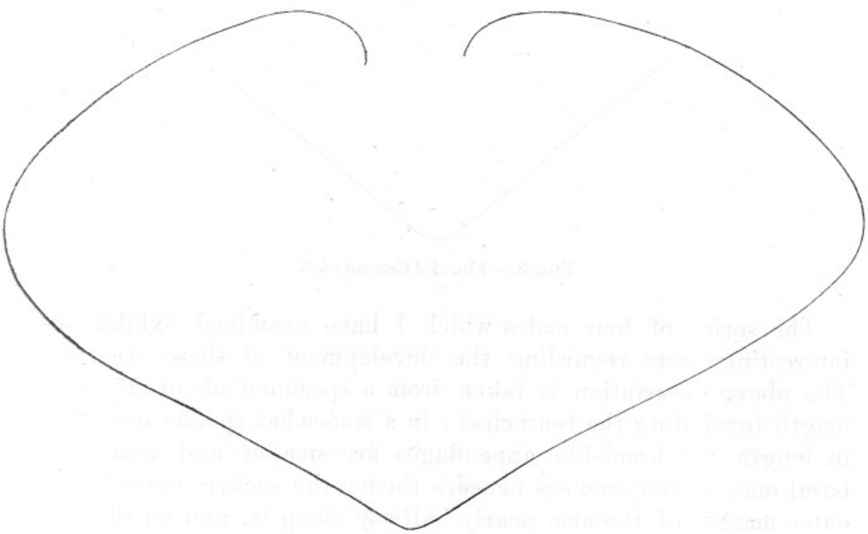


FIG. 2.—Fin of *Illex eblanæ.*

(see fig. 1). The alteration affects both arms symmetrically in their basal portions, but the right arm only is modified to the tip. About 2 cm. from the base of each arm, instead of a sucker, is a flattened bract-like appendage, growing out from a broad base. Its distal margin is slightly notched, and at the inner extremity bears a sharp tooth; at the outer margin it curves into the general surface of the arm. On the outer side of the oval surface of the arm this appendage is succeeded by three similar ones, gradually decreasing in size. On the inner margin of the arm, alternating with them, are three conical teeth, also directed towards the tip of the arm. The points of all these teeth are tough, and feel almost cartilaginous. Beyond this the left arm presents the normal arrangement of suckers, but the right arm has only two suckers placed near the inner margin; on the outer margin is a series of conical tubercles, extending the whole way to the tip and gradually diminishing in size. The inner margin is occupied by a series of slight swellings, some of the proximal ones of which look as though suckers had fallen from them.

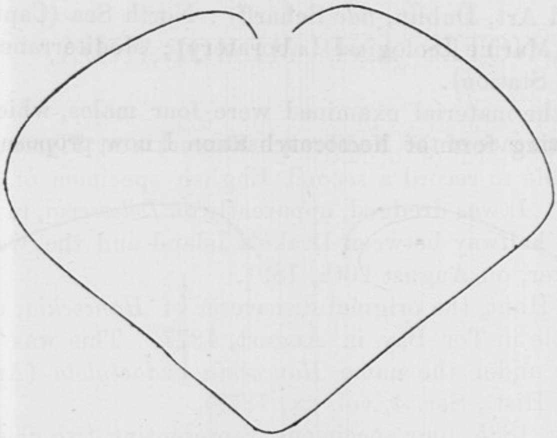


FIG. 3.—Fin of *Illex coindeti.*

The series of four males which I have examined exhibit some interesting facts regarding the development of these structures. The above description is taken from a specimen about 27 cm. in length (excluding the tentacles) ; in a somewhat smaller one, 20 cm. in length, the bract-like appendages are smaller and (except the basal one) shelter suckers beneath them : the suckers extend on the outer margin of the arm nearly halfway along it, and on the inner margin along three quarters of its length before they give place to the conical or rounded prominences.

In two still smaller specimens (about 10 cm. long) both series of suckers are present up to the tips of the arms, and the bract-like appendages are just beginning to appear at the bases of from three to five proximal suckers. It would appear, therefore, that on these hectocotylised arms suckers are normally developed, and then gradually disappear as the animal approaches maturity.

NOTES AND MEMORANDA.

On the Occurrence of the Nudibranch Hancockia at Plymouth.—I am glad to be able to record a second English specimen of this interesting form. It was dredged, apparently on *Delesseria*, in Plymouth Sound, about halfway between Drake's Island and the west end of the Breakwater, on August 20th, 1891.

Mr. A. R. Hunt, the original discoverer of *Hancockia*, dredged a single example in Tor Bay in August, 1877. This was described by Mr. Gosse under the name *Hancockia eudactylota* (Annals and Mag. of Nat. Hist., Ser. 4, vol. xx, 1877).

In January, 1885, four specimens, representing two closely allied forms, were taken near Naples, and described by Prof. Trinchese (Ricerche Anatomiche sul Genere *Goria*, 1886). He defined the genus *Goria*, apparently in ignorance of Gosse's paper, including his forms under two species, *G. rubra* and *G. viridis*.

The Plymouth specimen is about a quarter of an inch in length when extended. This is only half the length of Mr. Hunt's specimen and of Prof. Trinchese's *Goria rubra*.

It is of a dark claret colour, very similar to that of the *Delesseria* on which it lived.

The epidermis of the upper surface, seen by reflected light, is of a delicate bluish-green hue, as in *Hancockia eudactylota* (Gosse, loc. cit., p. 317).

There are four pairs of pleuropodial processes, with a rudiment of a fifth on the left side.

In its other characters, this specimen is apparently intermediate between *H. eudactylota* and *Goria rubra*.

In the number of processes of the oral veil (four on each side), in the form of the rhinophoral sheaths, and in the absence of the white spots which Trinchese has described, it agrees with *Hancockia* and differs from *Goria rubra*.

In the absence of rudimentary oral processes described by Gosse between the well-developed ones, in the presence of a more or less circular pigment patch at the base of the pleuropodial expansions, and especially in the form of the latter, it agrees with *Goria rubra* and differs from *Hancockia*.

More specimens, however, are required to settle the relations of these interesting forms.—F. W. GAMBLE.

Saphenia mirabilis, Haeckel.—In the same haul of the large tow-net in which the *Phyllosoma* elsewhere described were taken on the night of July 16th I captured a large number, some hundreds, of small Medusæ of a single species. These proved on examination to be the *Goodsiria mirabilis* of Strethill Wright, described and figured by him in a paper in the Edinburgh Philosophical Journal, vol. lxvii, 1859. The species has been placed by Haeckel (System der Medusen, Jena, 1879) in Eschscholtz's genus *Saphenia*, of which two other species only have been described. No other observer than Strethill Wright has recorded or described *Saphena mirabilis*, and he took only three specimens near Queensferry in the Firth of Forth. Strethill Wright's specimens were about an inch in diameter; those taken near the Eddystone were not so large, the largest being only about 12 mm. The species, however, is certainly the same; it is distinguished by the depressed form of the umbrella, the presence of only two extensile tentacles, and a very long and very extensile peduncle several times as long as the breadth of the umbrella. The genus *Saphenia* is placed by Haeckel in the family *Eucopidæ* of the order *Leptomedusæ*. All the *Leptomedusæ* whose development is known are developed asexually from a fixed hydriform stock. The development of *Saphenia* is at present entirely unknown, but it seems probable that the numerous specimens taken near the Eddystone were derived from some fixed hydroid which flourishes at the bottom of the sea in that neighbourhood.—J. T. CUNNINGHAM.

Pleurophyllidia Lovéni, Bergh.—Another interesting capture made last summer was that of the rare Opisthobranch *Pleurophyllidia Lovéni*, Bergh. A single specimen was taken in the shrimp trawl, about two miles to the north of the Eddystone on the night of July 9th. It was accompanied by many Nudibranchs and a Pleurobranchus; these Molluscs, as well as the Pleurophyllidia, were identified by Mr. W. Garstang, and the list of them is as follows:

Pleurobranchus membranaceus, 1 specimen; *Acanthodoris pilosa*, 10 specimens, all white; *Philine aperta*, 3; *Scaphander lignarius*, 1; *Eolis* sp., several.

The other contents of the trawl were a few small flat-fishes, a number of *Pecten opercularis*, and a large quanty of Cellaria. Only two specimens of *Pl. Lovéni* are reocrded as taken in the British area by Forbes and Hanley, and by Gwyn Jeffreys. But Mr. Holt has recently recorded the capture of two specimens in St.

Andrew's Bay; he obtained them from fishermen's haddock-lines (Ann. and Mag. Nat. Hist., August, 1891).—J. T. C.

Breeding of Fish in the Aquarium.—At the end of March the plaice in the large flat-fish tank were spawning, and the eggs floated at the surface of the water. But when examined, none of the eggs were found to be fertilized. A hatching box of Captain Dannevig's pattern had recently been fitted up in the aquarium for hatching floating eggs. I took out some of the ripe plaice and fertilized a number of eggs from them artificially. Some of the females yielded healthy eggs, and large numbers of these were successfully hatched in the hatching box. But some of the females yielded only ripe eggs which were already dead; the difference between these and unripe eggs being perfectly obvious. These same plaice spawned in the tank in 1890, and the eggs were naturally fertilized and found in a developing condition at the surface in the tank. It seems as though a prolonged residence in the water of the aquarium produced some abnormal disturbance of the reproductive functions in these plaice. In the same tank were two ripe female flounders, but no males of the same species. I squeezed a large number of eggs from these, and made the experiment of mixing them with milt from a male plaice. Fertilization occurred in a certain number of the ova, about half, and a few of these lived till they were hatched, and the larvæ lived several days. They died, however, like all my larvæ, soon after the absorption of the yolk-sac. In April and May many of the soles in the flat-fish tank were much swollen in the abdominal region, and it seemed as if the ovaries ware enlarged and the eggs on the point of being shed. But no soles' eggs ever appeared in the tank, although arrangements were made that no floating eggs shed in the tank could escape. After a time many of the soles gradually lost the swollen appearance. I took out a specimen 25 cm. long on June 10th, and found it was a male, and on teasing up a portion of the testis saw a considerable number of ripe active spermatozoa mixed with unripe spermatic cells. Afterwards I squeezed a swollen female, but no ripe eggs were expelled, but, instead, some curious translucent masses whose nature I did not understand. On June 27th I took out a large female sole which was still swollen, and on squeezing obtained some more of these masses of soft substance. When teased up under the microscope the substance proved to consist of degenerate ripe ova, looking as though they had been half digested. The vitelline membranes were present, but shrivelled and containing only granules of dead matter. I then opened the ovary, and found more of these masses in its cavity; the ovary itself was crowded with eggs not quite ripe. It appears, therefore, that in these soles the eggs, when nearly ripe, escaped in successive lots into the cavity of the ovary, and there died and degenerated. It is evident that soles will not spawn in our tanks. These specimens had been living in the same tank since the summer of 1889, and they showed no signs of spawning in 1890. Whether the cause of this inability to breed is merely the confinement, or the shallowness of the water in a tank compared to the depth of the sea, or the quality of the water, there is at present no evidence to show.—J. T. C.

The Amount of Fat in Different Fishes.—An inquiry has recently been made concerning the above, and in consequence of this I have made a number of determinations of the amount of fat in the flesh or muscle of various species. The fat was extracted with ether in a fat extraction apparatus; the ethereal solution thus obtained was separated from any water which happened to be present, and dried over calcium chloride. The ether was then distilled off, and after being heated to 100° C. the residue was weighed. The following table gives the results obtained:

Common name of fish.	Scientific name.	Weight of fish taken.	Weight of extract.	Percentage of fat.
		Grms.	Grms.	
Piper	Trigla lyra	150	0·250	0·166
Red gurnard	Trigla cuculus	135	0·192	0·142
Mackerel	Scomber scombrus	200	3·05	1·52
„	„	200	2·52	1·26
Thickback	Solea variegata	78	0·014	0·018
Turbot	Rhombus maximus	166	0·028	0·017
John Dory	Zeus faber	166	0·144	0·086
Hake	Merluccius vulgaris	190	0·057	0·030
Haddock	Gadus æglefinus	190	0·009	0·005
Pollack	Gadus pollachius	190	0·011	0·006
Cod	Gadus morrhua	190	0·009	0·005
Ling	Molva vulgaris	150	0·032	0·022

F. HUGHES.

ERRATUM.

In Mr. Cunningham's paper in the previous number of the Journal, p. 17, line 25, *for* 6 lbs. *read* 2 lbs.

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.

Professor HUXLEY, the 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, Professor MOSELEY, Dr. 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, at the expense of a small rent for the use of a working table in the Laboratory and other appliances, and have made valuable additions to zoological and botanical science. 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. The gentleman holding this post receives £200 a year and a residence. A naturalist has also been appointed at a salary of £250 a year, whose duties are confined to the study of food-fishes, and provision has been made for an assistant to the Director. THESE ARE THE ONLY SALARIED OFFICERS OF THE ASSOCIATION: its affairs are conducted entirely by voluntary service.

The Association has at present received some £15,000, of which £5000 was granted by the Treasury. The annual revenue which can be at present counted on is about £950, of which £500 a year for five years is granted by the Treasury, whilst £180 is in the uncertain form of Annual 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 £4000.

The ASSOCIATION URGENTLY NEEDS ADDITIONAL FUNDS FOR THE PURCHASE AND MAINTENANCE OF A SEA-GOING STEAM VESSEL, by means of which fishery investigations can be extended to other parts of the coast than the immediate neighbourhood of Plymouth; for the maintenance and completion of the library; and in order to increase the permanent staff engaged at Plymouth. The purpose of the Association is to aid at the same time both science and industry. It is national in character and constitution, and its affairs are conducted by a representative Council, by an Honorary Secretary and an Honorary Treasurer, without any charge upon its funds, so that the whole of the subscriptions and donations received are devoted absolutely to the support of the Laboratory and the prosecution of researches by aid of its appliances. The reader is referred to page 4 of the Cover for information as to membership of the Association.

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