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C. Spence Bate, Esq., F.R.S.

The Association has lost one of its ablest and most energetic members in Mr. C. Spence Bate, F.R.S., who died, after a painful illness, at his residence, The Rock, South Brent, Devon, on the 29th of July.

It is hardly necessary here to dwell on Mr. Spence Bate's scientific attainments; as a carcinologist he was distinguished throughout Europe, and his works on the British Amphipoda (in conjunction with Professor Westwood) and the Macrurous Crustacea of the Challenger expedition are testimony to his acute powers of observation and his patience in study.

From the date of its foundation Mr. Spence Bate took the keenest interest in the Marine Biological Association. He was elected a member of Council soon after its formation, and was among those who urged the advantages of Plymouth as a site for a Marine Laboratory. On Plymouth being chosen Mr. Spence Bate took an active part in the early arrangements necessary for acquiring the site and erecting the buildings; his influence was instrumental in securing for the Association that local support which has been so freely given by the authorities and inhabitants of Plymouth, and he personally took a large share in watching the progress of the building and arranging the details of its interior. Lately Mr. Spence Bate was a frequent visitor to the Laboratory, was ever ready to assist younger naturalists with his stores of knowledge on Crustacea, and was most helpful in lending from his own library scientific memoirs not in the possession of the Association.

Journal of the Marine Biological Association.

The Director's Report.—No. 3.

The present number of the Journal contains several memoirs of considerable practical importance. Mr. Bateson's paper on *The Sense-organs of Fishes* is the outcome of six months' work at Plymouth. It will be seen that he has dealt with the subject in the broadest possible manner; and whilst he is able to offer many practical suggestions as to the course to be pursued in further experiments with preserved and artificial baits, he has prepared the way for such experiments by his careful and interesting observations on the manner in which various fishes hunt for their prey. These observations give a far more accurate and well-founded account of the habits of food-fishes than anything that has been published before.

Through the kindness of Lord Revelstoke the Association will be able to institute a series of practical observations on the oyster in the river Yealm this year. In anticipation of these experiments Dr. G. Herbert Fowler and myself have studied literature of the subject, and have paid visits to some of the chief oyster beds in England for the purpose of obtaining information. Dr. Fowler has also visited the famous Dutch oyster establishments on the Schelde, and gives a very interesting account of what he learnt during his visit.

As I have found that Dr. Hoek's contributions to the natural history of the oyster are but little known in England, probably because they are published in a Dutch scientific periodical which has not a large circulation, even amongst scientific students, in England, I have written an abstract of the two papers published by him in 1883–84. In these abstracts I have confined myself to such matter as is of practical importance. Those who wish to enter more fully into the subject should consult his original papers, published in the Dutch and French languages, in the Tijdschrift der Nederlandsche Dierkundige Vereeniging.

Lord Montagu, of Beaulieu, who as Lord Henry Scott made a very complete exhibit of oyster culture at the International Fisheries

Exhibition of London, has allowed me to publish a letter describing the character and history of his oyster ponds in the Beaulieu river.

Mr. Cunningham has already attracted public attention to the possibility of an anchovy fishery in English waters. In a paper published in this number, he gives a further account of the observed frequency of the anchovy in our waters, and discusses at length the steps which might be taken for establishing a trade and fishery for English anchovies.

Mr. Johnson's paper on *The Flora of Plymouth Sound* although it might at first sight appear to be of little practical value, is of considerable importance. His observations on the growth of algæ in Plymouth Sound give a clear picture of the prejudicial effect of sewage and refuse matter on plant life. This disturbance of plant life necessarily leads to a disturbance of the numerous animal forms which are always found associated with plants, and which in turn afford food to other animals which are of importance to man. The impoverishment of a marine flora as a consequence of sewage contamination has not, as far as I know, been pointed out as clearly before, and it opens a wide field for research in districts, such as the mouth of the Thames, where the effects of sewage pollution are keenly felt, though the exact harm is inperfectly understood.

Finally, I must call attention to Dr. Fowler's abstract of the investigations made by the Dutch Fishery Officers, on the relation between the temperature of the sea and the annual catches of anchovies in Holland. The original paper, being written in the Dutch language, has met with very little attention. Nothing can show more clearly the importance of making extensive and continuous observations on the physical conditions of the sea, not in one place only, but all round our coasts, and of comparing those conditions with the observed movements or abundance of food-fishes.

Since the publication of the last Journal we have been passing through the winter months, and for obvious reasons there is little of importance to be said of the doings of the Laboratory during those months. The majority of the volunteer workers left Plymouth by the end of September, but Mr. Bateson returned in October for a month's stay, and Dr. Fowler stayed on till the end of November. Mr. T. H. Riches, B.A., arrived in October, and has been working nearly continuously ever since. Mr. Weldon is still residing at Plymouth to continue his investigations on the Crustacea, and Mr. Herbert Thompson, M.A., spent the month of February at the Laboratory in researches on Crustacean development.

During the whole of January we were prevented, by gales of exceptional severity, from doing any work at sea.

Special mention may be made of two circumstances. In November the fisherman in the employ of the Association, W. Roach, gave up his place to return to his old work, and an experienced trawl fisherman, E. G. Heath, was engaged in his place. The loss of Roach's services is to be regretted, as he possessed a minute and peculiar knowledge of the rocks and shoals in the neighbourhood of Plymouth, and could dredge in many places where other fishermen would not venture to try.

The Association has incurred a considerable expense in altering the connection between the storage reservoirs and the feed pumps. This operation involved the cutting through in two places of a solid concrete wall four feet thick, and the purchase and erection of new supply pipes, valve boxes, and fittings. The result has been most satisfactory. The pumps run more smoothly, the circulation of the water is improved, and the sediment which accumulates at the bottom of the storage reservoirs is undisturbed.

It has been asserted recently that the Plymouth Laboratory is placed in an unsuitable position as regards water supply, and that the sea-water in circulation is drawn from a contaminated source, is turbid, and below the normal density of sea-water. I may take this opportunity of giving an emphatic denial to these statements.

It is true that on the ebb tide, and in neaps at all tides, the water of the Sound below the Laboratory is polluted by the material carried out of the Cattewater, and is often of insufficient density. But in spring flood tides a large volume of water flows direct to the shores beneath the Laboratory from the sea, and it is only on these occasions that water is pumped into the storage reservoirs. Usually the water when first pumped in has a density of 1·0255 or 1·0266, and after it has been a short time in circulation its density is raised by evaporation to 1·027, after which we have to add fresh spring-water to make up for evaporation. By keeping both storage reservoirs full we have always a reserve of 100,000 gallons of sea-water, from which the circulation is supplied. Since the alterations in the supply pipes we are able to circulate from both reservoirs at once, and as it takes sixteen hours to pass their united contents through the circulation, the water in them is very little disturbed, and there is ample time for the settlement of all solid matter which it may contain. The water now in circulation is, and has been for several months past, remarkably pure and bright, and its density is perfectly normal. I cannot say more than that it is satisfactory in every respect.

No doubt visitors may have observed that the water in the aquarium has occasionally been of indifferent quality during the first twelve months' working. This was partly due to the imperfections in the original supply pipes, partly to the fact that the tanks were not properly seasoned. It is a matter of common experience that a sea-water aquarium cannot be got into good order for many months, and it was not to be expected that the Plymouth Laboratory should be exempt from the initial difficulties experienced by other institutions. It was further said that we were obliged to add salt to bring the water to the required density. This was done once, in August, 1888, immediately after the opening of the Laboratory. It has never been found necessary to do it since, and there is no reason to suppose that it will ever be necessary to do it again.

It is interesting to note that Dr. Dohrn, the experienced founder and director of the Naples Zoological Station, writing to Prof. Lankester about the choice of a site for the Laboratory of the Marine Biological Association, told him that the source from which the sea water was derived was not of so much importance as the size of the storage reservoirs, for no water that could be drawn from the sea would be as suitable for hatching and rearing delicate marine organisms as that which had been for some time in the reservoirs. Our experience proves the wisdom of Dr. Dohrn's advice.

G. C. BOURNE.

PLYMOUTH; *March 4th*, 1890.

The Sense-organs and Perceptions of Fishes; with Remarks on the Supply of Bait.

By

W. Bateson, M.A.,

Fellow of St. John's College, Cambridge, and Balfour Student in the University.

With Plate XX.

The Council of the Marine Biological Association appointed me, in 1889,* to make observations on the perceptions of fishes, and especially on those which constitute the modes by which they hunt for and recognise their food. It was suggested that this subject should be treated in as wide a manner as possible, and in accordance with this suggestion I have endeavoured to utilize any opportunities which presented themselves of getting an insight into the natural history of marine animals. In addition to this I have also made some experiments towards the practical solution of the bait question, both by making artificial baits, and by endeavouring to preserve materials which are already in use for bait.

The first part of this paper contains an account of those observations which seem to have a scientific interest; and it is followed by some remarks on the present condition of the supply of bait, together with suggestions as to possible solutions of the difficulty.

Evidence bearing on the perceptions of aquatic animals is somewhat difficult to obtain, owing to the absence of any points of similarity between the conditions of their lives and those of terestrial forms. To interpret their behaviour by comparison with our own is even more clearly an inadequate treatment than it is in the case of the other lower animals. From the nature of the case, moreover, satisfactory evidence as to their conduct in the wild state is scarcely to be had, so that it is necessary to depend largely upon observations made upon them while living in tanks. It must be understood, therefore, that the statements here made are, strictly speaking, descrip-

* This appointment was made in connection with Mr. Robert Bayly's grant to the Association for an investigation of the means whereby deep-sea fishermen may be better supplied with bait.

tive only of their habits under these artificial conditions. Though the majority of the fishes observed by me, being inhabitants of water of moderate depth, may be assumed to be under approximately natural conditions, it is important to bear this reservation in mind in considering the case of conger and other fishes which live in deeper water, and are exposed in the sea to very different influences, especially as regards pressure and light. As an instance of the need for caution in estimating the powers of fishes by their behaviour in tanks, it may be mentioned that the whiting, though a diurnal feeder, and apparently unable to find its food otherwise than by sight, is nevertheless under exceptional circumstances caught in the sea with a bait on dark nights at a considerable depth.

It will perhaps be convenient to give a general account of the sense-organs of the animals before describing their habits and modes of perception.

The Structure of the Sense-organs.

In examining the sense-organs of fishes I have been a good deal struck with a general fact concerning them, which, though sufficiently well known and obvious when stated, does not appear to be a matter of *a priori* necessity, and it may be well to call attention to it in this place. On comparing individual fishes of the same species but of different sizes, it is apparent that the size of the eyes varies with the size of the body. The same fact is true of the scales covering the body, which seem not to increase in number, but in size as the animal grows. In fact, so constant is the number of the scales that, as is well known, they have value as characters for the purposes of classification. In the case of the olfactory organs, increase in size takes place both by growth of the individual folds bearing the epithelium, and by the addition of new folds. Now the relation of such an organ as the eye to the organism may be compared to that of an instrument to a workman; and if this comparison is a true one, it is not a little remarkable that the sizes of the two should vary together. The question next arises, is a large eye, *cæteris paribus*, more efficient than a small one? It may easily be believed that a larger olfactory organ is more efficient, but such a case as that of the eye seems more difficult. If this question should be answered in the negative, it would be interesting to see if these facts are in harmony with the principle of economy of growth, in obedience to which it is believed that all superfluous parts tend to be eliminated from the body. If it is held by any to be manifest that a larger organ is obviously more efficient by reason of its greater size, it may be asked to what limit it is proposed to carry this principle. Is it applicable to all organs and parts of organs? Are the cells, for instance, of the tissues of a large individual larger than the similar cells in a smaller one, or would they be more efficient if they were? It would in any case be most desirable to know in what animals this relation of size between the whole and the parts is found, and to what organs it extends. In particular, it would be of the highest interest to know whether the eggs of a large individual are larger or more numerous than those of a smaller individual of the same species, and so on. An insufficient experience of Crustacea, fishes, and plants leads one to think that in these cases the number of eggs or seeds increases without change of size, though in the absence of more data it is unprofitable to discuss the matter. But as the relation between the size of the body and that of its organs has a high importance in any attempt to obtain a view of the modes of occurrence of variations, these facts in the structure of fishes are emphasized here, in the hope that persons who have the opportunity of handling large numbers of animals may be led to record their observations of similar particulars.

Eyes.

The general structure of the eyes of fishes is well known, but some points which have been observed in the course of this investigation may be worthy of notice. Particular attention was paid to the eyes of those fishes which are active at night, in order to see if there is any general common feature among them. The statement, for example, is made by Day (British Fishes, vol. i, p. xxviii) that "nocturnal fishes require larger eyes than diurnal ones." This may possibly be true, but it is by no means the fact that they are as a rule endowed with larger eyes, as is suggested in the passage quoted. The most typically nocturnal fishes are the conger and the eel. Of these the conger has a large eye, but not a remarkably large one when compared with that of the cod or the bream, which are diurnal, while the eel has a somewhat small eye. The eyes also of the sole, which is emphatically a nocturnal animal, are singularly small, while those of the angel-fish and torpedo are still smaller in proportion to the bulk. Among the rocklings, also night-feeders, the three-bearded rockling has an eye of average size, while that of the five-bearded rockling is decidedly small in proportion to its body. Under these circumstances any general statement is misleading.

Not even is there any uniformity with regard to the presence or absence of a contractile iris amongst nocturnal or diurnal fishes. In this Journal (N. S., i, 2, p. 215) I have given some account of my experience in this matter, which it may be convenient to repeat here, with the addition of other facts since noticed.

In the great majority of fishes observed, the shape and size of the pupil do not alter materially for light. Of the exceptions in which such a mechanism is found, some are nocturnal, as the skate and rough dog-fish, while others are diurnal animals, as the turbot. All of the Elasmobranchs which came under my notice are provided with a contractile iris, but the mode of contraction and the form of the pupil differ greatly among them. The eye of the torpedo (*T. marmorata*) presents the simplest form of this mechanism. In it the pupil is circular by night, but by day the *lower* limb of the iris rises up so as to close the pupil almost completely, leaving a horizontal slit at the upper part of the eye (*v.* fig. 8). In the rough dog-fish, the angel-fish, and the nursehound the pupil is also closed by day, but in it the edges of the iris meet to form an oblique slit passing across from the upper posterior margin of the iris to the lower anterior one. The arrangement in the skate is altogether peculiar, and seems to have no relation to either of these types of mechanism. In it the pupil is covered in daylight by a process of the *upper* limb of the iris, which falls over it, forming the well-known fern-shaped structure (*v.* figs. 7*a* and 7*b*). This peculiar irideal fold seems to consist of a constant number (eleven) of processes. By night this fold is completely drawn up, leaving the pupil clear. As described in the place referred to, the pupils of the dogfish and skate contract at night when the light of a lantern is turned on the eye, but this contraction is not sudden, as it is in terrestrial animals and Cephalopods, but, on the contrary, takes a long time to be completed. In the skate the process of the iris did not completely descend when the eye had been exposed to light for about twenty minutes, but the pupil of the dog-fish was almost entirely closed in that time. Illumination of one eye only in the skate causes the irideal fold of both sides to descend simultaneously, but the pupil of the dog-fish remained open on the dark side when the folds of the iris had nearly met in the illuminated eye.

The eye of the sterlet (*Acipenser*), a night-feeder, also has a contractile iris, which is arranged as a circle which is incomplete at the upper edge (*v.* fig. 10).

Among diurnal fishes, the turbot and brill, together with the weever, all have a semicircular flap from the upper edge of the iris which partially covers the pupil by day, but is almost entirely retracted at night, slowly returning under the light of a lantern. In the Brighton Aquarium I saw a turbot in which this flap of the iris was hardly developed at all. In speaking of the weever as a diurnal fish it is not intended to assert that it is not active at night. As is well known, it lives buried in the sand by day, but it has eyes which see well in daylight, for it will uncover itself and swim up to food just as a plaice does. As to its habits at night I have no evidence.

The pupil of the halibut is kidney-shaped, the concavity being upwards. The pupil of the plaice is of the same pattern, and without special irideal mechanism.

The pupil of the gurnard differs from all these in being slightly contracted by day so as to have a diamond shape, while it is circular by night.

All the fishes attainable were tested with a lantern by night, but in none was any alteration in the size of the pupil observed except in the cases mentioned. It is a somewhat remarkable fact that the reflex contractility of the iris, which is such a general character of land Vertebrata, should be so irregularly developed among fishes. In none of them does the usual sudden contraction for light occur, though it is nevertheless found in the Cephalopods (*v. loc. cit.*). Moreover, as the matter may have a bearing on the optical aspects of aquatic vision, attention is called to the fact that none of the animals mentioned which are provided with appliances for contracting the pupil have the circular aperture which is usual in many terrestrial animals and also in several of the other fishes which have no special mechanism of this kind.

The eyes of the three-bearded rockling (night-feeder) are extraordinarily convex, and protrude from the general level of the face so much that the lens can be seen through the cornea on looking down on the animal's head from the dorsal side. The same is true of the eyes of the boar-fish (*Capros aper*), which is a day-feeder; while those of the conger, also a night-feeder, are particularly flat.

The eyes of fishes are mostly not capable of much rotation, but those of the dory, wrasses, lump-sucker, and pipe-fishes can all be moved, and are used independently of each other (cf. p. 242). The eyes of the loach are also moveable, but to a less extent.

Olfactory Organs.

In all the fishes examined olfactory organs are present, but their development differs greatly in the different forms, the largest occurring in the eel, the conger, the *Raiidæ*, and the dog-fish, and the smallest in the top-knot (*Zeugopterus punctatus*). It might be expected that the olfactory organs of fishes which hunt by scent would be consistently larger than in those which seek food by sight, but this is only partially true. For though the great development of these parts in the eel, conger, and Elasmobranchs is accompanied by an acute sense of smell, yet in the rocklings, the loach, and the sole, which also seek their food by scent, the olfactory organs cannot be said to be proportionally more developed than they are in forms which feed by sight, such as the plaice and the pollack.

Nostrils.—In all forms (*? Zeugopterus punctatus*) examined, two nostrils occur on each side in the manner characteristic of most fishes. Of these two nostrils the anterior is to some extent tubular in all the fishes (except the Elasmobranchs) which seek their food by scent (*v.* p. 235). This tube is most developed in the conger, in which it is simple and straight, projecting beyond the surface of the nose. In the eel this anterior portion of the nostril is formed of two flaps of skin. In the rocklings it takes the form of a very short tube, the dorsal edge of which is produced into a long barbel. The anterior nostril of the loaches resembles that of the rockling, but the tube stands up more vertically from the head, and the posterior edge of the aperture is not produced into a barbel, but is bent over it to form a kind of hood. This latter form of nostril is also found in nearly the same shape in *Lepadogaster*. In all these forms the posterior nostril is a simple opening without a valve.

These tubular nostrils are ciliated as well as the olfactory epithelium itself, and a current is thus caused which enters by the anterior and leaves by the posterior opening. In the majority of fishes rhythmical oscillations of the water in the olfactory pits also occur, but these are not present in any of the animals mentioned below as seeking food by scent, except *Lepadogaster*.

In the ordinary round fishes (*Gadidæ, Labridæ,* &c.) the two nostrils are placed close together. Through these openings currents are no doubt caused by the cilia on the olfactory organs themselves, but the principal movement of water in the olfactory chambers is an oscillatory movement which occurs rhythmically, keeping time with and being probably dependent on the respiratory movements of the fish. The former movements may nevertheless be suspended while the respiratory movements continue. It did not appear that in these fishes the water entered or left by either nostril in particular, but rather that it oscillated in and out through both of them at once.

In the flat-fishes the arrangement of this current is more complicated. The plaice may be described as having the structure which is found in most of them. This fish lies on its left side. The anterior nostrils are tubular, that of the right side being produced considerably. The posterior nostril of the right side is valvular, and opens outwards. On inspiration water passes into the olfactory chamber through the anterior nostril, and on expiration the posterior nostril opens suddenly as the water passes out through it. The posterior nostril of the left side is not valvular, but simple. These remarks apply also to the dab and the flounder. In all these fishes the nostrils are so arranged that none of them are on the *lower* surface of the head, but rather on its dorsal side.

The sole has a different mechanism. It lies on its left side, and both the nostrils of the left side are on the under surface of the head—touching the ground, in fact, when the animal is at rest. On the left side the anterior nostril is large and open, and has a ciliated fold of skin which passes spirally down it; but the posterior one is very inconspicuous and valvular, being at some distance from the anterior opening. As the sole inspires, water passes in at the anterior opening, and on expiration it leaves by the posterior nostril, which opens and shuts with a jerk. The anterior nostril of the right side is tubular, and the posterior one is valved, acting like that of the left side.

In all these fishes, also, the flow of water through the olfactory organs may be suspended though the respiratory movements continue.

In the turbot, which lies on its right side, the left anterior nostril is guarded by a simple triangular flap of skin which projects forward from the posterior edge of the opening and covers it. This possibly forms a valve during life, though I have not had an opportunity of closely examining the currents through the olfactory chamber in a living specimen. The posterior edge of the anterior nostril on the left side is produced into a very large, leaf-like flap of skin, which in dead specimens usually covers the nostril. In one specimen (from Grimsby), however, this fold was reflexed, and lay against the side of the head in such a rigid manner that it could not have been used during life to cover the nostril.

The right posterior nostril of the turbot is widely open, and the left posterior nostril is also without any special valve, but the skin at its edges nearly meets across the opening. These structures do not materially differ in the brill (*R. levis*). In one brill (from Grimsby) the two nostrils of the right side were united, forming a common fossa in which the olfactory organ lay. In this specimen the leaf-like fold of skin, usually covering the anterior nostril, was divided into two parts, which were disposed on either side of this fossa. There was no indication that this variation was not congenital.

The left anterior nostril of *Arnoglossus laterna* is somewhat tubular, but the left nostrils of *Arnoglossus megastoma*, which also lies on its right side, were, in a preserved specimen, without valves or flaps of skin of any kind. The right anterior nostril, however, has a very large loose flap of skin. The olfactory folds are but slightly developed, and are mere ridges on the floor of the olfactory chamber. Their number in the left organ of a large specimen was thirty (*v.* fig. 3).

The olfactory structures of Müller's top-knot (*Zeugopterus punctatus*) are so abnormal and reduced that it will be best to reserve any statement about them until the homologies of the parts are more clear.

The **olfactory organs** themselves in fishes are composed of the well-known folds bearing the sensory and supporting cells of the epithelium. On this occasion I propose to give an account of the general structure of these organs, deferring the description of the histology until a full comparison can be made between the olfactory elements of the fishes which hunt by scent with the same parts in those which seem not to use their olfactory organs for this purpose.

The arrangement of the olfactory folds differs in the various fishes. Roughly speaking, they are built up on one of four types, or on some plan intermediate between them.

(1) In the skate and dog-fish the plates are arranged in a radiating manner on the inside of a hollow capsule, like the septa of an orange. In this case the free internal edges of the plates do not bear sensory cells, but are fibrous supporting tissues.

(2) The conger and eel have the plates of the organ arranged in two rows on each side of a central raphe, upon which the two rows are folded longitudinally so as to form the lining of the olfactory tube. The olfactory organ of the sole, though a much less considerable structure, is arranged on a similar plan; for on it the longitudinal raphe is depressed so as to form a groove from which the plates rise up on each side. The number of plates in an eel one and a half feet long was about thirty-eight pairs in each organ. As already mentioned, the number and size of these plates increase with the growth of the animal.

(3) The third type of olfactory organ, of which the second is a modification, is that most commonly found among fishes. In it the plates are fitted together in a radiating manner, forming a convex eminence in the olfactory chamber. The whole organ is either circular (as in *Cottus* and *Motella mustela*) or elliptical (as in the mackerel), according to the number and shape of the plates of which it is composed.

In all the Teleosteans hitherto mentioned most of the plates are placed at right angles to the long axis of the body, and each organ essentially consists of two rows of such plates united in the middle; for the circular collection of radiating plates of *Cottus*, &c., only differs in degree from the more common elliptical one.

Amongst the flat-fishes this elliptical series of plates arranged along a single axis is found in the genera *Rhombus* (turbot and brill) and *Arnoglossus* (merry sole and megrim). In a very large turbot the number of chief folds was thirty.

(4) In all the species of *Pleuronectes** examined, as well as in *Hippoglossus vulgaris* (the halibut), an entirely different arrangement is found. In these fishes (*v.* fig. 2) only one row of olfactory plates is present. The plates thus arranged in a single series lie in a direction parallel to the long axis of the body, and not transversely to it, as the majority of them do in other types. The arrangement in *Solea* has already been described.

In the pollack and rockling, and probably in all fishes, if the whole olfactory organ be destroyed with acid, the skin heals over the part, but the special epithelium and the nostrils are not reproduced; but in a conger in which the olfactory organ had been only partially destroyed, the plates of epithelium were found to be regenerating from the edges of the olfactory tissue which had remained undestroyed.

Sense-organs of the Mouth and Skin.

The scales and skin generally of fishes are supplied with remarkable sense-organs, which resemble the taste-buds of higher forms. These organs have been fully described and figured by Merkel in his monograph, *Ueber die Endigungen der sensiblen Nerven in der Haut der Wirbelthiere* (Rostock, 1880). In the course of these investigations a good deal of the ground covered by Merkel's work has been gone over, and to it there is little to add. It will be profitable, however, to mention those facts which specially concern the purposes of the present inquiry, and to describe the characters of some of these organs in forms which have not been investigated by Merkel.

Such organs consist essentially of clusters of long cells arranged together to form a bulb-shaped body, of which the apex is not covered by cuticle, but projects on the surface of the skin. The base of the bulb may be in contact with the basement-membrane of the skin, or may be separated from it by several layers of cells of the lower layer of the skin (cf. figs. 13 and 14). Into this base a nerve enters. Such an organ may be large and visible to the naked eye, as in the pharyngeal walls of most fishes, or it may consist of only a few such cells and be extremely minute. These minute "taste-

* Viz. *P. platessa* (the plaice), *P. flesus* (the flounder), *P. limanda* (the dab), *P. microcephalus* (the lemon sole of the east-coast fisheries).

buds" are found in clusters on the large papillæ which occur on the gill-bars of the dog-fish (as observed by Merkel), of *Cottus*, and many other forms. The whole sense-organ may be placed on the general surface of the skin, or it may be depressed into a pit or elevated on a papilla, according to its situation and the animal in question.

The cells forming these sense-organs consist of a very long, narrow cylindrical head, which is external, an internal enlargement in which the nucleus lies, and a tail passing into a fibre of varying length (*v.* fig. 15).

These sense-organs have a general resemblance to those of the lateral line, but the cells of which they are made do not appear to bear a hair on their peripheral buds, as those of the lateral line do.

I have examined them in the following forms, and have found them on the parts stated.

Bream (*Pagellus centrodontus*). On the palate.

Bullhead (*Cottus scorpius*). On the palate and on the papillæ of the gill-bars.

Gurnards (*Trigla*). On the palate and *not* on the fingers of the pectoral fin.

Pogge (*Agonus cataphractus*). On the villiform tentacles beneath the head.

Wrasses (*Labridæ*). On the palate as patches of minute sense-organs surrounded by ridges of skin.

Grey mullet (*Mugil*). On the palate and in great numbers upon the fleshy thickenings in the pharynx; also in rows upon the white rugæ which form the anterior borders of these thickenings.

Pollack (*Gadus pollachius*). On the lips and palate (a few).

Pouting (*G. luscus*). On the lips, palate, barbel, and pelvic fins in great numbers.

Whiting (*G. merlangus*). On the lips and palate.

Rocklings (*Motella*). On *all* the barbels, pelvic fins,* and palate.

Blenny (*Blennius gattorugine*). No sense-organs were found on the tree-shaped processes, which stand up from the anterior nostril and from the orbit. As these are parts which might have been expected to bear such organs, mention should be made of their absence.

Plaice (*Pleuronectes platessa*). On the palate.

Dab (*Pleuronectes limanda*). No sense-organs were seen on the palate.

Sole (*Solea vulgaris*). Contrary to the natural presumption, the

* In the last number of this Journal I stated that the pelvic fins of the rockling bore no organs of special sense. In specimens since prepared with gold chloride they are easy to see.

villi on the lower (left) side of the head do *not* bear sense-organs, though, as Mr. Cunningham informs me, such organs are found between the villi.

Conger (*Conger vulgaris*). On the outer and inner lips and palate.

Eel (*Anguilla vulgaris*). On the tongue and lips and on the skin of the tubular anterior nostril.

Dog-fish (*Scyllium canicula*). On the tongue and palate and in groups on the papillæ of the gill-bars.

Torpedo (*Torpedo marmorata*). No opportunity of dissecting this torpedo occurred, but these organs should be looked for on the papillæ bounding the spiracle of this species, in which place their occurrence would be interesting.

It is of course not suggested that these organs do not occur also on other parts of the animals named, as such structures are very generally distributed among fishes.

The nature of these structures is sufficiently shown by the figures. Upon the lips of the conger two types are found, of which the most usual is shown in fig. 13. The sense-organ is here seen to lie on the general surface of the skin, which is very thick. Below the sense-organ a narrow channel passes up through the whole thickness of the skin, and in this the nerve travels up to the sense-organ. The other type of sense-organ found in the same situation is precisely similar, except that it does not lie superficially but at the bottom of an open pit, depressed below the surface of the skin.

The nerve-supply of the sense-organs of the pharynx of the mullet (*Mugil*), &c., and of the barbels of the rocklings (*Motella*), &c., differs from these in that the skin is not channelled for the passage of the nerves to them. On the contrary, the fibres, after leaving the nerve-trunks, *pass bodily through the basement-membrane* and amongst the cells of the skin to break up on the sense-organs (*v.* fig. 11).

Senses of Fishes which seek their Food by Scent.

Smell.—The majority of fishes seek their food chiefly if not entirely by sight, but a certain number hunt for and recognise it by the sense of smell alone, while a few species are also aided in seeking by special organs of touch. The following is a complete list of the fishes which have been observed by me to show consciousness of food which was unseen by them; and, as will be hereafter shown, there is evidence that they habitually seek it without the help of their eyes.

Protopterus annectens.
Rough dog-fish (*Scyllium canicula*).
Nursehound (*Scyllium catulus*).
Skate (*Raia batis*).
Conger (*Conger vulgaris*).

Eel (*Anguilla vulgaris*).
Three-bearded rockling (*Motella tricirrata*).
Five-bearded rockling (*Motella mustela*).
Loach (*Nemacheilus barbatula*).
? Sucker (*Lepadogaster Gouanii*).
Sole (*Solea vulgaris*).
Little sole (*Solea minuta*).
Sterlet (*Acipenser ruthenus*).

To this list may almost certainly be added the remainder of the *Raiidæ*, together with the angel-fish (*Rhina squatina*) and torpedo. Unfortunately, however, the examples of these forms living in the tanks at Plymouth have never become thoroughly at home, and still (November, 1889) take food reluctantly. In fact, the skates have for many months subsisted entirely on shrimps, and very rarely take notice of other food; but owing to the kindness of Mr. Wells, the superintendent, I had an opportunity of seeing the habits of the skate under more favorable conditions at Brighton.

Of the fishes in this list the conger, rocklings, sole, and rough dog-fish were the most frequently and minutely watched.

There are many points of resemblance in the habits of the various animals mentioned above, and some general observations may be made with regard to them collectively before pointing out the special features of interest in the natural history of each. In the first place they are all more or less nocturnal animals, and (? sterlet and *Protopterus*) remain in hiding by day, many of them being furnished with special modes of concealment. For example, the conger and the rocklings live in holes in the rocks, the eel and *Protopterus* in mud, the sucker and the loach under stones, while the sole lies completely buried in the sand, the eyeballs alone being exposed. When left to themselves they generally lie motionless until dusk, when they begin to swim about with more or less activity. If, however, while they are lying thus hidden the juice of food-substances (such as squid or pilchard) is poured into the water, they come out and feel about for a considerable time, clearly perceiving the odour. The dog-fish, conger, and eels feel for food with their noses, *Protopterus* with its pectoral and pelvic fins, the rocklings with the barbels and pelvic fins, the loach with its barbels, and the sole with the villi on the left (lower) side of its head.

None of these fishes ever start in quest of food when it is first put into the tank, but wait for an interval, doubtless until the scent has been diffused through the water. Having perceived the scent of food, they swim vaguely about and appear to seek it by examining the whole area pervaded by the scent, having seemingly no sense of the direction whence it proceeds.

Though some of these animals have undoubtedly some visual perception of objects moving in the water, yet at no time was there the slightest indication of any recognition of food-substances by sight.

The process of search is equally indirect and tentative by day and by night, whether the food is exposed or hidden in an opaque vessel, whether a piece of actual food is in the water or the juice only, squeezed through a cloth, and, lastly, whether (as tested in the case of the conger and rockling) the fish be blind or not. On the other hand, if the olfactory epithelium is destroyed in the rockling or conger, the animal does not leave its hiding-place to hunt, though it seizes food placed near its face. Stones or other objects rubbed with food attract these fishes as much as food itself, and when very hungry they will snap at such uneatable substances, though they are rejected after being taken into the mouth. I saw no reason to suppose that any of these animals have the instinct of following a scent (as a prawn seems to do to some extent), though they always stop to examine bodies upon which food has lately rested. The scent of the food does not seem to remain long in the water, and apparently the scent of the surface of the food itself is dissipated or decomposed in a short time; for when, for instance, a piece of squid is not found after searching, it often happens that the fishes give up and retire, but will come out again in quest if the same piece of squid be taken out, cut in half to expose a new surface, and put back. None of the fishes were ever seen to hunt for more than about fifteen minutes unless the scent was renewed. It is difficult to estimate the distance to which a scent can be diffused in the water, but it is likely that, in water which is not rapidly moving, its virtues are destroyed before it has been carried far. There is, I think, no reason for supposing that scents are diffused through the water otherwise than by currents. This is most easily tested by experimenting with shrimps in a large shallow vessel. The shrimps remain buried until the scent reaches them. When the water was not in motion, if food was gently dropped in, the shrimps gave no sign for an indefinite time, but on stirring the water they began to seek. The longest tank at Plymouth is about twenty feet long, and an interval of from five to ten minutes elapses before conger at one end are aware of the presence of food put in at the other.

The perceptions, then, by which these animals recognise the presence of food are clearly obtained by means of the olfactory organs, and apparently exclusively through them. I was particularly surprised to find no indication of the possession of such a function by the sense-organs of the barbels and lips, or by those of the lateral line. As has been already described, the pelvic fins and barbels of the rocklings (*Motella*) and the lips, &c., of most fishes bear great numbers of sense-organs closely comparable in structure with the taste-buds of other vertebrates. No one who has seen the mode of feeding of the rockling or pouting (*Gadus luscus*) can doubt that these organs are employed for the discrimination of food-substances; but the fact already mentioned, that the rockling in which the olfactory organs had been extirpated did not take any notice of food that was not put close to it, points to the conclusion that they are of service only in actual contact with the food itself.

Sight.—In view of the fact that these fishes do not habitually recognise food by sight it would be especially interesting to determine what part in their economy is played by visual perceptions. Though nocturnal animals, they all have functional eyes, which in the conger, skates, and dog-fishes are as well developed as those of other fishes (*v.* p. 228). In the angel-fish, torpedo, and soles the eyes are, however, of small proportional size. Nevertheless, with the exception of the dog-fish and skates, in which the pupil is covered in daylight by the iris, there is nothing to suggest that there is any difference between the eyesight of these forms and that of other fishes. Positive evidence as to the class of objects which they distinguish is difficult to obtain owing to the general absence of facial or other expressions among fishes; and it should always be remembered that the fact that animals take no notice of objects is no proof that they do not see them. For example, wrasses, mullet, and other fishes with excellent sight take no notice of a handkerchief suddenly flipped against the glass of the tank in which they are, which would scare away a terrestrial animal; but it is perfectly certain that they see the handkerchief, for they will snap at a worm hanging by a thread or sticking to the outside of the glass. Similarly they take no notice of a *straight* wire held up and waved outside the tank, but if the wire be *bent* into a sinuous curve like the body of a swimming worm they (pollack) will often dash at the glass in the attempt to seize it. It would appear, however, that fish are by no means slow at gaining knowledge of this kind. A curious instance of this occurred in the case of the rockling (*Motella tricirrata*). When I first began to observe the mode of feeding of this fish I was inclined to believe that it did not *see* worms, &c., thrown in for food. As mentioned above, it does not come towards them until they have been for some time in the water, and then, moving its head and fins, it swims wildly about until it comes in contact with the food, even though it be hanging freely in the water directly in the line of sight. But one of these fishes which has been living for some months in a shallow tank has been constantly fed by persons leaning over the top; and now when hungry not only comes up and splashes about on the surface of the water as soon as any one approaches, but will lift its head out of the water to snap at the fingers held above the surface, which it obviously sees and recognises. When last observed, however, it still did not appear to have learnt to recognise a worm swimming in the water, but only the presence of the person feeding it. When it is remembered that this fish naturally hunts by scent, the acquirement of this new instinct seems somewhat remarkable, and suggests that it is not the vision which is defective, but the power of appreciation. Being a nocturnal animal, it must be supposed to have never *seen* food, or to have seen it so rarely that it made no impression on it. These considerations suggest the possibility that these fishes may in the course of time learn to distinguish food by sight as they are now habitually fed by day.

There can be no doubt that soles also perceive objects approaching them, for they will bury themselves if a stroke at them is made with a landing net; yet they have no recognition of a worm hanging by a thread immediately over their heads, and will not take it even if it touch them, but continue to feel for it aimlessly on the bottom of the tank, being aware of its presence by the sense of smell. Soles, eels, and rocklings, moreover, have a clear appreciation of light and darkness being always buried or hidden by day (unless food is thrown in), but swimming freely about the tank like other fish at night. When thus swimming at large they bury or hide themselves if a light be flashed on them. Conger and loaches have some appreciation of moving objects, and occasionally snap at them, but their perceptions are extremely vague, as may be shown by watching their attempts to take a piece of food trailed through the water with a line. Their movements altogether are suggestive of a blurred perception, and perhaps it may be that their eyes are capable of distinct vision under greater pressure or in less light or at a greater distance. That greater pressure might produce an effect is very possible, but on watching their movements at night with a dark lantern, or in a tank from which the light was screened, there was no perceptible difference in their aptitude in discovering food.

None of these fishes have much apparent difficulty in avoiding obstacles, but as *large* obstacles seem to be easily avoided by the same animals when deprived of sight, it may be doubted whether this perception of obstacles is not as much obtained by general sensation, especially of currents, as it is by sight.

As to the sight of the sterlet no experiments have as yet been made.

Touch.—In the rocklings, as mentioned in this journal (N. S., i, 2, p. 214), the pelvic fins are developed as special tactile organs, and are used in the mode there described. By these organs they are not only able to distinguish food-substances alone, for a rockling on brushing with its pelvic fins against a piece of glass or a stone smeared with vaseline, turns and examines it, clearly remarking the peculiar feel of such surfaces.

Filamentous fins similar to those of the rocklings are found in *Protopterus annectens,* in which both the pectoral and pelvic fins have this structure. Through the courtesy of Mr. Wells I was enabled to watch the mode of feeding of this fish in the Brighton Aquarium. The fins are used in a manner somewhat different from that of the rockling, which merely extends the fins at right angles to the body, and swims wildly about until they happen to touch the food. *Protopterus,* on the other hand, whips with them on the bottom of the tank until the food is struck. The tail also of this fish is, perhaps, used for seeking food, but this was not clearly established.

In connection with the sense of touch, the mode of feeding of the soles may be fitly described. The sole feeds in a manner peculiar to itself, and unlike that of any other fishes which have come under my notice. As already stated, it remains buried by day, and generally speaking, if the sand be fine its body is completely covered. When shrimps or pieces of other food are thrown in, after an interval the soles perceive it; they then give a writhing jump or succession of jumps from the bottom of the tank, and begin to search on the ground. When searching for food the upper (right) side of the sole is nearly always covered with a coating of sand so uniform that little or none of the skin can be seen. There can, I think, be little doubt that this sand sticks to the body owing to an outpouring of mucus on the surface of the skin, which probably occurs when the smell of food is perceived, and is comparable with the watering of the mouth in ourselves.* This covering of sand is no doubt dusted over them by these energetic movements, but it only adheres when the sole is searching for food. At night, for example, when the soles are active, they carry no sand. The coating of sand must be pretty firmly attached, for if a sanded sole is made to swim rapidly the covering of sand remains.

In seaching for food the sole creeps about on the bottom by means of the fringe of fin-rays with which its body is edged, and thus slowly moving, it raises its head upwards and sideways, and gently pats the ground at intervals, feeling the objects in its path with the peculiar villiform papillæ which cover the lower (left) side of its head and face. In this way it will examine the whole surface of the floor of the tank, stopping and going back to investigate pieces of stick, string, or other objects which it feels below its cheek. As already stated, the sole appears to be unable to find food that does not lie on the bottom, and will not succeed in finding food suspended

* At the moment when a conger lying still first perceives the smell of food, he generally shakes himself, and takes a gulping inspiration, freeing a variable quantity of mucus from the skin and pharynx, which floats up through the water, owing to small bubbles of gas which are enclosed in it.

in the water unless it be lowered so that the sole is able to cover part of it with the lower side of its head, when it seizes it at once. These remarks apply to the common sole (*Solea vulgaris*), to *Solea minuta,* and probably to all the other species, but none of these have lived in the aquarium long enough for observation.

The fact that soles are hardly ever taken with a hook is no doubt due to this manner of feeding; for the bait is not allowed to lie on the bottom except in long line fishing, which is done with large hooks only and on rough ground. If long lines with small gear were laid on the soft ground where the soles live, it is by no means unlikely that they would be taken. In this case it would probably be found to be the most rational way of catching soles.

The sterlet and loaches on perceiving the smell of food hunt for it with their noses and barbels on the bottom. The barbels of the sterlet do not appear to be moveable as those of the pouting, &c., are, and the specimens watched at Brighton did not shovel with their noses, but protruded their remarkable jaws, and appeared to make random bites at the bottom when food was thrown in.

The Senses of Fishes which seek their Food by Sight.

The majority of fishes belong to this class. The following is a list of all the species which have been observed in the Aquarium either at Brighton or Plymouth to feed in this manner. Many others—as, for example, the *Salmonidæ* and *Scombridæ*—might have been added, but I have only given the names of those which have come under my own observation.

Bass (*Labrax lupus*).
Bream (*Pagellus centrodontus*).
Bullhead (*Cottus scorpius*).
Red gurnard (*Trigla cuculus*).
Grey gurnard (Tub) (*T. hirundo*).
Pogge (*Agonus cataphractus*).
Weever (*Trachinus vipera*).
Horse-mackerel (*Caranx trachurus*).
Herring (*Clupea harengus*).
Dory (*Zeus faber*).
Boar-fish (*Capros aper*).
Goby (*Gobius minutus*).
Dragonet (*Callionymus lyra*).
Lump-fish (*Cyclopterus lumpus*).
Blenny (*Blennius pholis*).
Gattorugine (*Blennius gattorugine*).
Butter-fish (*Centronotus gunnellus*).
Grey mullet (*Mugil chelo*).
Three-spined stickleback (*Gasterosteus aculeatus*).
Fifteen-spined stickleback (*G. spinachia*).
Spotted wrasse (*Labrus maculatus*).
Rainbow wrasse (*Coris julis*).
Pouting (*Gadus luscus*).
Whiting (*Gadus merlangus*).
Pollack (*Gadus pollachius*).
Cod (*Gadus morrhua*).

Turbot (*Rhombus maximus*).
Brill (*Rhombus levis*).
Müller's topknot (*Zeugopterus punctatus*).
Plaice (*Pleuronectes platessa*).
Dab (*P. limanda*).
Flounder (*P. flesus*).
Shorter pipe-fish (*Nerophis æquoreus*).
Worm pipe-fish (*N. lumbriciformis*).

Sight.—The sense of sight in these fishes is developed in various degrees. In some, as in the bream (*Pagellus*), the eyes are practically fixed ; while in others, as in the pipe-fishes (*Syngnathidæ*), dory (*Zeus faber*), and wrasses (*Labridæ*), the eyes are capable of considerable movement, and are used independently like those of the chameleon. None of the fishes observed appear to distinguish food (worms) at a greater horizontal distance than about four feet, and for most of them the vertical limit seemed to be about three feet; but the plaice at the bottom of the tank perceived worms when at the surface of the water, being about five feet above them. Though the distance of clear vision seems to be so small for objects in the water, many of these fish (plaice, mullet, bream) notice a man appearing on the other side of the room, distant about fifteen feet from the window of the tank. When hungry they swim up to the side of the tank and show great excitement if a person approaches. The same may be seen in the case of *Octopus* at Brighton, which, when the crowd collects in front of the tank, by its rapid and excited movements shows that it recognises the signs of approaching feeding-time.* The range of sight of fishes on the whole appears to be short. The sight of the wrasses (*Labridæ*) in particular is plainly adapted for vision at very close quarters ; for the habit of these fishes is to search for their food by minute examination of the bottom, weeds, &c., after the manner of insectivorous birds.

None of the fish seem to get any lasting appreciation of the nature of the plate-glass wall of the tank. The same fish will again and again knock its head against the glass in trying to seize objects

* In this case there is some doubt as to whether the *Octopus* does not recognise feeding-time by the help of its internal sensations. I have as yet had no opportunity for accurate experiment; but Mr. Wells tells me that both the *Octopus* and conger begin to swim about at feeding-time, whether any one is at the top of the tank or not. The conger are fed on alternate days, and Mr. Wells assures me that they distinguish these days, and do not get excited on the off days. On two occasions only I have watched them myself. The first was not a feeding-day, and they were not swimming about; but they certainly were actively moving to and fro on the second visit, which was one of their feeding-days, as also were the eels, which is still more surprising in view of their exceedingly nocturnal habits. So far, therefore, as my observation went, it quite bore out the statement of the superintendent. The fishes at Plymouth have not hitherto been fed with regularity, as their meals have to be arranged with a view to other experiments, so that no conclusions on this point can be drawn from them.

moving on the other side. Any small oscillating substance may attract them, such as a button dangling to a thread; and pollack (*G. pollachius*) often snap at even a curl of smoke from a pipe. After repeated attempts to take food on the other side of the glass they will desist; but some of the oldest inhabitants (plaice, pollack, and bream), which have been living in the aquarium for about a year, will perseveringly try again the next time. Fishes brought newly to the aquarium injure themselves by trying to escape through the glass, and I have seen gurnard fretting themselves for hours against it when the water of the tank has been made turbid by pouring in sand, being evidently of opinion that it is a way into clearer waters. It may here be suggested that perhaps the result of the famous experiment of Möbius has been wrongly interpreted. The story runs that pike, having lived for some time in a tank separated by a glass plate from another in which small fish were living, desisted from trying to catch them, and on the glass plate being removed never attempted to do so. The suggestion is that the pike had come to believe these particular fish to be under special protection. While this may be so, it is nevertheless a fact that fish, like other animals, having grown accustomed to the presence of forms which they would naturally eat, do not molest them. On one occasion several pollack were put into the congers' tank at Plymouth, and in the morning two only remained, but these two continued undisturbed for a long period; and other similar cases have been observed. The explanation should perhaps be referred to that paradoxical instinct which is widely developed among animals of many kinds, in obedience to which they occasionally do not eat or molest those with whom they are constantly associated. It is, of course, this unexplained instinct upon which the "happy family" of the travelling showman is constructed. Probably it is closely akin to many feelings and superstitions of which we are ourselves conscious, and which have received inadequate but rational explanations.

Many of the actions of fishes are of this paradoxical character. It is a common thing, when two fish swim up to the same worm, for the foremost to retire in a nervous way, leaving the worm for the other; and this quite independently of the relative sizes of the individuals. A small cod whose gills were injured lived for some time in a tank with bream and bass. This fish rarely if ever ate anything, but always swam up for a moment to each piece of food as it was put in, and then left it. When the cod approached, the bass, though many times his size, used to fall back, and return to eat the food when the cod retired. This process would be repeated again and again, and happens so often in the case of bream and bass that it appeared almost the rule for a fish to refuse at food if another fish came up behind it. Sticklebacks and blennies, on the other hand, snatch pieces from each others' mouths like hens; so also do eels and other fish which hunt by scent. Conger, in particular, fight lustily over their food; and though they may hesitate for some time to take a piece of food which is tainted, or a substance of otherwise doubtful scent, yet they bolt it at once if another conger or a crab begins to examine it or pull it away; afterwards, if need be, they reject it. These remarks illustrate the necessity for caution in making deductions as to the likes and dislikes of fishes from scanty observations.

It has been mentioned that various fishes differ in their powers of seeing things above or on a level with them, but far more remarkable is the difference in the degree to which they are able to see downwards. Of the fish mentioned above the following were never seen to eat food after it had fallen to the bottom of the tank:—bass, bream, dory, boar-fish, lump-sucker, and pollack. The pollack are particularly interesting to watch in this connection, appearing absolutely unable to find objects which have reached the ground. It may be that their vision is such as not to admit of the perception of things below them, or it may be that the whole surface of the bottom is to them indistinct and blurred, or possibly the protruding lower jaws of these fish prevent them from picking up objects lying on the ground, but certainly they never seem to attempt it; and if they fail to catch worms, shrimps, &c., as they are falling through the water they give up at once. It is to be regretted that the majority of the fishes living at Plymouth are littoral forms, and such as are accustomed to live and feed on the bottom; for it is likely that there are many other fishes which are similarly unable to find food which is below them. It may be mentioned that, in addition to those given above, it is rarely that mullet or *small* pouting find food on the bottom. Pouting of larger size, however, use their pelvic fins for this purpose, as hereafter described. In fact, it is probably exceptional for an ordinary freely swimming fish, which hunts by sight, to seek food which is not in suspension; for nearly all those that have the power of feeding on the bottom either possess organs of touch, as the gurnard and pouting, or moveable eyes, as the wrasses and pipe-fishes, or else have the eyes peculiarly placed, as the flat fishes and blennies.

The mode of feeding of the dory and pipe-fishes is sufficiently singular to call for special remark. These animals are both provided with transparent, vibratile membranous fins. In the dory these are caudal, anal, and pectoral, while in the pipe-fishes the pectoral and dorsal only are thus developed. By the oscillation of these the animal approaches its prey without making any general movements, and in fact stalks it. The flattened body of the dory is most inconspicuous when seen from in front, as is that of the pipe-fishes when seen end-on. The dory feeds on small fish, working up to them in this way very slowly and with precision, like a man working up to game in open country where there is no cover. On getting within range, which is some inches from the prey, the immense protrusible jaws are shot out, and the fish is drawn back with them into the mouth. When the dory sights his prey the whole aspect of the fish changes. The curious brown markings on the body, which are at times scarcely visible, blush up and become dark. Of these the most conspicuous is a wide dark band passing down the middle of the nose and continuing between the jaws; this dark stripe gives the fish a most singular appearance when seen from in front. In the case of the pipe-fish, which feeds largely on small shrimps, the face is drawn out into the well-known pipe-like process which is gradually pushed right up to the victim, who would be alarmed and escape at the approach of a more clumsily organised fish. During this proceeding the pipe-fish frequently comes forward on its ventral surface.

None of these sight-hunting fishes while living in the tanks appear able to see their food by night, or even in twilight; worms thrown in after dark fell through the water unnoticed. It did not appear that this was due to reluctance on the part of the fish to eat by night, for on some occasions pollack took worms by night when the light of a bull's eye was turned on them so that the fish could see them. In view of this fact it would be interesting to see if fishes would take an object made luminous with Balmain's luminous paint or otherwise. I made experiments with pieces of india-rubber and with twisted glass tubes filled with luminous paint and sealed up, but none of the fish took any notice of them. Perhaps, however, such fish as mackerel might be attracted by similar objects trailed along in the open sea by night; for so many of the animals which are preyed upon by fishes are phosphorescent, that it is likely that some at least are accustomed thus to recognise them.

In view of the brilliant colours which are so common among marine animals it would be highly interesting to get some idea of the colour sense of fishes, but so far my results have been chiefly negative. In the first place I endeavoured to find out if light of any particular colour were invisible to soles and other nocturnal fish which, as already stated, swim about in the dark, but hide themselves when a light is turned on them. My experience was that their behaviour did not appreciably differ whether the light was red, blue, or green; and in fact they (eels and soles) seemed to be conscious of and to avoid coloured light almost as much as plain light. On the other hand, the pupil of *Eledone* contracts much less for red light than for other colours; and the larvæ of the lobster, which swim *towards* a light, leave red for yellow, and yellow for green, preferring blue-green to violet and to all the coloured glasses with which they were tested. As these animals seek the light it may be supposed that the blue-green seems to them the most intense. Whether, as happened in the case of Sir John Lubbock's experiments with ants, any of these animals perceive vividly the ultra-violet rays I cannot say, as I had not the necessary appliances.

As it has been suggested that the bright colours of animals may have a protective value, which suggestion has recently been extended by Garstang (*Journ. M. B. A.*, N. S., i, 2, p. 175) to marine animals, I endeavoured to ascertain in the case of mullet whether bright colours have any such deterrent power. The mullet in question were a shoal of small fry about one and a half inches long. They were accustomed to eat minced worms off a slate slab. Upon the slate slab I arranged a number of brightly coloured tiles, some having plain and others mottled surfaces, and the minced worm was laid on these. The tiles were dark red, white, pale blue, dark blue, and mottled greenish brown. On several occasions the food was first cleaned off the pale blue and the white tiles upon which it was most conspicuous, and next off the mottled ones. The food on the dark blue and dark red tiles generally remained the longest, but was eventually eaten. On the whole it seemed to me that the fish distinguished between the tiles, but there was nothing to suggest that they were afraid of any of them. Certainly the bright colour of the pale blue tile did not seem to trouble them. It would perhaps be worth while to make a similar experiment with some of the glass models of anemones, &c., which are now obtainable, in order to test whether the colours, *per se*, have any deterrent effect.

It has been stated above that pollack will snatch at a wire curved into the shape of a worm when it is held up outside the tank. The same wire when painted white, or bright yellow, or blue, proved equally attractive.

Smell.—It was stated above that the great majority of fishes hunt their food by sight, and there is a good deal of evidence that it is sought for by sight alone. None of the fishes mentioned on pp. 241-2 show symptoms of interest when the juice of food-substances is put into the water. They will attempt to take worms, shrimps, pieces of fish, &c., which are lowered into the water inside a glass tube, or which are simply sticking to the glass window of the tank. When hungry they are unable to find food in the dark, while by day they will seize uneatable substances which are quickly moving in the water. This evidence goes to show that the sense of smell plays little or no part in helping them to discover their food. On the other hand, both pollack and whiting, when their first hunger is satisfied, swim under the food so as to touch it with their noses and presumably smell it; and this gesture is often performed by individuals in which the olfactory organs have been destroyed, probably by force of habit. Mullet examine food by sucking water from it, and bass, bream, &c., touch doubtful food with their lips before seizing it. Plaice, turbot, blennies, and wrasses do not seem to make any preliminary examination of the flavour before taking food into their mouths. The importance of the olfactory organs to such animals as these is therefore obscure.

The range of tastes and scents which fishes are capable of perceiving seems to be very small. Conger are equally willing to eat a piece of squid or pilchard if it is covered or smeared with spirit, trimethylamine, turpentine, iodoform, camphor spirit, cheese of various sorts, anchovy extract, or *Balanoglossus*,* as if it had been unpolluted. On the other hand, they will refuse cooked or tainted food and food which has been soaked for a few moments in dilute acids. The same remarks apply generally to the other fishes. None of them paid the slightest heed to stones or other objects covered with any of the substances mentioned. I was particularly surprised that none of the fishes in the tanks took notice of *rogue*—the fermented roe of the cod, which has a most powerful odour, and is used with great success to attract sardines by the fishermen of Brittany —but of course none of my fish were *Clupeidæ*. It is supposed by the sardine fishermen that the odour is of great importance, and must be of the right quality. Hence it may be imagined that it does not merely attract the sardines by sight.

In this place mention should be made of the fact that some of the *Gadidæ*, which are, generally speaking, day feeders, are sometimes taken with a bait at night. At certain times of the year this is the recognised mode of catching hake (*Merluccius vulgaris*), while occasionally whiting are so taken. In both these cases the bait is sent down about *halfway* to the bottom, and not, as usually, to within a fathom of it. I was assured by fishermen that this mode of feeding is a most exceptional thing with whiting, and is supposed to be connected with the continued prevalence of calms, for under ordinary circumstances whiting-catching is not continued after dusk. In addition to these instances it sometimes happens that *large* pollack are taken on ground-lines by night. Whether in these cases the food is found by sight or by smell there is no evidence to show, for both the pollack and the whiting living in the tanks seem unable to find food in

* As the disgusting smells emitted by various species of *Balanoglossus* may be thought to be protective, I tested various fishes with pieces of a single damaged specimen of *B. salmoneus* which was dredged in Plymouth Sound. It was refused by both mullet and wrasse after trial, but was eaten by a sole and by a plaice.

the dark. Taken in connexion with the fact that this habit of whiting is supposed to occur in fine weather, it is possible that the fish are guided by the phosphorescence either of the bait itself or of the animals carried past it by the tide. Mention should also be made of the fact that trout are often taken with a worm at night.

Touch.—Of the fishes which seek their food by sight some are provided with barbels, as the pouting and the cod, while a few have special tactile organs, as the gurnards, and again the pouting. When the pouting is hungry it takes its food promptly, without hesitation, but when it has had about enough it frequently erects the barbel so that it projects forward and touches the food with it, probably thus tasting it. In the Brighton Aquarium I saw that the pelvic fins of the pouting are used just as those of the rockling are, the fish swimming with them set at right angles to the body and touching the ground, but those at Plymouth were not seen to do this. The latter are much smaller specimens, which fact may possibly account for this difference in habit.

The fingers of the pectoral fin of the gurnards are certainly used in the search for food. Although the gurnards have good sight and will swim up to a bait, they are chiefly bottom-feeders, and move about with these fingers, half walking and half swimming as they seek their food. On touching a worm with the fingers they stop and scratch it about for some moments, as though raking it out of the sand, and then suddenly turn and snap it up. Though the fingers are thus employed, the gurnards often take food off the bottom without touching it with the fingers. I did not succeed in seeing the gurnards feed by night, but it is quite possible that they may do so.

I was surprised to find that the pogge (*Agonus cataphractus*) did not appear to use the filamentous villi of the lower side of the head for finding food. These villi are developed to a great degree, and bear sense-organs which suggest that they may be used for this purpose; but though repeatedly watched, it was never seen to seek food otherwise than by sight. Thinking that these structures might be of use to it in discovering food buried in the sand, I made some trials, but the fish never seemed to recognise the presence of the buried food.

General Sensation.—The power which fishes possess of avoiding obstacles even when deprived of sight is very remarkable. For example, a bream in which the cornea has been rendered opaque, after recovery from the shock does not run into the sides of the tank, but swims round in a circle avoiding them. If a large obstacle, such as a glass plate, is put in the way, the fish avoids that also. But it would seem that this is because such an object cannot be brought into position without causing a disturbance in the water which the fish perceives. For if wire rabbit-netting or straight wires are gently lowered while the fish is at the other part of his circle, he does not avoid them on returning the first time. After colliding with such an object, though very gently, the fish seems to lose its balance, and does not swim upright for some seconds after, lying over generally towards the left side. If the wires are left in place the fish does not again run into them, but swims in a reduced circle. The sensibility of these fishes to movements in the water must be exceedingly delicate; for if a straight wire is put in the path of a blind fish it will be avoided if the finger only is kept on the top of the wire, though it does not avoid it if the wire is standing by itself. The same is true of pollack which had become blind from disease (apparently of the nature of cataract, to which fishes in captivity are very liable). It has been held by some observers that the sense-organs of the lateral line are of importance to the equilibration of the animal. Apart from the difficulties presented by the structure of these organs, which closely resemble taste-buds, it must be held that the case of the flat-fishes is practically conclusive against this view. For in the flat-fishes not only do the lateral lines retain the same position relative to the symmetry of the animal that they occupy in other fishes, but in those fishes (*e. g.* the dab, &c.) in which the course is peculiarly curved, this curve occurs equally on the upper and under surfaces. But as the flat-fishes swim in a plane at right angles to that of ordinary fishes the two lateral lines come to lie in the same vertical planes, and can therefore hardly be supposed to assist in equilibration. The fact that a fish in which the lateral nerve has been severed is unable to swim uprightly scarcely bears on this question, for almost any severe injury upsets the equilibrium of a fish.

Shoaling.—It was suggested to me by Professor Lankester that inquiry should be made as to the manner in which fishes keep together in shoals, and especially whether they follow each other by sight or otherwise. The only shoaling fish which was living in quantity in the tanks at Plymouth is the grey mullet. By day the whole shoal of about fifty little ones stays together more or less. Sometimes it divides into two or three shoals, but they run closely together if alarmed.* At night they lie *on the surface* of the water, and seem not to swim about as a body, nor are their heads all pointing one way as they generally are by day. The shoal seems at no time to have any leader, but will sometimes follow the front fish until one

* This instinct of packing together when afraid seems to be general among fishes which move in shoals. Mr. Dunn tells me that the proverbial phrase, "as close as hakes in a hoop," is derived from the fact that such fishes huddle together when surrounded by a net. Shoals of pilchard, herring, &c., also pack together when attacked by sea-birds.

of those that are behind makes a dart elsewhere, when the whole shoal turns round and follows. They certainly have no tendency to follow the largest fish in the shoal, or indeed any fish in particular. Similarity in size seems to be usual in these shoals. In one of the tanks there are two mullet which have been there for about a year, and are now about three inches long. They live apart on the ledge of the overflow, and never consort with the other mullet, which are about six inches in length. When, however, some of this year's fish (three-quarter inch) were put in, these two immediately swam out to them, and they all retired together into the overflow channel, where they afterwards remained habitually.

To the fifty small mullet in the long tank I introduced twenty more of rather smaller size, but of the same age, which had lived in another tank. The fifty at once ceased feeding, and huddled timidly away behind the stand-pipe, where they were joined by the new-comers. After a time the latter all left them in a body, thus showing that they recognised each other in some manner. They soon returned, however, and after staying together for a little a detachment of the new-comers again left, and so on; but on the following day the two shoals had amalgamated and fed together. Weakly fish never swim with the shoal, but keep apart—whether by choice or compulsion could not be determined.

Two specimens of horse-mackerel (*Caranx trachurus*), about two and a half inches long, put in in September, shoaled with the mullet, but the gobies never do so. In November on returning to Plymouth I found that one of the horse-mackerel was dead, and the other had left the mullet and moved about alone, but if alarmed it at once joined the mullet.

From the fact that the mullet do not move as a shoal at night, it may be so far inferred that they follow each other by sight alone, but it would be interesting to know whether other shoal-fishes travel at night. It may, in fact, be doubted whether such fish as pilchards habitually move about as a shoal at night. Of course drift-netting is carried on at night; but the nets are shot in places where the pilchards or herrings are known to be, and possibly the slight movements of the individuals and currents may take them into the net. That the shoals under some circumstances do not travel at night is seen by the use of the method of seeking pilchards known as "briming" for them. In this operation, which I have never seen, but which has been described to me by several fishermen, as the boat sails along, a man stands on the cuddy and stamps his foot at intervals. When the boat is among the pilchards, they are then seen by means of the "briming" or phosphorescence to dart away in all directions. Presumably, then, until disturbed by the noise they were lying at the top of the water, as the mullet were observed to do in the aquarium.

Hearing.—Several attempts were made to determine the class of sounds which fishes can hear. During the month of November some blasting operations were carried out on the premises of the Association, and particular notice was taken of the behaviour of the fish. The pouting scattered for a moment in all directions when the report came, but were quiet directly afterwards. The soles, plaice and turbot buried themselves. The conger drew back a few inches, as is their habit also when a light is turned on them at night, and generally on being disturbed. None of the other fishes were seen to take any notice of the report.

As mentioned in this Journal (N. S., i, 2, p. 217), satisfactory evidence was obtained that the creaking sound made by smearing a wet finger on the glass window of the tank was heard by a Lamellibranch (*Anomia*). For some time I was of opinion that the same sound was heard by some fishes (pollack, &c.) which at once come to the spot and follow the finger. Mr. Wells, of the Brighton Aquarium, told me that his own observations led him also to believe this, especially in the case of bream, which come to the front in a body when this sound is made. Nevertheless, on further trials I saw no reason to suppose that the fish were not merely following the finger by sight, and I never saw them (pollack) attracted when the sound was made behind a screen of silk or weeds sunk in the water, and such a screen would scarcely interfere with the transmission of the sound. The movements of the bream at Brighton did not, however, resemble those of fishes trying to catch a particular piece of food, but were distinctly suggestive of general expectation. Seeing that the case of the *Anomia* proves that sensible vibrations are thus actually set up in the water, it may be that they hear them. The sound made by pebbles rattling inside an opaque glass tube does not attract or alarm pollack; neither are they affected by the sharp sound made by letting a hanging stone tap against an opaque glass plate standing vertically in the water. If they *see* the stones in either of these cases they follow them, but if the glass is opaque they do not. When the wall of the tank is struck with a heavy stick they behave as described in the case of blasting. As might be expected, none of the fishes were seen to take notice of sounds made in the air. Various loud noises were tried, but soles, for instance, when exposed did not bury themselves as they do when the side of the tank is struck. Probably, therefore, they did not hear the noises. The stories, for example, quoted in Day's British Fishes, p. xxxviii, of fishes coming to be fed when a bell was rung, can scarcely be taken to prove that the sound of the bell was heard by them, unless it be clearly proven that the person about to feed them was hidden from their sight. The sound of the chopper which is also there mentioned in this connexion may have been communicated directly by the walls of the tank. There is no reasonable doubt that in the operation of "*briming*" for pilchards (*v.* p. 250), the sound made by the stamping of the foot is actually heard.

Though it may, therefore, be regarded as clear that fishes perceive the sound of sudden shocks and concussions when they are severe, it can scarcely be supposed that sounds of this nature play much part in their ordinary life, even if they occur at all. On the other hand, they do not seem to hear the sound of bodies moving in the water which they do not see. It may be remarked that the sounds emitted by fishes and *Crustacea* (dory, gurnard, crayfish, &c.) are of a stridulating or grumbling nature. In addition to these Mr. Wells called my attention to a peculiar snapping sound (audible in the room) which is made by large wrasses when feeding and biting with their strong jaws.

Remarks on the Supply of Bait.

The observations recorded above were made as a first step towards a practical solution of the difficulties which beset the bait question. It was felt that any attempt to find a cheap bait must be begun by getting a knowledge of the ways in which fishes find and recognise their food; and it was anticipated that when such knowledge should have been acquired, it would be possible to make use of it in a practical manner. Though the practical side of the subject was beyond the scope of this part of the investigation, it may be permissible to make a few remarks upon this aspect of the matter, and to indicate the lines of practical experiment to which these observations point.

The fishes which are chiefly sought by long-line fishermen on the south coast of England are conger, skates, and rays; while elsewhere the most important fishes which are taken with a hook are cod and halibut (*Hippoglossus vulgaris*). The chief substances used as bait are—for the east coast of England and North Atlantic, the herring; for the Scotch fisheries, the whelk (*Buccinum undatum*) and the mussel (*Mytilus edulis*); on the south coast of England the squid (*Loligo vulgaris*) and the pilchard are most in demand; while in the Channel Islands *Eledone* is used in great quantity. Everywhere the supply of bait is costly, and at times it fails, owing to calms or bad weather. It is therefore important that some substance should be obtained or manufactured which is attractive to fishes, but cheaper and more regularly accessible than the natural baits at present used.

In any attempt to prepare such a substance it is of the first importance to ascertain the mode by which fishes find and distinguish their food. As has been here set forth, satisfactory evidence was obtained that conger and the *Raiidæ* seek their food by smell. While I was at Plymouth no opportunity occurred of watching the habits of the cod, for only one injured specimen was obtained. It was quite clear that this fish saw exceedingly well, but whether or not the barbel or olfactory organs may not be used also in seeking food on the bottom or at night I am unable to say, but from experience of other fishes it is *a priori* unlikely that they are of great value as organs of search. The halibut is of course not found on the south coast, and has not come under my observation in the live state; but the structure of the fish, which closely resembles the plaice, suggests that it feeds by sight. This suggestion is strongly supported by the statement of Pennant quoted in Day's British Fishes (ii, p. 7) that on two occasions halibut had been known to take a sounding-lead. The fishes, then, which are sought by the North Sea fishermen and others differ from those upon which the Plymouth men most depend, for the former feed by sight and the latter by scent. As might be expected, therefore, the same bait is of different value in the two cases. For while in the North Sea the herring is thought to be the best bait, Plymouth fishermen scarcely think it worth their while to go to sea with it. At Plymouth, for catching conger fresh squid is thought to be the best bait, and fresh pilchard is by some considered as good as regards attractiveness, but as it has not the toughness of squid it does not stay on the hook so long. My own experience with conger in the tanks leads me to think that squid is also more attractive as a scent than pilchard is. In the absence of pilchard and squid, mackerel is used when abundant, but usually this fish is too dear to be in use as bait, and it certainly does not attract conger as much as squid.

The facts already given point to the conclusion that for the purposes of the conger and skate fishery the bait question may be solved in one of three ways: either—

(1) By extracting the flavour of squid or pilchard, and compounding it with some tough substance which will not wash off the hook; or—

(2) By finely dividing squid or pilchard and mixing it with some cheap substance, so as to make a little of it go further; or—

(3) By preserving squid or pilchard when abundant in such a manner as not to destroy its flavour and scent: of course this last method would only help the fishermen to tide over periods of scarcity of bait.

I have made some experiments in each of these directions, and perhaps a record of my experiences may be useful to those who intend to go on with the subject.

(1) This would no doubt give the most complete solution of the whole difficulty. I made some preliminary experiments with extraction by ether, and found that both from *Nereis* and from herrings after the ether had been distilled off, an oily fluid remained, which certainly attracted rocklings most powerfully, and caused them to snap at stones dipped in it. That obtained from herring also brought the conger out of their holes, but they did not show the eagerness that they do when seeking actual food.

Mr. Bourne has prepared a remarkable fluid by simple distillation of squid and water. This has a strong smell resembling that of cooked squid, and has stood for over a year without decomposition. It did not appear, however, that the fish noticed it at all.

By adding spirit very gradually day by day to mashed squid mixed with sea water which was kept warm, a good deal of the scent was extracted, and when the conger were very hungry a few c.c. of this extract poured into the tank sufficed to put them into a state of great excitement; they would seize rags which had been dipped in it, but I did not succeed in compounding it with any substance which they cared to eat. These results, though incomplete, are so far fairly encouraging.

(2) Many attempts were made to incorporate finely divided squid with gelatine. It seemed possible that if gelatine into which mashed squid had been stirred whilst warm and liquid, could be cast into sheets and dried, it might perhaps retain its flavour sufficiently to be eaten on being again softened with water. Consistency was given to these sheets of gelatine by stretching a sheet of butter-cloth in them when warm. When the conger were *very* hungry they would eat this substance with hesitation, and in the sea I caught an occasional fish (rockling and conger) with it, but it was by no means satisfactory, probably because each particle of squid was so coated with gelatine that its scent could not get out.

The next experiment was made by pouring melted gelatine into dishes smeared with mashed squid or mackerel, and then laying sheets of tissue-paper similarly smeared on the upper surface of the gelatine before it had set. When the gelatine was cold the paper was stripped off, and the gelatine remained covered on each side with a thin smearing of fish. The fish in the tanks ate this substance when fresh as readily as ordinary food, but it is unsuited to the purposes of fishing in deep water, as the coating of fish is washed off, and no doubt soon loses its scent. Probably the difficulty arising from the fact that the scent is soon destroyed on the surface of the food would prevent its being used in a finely divided form, however compounded.

(3) In experimenting with squid on a small scale I found that it could easily be preserved for about a month by cutting it open, cleaning and drying it with a cloth, and then powdering it with boracic acid and flour. This squid was apparently unchanged, and was in excellent condition for bait. Unfortunately, now that so many of the trawlers go away to the Bristol Channel, but little squid is landed at Plymouth.

Salted squid and salted pilchards are used, but are very unsatisfactory.

On a small scale pilchards were preserved for three weeks in the same way with boracic acid and flour, and were satisfactory as bait for conger. I succeeded also in catching mackerel at the time when they were feeding near the bottom (August and September) with preserved pilchard and preserved squid.* With the kind assistance of Mr. Matthias Dunn, of Mevagissey, I laid down several barrels of pilchards with boracic acid and flour as described, but for some unknown reason they did not answer. Though not decomposed, in a month's time they had become what is called by fish-curers "rusty," and their scent was that of cured fish rather than that of fresh. My experience with them on a small scale leads me to believe that with experience and precautions they might be kept with boracic acid in the dry state. Of course this preservation should be made with winter fish, which contain much less oil than summer fish. There is little hope that they could be preserved for bait in a *solution* of boracic acid, from the fact already mentioned that the scent of these things seems to be destroyed by contact with water.

In conclusion, I may repeat that the experiences here given suggest that the first step to a proper solution of the bait question for the south coast and Channel Island fisheries, where *fishes which hunt by scent* are caught, must be made by the extraction of the scent of squid or pilchards. Whether an artificial bait flavoured with such an extract would be useful in the fisheries of the North Sea, &c., cannot be predicted, but if made of some bright or white material (as dough or china clay) it might probably prove equally attractive to fish which hunt by sight. At the same time it must be borne in mind that any artificial bait must be extremely cheap if it is to be preferred (in the North Sea) to herrings, which are to be had for a great part of the year. It would, moreover, be interesting to see

* When mackerel are fished for at anchor with a hand-line, these two baits are used *together*, a small piece of each being put on the hook. It is difficult to explain the reason of this curious practice, but either bait alone is said to be of little use, which my own experience fully confirms as far as it goes.

whether the conger, &c., of the North Sea would take pilchard or squid, which they have probably never met in their ordinary experience.

DESCRIPTION OF PLATE XX.

Illustrating Mr. Bateson's paper on "The Sense-organs and Perceptions of Fishes; with Remarks on the Supply of Bait."

FIG. 1.—Head of a dab (*Pleuronectes limanda*), nat. size, showing the position of the olfactory organ as seen when the skin is removed.

FIG. 2.—Diagrammatic representation of the right olfactory organ of the dab.

FIG. 3.—Outline of the face of a megrim (*Arnoglossus megastoma*), showing the left olfactory organ as seen when the skin is removed (nat. size).

FIG. 4.—The olfactory plates of the left olfactory organ in a turbot (*Rhombus maximus*). The dotted circles show the position of the nostrils, and the arrows the course of the current.

FIG. 5.—Diagram of a single olfactory plate in the turbot, showing the mode of attachment to the rachis.

FIG. 6.—Diagram of the pupil of the rough dog-fish (*Scyllium canicula*). *a*, by day; *b*, by night.

FIG. 7.—Pupil of skate (*Raia batis*). *a*, by day; *b*, by night.

FIG. 8.—Eye of torpedo. *a*, by day; *b*, by night.

FIG. 9.—Pupil of angel-fish (*Rhina squatina*). *a*, by day; *b*, by night.

FIG. 10.—Pupil of sterlet (*Acipenser*). *a*, by day; *b*, by night.

FIG. 10A.—Pupil of turbot (*Rhombus maximus*). *a*, by day; *b*, by night.

FIG. 11.—Longitudinal section of skin of barbel of rockling (*Motella tricirrata*), preserved with gold chloride to show the nerve-fibres traversing the skin to supply the "taste-buds." Zeiss' obj. D, oc. 2.

FIG. 12.—Horizontal section of skin of barbel of rockling (*Motella tricirrata*), to show the immense numbers of "taste-buds" which it contains. Zeiss' obj. A, oc. 2.

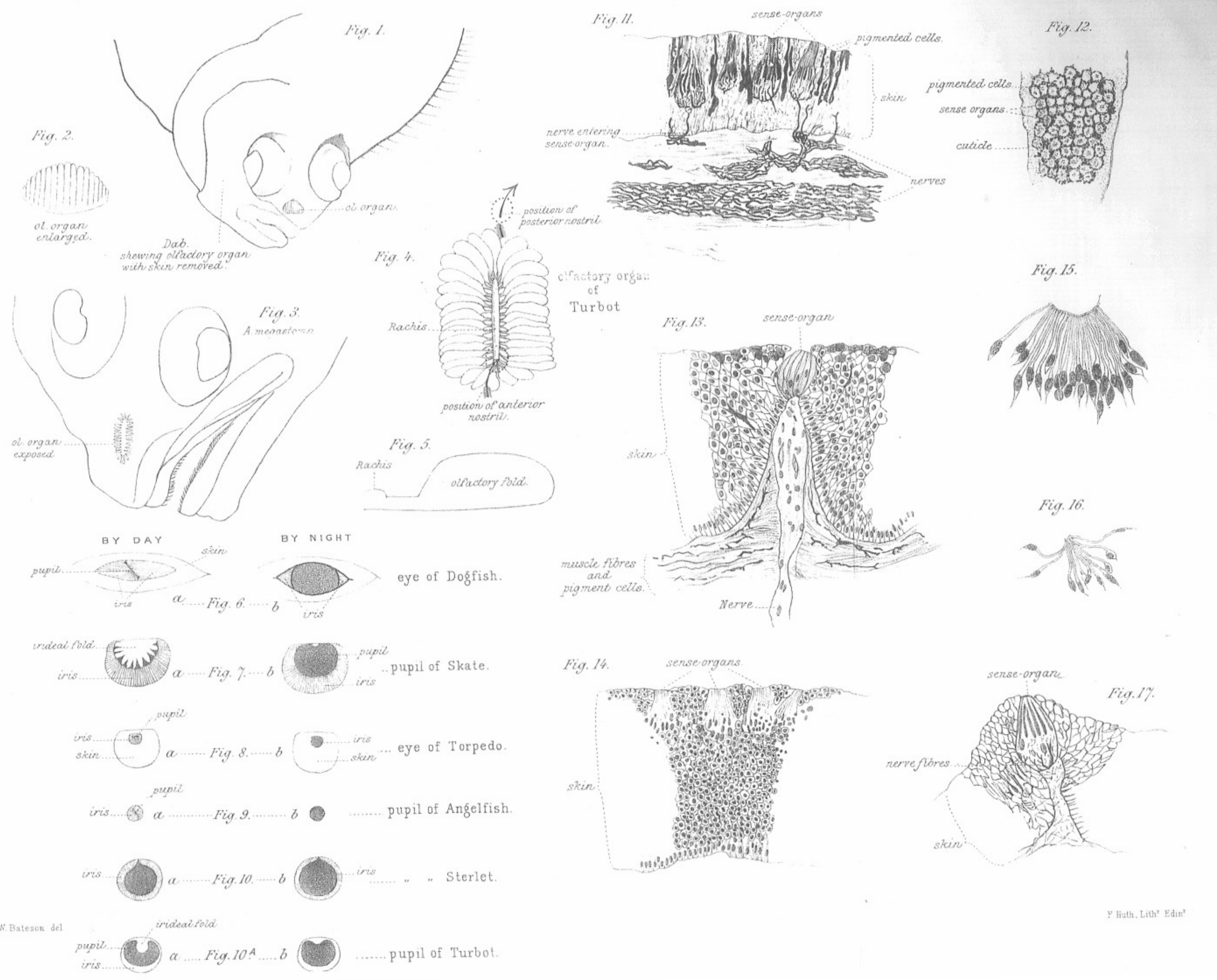
FIG. 13.—Vertical section of skin of lip of conger, showing a "taste-bud," and the nerve running to it in a channel through the skin. Zeiss' obj. D, oc. 2.

FIG. 14.—Vertical section of skin of pharynx of mullet (*Mugil*), showing a row of "taste-buds." Zeiss' obj. D, oc. 2.

FIG. 15.—Cells of one of the "taste-buds" of a mullet (*Mugil*) macerated in Hertwig's fluid. Zeiss' obj. F, oc. 2.

FIG. 16.—Cells of "taste-bud" of pollack (*Gadus pollachius*). Zeiss' obj. D, oc. 2.

FIG. 17.—"Taste-bud" in skin of the tongue of an eel (*Anguilla vulgaris*), preserved with gold chloride to show the nerve-fibres. Zeiss' obj. D, oc. 2.



W. Bateson del.

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Notes on Oyster Culture.

By

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

With Plate XXI.

I. Oyster Farming in Holland.

While on a visit to Holland last December, I took advantage of the opportunity to learn something of the extent and methods of oyster culture there practised. To Mr. C. J. Bottemanne, of Bergen-op-Zoom, the Inspector of Fisheries, and to Prof. A. A. W. Hubrecht, of Utrecht and his published papers, I desire to acknowledge my indebtedness.

Though the invention of the modern system of culture is to be credited to France, it is at present carried to its highest perfection on the Eastern Schelde, in the Dutch province of Zeeland. This, no doubt, is partly attributable to the fact that the geographical conditions are here almost ideally perfect for the purpose. Originally continuous with the Western Schelde, but now for many years cut off from it by the railway embankment (see map on Pl. XXI), the Eastern Schelde forms a quiet, almost land-locked, shallow bay, about twenty miles in length, which at low tide leaves acres of good hard ground exposed on both sides of its bed. There are two other exceptional advantages in this position: the one, that on the ebb tide the main bulk of the water lying in the extremity of the bay is never lost in the sea, so that the floating spat of the oyster, though carried down by the tide, is swept up again into the bay and over the collectors placed to catch it, without ever reaching open water; the other, that on the stone bases of the dykes, within 546 yards (500 metres) of which no one is allowed to dredge for fear that their foundations should be injured and the country be flooded, are at certain points enormous natural colonies of oysters, which provide every year a plentiful supply of spat for the artificial cultivation. The fact, also, that much of the land lies below high-water mark and is surrounded by dykes, makes it easy and cheap to construct store-ponds, &c., on shore, and to admit salt water through sluices. Beside, however, these natural advantages, there are further reasons for the success of the Dutch oyster culture: the patient and careful industry of the people, the public spirit of the Government, and the fact that throughout the enterprise several members of a body of naturalists, the Nederlandsche Dierkundige Vereeniging, have constantly inaugurated fresh experiments and investigated causes of failure.

With all these advantages, it is hardly surprising that the industry has attained enormous proportions in a few years. In 1870, at the commencement of the enterprise, the rental of the (hitherto valueless) low-water flats, 7720 acres in area, leased by the Government to oyster farmers, was £1720; in 1885, when the leases were renewed, the rental amounted to £28,765. In 1888 (a bad year) there were despatched from five stations on the Flushing line *more than 2580 tons* of oysters, besides what was conveyed by water; 954 tons being destined for England by the Flushing route, and many more by way of Rotterdam. As to the amount of hands employed in the industry, it is not easy to give exact figures, since at some times of the year the whole population of the district, men women, and children alike, take a part; but about 480 boats, averaging three hands each, are regularly licensed for the oyster fisheries. A small fact, but one which indicates the importance of the interests concerned, is that it is intended in the course of this year to supply the police-boats, entrusted with the duty of watching the ground and preventing depredations, with electric search-lights for night service.

The statistics given above refer, be it noted, only to the artificial oyster culture; the natural beds (public beds) have, as in England, practically ceased to exist, owing to the rapacity of the dredgermen. Nominally dredging on these beds is permitted by the Dutch Government from March to September inclusive; but they are nearly valueless. It is only by sowing annually large numbers of clean oyster shells for cultch, and by absolutely prohibiting the free taking of oysters for years, that an overdredged bed can be restored to an effective condition. As during these years the bed would have to be policed, and occasionally dredged to clean away weeds and mud, it is probably only by action on the part of the Government that dredged-out banks in England could be again made valuable; action which, in despite of the bulky Reports of Commissioners, England has shown no inclination to take. In Holland, on the other hand, the Government, with a view to restoring the once celebrated but almost ruined Texel beds, some few years ago prohibited free dredging on a part of the beds and leased it out in parcels. A considerable amount is already paid for the lots, oysters have been imported from France and Zeeland, and the beds are already flourishing without any further interference from Government than the supply of police. To achieve this in England by private enterprise, an order of the Board of Trade under Part iii of the Sea Fisheries Act would be necessary, and it is more than doubtful whether it could in such a case be obtained.

It is therefore from the artificial cultivation only, from the oyster farms, that these tons of oysters are produced. The farms vary naturally in size and complexity according to the amount of capital invested in the undertaking, and in the details of management, but they conform to a general type of the following character. Each consists of two sections; the one, an area of ground from 12 to 150 acres in extent in the bed of the Schelde, rented from the Government, covered at half tide and marked off by stakes from other similar properties; the other on dry land comprising the necessary buildings and the ponds (Fr. *claires, parcs*; Dutch, *putten*). The river section of the farm is generally divided into one area on which are set the collectors for the spat, and another (often some distance off and in deeper water), where the "half-ware" or young oysters are placed to grow to a marketable size. The plan of the land-section of a typical farm is drawn in Pl. XXI (slightly altered from one at Bergen-op-Zoom); through the dyke communication is made by a sluice between the Schelde and a canal; from the latter the water passes by smaller sluices into the ponds I—III, which can also be put into direct communication with each other by other sluices. The natural rise and fall of the tide effect the changing of the water. A few buildings for packing and sorting houses, watch-house, carpenter's shop, &c., and a clear space of ground for stacking the tiles and "hospitals" during the winter are the chief other requirements. The method of procedure is thus arranged: the collectors, common roof tiles, coated first with hard, afterwards with soft lime, and thoroughly dried, are set about June in the bed of the Schelde at low water at right angles to the current, and sloped so as to make little eddies into which the swimming spat may be swept; they lie here, except for being occasionally swirled in water to wash off the mud, till September or October, by which time, if the season be good,* numbers of tiny oysters will be found to have adhered to them. The tiles are carefully brought on shore and arranged in the pond marked II (Pl. XXI); they are generally set like the Greek capital Π, two vertical covered by one horizontal, and stand in about three to four

* A good season is conditioned chiefly by wind, state of the water, and most of all by temperature. With rough weather, foul water, and a cold summer, there will be no young oysters; but the statement so often to be met with in the evidence before committees that "there has been no spat here for many years" means, not that the oysters have failed to spat, but that the spat has been killed by unpropitious physical conditions, or has failed to find a suitable foothold. Plenty of spat is thrown off every year.

feet of water. Clean salt water is of course admitted constantly. Here they remain till about February; they are then taken up and the young oysters detached. This is not difficult owing to the layer of soft lime with which the tiles are coated. When detached they are placed in the "hospitals;" these are generally made of tarred wood (fig. 1, Pl. XXI), and are shallow trays about six inches deep standing on legs about six inches off the ground; they rest on the bottom of ponds II and III, singly or in two tiers, according to the depth of water (three to five feet) in the pond; in some cases they are allowed to float. Here the young oysters remain for about two months, increasing in bulk and strength, and recovering from any damage which they may have incurred in detachment from the tiles; at the end of this time they are sowed out on the private banks in the Schelde as "zaai-goed," it being found that, though the percentage of loss is here greater, growth is much more rapid and quality better than if they are kept in enclosed ponds. The grounds on which they are placed are occasionally cleaned by dredging without a net. The oysters are considered marketable in the third and fourth year; they are dredged up* and brought to the sorting houses, and, according to size, are either replaced on the beds to grow larger, or are laid down in the store pond marked I. This latter is generally floored with tarred planks, an expensive material, but found to be better than either the natural ground, which becomes foul, or than brick, which is too "cold." On little piles driven into the bottom of this store pond run plank gangways, so that ready access may be had to any part and the oysters lying there be removed by a pole-dredge when required for the market; the water is kept at about four feet in depth.

In order to collect the maximum amount of available spat, or, in other words, to bring all the spat within reach of the collectors, experiments have for several years been conducted under the auspices of the Nederlandsche Dierkundige Vereeniging on the principle of enclosing breeding oysters with the collectors in ponds. At present the experiments cannot be said to have been entirely successful; spat is thrown off, and a small quantity certainly adheres to the tiles; but the difficulty of oxygenating the water and supplying food artificially in the one case, and, if water be pumped through the pond, of keeping the spat from passing through the filter in the other, have so far proved too great.†

* In some cases steam dredges are used, working six dredges simultaneously.

† Similar experiments carried out in England have in one or two cases been more successful, though not as yet financially so. Prof. Ryder, in the United States, has devised an ingenious apparatus for the purpose, but no account of its working has as yet appeared (Rep. U. S. Fish Comm., 1885, p. 321).

Such is the outline of the method of procedure, evolved by many experiments and many failures, which the Dutch have found to be the best, at least for their own locality. Good as it is, however, there must occasionally come bad years when unfavourable weather ruins the crop; in 1888, for example, the severe winter wrought havoc among the old oysters, the cold summer killed the spat. Hence the enterprise of an oyster farm must be backed with a considerable capital, not only because there can be no appreciable return on the money invested for at least four years, and a bad season may defer it even longer, but also because out of this capital some must be held in reserve in order to replace the brood-oysters in case of disaster (elsewhere of course than in the Schelde, where the brood-oysters are on the dykes). On the other hand, however large the capital, it will be utterly thrown away unless expended with the most rigid economy; and in this fact we probably find the chief reason for the failure of so many oyster culture companies in England. It has often been shown that it is perfectly possible to raise oysters artificially in England, but it must be done at a less cost than the market price of the oyster if a dividend is to be expected. Each oyster raised by the Herne Bay Company was estimated by Mr. Blake (Rep. Sel. Comm. Oyster Fisheries, 1876) to have cost them £100. Most instructive in this connexion is the history of this unfortunate company. It was founded in 1864 with a capital of £100,000 and a right of "several oyster fishery" over nine square miles at Herne Bay, in the estuary of the Thames. Before a single oyster had been laid down no less than £43,700* had been spent; its area was utterly disproportionate to the remaining capital, and it gradually dwindled away for want of vitality.† Against this, however, must be set the fact that in a few places in England oyster farming with collectors, &c., has been carried out for many years, if not with signal commercial success at least without disaster; but the problem of raising oysters cheaply on a great scale has not as yet been solved (except on paper) so far as England is concerned; and this, it may be noted, is not for want of suitable localities.

It is not my purpose to discuss here the means by which this solution may be attained, but I cannot conclude without a reference to one great obstacle to private enterprise in this direction, which has been pointed out again and again by those who have interested themselves in such subjects; namely, the absolute impossibility in the present state of legislation of ascertaining in many cases the ownership of any particular section of foreshore. As soon as a piece

* Preliminary and Parliamentary expenses, £12,600!

† Its melancholy history may be read in the three Reports of the Inspector under the Board of Trade, Mr. Walpole, dated 1875, 1876, and 1882.

of otherwise worthless foreshore is judged to have capabilities for oyster or mussel culture, there crop up municipal charters, private charters, manorial rights, ducal rights, and what not, backed generally by wealth which can crush intruders with long and expensive lawsuits. Sir T. H. Farrer has expressed himself clearly on the matter :—" Where there were any rights below low watermark on the bed of the sea, there it was provided by a clause inserted in the Bill [of 1868] by the House of Lords that those Orders [of the Board of Trade which are described below, p. 264] should give no power whatever; and as there exist a number of rights—some very clear and some very shadowy—over the foreshore and bed of the sea, under all sorts of feudal grants and charters, and prescriptions, it is a question to say whether that restriction may not have had a very injurious effect both in preventing people from applying for Orders and in preventing the grant or due operation of such Orders." (Rep. Sel. Comm. Oyster Fisheries 1876, Farrer 7.) It is true that under Part iii of the Sea Fisheries Act, 1868, a right of several oyster fishery may be granted by the Board of Trade, but this only after filing of petitions, inquiry by a Government Inspector, examination of witnesses—itself a tedious and expensive process* and a check to private enterprise. Nor is this vagueness of title a cause of trouble in oyster fisheries only, but in estuarine fisheries of all kinds. An Act requiring that by a certain date all titles to estuarine and foreshore rights should be satisfactorily proved and registered with the Board of Trade, and vesting foreshores not so claimed in the Crown, would commit no real injustice and would prevent much.

II. Notes on Recent Legislation relative to English Oyster Fisheries.

When desirous lately to ascertain the state of the law relative to oyster culture in England, and the working of that part of the Sea Fisheries Act, 1868, which permits the Board of Trade to grant "rights of several oyster fishery" to applicants under certain cir-

* "A fee of thirty-five pounds has to be paid to the Board of Trade in respect of Fishery Orders under Part iii of the Sea Fisheries Act, 1868, and a deposit of the same amount has also to be made to cover the travelling and personal expenses of the Inspector when making the inquiry;" but this appears to be a small item in the total legal expenses. For this and for other information, most courteously rendered, I am indebted to the Fisheries Department of the Board of Trade. The author of a recent work on this subject (S. A. Moore, A History of the Foreshore. London. 1888. 8vo.) is extremely severe upon the Board of Trade for not adjudicating on these claims when brought under their notice; but examination of title can hardly be said to be among their already varied functions.

cumstances, I found some considerable difficulty in the task, and have therefore put together these few notes in the hope that they may prove serviceable to others interested, by indicating in what direction to search for information. It is to be remembered that they apply only to England and Wales, the fisheries of the two other countries being under the jurisdiction respectively of the Scotch Fishery Board and of the Inspectors of Irish Fisheries.

There is no need to refer in detail to the earlier legislation in the matter; in many places along the coast both private individuals and co-operative bodies of dredgermen enjoy rights of several oyster fishery under charters of greater or less age. The Whitstable Company is at present the best known of such societies; the constitution of another, under the jurisdiction of the City of Rochester, may be read at length in the preamble to an Act of 1728 (2 Geo. II, c. 19) which was framed in its defence. This society, which may be taken as typical, was a close corporation of fishermen and dredgermen, admission to which was gained only by a seven years' apprenticeship to a member; it was governed by an "Admiralty Court," the "jury" of which was elected partly from the dredgermen, partly from the Corporation of Rochester. The jury decided upon the close time, upon the temporary closure of any parts of the beds, and upon the quantity or "stint" which any dredger might take in a day; the bailiffs appointed by them had the right to board suspected boats, and to seize oysters or implements there found in contravention of their rules, and also to impose fines and penalties on those who disobeyed them. Similar Acts are 3 Vict., c. 59 (Faversham), and 22 and 23 Vict., c. 72 (Ipswich); and an Act of 1756 (30 Geo. II, c. 21) permitted the City of London to make general fishery regulations affecting the Thames and Medway. The earlier legislation will be treated in detail in a general work on the Oyster, for which material is at present being collected by Mr. Bourne and myself.

The present period of legislative activity, the result of constant complaints as to the scarcity of oysters, begins with the Herne Bay, &c., Fishery Act, 1864 (27 and 28 Vict., c. 280); this was followed by the Ham Oyster Fishery Act, 1865 (28 and 29 Vict., c. 147), and the Roach River Oyster Fishery Act, 1866 (29 and 30 Vict., c. 145); all these three created "rights of several oyster fishery" in favour of the companies concerned. Facilities for further enterprise in this direction were afforded by **The Oyster and Mussel Fisheries Act, 1866 (29 and 30 Vict., c. 85)**, which arranged for the granting of private rights of oyster and mussel fishery by means of Orders of the Board of Trade; most of its provisions were re-enacted by Part iii of the Sea Fisheries Act, 1868 (*q. v.*), and the Act itself repealed; no further notice of it is therefore at present necessary. **The Oyster Preserva-**

tion Act, 1867 (30 Vict., c. 18), concerned with the better protection of such private fisheries as might be constituted under the last Act, was also embodied in the Act of 1868 and was itself repealed.

The Sea Fisheries Act, 1868 (31 and 32 Vict., c. 45), forms, together with the Act of 1888, the main body of the legislation by which sea fisheries are at present regulated; Part iii of this Act is exclusively concerned with the oyster and mussel fisheries of England, and the following are its most important provisions:—"An Order for the Establishment or Improvement and for the Maintenance and Regulation of an Oyster and Mussel Fishery on the Shore and Bed of the Sea, or of an Estuary or Tidal River above or below or partly above and partly below Low-water Mark" may be made by the Board of Trade on the presentation of a memorial to the Board to that effect, after due notice given to all persons concerned as "Owners or reputed Owners, Lessees or reputed Lessees, or Occupiers (if any) of the portion of the Sea Shore to which the proposed Order relates"; and after an inquiry held by the Board's Inspector on the spot (evidence may be taken on oath) and the consideration of his report. Such an Order is to be confirmed by Act of Parliament before it can take effect (but *cf. infra*, 40 and 41 Vict., c. 42); and if a petition against it should be presented in the course of its passage through Parliament, it is to be referred to a Select Committee and there opposed as a private Bill. All the expenses of the Order are to be borne by the promoters. The Order grants, for a period not exceeding sixty years (*cf.* 48 and 49 Vict., c. 79) *either a Right of several Oyster and Mussel Fishery*, i. e. "the exclusive right of depositing, propagating, dredging, and fishing for, and taking Oysters and Mussels," and permission to the grantees to "make and maintain Oyster and Mussel Beds, or either of them, and at any Season collect Oysters and Mussels, and remove the same from Place to Place, and deposit the same as and where they think fit" within the limits of the Fishery; or *a Right of regulating an Oyster and Mussel Fishery* with power to carry out restrictions on the fishery and to exact tolls from persons fishing. The grounds over which the grant extends must be duly buoyed or marked out. The Order is determinable at any period by a Certificate of the Board to the effect that they are not satisfied that the ground is being properly cultivated, or that the regulations are not being properly enforced, and an inquiry may be held by the Board's Inspector to ascertain how far this is the case. A special clause states that no Order "shall take away or abridge any Right of several Fishery, or any Right on, to, or over any portion of the Sea Shore, which right is enjoyed by any person under any Local or Special Act of Parliament, or any Royal Charter, Letters Patent, Prescription, or immemorial Usage, without the consent of such Person" (*cf. supra*, p. 262, and note). A Report by the Board of Trade respecting their proceedings under this part of the Act is laid annually before both Houses of Parliament.* There follow then clauses concerned with the protection of oyster beds, whether held under this Act or independently of it, vesting ownership of the oysters absolutely in the grantees or owners of the beds "for all purposes, civil, criminal, or other," and providing penalties for such offences as dredging for ballast or depositing rubbish on the beds, supposing their limits to have been sufficiently well marked out. The first schedule to the Act contains the **Convention of 1867** between France and England relative to fisheries in the seas between the two countries; for various reasons this Convention has never come into operation, but Article xi, prohibiting the fishing for oysters between June 16th and August 31st outside the three-mile limit between lines running from the North Foreland to Dunkirk, and from Land's End to Ushant, has been brought into effect by agreement between the Governments (Rep. Sel. Comm. Oyster Fisheries, 1876, ans. 5, Mr. T. H. Farrer).

Two Acts, 32 and 33 Vict., c. 31, and 38 Vict., c. 15, deal respectively with the Langston Fishery Order and with the Herne Bay Company, and are not of general interest.

An attempt was made in 1876 (39 Vict., Bill 65) to prevent the sale of any oysters from May to August inclusive, but the Bill fell through, and a less rigorous clause was substituted for it in **The Fisheries (Oyster, Crab, and Lobster) Act, 1877 (40 and 41 Vict., c. 42).**† This prohibited the sale or purchase of "deep-sea" oysters from June 15th to August 4th, and of other oysters from May 14th to August 4th, unless (1) taken in the waters of a foreign state; (2) cured in some way; (3) "intended for the purpose of oyster cultivation within the same district in which the oysters were taken, or were taken from any place for cultivation with the sanction of the Board of Trade." Power was also given by this Act to the Board of Trade to restrict or prohibit during a period not longer than one year the taking of oysters from any particular bank or bed on the application of fishermen of the district, or of certain bodies specified. It was further enacted that an unopposed Order of the Board of Trade, under Part iii of the Sea Fisheries Act, 1868, might be confirmed by an Order in Council instead of an Act of Parliament. A Bill to repeal the restrictions laid by the last Act on the sale of "deep-sea" oysters (50 Vict., Bill 151) was dropped.

* References to these Reports are appended below.

† This Act was the outcome of the interesting and valuable Report from the Select Committee on Oyster Fisheries, 1876.

The **Sea Fisheries Regulation Act, 1888 (51 and 52 Vict., c. 54)**, will, it is hoped, prove of great advantage to the fisheries of all kinds. It enacts that the Board of Trade may, on the application of a county or borough council (or, if they refuse to apply, on the direct application of twenty rate-payers), create a "sea fisheries district" and provide for the constitution of a "local fisheries committee" for the regulation of the sea fisheries carried on within the district. Due notice of the proposal is to be given beforehand, and an inquiry, if necessary, to be held on the spot. The "local fisheries committee" is to be a committee of the county council, or the borough council, or a joint committee of both, "with the addition in each case of such members representing the fishing interests of the district . . . as may be directed by the Order creating the district." The committee is empowered to make bye-laws regulating the methods and instruments used for fishing, for creating a district of oyster cultivation such as is contemplated by the heading (3) quoted above (p. 265) from the Act 40 and 41 Vict., c. 42, and for "prohibiting or regulating the deposit or discharge of any solid or liquid substance detrimental to sea fish or sea fishing" but not "affecting any power of a sanitary or other local authority to discharge sewage in pursuance of any power given by a general or local Act of Parliament, or by a Provisional Order confirmed by Parliament." The bye-laws are to be approved by the Board of Trade. The committees may also impose penalties for breach of their bye-laws, and appoint fishery officers with power to stop and search suspected vessels or vehicles within the limits of the district. A meeting for consultation with the Board of Trade, to which each committee may send at least one member, is to be held annually. Special regulations define the relations of the committee to boards of salmon conservators and harbour authorities; and they may not pass bye-laws prejudicially affecting any rights of several fishery, any bye-laws of salmon conservators, or any powers of sanitary authorities mentioned above.

The Reports by the Board of Trade of their proceedings under Part iii of the Sea Fisheries Act, 1868, will be found in the following places, among the Sessional Papers:

Session.	Volume.	MS. page.	Session.	Volume.	MS. page.
1868–9	L	569	1879	LXV	627
1870	LVI	707	1880	LXVII	875
1871	LVI	783	1881	LXXXIII	547
1872	LIII	899	1882	LXIV	685
1873	LXI	475	1883	LXIV	759
1874	LXII	613	1884–5	LXXI	977
1875	LXXI	707	1886	LX	689
1876	LXVIII	589	1887	LXXV	743
1877	LXXVI	501			
1878	LXVIII	623			

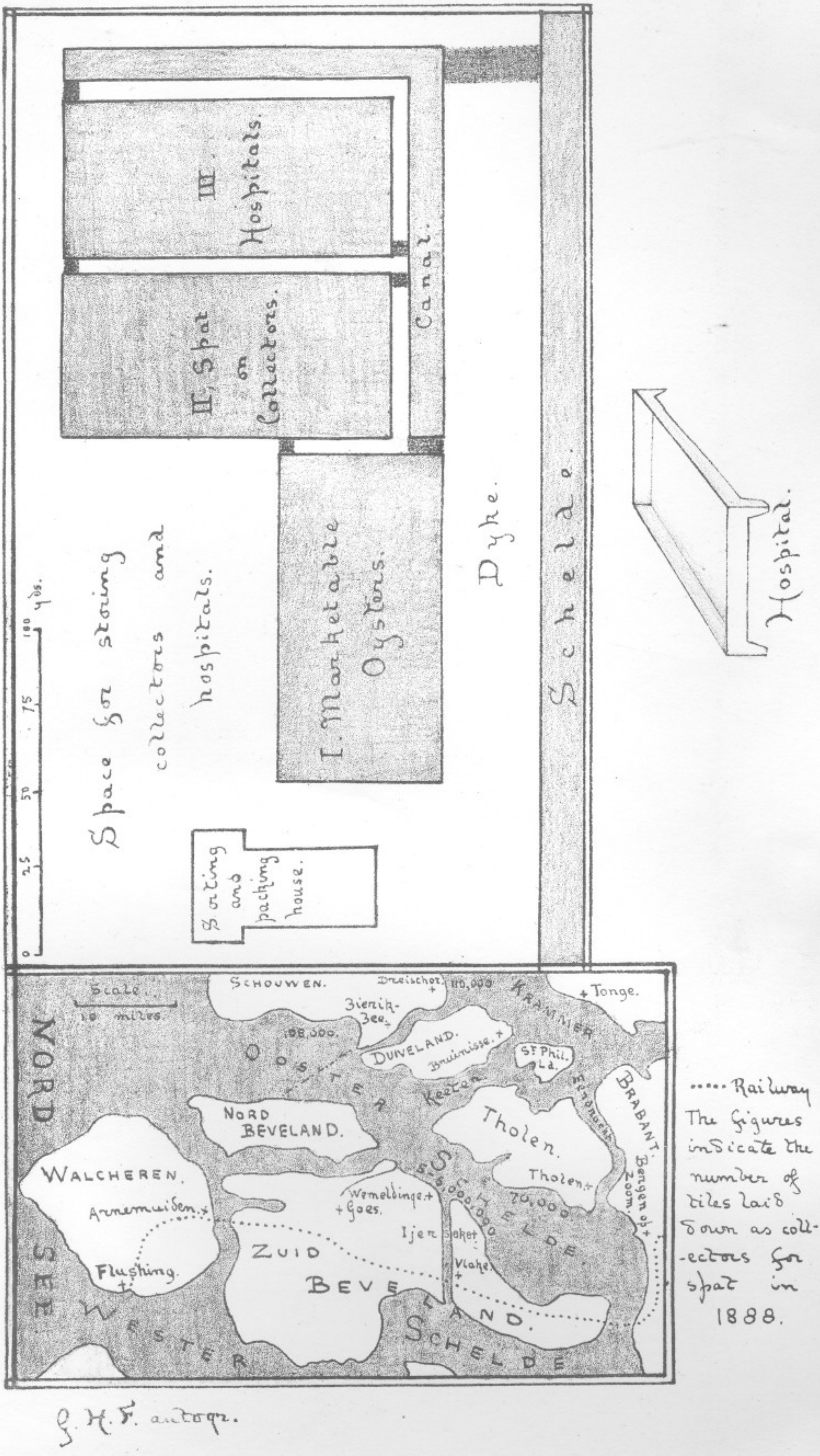
1888 and 1889 were not bound and paged when the above paper was sent to press.

Further information relative to these grants will be found in the Reports to the Board of Trade by their Inspectors

Session.	Volume.	MS. page.	Session.	Volume.	MS. page.
1870	... LVI	... 703	1878	... LXVIII	.. 625
1877	... XXIV	... 465	1882	... LXIV	... 369

Also in the appendices to the Report of the Select Commission of 1876, and in Returns made to the House of Commons in 1872 (vol. liii, p. 891), 1880 (vol. lxvii, p. 877), 1882 (vol. lxiv, p. 179), and 1887 (vol. lxxv, p. 853). Twenty-six Orders in all have been made on behalf of oyster fisheries, of which nine have been revoked; of the existing seventeen, seven are Regulating Orders made to the corporations of six towns, the remainder grant rights of several oyster fishery to individuals and companies on various parts of the coast. The Reports of the Commission on Sea Fisheries of 1863 (pp. 82—105), and of the Select Committee on Oyster Fisheries of 1876, are the two which deal with England. The latter is full of valuable information on the subject.

Note.—The dotted line on the map (Pl. XXI) running across the Ooster Schelde, from Schouwen to Nord Beveland, marks approximately the limit reached by the water of the upper part of the Schelde on the ebb tide (*cf.* p. 257).



III. Hospitals.
II. Spat on Collectors.
Canal.
I. Marketable Oysters.
Space for storing collectors and hospitals.
Sorting and packing house.
Dyke.
Schelde.
Hospital.
0 25 50 75 100 yds.
Scale 10 miles
NORD SEE
WALCHEREN.
Arnemuiden.
Flushing.
WESTER SCHELDE
ZUID BEVELAND.
NORD BEVELAND.
Wemeldinge
Goes.
Ijer Saket
Vlake
OOSTER SCHELDE
Keeten
5-6,000,000
70,000
Tholen.
Tholen
BRABANT.
Bergen op Zoom.
St. Phil. Ld.
DUIVELAND.
Bruinisse.
Zierik-Zee.
108,000.
SCHOUWEN.
Dreischor.
110,000
KRAMMER
Tonge.
..... Railway
The figures indicate the number of tiles laid down as collectors for spat in 1888.
G. H. F. autogr.

The Generative Organs of the Oyster.

Abstract of a paper by Dr. P. P. C. Hoek.*

By
Gilbert C. Bourne, M.A., F.L.S.,

With Plates XXII and XXIII.

The following description of the reproductive organs of the oyster cannot well be understood without some acquaintance with the general anatomy of the animal. With the help of Pl. XXII, fig. 1, the most important features of its anatomy may readily be understood. It must be remembered that the valves of the oyster's shell lie right and left of the animal; that the concave valve which lies undermost in the natural position of the animal is the left valve, and the flat upper valve is the right valve. The hinge marks the dorsal border of the animal, and the opposite border is the ventral border. That side which is on the observer's right in fig. 1 is the anterior surface, and that on the left hand is the posterior surface. As the animal is compressed from side to side the anterior and posterior surfaces are very narrow. The great adductor muscle, by which the valves of the shell are closed, is seen lying in the centre of the animal in fig. 1.

If the right mantle lobe is cut through along the anterior and ventral border of the adductor muscle, as in the figure, a finger-shaped process, called by Dr. Hoek the *oral process*, is seen to project from the trunk of the oyster, and to lie closely applied to the ventral border of the muscle. This oral process contains a loop of the intestine and, in addition, a portion of the reproductive organs and of the excretory organ. A large nerve-ganglion, the branchial ganglion, lies between the adductor muscle and the oral process. From this ganglion a number of nerves are given off, the most con-

* Tijdschrift der Nederlandsche Dierkundige Vereeniging, Supplement Deel i, Aflevering i, p. 115. Leiden, 1883. See also Dr. Hoek's prize essay in the Literature of the International Fisheries Exhibition. London: Wm. Clowes and Son.

siderable of which passes forward for a short distance, curves over the oral process, and supplies the posterior part of the gills. It is shown in fig. 1. If this nerve is carefully examined in its course over the oral process, a slit may be distinguished, lying close and parallel to it, on the oral process. This slit—which may be seen on both the right and left sides of the oral process—is the *urogenital aperture.*

Fig. 2 is a diagram to exhibit the relations of the organs which open on each side of the body by the urogenital apertures. The so-called kidney or organ of Bojanus, first discovered and described by Dr. Hoek, is represented in shading. Its structure need not detain us; it is sufficient to say that it is a paired organ, and that it communicates on either side of the body with the pericardial cavity by a canal, marked *Rp.C.* in fig. 2. The generative organs are represented by thick black lines, but are shown smaller than they actually are to avoid encumbrance of the figure.

Like the organ of Bojanus, the reproductive organ is paired, but its branches interlace and anastomose to such an extent that the two members of the pair become confounded with one another, and the paired apertures are the only evidence of the double character of the organs.

Two portions may be distinguished on either side, the reproductive organs properly so called, and the genital duct. There are no accessory organs, such as yolk-glands.

The generative organs may most conveniently be studied in a year-old oyster. The genital duct opens into the anterior part of the slit-like urogenital aperture. At a short distance—half a millemetre, for example—from its opening the duct begins to give off a number of *culs-de-sac,* which are placed perpendicularly to the direction of the duct, and are nothing more than outgrowths of its wall which project into the surrounding connective tissue. The epithelium of the wall of the canal is continued along the walls of the outgrowths, but the cells are not provided with vibratile cilia and are not distinctly marked off from one another. It appears that at a subsequent period they multiply and become metamorphosed into generative products, ova or spermatozoa. If the genital duct is followed further forward to the pericardial cavity, a number of similar canals are seen to originate as outgrowths of the genital duct. These lateral canals penetrate into the connective tissue of the oral process or spread out parallel to the surface of the oyster. In the former case the genital products are developed on both sides of the canals, in the latter case only on that side opposite to the surface of the body. In the latter case the wall of the canal which runs parallel with, and at a little distance from the surface of the body, is composed of an epithelium provided with vibratile cilia quite similar to that of the genital duct, of which it must be considered as a continuation.

In front of the pericardial cavity it becomes difficult to follow the genital duct. It divides into several branches, which spread on the surface of the body, and, like the outgrowths of the first part of the duct, run for a short distance parallel with the surface of the body. All these canals are oval in section, and their outer and inner walls differ in minute structure; the outer wall is lined with a ciliated epithelium, whilst the epithelial cells of the opposite wall are evidently already in the process of transformation into generative products.

The canals themselves are placed at considerable distances from one another. Their interior walls often show the commencement of a number of *culs-de-sac*, which enter the surrounding connective tissue. The *culs-de-sac* seem always to be longest near the genital aperture, and decrease in size and development the further they are from it.

In a ripe oyster several changes have taken place. The growth of the whole body is accompanied by a growth of the lateral branches of the genital duct, both in length and in size. The number of the branches is much increased, and they anastomose to form a network of branches and branchlets on the two sides of the body of the oyster, which is not the case, as far as can be as ascertained, in a yearling oyster. Extending still further, the branches of the two sides of the body unite and anastomose. At this stage the generative organs nearly surround the trunk in front of the adductor muscle. They lie near the surface, but are separated from it by a thin layer of connective tissue, and are continued by the anastomoses of the network of either side, over the anterior and posterior surfaces, but are more conspicuously developed on the posterior than on the anterior surface.

The productiveness of the generative organs is dependent on the increase of their surface. This is attained not only by the multiplication of their branches, but also by the growth of the walls of each branch. That part of the wall of each canal which is opposite to the surface of the oyster increases greatly, and penetrates into the connective tissue. These outgrowths, at first small, grow longer afterwards, but remain comparatively small as long as the genital products are not ripe. Their extent continues to increase, both because they become individually larger and because the number of branches is considerably augmented, until in the breeding season the maximum development is found in oysters of four and five years old, in which the follicles and their ramifications form a layer several millimetres in thickness, in which very little connective tissue can be distinguished.

The genital ducts are lined by a cubical ciliated epithelium, which is continued into the main branches given off from them, and it may be asserted that the cell-walls of all the ultimate ramifications of the organ are derived from an epithelium continuous with and derived from that lining the ducts.

The genital products are developed from the wall of the follicles, probably at the expense of the epithelial cells which line them. Both ova and spermatozoa are developed in the same follicle.

In the youngest stage observed the ovum of the oyster is a little cell, 20—24 μ in diameter, flattened on the side of the canal-wall, and rounded on its free surface. The protoplasm of the cell-body is feebly granular, the nucleus is large, spherical, and has a highly refringent single nucleolus of a moderate size. The youngest ovules pass by in sensible gradations into the more advanced, and these again into the mature ova. The granulations of the protoplasm become more and more numerous and more distinct, and little refractive granules accumulate in great numbers. The ripe ovarian ovum acquires, as soon as circumstances are favorable, a spherical form, and is rather more than 0·1 mm. in diameter. The manner in which the ova separate from the follicles has not been observed. After their separation there remains a lining of epithelial cells in the follicle, from which new generative products are formed.

It appears to be invariably the case, as will be shown afterwards, that the formation of ova is always followed by the formation of spermatozoa, but the process of spermatogenesis is much more complicated than that of oogenesis. The most favorable preparations for the study of spermatogenesis are procured from follicles which have been previously filled with ova. To procure this one must search in the manner common among ostreiculturists for an oyster with spat in its gills; when found it must not be opened at once, but must be marked and placed in an aquarium in a current of water. If it is examined a fortnight later the different follicles of the reproductive organ are found to be actively engaged in spermatogenesis. A follicle in this condition is found in Pl. XXIII, fig. 3. In the centre is a loose mass of ripe spermatozoa, and the tissue composing the walls is seen to be in the process of transformation into spermatozoa. The minute mother-cells of the spermatozoa have a diameter of scarcely 8 μ, they stain deeply with alum carmine, and have dark granular contents and a small nucleus. The spermatozoa are developed from them as follows. In each cell after the division of the nucleus the cell-body divides in two portions. Of these one is destined to give rise to numerous spermatozoa, the other seems to serve only as a provisional connection between the developing spermatozoa and the wall of the follicle. The former cell grows rapidly, and the nucleus subdivides rapidly and repeatedly until a large cell is formed 25—30 μ in diameter, containing 40—50 nuclei. Each nucleus is about 4 μ in length. At this stage the whole structure looks somewhat like a club (Pl. XXIII, fig. 4), of which the swollen part is formed by the large multinucleated cell just described, and the handle is formed by the other derivative of the primitive cell. At this stage the multinuclear cell becomes separated from its peduncle. Its nuclei continue to subdivide and become darker and more opaque. Finally the mother-cell becomes entirely developed into spermatozoa derived from the sub-divided nucleus, but one cannot explain precisely the steps by which the smallest nuclei are transformed into spermatozoa.

The Physiology of Generation in the Oyster.

Numerous researches have been made with the view of determining whether the oyster is a functional hermaphrodite, having the power of occasionally or generally fertilising its own ova, or whether it is physiologically unisexual whilst anatomically hermaphrodite. Davaine, de Lacaze Duthiers, and P. J. Van Beneden pronounced in favour of the former view, that the oyster is, potentially at least, a functional hermaphrodite, but subsequent investigators have inclined more and more towards the latter view. Dr. Hoek's researches lead him to the conclusion that, so far from being a functional hermaphrodite, the oyster is a unisexual animal at the moment when it performs the act of generation. He continues:

"It goes without saying, and should not be forgotten, that it is much more difficult to arrive at a certain result in this part of my researches than in the anatomical part. In the latter direct observation is possible, but in the former it is only possible within certain limits. One is obliged, indeed, to make observations from the very first, but one has afterwards to draw conclusions from them, and then everything depends on the greater or less importance which one attributes to each fact observed. A multitude of observations may give more solid grounds for one's conclusion, but cannot exclude the possibility of a fault in reasoning.

"The number of oysters examined was not very large. I call 'examined' those only which gave me satisfactory preparations and in which I could judge with mathematical certainty the condition of the generative organ at the moment of opening. Adult oysters (three years old or more) opened during the breeding season do not always present the same appearance. Omitting all reference to diseased organs, the condition observed may always be classed under one of the five heads following.

"1. Abundance of ripe spermatozoa and scarcely any ovules. Early stages in spermatogenesis rare. Everything seems to concur in the production of as many spermatozoa as possible. The oyster fat.

"2. Spermatozoa ripe and in course of development. Ovules pretty numerous on the walls of the follicles, but not a single ovum ripe and in a condition to be fertilized. Oyster pretty fat.

"3. Spermatozoa in the course of development everywhere, and here and there a little mass of ripe spermatozoa. A single ovule still remaining on the wall of the follicles. Oyster thin.

"4. Abundance of ripe or nearly ripe ova (in condition to be fertilized) both on the walls of the follicles and free in their cavities. Among the ovules on the walls of the follicles some very small cells whose nature could not easily be distinguished. No spermatozoa. Oyster very fat.

"5. Abundance of ripe or nearly ripe ova. Ripe spermatozoa in the efferent ducts and in the primary lateral ducts leading into it. No younger stages of spermatozoa. Cellular elements among the ova on the walls of the follicles as in the previous case. Oyster very fat."

It should be added that the oysters in the second category show differences both in the number and condition of development of the ovules, but Dr. Hoek never saw ova in a condition for fertilization alongside of ripe spermatozoa, unless indeed Case No. 5 is a question. As for No. 3, it must be added that the preparations of these oysters corresponded exactly with those made from oysters which were known with certainty to have had brood in their gills from one to four weeks before being opened.

Two facts may here be noticed which are of the greatest importance for the physiology of the organs of generation of the oyster. These are:

1. That the ova of the oyster at the moment of their escape from the genital aperture are already fertilized, and that they have already passed through the earlier stages of segmentation.

2. That on several occasions spermatozoa have been found surrounding the edges of the urogenital aperture as well as in the terminal portion of the genital duct, in the ureter, and even in the renal chamber.

When it is considered that autogamy, or the faculty of self-fertilization, is extremely rare in the animal kingdom, and that the nearest allies of the common oyster (*Ostrea virginica* according to Brooks and Ryder, *Ostrea angulata* according to Bouchon Brandely) are unisexual, one can hardly escape the conclusion, in face of the facts above mentioned, that the oyster is at the moment of propagation a functionally unisexual animal. One could not otherwise explain the different conditions in which the generative organs are found during the breeding season. M. de Lacaze Duthiers, it is true, has found a few ova in oysters filled with semen, and a few spermatozoa in oysters filled with ova, but in the former case the spermatozoa could hardly be destined to fertilize such a very small number of ova, which are besides unripe; and in the latter case the number of spermatozoa found by him are altogether insufficient for the fertilization of the ripe ova contained in the animal. Further, it must be remembered that not only is it impossible that two oysters should copulate, but that it is equally impossible that the generative products of the two sexes should be brought together when floating freely in the sea; for how if this were the case could the development of the brood in the gills of the mother be explained? Nobody has attempted to deny that the brood contained in the gills of an oyster is derived from that oyster. It is impossible to believe that it could collect in its gills a number of ova from the surrounding water, when those ova, being denser than the water, do not float. At the moment of their exclusion the ova are fertilized, and as soon as "white spat" is observed in the gills of an oyster, its generative organs are found on examination to be empty and exhausted. Clearly the white spat in the gills has been produced by the same individual in which it is found. The spermatozoa by which those ova are fertilized might be produced by the mother oyster itself, or might be derived from another oyster. The former supposition is sufficiently refuted by the fact that the reproductive organs of a ripe oyster are either entirely filled with ova, or nearly entirely filled with spermatozoa. The fertilizing spermatozoa must therefore be derived from other oysters.

The only possible conclusion is that during the breeding season a number of oysters produce and emit such a large quantity of spermatozoa that the water passing over an oyster-bed is charged with them, and that a sufficient quantity are able to penetrate into the mantle cavities, and thence into the bodies of the ripe females, and thus fertilize their ova. The number of spermatozoa which are lost must of necessity be much greater than those which are utilised. In the only case in which the two genital products are found side by side and perfectly ripe in the reproductive organs the spermatozoa are all free, none are united into masses, and they are only found in the main genital duct and its principal branches, which is evidently in favour of the view that they have found their way there from without.

Another question remains, Do the reproductive organs of the oyster produce ova and spermatozoa in regular alternation? Robin, on theoretical grounds, and other authors as the result of observation, have asserted that oysters are androgynous hermaphrodites—that is to say, hermaphrodites which function first as fertilizing males, and afterwards as females requiring fertilization. Möbius (Auster und Austernwirthschaft, p. 20) simply states that ova and spermatozoa are not developed at one and the same time in the reproductive organs of the oyster, but successively; that spermatozoa may be formed soon after the ova are laid, and that probably, in the same season, half the oysters in any locality produce ova only, and the other half spermatozoa only. Dr. Hoek agrees entirely with the last-named author. An oyster which contains ripe spermatozoa in the breeding season almost always shows younger stages of spermatozoa in its reproductive organs, whilst, on the contrary, an oyster temporarily acting as a female, and full of ripe or nearly ripe ova, has all its ova in nearly the same condition; it follows, therefore, that it is able to produce spermatozoa for a long period, but that all the ova are laid at nearly the same time. This last point can also be demonstrated by the examination of an oyster which has very young spat in its branchiæ; in this case the reproductive organs are void of ova. In the case of oysters which come under the second category on p. 273, one may well suppose that they have acted and will act as males, but as females only in the following year; nevertheless there is no proof that this must necessarily be the case. But a very simple experiment, which has been several times mentioned, shows that oysters which have acted as females begin immediately to produce spermatozoa, and the latter may very probably serve in the same year for the fertilization of ova produced by other oysters.

Age at which Oysters become Sexually Mature.—Gerbe has examined a great number of young oysters (425, a year old). Of these 35 had spat in their branchiæ, 127 had their ovaries full of ova, and 189 had spermatozoa. It is doubtful, however, whether the oysters on the cultivated grounds of the East Schelde reproduce themselves when only one year old. Of a number of well-developed oysters which were opened at the end of the first year some appeared as though they would function as males in the following summer, others undoubtedly gave the appearance of being about to develop mature ova in the following year. It is impossible to decide whether these latter oysters must necessarily produce ripe spermatozoa first.

However, it is not at all impossible that the oysters of the East Schelde may be inferior in this respect to their relatives in a state of nature. If manipulation exercises an unfavorable influence on the number of breeding oysters, it is not at all unlikely that it should also exercise an unfavorable influence on the age at which the animal begins to breed, so that a considerable number of natural oysters a year old might produce ripe ova and spermatozoa, whilst this might never be the case, or at least might be very exceptional, in cultivated oysters. The question can only be settled by further observation. Particularly it is necessary to compare cultivated and natural oysters. It is probable that it will be found that cultivated oysters differ greatly among themselves, since the brood, fixed in the summer, and usually detached in the spring months, is not always treated in the same manner. If the collectors with the young brood are placed in the sea for the winter, and if afterwards the young are left on the collectors, the oysters are flat and too much crowded; they have a low market value, but in the development of their generative organs they approach much nearer to natural oysters than do cultivated oysters.

The more a cultivator deviates from the course followed by nature the greater the danger of weakening the reproductive capacity of the oyster. It is certainly a considerable deviation to place the collectors in ponds during the winter. To detach the oysters from the collectors is another deviation; a third is the crowding of hundreds of oysters in small reservoirs; a fourth to keep young oysters for a whole year in parcs, &c. Although many of these deviations do not appear to be dangerous to the life of the nurselings, and are even necessary to the advantageous application of culture, one must not lose sight of the fact that they must necessarily exercise an unfavorable influence on the reproductive faculty.

It may be added that among cultivated oysters those of the fourth and fifth year are the most prolific. Oysters six years old still have well-developed reproductive organs, but in oysters of nine or ten years they are always poorly developed, and rarely contain generative products. The liver too, in these last is greatly enlarged, so that the layer of connective tissue between it and the body-wall which contains the follicles of the reproductive organs, is of very slight thickness. Ordinarily the follicles of these aged oysters contain no ova, but a few spermatozoa. The conclusions arrived at by Dr. Hoek in the course of his work are as follows:

A. *Anatomical.**

1. The reproductive organ of the oyster consists of a genital gland and efferent ducts. There are no accessory organs.

* Several of the anatomical conclusions arrived at by Dr. Hoek are omitted, as being beyond the purpose of the present abstract.

2. The genital gland is not a compact organ situated in a definite position. It is spread out superficially so as to cover nearly the whole of the trunk properly so called. At a short distance from the surface of the body, separated from the integument by a thin sheet of connective tissue, the genital gland spreads out as a system of canals which unite secondarily with one another, and their internal walls give rise to follicles placed vertically to the surface of the body and buried in the connective tissue.

3. The generative products are developed from the walls of the follicles. Spermatozoa and ova are developed alongside of one another in the same follicle. The two generative products are developed in all probability from the epithelial cells, which must be considered as the derivatives of the epithelial cells lining the walls of the genital ducts.

4. It is probable that a single epithelial cell is metamorphosed into a single ovum, whilst only a portion of a single epithelial cell becomes the mother-cell of spermatozoa. All the spermatozoa derived from a single mother-cell are united into a bunch of characteristic shape.

5. The ducts of the genital gland communicate directly or indirectly on the two sides of the body with a principal efferent duct, which opens to the exterior at the anterior end of an open groove, running along the muscle of the valves at a short distance from the great posterior branchial nerves.

B. *Physiological.*

1. An oyster with spat in its branchiæ is the mother of that spat.

2. At the moment of extrusion the ova are not only fertilized, but have already passed through the earlier stages of segmentation.

3. The spermatozoa necessary to fertilization do not come from the mother oyster itself.

4. The water which passes over the oysters brings the spermatozoa which have been emitted by other oysters. Some of this enters the mantle cavity, penetrates to the genital aperture, traverses it, and spreads not only into the principal duct of the genital aperture, but also into its larger branches.

5. The oysters of the East Schelde may have spat in their gills when two years old. Ordinarily oysters in spat are older. Oysters of four or five years produce the most spat.

6. Similarly two-year oysters may produce spermatozoa, but the larger part is derived from older oysters. Neither earlier researches nor my own have established with certainty that year-old oysters from the East Schelde emit spermatozoa.

7. The number of oysters producing spermatozoa is, in the East Schelde, greater than those producing ova.

8. The ova of a ripe oyster are laid all at once, excepting a few which are ill developed. The production of spermatozoa probably for a longer period.

9. In every oyster examined the production and emission of ova was followed by a period in which only spermatozoa were formed.

10. A large portion of the brood which attaches itself every year on the banks of the East Schelde is not, in all probability, derived from the oysters in the establishments.

11. It would appear that cultivation exercises an unfavorable influence on the fertility of oysters.

12. In aged oysters the liver is much more developed than in young. This development is correlated with the retrograde condition of the reproductive organs.

A Comparative Examination of Cultivated and Natural Oysters, made to determine the Number which annually take Part in Reproduction.*

After the publication of his first paper, Dr. Hoek received from Baron Groeninx van Zoelen and Baron G. H. Clifford, oyster culturists of the East Schelde, an offer of a sufficient number of oysters for the continuation and completion of his researches. This offer he willingly accepted, and received towards the end of June, 1883, 200 oysters from an establishment where only cultivated oysters had been laid down, and 200 others from a locality where no cultivated oysters had ever been laid down. The age of every oyster was noted, and also whether it had been growing on a tile, a shell, or a stone. Each individual was numbered, and a piece was taken and preserved in alcohol for further investigation. A thin section was eventually made from each piece, which was stained and treated for microscopical examination.

The oysters examined were opened between June 16th and 28th, and as the pieces removed were immediately placed in spirit, subsequent examination of them gave an exact idea of the condition of the sexual organs on the day on which they were opened. In several cases the examination of these pieces was not wholly satisfactory. Some of the oysters had spat in their beards; these might have been pronounced as functional females for the current year without any further examination: some others contained a great number of ripe

* Dr. P. P. C. Hoek, Tijdschrift der Nederlandsche Dierkundige Vereeniging, Supplement Deel i, Aflevering ii, 1883–4, p. 483.

or nearly ripe ova; these they would have emitted in a few days. Others, again, contained spermatozoa either ripe or nearly ripe—one could see that they would participate in the season's breeding. On the contrary, the oysters which contained young cells producing ova and sperm mother-cells were in a condition in which it was very difficult to determine whether they would participate in the season's breeding, and what would be their function.

According as the male or female elements appeared to predominate they were classed as likely to become males or females. A certain number, though not many oysters remained in which the sexual organs were very feebly developed. It is impossible to say whether these oysters had already bred, or whether they were weak or diseased.

The results of the examination of 190 oysters from each locality are given in the following table:

Condition of reproductive organs.	Cultivated oysters.	Natural oysters.
A. Oysters with white spat	11	19
B. ,, with black spat	17	12
C. ,, with ripe or nearly ripe ova . . .	21	42
D. ,, with ripe or nearly ripe spermatozoa .	75	94
E. ,, which seemed likely to become females .	11	7
F. ,, which seemed likely to become males . .	17	6
G. ,, with ill- or non-developed reproductive organs .	38	10
Total number of oysters examined .	190	190

Of 190 cultivated oysters, there were at least 49 functional females, and of the same number of natural oysters, 73, or 12½ per cent. more, were functional females. But the more numerous examples of cultivated oysters classed under E should probably be classed as females, and thus the difference is made less; and since many of those classed under G had doubtless acted as females, the difference, which looks large at first, loses its importance. The same is the case with the males. The advantage remains with the natural oysters, but the advantage is so small that any conclusions founded on these data would be valueless.

One circumstance shown in the table is remarkable. The cultivated oysters are in advance of the natural oysters in their development at a certain season of the year. Ordinarily the consignments received comprised an equal number of the two kinds, so that they might be considered as having been opened at the same date. If we allow that, of those classed under G, one half had been functional females, we should have to class the oysters which had already acted or were yet to act as females under the following categories :

Oysters with ripe or nearly ripe ova :	cultivated	21,	natural	42.
,, ,, white spat	,,	11,	,,	19.
Oysters with black spat	,,	17,	,,	12.
,, which had produced young .	,,	19,	,,	5.

The table shows sufficiently well that, in this particular instance, the cultivated are in advance of the natural oysters. This observation is confirmed by the assertion of oyster breeders, viz. that natural oysters spat after those under cultivation. In the establishments where the mass of spat to be collected is believed to be derived from natural oysters, the tiles are set out some time after they are set out in the cultivated beds.

As to the age necessary for reproduction, these researches give no certain information, since all the oysters received were nearly of the same age. The majority were three or four years old, some few two or five years. Even if the ages had varied more, the number of specimens examined would have been too small to give decisive results on this point.

To arrive at a definite conclusion it would be necessary to begin investigations in March, and to continue them till October. Each month, at nearly the same date, at least 100 specimens both of cultivated and natural oysters should be opened. The oysters should be two, three, and four years old. A section of each individual which would leave no doubt as to the actual condition of the reproductive organs should be made. With such materials one could arrive at numbers admitting of a comparison.

Suppose that the result still showed scarcely any difference in the number of females in the two kinds of oysters, it would be rash to conclude that the greater part of the free spat is not produced by natural oysters. Their spat might be hardier than that of cultivated oysters, and it might reasonably be admitted that the spat produced by a natural oyster is larger in amount than that produced by a cultivated oyster.

DESCRIPTION OF PLATES XXII, XXIII,

Illustrating the abstract of Dr. Hoek's paper on "The Generative Organs of the Oyster."

All the figures after Dr. P. P. C. Hoek.

Fig. 1.—View of a freshly opened oyster lying in the left valve after removal of the right valve. A portion of the mantle has been removed to show the oral process situated in the suprabranchial chamber.

Fig. 2.—Diagram of an oyster of which a part of the branchiæ and mantle have been removed to show the general arrangement of the generative organs and organ of Bojanus. The black lines represent the canals and ducts of the generative organ; the organ of Bojanus is shown in shading. To avoid encumbrance of the figure the genital ducts and canals are made to appear much smaller than they are in reality. *U. A.* Urogenital aperture. *Rp. C.* Renopericardial canal.

Fig. 3.—Section of a follicle of the generative organ of an oyster which has laid ova. *s′*. Mother cells of spermatozoa in division with numerous nuclei. *s″*. Ripe spermatozoa (× 190).

Fig. 4.—A portion of the preceding figure more highly magnified (× 900). *a.* Epithelium. *b.* First stage of division of mother-cell. *B.* Numerous nuclei derived from the primitive nucleus. *A.* Stage previous to the separation of the swollen multinuclear mass from its pedicle. *y.y.* Blood-corpuscles.

Fig. 5.—Mass of ripe spermatozoa (× 575).

Fig. 6.—Ovules on the wall of a follicle. *e.* Epithelium of the follicle (× 190).

Fig. 1

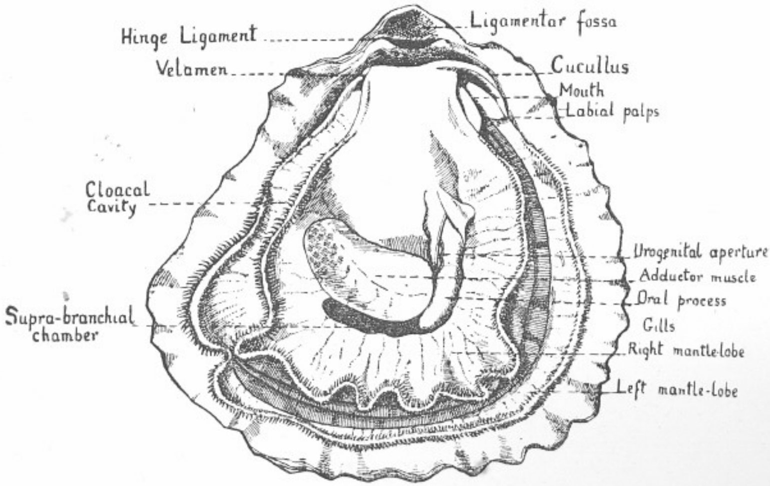
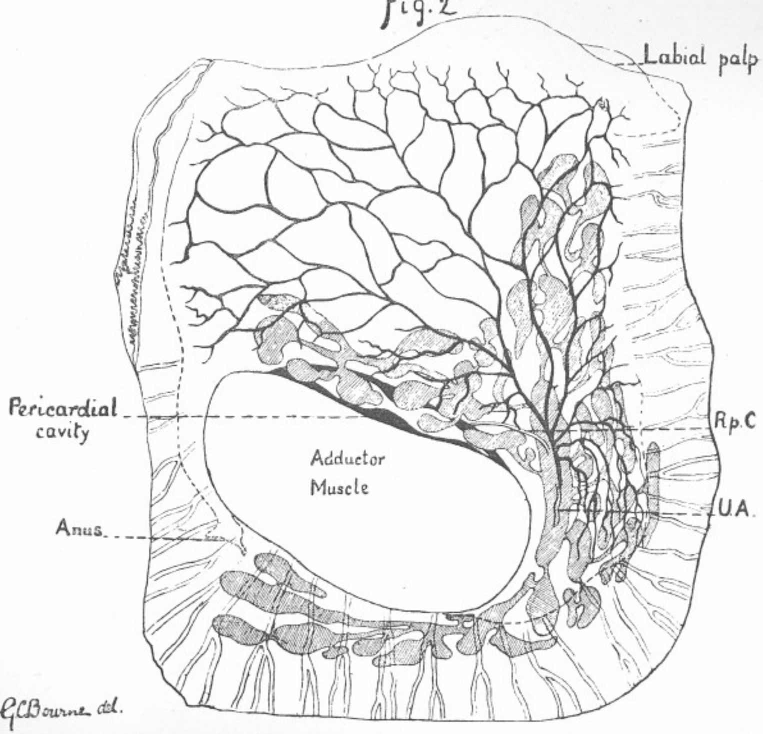


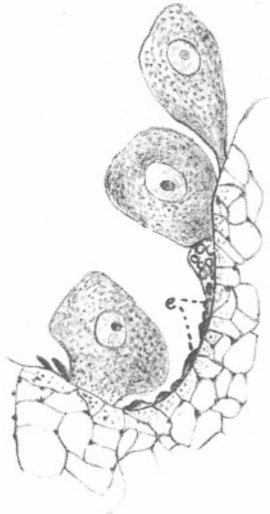
Fig. 2



G.C.Bourne del.

Fig. 3

Fig. 6



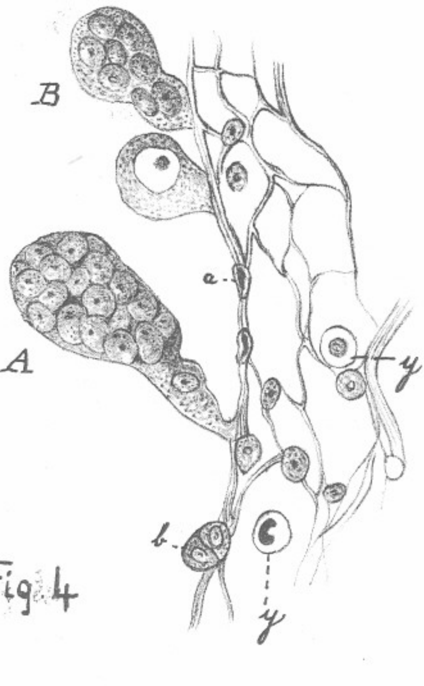


Fig. 4

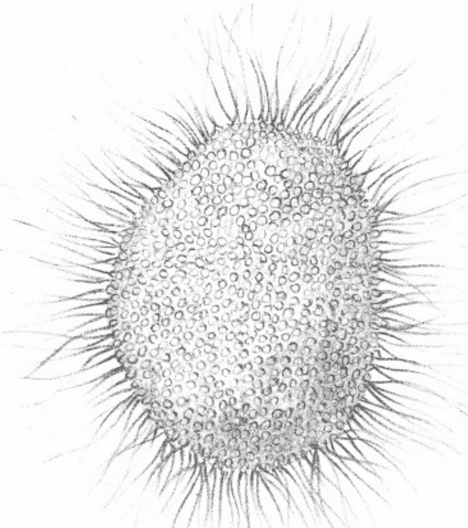


Fig. 5

G. C. Bourne. autogr.

Letter on Oyster Culture.

By

By Lord Montagu of Beaulieu.*

I HAVE tried breeding oysters in two enclosed ponds for over ten years. I began my experiments in 1878. These ponds are situated on the banks of the Beaulieu River, about three miles from the estuary. They were excavated from the mud-bank, and banked off from the river; the bottom was well chalked, and afterwards well coated with gravel. They are about half an acre each, and are divided by an embankment. There are three sluices communicating with the river from the ponds, and two between the two ponds. The situation of the ponds is very sheltered, being in the west bank of the river, with a wood on the west side, and the woods on the east side of the river also sheltering them. The water of the river at the spot is brackish to a certain extent, and decidedly so when there is much rain. At spring tides it is nearly as salt as the sea, but there is always a considerable mixture of fresh in the river. I have only once succeeded in obtaining any large fall of spat, and that was in the first year the ponds were made, 1878. That year there was a very early fall of spat, middle of June, and the tiles were fairly smothered with it. Since then there has been occasionally a little fall of spat, but nothing at all satisfactory.

I have used all kinds of collectors—tiles, brushwood, hurdles, shells. When spat is really *mature* it will adhere to *anything*. The tiles I have always coated with a mixture of lime and sand, so that it should not get too hard and adhere too strongly to the tiles, as if so it is impossible to remove the young oysters without breaking their shell, when they die. The labour of removing is great, and the expense also, and it is imperative to put these young oysters into boxes or ambulances, and to remove them to ponds on the sea foreshore. The best, cheapest, and most effective collectors are small shells, and oyster culch, especially if they can be put on fine wire netting, a little above the bottom of the pond. I have tried to collect spat on artificial tile collectors in the river, but have not

* Lord Montagu has kindly allowed me to publish this letter, which was written in answer to some questions of mine as to his experiences in oyster culture.—ED.

been successful in getting much, the amount being quite insignificant to the labour and expense of putting them down.

There are plenty of shells and natural stuff for oysters to settle on in the river if ever a fall of spat matures. That some do mature every year I have no doubt, but the quantity is very small.

I do not know that new natural spat in the river is stronger than that collected in the ponds. The shallowness of the water in the ponds causes the water to be warmer in summer, and this stimulates a greater growth in the young oysters in the ponds, but exposes them to greater risk from cold or snow water in the winter.

That oysters sicken and give a fall of spat every year I do not doubt, but it has always been a difficulty to ascertain if that spat is mature.* There has been a fall of spat every year in the ponds more or less, but it has most years come to nothing. After floating about for a week it will disappear altogether. I should like to know the cause of this, and here is where some scientific research is greatly needed. The problem is, why does this spat disappear? I have not been able to account for it from any natural causes. I have had large bottles of spat and watched it through powerful magnifying glasses and under a microscope, and have never been able to see any other living organism preying upon it. The spat has been very lively and moving about, apparently full of life, and, as far as I could see, having no marked difference from spat which has matured and adhered properly to collectors. Why does it not do so?† I have tried every kind of oyster in the ponds, putting about 10,000 in each pond. French oysters from Arcachon, French oysters from Auray, Solent oysters, river oysters, Falmouth oysters. The former breed much the most prolifically; and my belief is that this is owing to their being matured in a warmer climate. If, therefore, there happens to be a fine week when they emit their spat, the chances of realising a good result are greater with them than other oysters. I have usually placed the oysters I intended to breed from in *shallow* ponds by the sea-shore; this has the effect of bringing them on, and causing them to mature their spat. I believe that climate and warm weather has more to do with success than anything else, and the maturity of the spat when it is emitted from the oyster depends greatly on this also.

It is also most essential that the surface for oysters to spat upon

* The fall of spat has varied greatly in date: sometimes in June, often not till the end of July. I have hardly ever known a late spat come to maturity.

† I have generally put the mother oysters into the ponds about the end of May or beginning of June. The oysters I have selected have been generally about three years old. It is a question perhaps whether the spat from older oysters do not mature better. Those I have had from France have been between three and four years old.

should be clean, and not covered with slime, weed, &c. I have, therefore, latterly adopted the plan of waiting for a spat of oysters, and then throwing shells broadcast into the ponds. I believe this is a good plan. To show how capricious the oysters are, this last season I bred a few oysters in one pond, and there were none in the other close by, yet both were treated alike. I allow the tide to flow in and out through the sluices while the breeding is going on. Some hold this to be a bad plan, as it allows spat to escape. Some may perhaps, but the continual flow and reflow of fresh water into the ponds is most important. I believe it is true that spat rises to the surface in the day and falls to the bottom at night. I have tried this by experiments in large bottles, and there is no doubt that it did fall to the bottom in the dark, and rose to the surface with great activity on being brought out in the light.

There is no doubt that an oyster *must* have innumerable enemies. When it is an established fact that one oyster will emit a million little eggs or spat, it is clear that if it were not for wholesale destruction the stock of oysters would be always abundant, but it is not so. After maturing on a piece of stone, rock, tile, shell, or any other natural collectors in its youth the oysters are devoured wholesale by crabs, &c.; but what destroys them almost at their birth? This is the most important question. The principal cause of our having no spat deposited in this river is the violence of the tide. Unless the oyster spat* attaches itself to something during the lay tide and at neap tides the chances are it is all swept out of this river into the Solent; it may deposit itself in places there, but I hold this to be the greatest obstacle to spat getting attached to anything in the river. The same reason, I think, applies to spat in the Solent, that part of the Solent between St. Helens and Osborne Bay being quite the best bed for oyster-dredging. It is between these two points that east and west going tides meet, and where there is no great current, and it is on this ground that the Solent oyster-dredgers work.

I believe that one of the reasons of a yearly fall of spat in the Essex rivers is much due to the same cause, and undoubtedly the *Whitstable*† beds are in an equally favorable position. The bay or inland sea of Arcachon is for the same reason most favorable for securing a fall of spat, the tide simply passing up and down the bay, and never running the spat into the sea. The Dutch beds at Bergen-op-Zoom are similarly situated. But I think there are other causes why our oyster beds at home are becoming yearly less

* I believe that if an oyster spat is really fit, it will fix itself to some object in a very few hours of its being emitted from the parent oyster.

† Most of the Whitstable natives have for years past been supplied from Arcachon, and laid in the Whitstable grounds.

prolific. This, I believe, is over-dredging, and never having any reserved beds of oysters for breeding puposes. This, however, is a larger question into which I cannot now enter, and it is beyond your inquiry. I should add that there is a natural or native bed of oysters in the river here; it is too small, and should be extended, and more ground opened for laying oysters. This is only a question of £ s. d., but if one has not the money one cannot spend it. I should say that the South of England Oyster Company's breeding ponds at Hayling Island, and Emsworth, in Langston Harbour, near Portsmouth, are well worth a visit, and, I believe, particularly well situated for oyster breeding. They have had varied success, but never can pay a dividend on their capital expended, which has been very large.

I can only say in conclusion that I shall be very glad to see you, and any one whom you may like to accompany you, at any time here; and if my ponds can be of any use for making experiments, I shall be most happy to place them at the service of the Association on any terms that might be agreed upon. I am deeply interested in the whole matter, and should be very glad if the result of the investigations of the Association may solve some of the problems which have up to now defied private efforts.

Yours truly,
MONTAGU.

Flora of Plymouth Sound and Adjacent Waters. Preliminary Paper.

By

T. Johnson, B.Sc.,
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A Government grant by the Royal Society enabled me to spend the months of August and September of 1889, in the investigation of unknown or obscure points in the marine algæ, in the Laboratory of the Marine Biological Association, Plymouth. One of my chief objects was to obtain such material of the various members of the *Gigartinaceæ*, of *Spyridia, Stenogramme,* and other genera, as would permit me to make a detailed examination of the development of the fruit (cystocarp) from the earliest stage to maturity. Several of the genera required were very rare or of unknown locality, and in many cases only to be found by dredging. In searching for these, new weeds, or new localities for known weeds, were met with, and it seemed to me the notes I made would be of use to algologists. Cocks, Hore, Boswarva, Gatcombe, &c., and of late years Holmes,* have combined in their work to give a very full account of the marine algæ to be met with without the use of the dredge. For twenty years Cocks, I am told, did not miss a single low tide at Plymouth (or, if not, Falmouth). Up to the present our knowledge of the weeds of Plymouth has been derived almost entirely from shore-hunting, some of the rarest weeds being described as washed ashore, so that it was a question as to whether such weeds were locally established or merely "drift" specimens. In 1867 Boswarva published his *Flora of Plymouth Sound* in the Transactions of the Plymouth Athenæum, his catalogue being compiled from the discoveries of himself, Cocks, &c. This list appears word for word in the Marine Biological Association Journal, No. 2, 1888. I am permitted by Mr. Holmes to say that through a misunderstanding he is stated to give the names of eight *additional* species. It is only fair to the early algologists to point out that *five* at least of

* Through the courtesy of Mr. Holmes I have seen a list of species added by him to the Flora of Devonshire (Journal of Botany). I believe I am not overstating the case in saying that he has added one hundred species of algæ to the British Flora, some new to science.

these were known to occur in the Sound in Boswarva's time. I shall suppose readers of the following pages to be familiar with the above-mentioned catalogue, and to have a general knowledge of the Sound, from the Admiralty chart or otherwise. My chief objects when dredging were to see if the rare "washed ashore" weeds had any local habitat, if there was a well-marked connection between the east and west shores of the Sound by extra-tidal weeds, and to work out as fully as possible the extra-tidal flora. For the accomplishment of these objects it was necessary to work as near in to the shore as it was safe* to take the steamer ("Firefly") or the sailing boat ("Mabel").

Disturbing Influences in the Flora.

Many disturbing influences have been at work since the date of Boswarva's catalogue, the weeds mentioned by him as occurring in particular localities being in many cases no longer to be met with, or only after very diligent search. Of these influences it will be well to notice a few.

The Breakwater.—This immense structure, completed in 1841, and extending for more than a mile across the Sound, must have had an impoverishing effect on the flora of the Sound internal to it. This is more especially seen in the eastern inlets. Rum Bay, Jennycliffe Bay, Batten Bay, protected by the Breakwater from the south-west gales, are also cut off, to a large degree, from communication in a south-west direction with the English Channel and the Atlantic Ocean, and, to this extent, deprived of the spores of weeds brought by south-west currents. Batten Bay has been still further denuded by the presence, since 1882, of Batten Pier, and, spite of the presence of several rare weeds, has changed from a locality rich in seaweeds to one of the poorest, the effects of town and harbour refuse on the seaweeds in these eastern bays being also very marked.

Refuse.—No doubt in the Sound, as elsewhere, the increase, with population, of refuse has had a deteriorating effect on the algæ, as *e. g.* in Batten Bay just cited. I was given to understand that during recent years the bed of the *Laira* has been raised five feet by the deposit of clay and general refuse from the china clay works on Dartmoor. This cannot but have an effect on the weeds of the Laira and the Cattewater. Batten Pier seems to tend to drive the water from the Cattewater, Laira, and Sutton Pool, westward, where, between the west end of Batten Pier and the ladies'

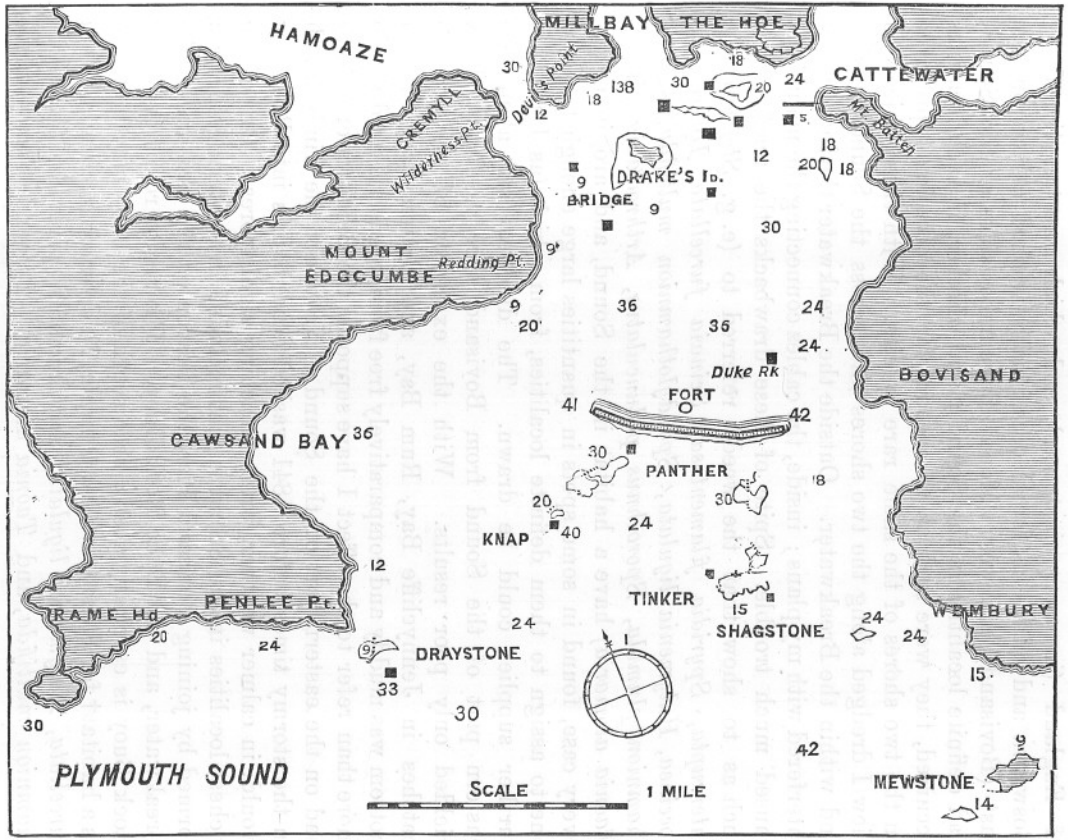
* I have much pleasure in acknowledging the great help I received from the fisherman to the Laboratory, W. Roach, without whose astonishing knowledge of the submerged rocks, &c., it would have been impossible for me to do as I did.

open bathing-place below the Hoe, the weeds are not so clean as in many other localities.

Firestone Bay.—The shore of this bay is being completely altered. The west part of the beach has been converted into an artificial stony embankment, on which now the commonest of weeds grow. It seems useless to look for the rare forms at one time found on its shores—*Crouania attenuata, Spyridia filamentosa, Chrysymenia rosea, Striaria attenuata.* Blasting is in full operation in the eastern part of the bay, with a consequent disturbance of the flora.

I would record here my great indebtedness to Mr. G. C. Bourne, the Director of the Laboratory, for the liberal use I was allowed to make of the resources of the Association for the supply of material. I could not have wished for more use,* having regard to the needs of the zoologists engaged in investigations in the Laboratory. I cannot hope to give an adequate idea of the innumerable opportunities for research. The brackish waters, with their accompanying mud-banks, furnish many plants needing investigation; Plymouth waters were long ago pointed out by Harvey as pre-eminently a habitat of the genus *Callithamnion.* There is quite enough material obtainable for the study of the unknown life-history of the plants *Dictyotaceæ, Ectocarpus, Tilopteris Mertensii, Pylaiella, Mesoglœa, Punctaria, Arthrocladia villosa, Sporochnus pedunculatus, Asperococcus, Bryopsis, Codium,* &c., and many *Florideæ* (until the great work on the *Florideæ* by F. Schmitz appears it is impossible to say what requires to be done in this group). One or two examples may be given. *Arthrocladia villosa,* described as occurring in Firestone Bay only, I found in at least seven other localities, and in several places in quantity. *Stenogramme interrupta* is a plant of which very little is known. There is doubt even as to the position of the tetraspores; male organs are unknown, and there is no description of the procarpia or fruit formation. I have got material in which I am able to come to definite conclusions on all these points.

* The greater part of my work was done by the help of the dredge in the "Firefly," "Mabel," or "Anton Dohrn." Occasionally I used grappling-irons, working alone in a punt. In this case I either made the punt stationary to buoys, &c., and then hurled the grapples as far as possible, drawing them in slowly and with steady motion, or else I fastened the rope of the grapples to the boat, and rowing slowly dragged the grappling-irons for some distance. I used sometimes a small anchor with half a dozen curved, radiating teeth; or, better, grapples of a similar form, but made of soft iron, so that if caught on a rock a vigorous pull bent the iron and released the whole. A straight bar of iron, with a horizontal row of curved teeth on one side, was also very useful. In some localities where *Laminaria* is growing in plenty, *e. g.* some parts of Firestone Bay, grappling is better than dredging, for the dredge becomes choked in the first few yards with *Laminaria* and nothing can then enter.



Map of Plymouth Sound, illustrating the localities mentioned in Mr. Johnson's paper on the Flora of Plymouth Sound. The figures show the depths in *feet*.

Dredging Results.

I was early anxious to ascertain whether the southern and subtropical weeds which reach their northern limit on the south coast of England (in many instances), and which are mentioned by Boswarva and others as found occasionally washed ashore on the east (Bovisand) and west (Mount Edgcumbe) sides of the Sound, had definite localities in the Sound; and whether, if such localities occurred, they were such as to account for the occasional presence on the two shores of the same rare species. With these objects in view I dredged along the two shores and across the Sound, outside and within the Breakwater. Outside the Breakwater the huge rocks interfered with my plans; inside, the cables connecting the main forts caused much trouble. Spite of these drawbacks the results were such as to show that the weeds referred to (e. g. *Stenogramme interrupta, Spyridia filamentosa, Scinaia furcellata, Dudresnaia coccinea, Halymenia ligulata, Spondylothamnion multifida,* Antithamnion plumula, Sporochnus pedunculatus, Arthrocladia villosa, Taonia atomaria*) have a habitat in the Sound, and are, in nearly every case, found in some spots in quantities large enough to allow one to assign to them definite localities, from which (as I proved) further supplies could be drawn. The dredge, used along the eastern part of the Sound from Bovisand Pier to Batten Pier, yielded only poor results. With the exception of one or two patches in Jennycliffe Bay, Rum Bay, and Batten Bay, the sea bottom was muddy and comparatively free from weeds. I need not do more than refer to the effect I have supposed the Breakwater to have had on the eastern part of the Sound. No doubt the winds which in the stormy times before 1841 washed dead bodies into Rum Bay would, in calmer weather, bring enriching algal spores. One of the richest localities in the Sound is that included in the triangular area formed by joining Bovisand Pier, the Beacon on the east end of the Breakwater, and the Duke Rock Buoy. The region round the Duke Rock Buoy is especially good; that south of the buoy may be taken as a habitat† for *Stenogramme interrupta, Dudresnaia coccinea, Scinaia furcellata, Halymenia ligulata, Antithamnion plumula, Spondylothamnion multifida*, and *Taonia atomaria*. I found *Stenogramme*

* I use throughout these pages the specific names employed by Hauck in *Die Meeresalgen*, 1885 (Rabenhorst's Cryptogamen-Flora, ii).

† It should be remembered that my personal knowledge was gained in the months of August and September, and that my remarks refer of necessity to these two months. I do not attempt any comparison between the flora of Plymouth, Torquay, Falmouth, and such places.

interrupta in plenty, tetrasporous, *male* and female plants, and hope to publish shortly the results of my examination of this interesting plant. *Dudresnaia coccinea* (tetrasporous and ♀ plants) was also in quantity, and in such a condition as to allow one to follow out all the stages in the strange formation of the cystocarps, first made known by Thuret and Bornet. A month earlier (middle of June to middle of July) would have yielded still better results.

The following are the more important forms met with in the triangular area:

S. interrupta, and the others just named.
Callithamnion seirospermum, and other species.
Antithamnion plumula, α genuinum, and β crispum, tetraspores, ♀, ♂, fruits.
Naccaria Wigghii, ♀, fruit.
Bonnemaisonia asparagoides, ♀ fruit.
Delesseria ruscifolia, fruit.
Rhodophyllis bifida, tetraspores, fruit.
Nitophyllum Hilliæ, tetraspores, fruit.
Gracilaria confervoides.
Sporochnus pedunculatus.
Dictyota dichotoma, ♂, ♀, tetraspores.
Sphacelaria cirrhosa.
Striaria attenuata.

Dredging between (1) the lighthouse on the west end of the Breakwater, and Picklecombe Fort on the mainland yielded *Halymenia ligulata* in abundance, with cystocarps, *Scinaia furcellata, Sporochnus pedunculatus, Bonnemaisonia asparagoides, Rhodophyllis bifida,* and *Dictyota dichotoma,* all fertile; and combined with dredging between (2) Queen Ground Buoy, Panther Buoy, and Breakwater lighthouse showed (spite of the nature of the sea bottom, which in some places is very rocky, in others sandy, neither condition being favorable to dredging) that, except for *Stenogramme interrupta* and *Taonia atomaria,* the weeds found at the west entrance to the Sound are very much the same as those found in the east entrance (round the Duke Rock Buoy). In all, representatives of at least forty genera (in some cases several species) were found. *Monospora pedicellata* and *M. clavata* with monospores, *Phyllophora rubens* with nemathecia, *Arthrocladia villosa* with zoosporanges, *Punctaria tenuissima* were met with here, and not in the east entrance.

E → W

Inside Breakwater. ↓

N

Dredging inside the Breakwater across the Sound, east to west, was, as already said, interfered with by the forts' cables. The weeds found are not improved in quality by the use of this ground as the anchorage for the men-of-war, cinders, &c., being dredged in abundance. *Stenogramme interrupta, Dudresnaia coccinea, Scinaia furcellata, Halymenia ligulata,* were not met with behind the Breakwater. Near the western buoy *Arthrocladia villosa* was obtained in quantity. In addition the following more important forms:

Antithamnion plumula, β.	Hydrolapathum sanguineum.
Callithamnion thuyoideum (♂, tetraspores), &c.	Rhodymenia palmata, R. palmetta, R. ciliata.
Spondylothamnion multifida.	Phyllophora membranifolia, P. rubens (fruit).
Chantransia virgatula.	Dictyopteris polypodioides (a little).
Ceramium tenuissimum, fruit, tetraspores.	Striaria attenuata.
Nitophyllum punctatum, N. Hilliæ, N. laceratum, N. Bonnemaisoni, ♂.	Desmarestia aculeata, D. ligulata.
Delesseria alata, D. ruscifolia.	Dictyota dichotoma.

Area enclosed by East Winter and other Buoys in Centre of Sound.

Here (the mud "cakey" and a home for nemertians) the following are the more important forms observed:

Antithamnion plumula.	Rhodophyllis bifida.
Monospora pedicellata.	Delesseria ruscifolia, D. hypoglossum.
Chrysymenia rosea.	Phyllophora palmettoides.
Chylocladia clavellosa.	Punctaria latifolia.
Lomentaria corallina.	Desmarestia ligulata.
N. punctatum.	

The western part of the Sound, from Picklecombe Fort in the south to the bridge on the Mount Edgcumbe side in the north, is too dangerous for any nearer examination in the "Firefly" than that part marked out in the Admiralty chart as the regular passage to the Hamoaze. The bridge itself is covered with *Rhodymenia palmata* and *Laminaria digitata,* only a few other, and these common, forms being found. *L. digitata* is well exposed at low tide, thus illustrating a statement of Cocks, made twenty years ago, that this plant was gradually taking up a littoral position, and ceasing to be met with only as an extra-tidal weed.

North of the Bridge.

Dredging here showed a poor flora, the strong currents, no doubt, being to a very great degree accountable. It was of interest to find, though as scraps only, *S. interrupta, Chrysymenia rosea,* and *Dudresnaia coccinea.*

Barn Pool.

Owing to the very strong currents, dredging here is not possible, except for an hour before and after the turn of the tide. The results, so far as seaweeds are concerned, were negative,* the dredge, in the parts nearer the shore, filling each time with large stones covered with ascidians.

The Hamoaze.

Owing to the extremely muddy nature of the bottom of the Hamoaze, dredging, except in one or two localities, is almost useless. The dredge quickly fills with mud, in which only a few weeds, not essentially different from the adjacent shore forms, are found imbedded, and not until much washed, fit for examination. The bottom of the Hamoaze, along the Royal Victualling Yards and along the building sheds, is not muddy—indeed, in the latter region it is very rocky in places, but yields weeds of the commoner kind only. Shore-hunting, either on foot, when one must be prepared to sink ankle-deep in mud, or better, in a punt, is the most successful mode of examination. Mr. Holmes has made many interesting "finds" at Torpoint. Owing to the regulations affecting the approach of steamers to the powder magazines, I was not able to take more than three or four dredgings off St. Peter's Point. Shore-hunting on foot at the Point itself is full of interest, but very disagreeable. On the Saltash side of the Point the beach is stony for a short distance, and here it is useful to wade at low spring tide, and to pick up, in the muddy water, stones which will be found, in many cases, covered with delicate, filamentous, red weeds. Nearer Saltash it is necessary to take to the punt and to continue the shore examination in it, as the rocky beach ends abruptly, and wading is impossible. In the following list I give only the more important of the locally established weeds, making no mention of the many evidently Sound-drifted ones:

Delesseria hypoglossum, in all conditions, in abundance.
Griffithsia corallina, tetraspores, ♂, ♀.
G. setacea.
G. devoniensis.
Antithamnion plumula, β, ♀, &c.
Dasya ocellata.
Callithamnion seirospermum, C. gracillimum, &c.
Chylocladia clavellosa, tetraspores, ♀.
Chondrus crispus.
Species of Ulva and Enteromorpha, abundant.

* This was the more disappointing, as I hoped to find the rare weed *Carpomitra Cabreræ*, which twenty years ago was found by Cocks established on Mount Edgcumbe mud-bank.

The preceding forms were, on the whole, better represented on the rocky beach.

Beggar's Island (Rat Island).

No algologist visiting Plymouth should omit to examine Beggar's Island and the region round St. Peter's Point, just described. Beggar's Island at low spring tide, on its west and south-west sides, presents a most interesting sight of weeds growing in brackish waters.* The more interesting forms found were—

Antithamnion plumula, β, very fine plants.
Griffithsia corallina.
Pleonosporium Borreri.
Dasya ocellata, D. coccinea.
Polysiphonia, several species.
Halymenia ligulata, several pieces, probably drifted.
Ectocarpus siliculosus, E. tomentosus, &c.

Firestone Bay.

I have already mentioned how poverty-stricken the beach here is, the shore embankment, &c., being covered with the commoner species of *Fucus, Ascophyllum nodosum, Rhodymenia palmata, Gigartina mamillosa, Ectocarpus, &c.* I saw no signs of such rare forms as *Crouania attenuata, Arthrocladia villosa, Spyridia filamentosa.* In the extreme south-west of Firestone Bay, just off the beach, the dredge mouth became choked almost at once with *Laminaria digitata.* Deeper in, and in a north-easterly direction, the results are better, including—

Stenogramme interrupta, tetraspores, ♀.
Spondylothamnion multifida, fruit.
Antithamnion cruciatum.
A. plumula, β.
Chylocladia clavellosa, fruit.
Bonnemaisonia asparagoides.
Monospora pedicellata.
Delesseria hypoglossum, D. ruscifolia.
Rhodymenia laciniata,† fruit.
Nitophyllum punctatum, 4-spores, ♂, ♀.
Chantransia virgatula, on Zostera.
Gracilaria confervoides.
Ceramium diaphanum.
Scytosiphon lomentarius.
Chorda filum.
Punctaria (plantaginea ?).
Desmarestia aculeata.
Cladostephus, Ectocarpus.

I dredged in this bay a *Crouania*-like plant which seemed to

* Care must be taken in passing from the west to the less interesting central and eastern parts. Several times I sank knee-deep in mud.

† Miss A. L. Smith, of the Normal School of Science, is at present engaged on the examination of the development of the fruit of *R. laciniata,* and has already obtained many interesting results.

agree with Kützing's genus *Sporacanthus*. Through the kindness of the distinguished algologist, Dr. E. Bornet, I am able to say that it is a form of *Antithamnion cruciatum*, with pentamerous whorls of ultimate simple acicular branches, on which the scooped-out intercalary tetraspore-like bodies are *reserve-spores* according to the observations of Berthold.* Dr. Bornet sent me a plant of *A. cruciatum*, dredged at Antibes, having both tetraspores and reserve-spores.

Drake's Island.

The shore of the greater part of this island is not rich in weeds. In the extreme south-west I found *Bryopsis plumosa* growing in half a dozen half-tide rock-pools—the best locality in Plymouth Sound for this weed. The south-west rock-pools are fairly rich, the weeds, for the most part, like those found on the north-east and east shores, the more important forms being—

Gigartina mamillosa, in great abundance.
Lomentaria ovalis, ♀, tetraspores.
Chylocladia articulata.
Gracilaria confervoides.
Chondrus crispus.
Porphyra.
Dictyota dichotoma.
Desmarestia.

Dredging and grappling combined showed the region north and north-west of Drake's Island to be surprisingly rich in weeds, as the accompanying list will indicate:

Stenogramme interrupta, fruits, in abundance.
Dudresnaia coccinea.
Sphærococcus coronopifolius.
Gracilaria confervoides.
Griffithsia corallina.
Antithamnion plumula, β.
Callithamnion, several species.
Bonnemaisonia asparagoides.
Ceramium tenuissimum.
Sarcophyllis edulis.
Phyllophora membranifolia (P. palmettoides ?).
Rhodophyllis bifida, fruit.
Nitophyllum venulosum (N. thyrsorhizans of Holmes).
N. laceratum.
Rhodymenia laciniata.
Chylocladia articulata.
C. clavellosa.
Gigartina mamillosa.
Gelidium corneum.
Dasya coccinea (almost everywhere).
Cutleria multifida, ♀.
Dictyopteris polypodioides.
Taonia atomaria.
Dictyota dichotoma.
Asperococcus compressus.
Scytosiphon lomentarius.
Cladostephus, Sphacelaria, Ectocarpus, Cladophora, species.

Up to the present the different observers of fertilization in the *Cutleriaceæ* have failed to observe the nucleus in the ovum. I am

* Berthold, U. d. Vertheilung d. Algen, i, S. v, Neapel.

about to publish the results of an examination of the ova of *Cutleria multifida* at the time of fertilization, my examination by means of the microtome leading me to say that the ovum is, as to be expected, nucleated. Hence, if I am correct, a re-examination of the process of fertilization in the *Cutleriaceæ*, in which account will be taken of the behaviour of the ♀ pronucleus, is necessary. I propose to use the microtome in the examination of the ova of other brown sea-weeds, making use of much the same method as that which has been so successfully employed in the investigation of the maturation, &c., of the animal ovum.

I was quite unsuccessful dredging off the entrance to Mill Bay, the inner waters of which I did not examine. Dredging off the Laboratory, and in an easterly direction towards Batten, the specimens found were generally small and dirty, especially in Batten direction.

The chief forms found were—

Halymenia ligulata (a little).
Nitophyllum seirospermum, N. punctatum.
Rytiphlæa complanata.
Callithamnion, several species, including C. thuyoideum.
Antithamnion cruciatum, A. plumula.
Bonnemaisonia asparagoides.
Sarcophyllis edulis.
Kallymenia Dubyi.
Gigartina mamillosa.
Gracilaria confervoides.
Rhodophyllis bifida.
Rhodymenia laciniata, R. ciliata, R. palmata.
Delesseria alata, D. hypoglossum, D. ruscifolia.
Chylocladia clavellosa, C. articulata.
Monospora pedicellata.
Chantransia virgatula.
Gelidium corneum.
Ceramium diaphanum.
Punctaria, Desmarestia, Chorda filum.
Laminaria saccharina.

Bryopsis plumosa is found in several pools on the beach below the Laboratory, immediately east of the ladies' bathing-place. In one plant found here I saw zoospores, without, however, being able to bring about the dehiscence of the zoosporange.

The Laira.

Dredging in the Laira, as in the greater part of the Hamoaze, is, owing to the mud, out of the question. Under the Laira railway bridge, at the bases of the pillars, the genera *Ulva* and *Porphyra* are to be found in great plenty. The mud-banks above the railway bridge were, owing to the thick deposit of china clay works' refuse, too soft for extensive searchings on foot. I found it necessary to stay in the punt, and to pick up with the boat-hook as I moved along any weeds required. The brackish waters of the Laira are not so rich as those off St. Peter's Point and Beggar's Island in the Hamoaze. I found—

Antithamnion plumula, α and β.	Pleonosporium Borreri.
Delesseria hypoglossum.	Pylaiella littoralis.
Species of Callithamnion, Polysiphonia, and Ceramium.	Ectocarpus tomentosus.

I must have overlooked *Griffithsia*. Leaving the Laira, one may find, on the projecting end of Batten Pier amongst other plants, *Antithamnion plumula*, β, and *Callithamnion gracillimum*; and in Batten Bay, in the region of the Cobbler Buoy,—

Callithamnion thuyoideum.	Rhodophyllis bifida.
Antithamnion cruciatum.	Chylocladia clavellosa.
Monospora pedicellata.	Stilophora rhizodes, 1-loc. and 8-loc. sporangia.
Rhodymenia palmata, R. laciniata, R. palmetta.	Bryopsis plumosa.

I propose now to consider that part of the Sound which is on the English Channel side of the Breakwater, and to begin with—

Cawsand Bay.

This bay, especially in its south-west part, is pre-eminently the habitat for *Spyridia filamentosa* and the different species of *Ceramium*. The sandy rock-pools with stones in them, on the north side of the bay from Picklecombe Fort westwards, are especially good, and provide one of the best localities in Plymouth for the examination of littoral weeds, the following amongst others being found here:

Gracilaria confervoides, in abundance.	Chantransia virgatula.
Polyides rotundus.	Gymnogongrus plicatus.
Fastigiaria furcellata.	Porphyra.
Rhodomela subfusca.	Scytosiphon lomentarius.
Dasya arbuscula and D. coccinea.	Asperococcus.
Chylocladia, Ceramium, Polysiphonia, Callithamnion.	Pylaiella littoralis.
Rhodymenia, species.	Myriotrichia clavæformis, 1-loc. sporangia.
Gelidium corneum.	Sphacelaria, Cladostephus, Desmarestia aculeata.
Gigartina mamillosa.	Ectocarpus, Ulva, Enteromorpha, Cladophora.
Very little Delesseria or Nitophyllum.	Bryopsis plumosa.

Shore-hunting on the south side can scarcely be carried on at all except in a boat, and the flora is not rich in variety, Laurencia, Chylocladia, Polysiphonia, Ceramium, being the more important genera represented. Dredging in Cawsand Bay yields a rich harvest of interesting forms, including in the north part of the bay—

Stenogramme interrupta.
Spyridia filamentosa, tetraspores, ♀.
Dudresnaia coccinea, tetraspores, ♀.
Halymenia ligulata.
Naccaria Wigghii, fruit.
Spondylothamnion multifida.
Sarcophyllis edulis.
Gracilaria confervoides.
Phyllophora, Fastigiaria, Rhodomela, Delesseria.
Ceramium, Dasya, Gelidium, species.
Rhodymenia jubata and other species.
Rhodophyllis bifida.
Gigartina mamillosa.
Callithamnion seirospermum and other species.
Antithamnion plumula, α and β, ♂, ♀.
Chantransia virgatula, ♂, ♀.
Chylocladia parvula.
Arthrocladia villosa.
Sporochnus pedunculatus.
Sphacelaria cirrhosa, and pennata with propagula and sporangia.
Asperococcus compressus, with sporangia.
Scytosiphon lomentarius.
Chorda filum.
Dictyopteris polypodioides.
Ulva, Enteromorpha, Cladophora.

I found no better dredging locality for the different species of *Ceramium* than that between North Point and Pier Cove, in the 2—4 fathoms limit as indicated on the Admiralty chart. In this part and towards Penlee Point Zostera beds are plentiful, affording anchorage for different algæ. I was pleased, too, to find a definite locality for the rare (Plymouth) weed, *Spyridia filamentosa*. Most of the specimens found were tetraspore-bearing plants (a good sign so far as the propagation of the species is concerned) ; ♂ and ♀ plants were also found in sufficient quantities to permit one to work out in detail the sexual organs and fruit formation. The dredge should be used in the "$1\frac{3}{4}$—$2\frac{1}{4}$" fathoms belt, as near in to the rocks as possible, immediately south of Cawsand landing beach, and on the shore side of any moored boats. Cawsand Bay is not one of the easiest waters in which to dredge ; on the south side the boat-anchors are very troublesome, and on the north side there is a very rocky shore with many submerged rocks close in. In addition to many of the species of *Ceramium* and *Spyridia filamentosa, Callithamnion seirospermum, C. gracillimum, Antithamnion cruciatum* with reserve-spores, *Phyllophora rubens,* and the more important (though by no means all) of the weeds found in the north part of the bay, *e. g. Halymenia ligulata, Dictyopteris polypodioides, Gracilaria confervoides, Pylaiella littoralis, Ectocarpus siliculosus,* were dredged in the southern part of the bay.

Rame Head to Penlee Point.

This part of the coast is fully exposed; the rock-pools are not good, numerous, or easily approached. In a cove south of Eastern Gear I found scarcely one filamentous weed, membranous weeds only. Dredging showed, on the whole, a similar general scarcity or absence of weeds. *Hydrolapathum sanguineum* is especially abundant here. In addition I found—

Bonnemaisonia asparagoides.
Spondylothamnion multifida, in plenty.
Antithamnion plumula, α and β, in plenty.
Delesseria alata, D. ruscifolia.
Sarcophyllis edulis.
Dictyopteris polypodioides and pennata.
Sphacelaria cirrhosa.
Cladostephus, Ectocarpus, and several others (6—8) common genera.

Whitsand Bay.

Owing to the very sandy nature of the bottom of this bay, and the scarcity of weeds, the dredge is of very little use, digging into and filling with sand in a few yards, with a resulting stoppage of the steamer if slowly moving. In the extreme east of the bay the ground is very rocky, and, owing to weather and want of time, my work here was confined to the shore weeds. Nowhere did I find more driftweed, and probably after a storm a rich harvest would be reaped in Polhawn Cove, below the Coastguard Station. The rock-pools are good, and well stocked with most of the weeds to be met with in the littoral zone of Plymouth waters, well repaying examination. The beach, 300 yards west of Polhawn Cove, is very barren for miles. Time after time the dredge when hauled in showed only one or two weeds, and had I relied for my conclusions on the contents of the dredge, I should have supposed that only very few weeds were present in Whitsand Bay, and that these were confined to half a dozen genera (excluding from this generalisation the unexamined eastern part of the bay). Fortunately I was allowed to overhaul the trawl of the "Penguin," after a run from west to east of the bay (nearly three miles).

On this trawl I found representatives of at least forty genera. I took off every weed on the trawl for detailed examination later. The weeds from this trawl, with a fifteen-foot beam, after a run of nearly three miles, occupied no more space than those taken in Cawsand Bay in the dredge after a run of 30—40 yards. The more interesting forms trawled were—

Stenogramme interrupta, 4-spores, ♀.
Phyllophora rubens.
Polyides rotundus.
Spondylothamnion multifida.
Antithamnion plumula, β, A. cruciatum.
Bonnemaisonia asparagoides.
Hydrolapathum sanguineum.
Rhodomela subfusca.
Gracilaria confervoides.
Cutleria multifida.
Dictyopteris, ♂, ♀, 4-spores.
Dictyota dichotoma.
Sporochnus pedunculatus.
Arthrocladia villosa.
Desmarestia ligulata, D. aculeata.
Sphacelaria filicina.
Fucus canaliculatus.

It is naturally impossible to say at what particular point in the three miles course the different weeds were gathered by the trawl. Later in the same day the "Penguin" trawled inside the Sound from the Breakwater lighthouse to Batten Pier, and on the trawl many of the rarer weeds, previously described as growing in the Sound, were found, but in what particular locality they were taken up it is not possible to say. Such weeds were *Spyridia filamentosa* (the only time I found it in the inner part of the Sound), *Stenogramme interrupta* (in abundance), *Nitophyllum Bonnemaisoni* and *N. Hilliæ, Scinaia furcellata, Sphærococcus coronopifolius, Griffithsia corallina, Arthrocladia villosa, Dictyopteris polypodioides.*

Bovisand Bay.

The local interpretation of "Bovisand Bay" is much wider than that sanctioned by the Admiralty chart. Locally, one understands the waters between Staddon Point in the north, Renny Point and the Shagstone in the south. The beach of Bovisand Bay proper ordinarily presents but few weeds; after a storm the weeds, it is said, lie ten to twelve feet thick, tons being carted away as manure. Between Andern Point and Renny Point, especially in the immediate neighbourhood of Renny Point, the rock-pools are well stocked with various weeds, including *Nemalion multifidum, Chylocladia articulata, Lomentaria kaliformis, Ceramium acanthonotum, C. ciliatum,* and species of *Chantransia, Griffithsia, Rhodomela, Laurencia, Delesseria, Gymnogongrus, Spondylothamnion; Ptilota elegans* (in great abundance), *Gelidium corneum* (several varieties, in plenty), *Mesoglœa vermiformis, Dictyota, Ectocarpus, Cladophora, Bryopsis plumosa.*

Dredging in the waters between Staddon Point and Renny Point brings to light many interesting plants, which, taken in connection with those dredged round the Duke Rock Buoy, readily explain the occasional finding, as cast-up weeds, of *Stenogramme interrupta, Spyridia filamentosa,* &c. I dredged in Bovisand Bay at least 90 of the 350 species found in Devonshire waters, including—

Stenogramme interrupta.
Spyridia filamentosa.
Dudresnaia coccinea.
Scinaia furcellata.
Microcladia glandulosa.
Nitophyllum versicolor, Hilliæ, laceratum, punctatum.
Phyllophora Brodiæi, palmettoides, rubens, membranifolia.
Rhodymenia laciniata, ciliata, palmata.
Rhodophyllis bifida.
Chylocladia articulata, parvula, clavellosa.
Lomentaria kaliformis, ovalis.
Delesseria alata, ruscifolia, sinuosa, hypoglossum.
Hydrolapathum sanguineum.
Gracilaria confervoides.
Polyides rotundus.
Fastigiaria furcellata.
Sarcophyllis edulis.
Kallymenia microphylla (K. reniformis).
Antithamnion plumula, α and β, A. cruciatum.
Ceramium echionotum, ciliatum, diaphanum, decurrens, tenuissimum, flabelligerum, rubrum.
Spondylothamnion.
Bonnemaisonia.
Callithamnion, Chantransia.
Gigartina, Chondrus.
Gymnogongrus plicatus.
Griffithsia corallina.
Corallina officinalis, C. squamata.
Species of Porphyra, Dictyopteris, Dictyota, Cutleria, Sphacelaria, Cladostephus, Ulva, Enteromorpha.

I found Bovisand Bay the best locality for *Nitophyllum* and *Phyllophora.*

Wembury Bay.

Passing south-east from Renny Point one comes to a number of fine rock-pools, the ridge on which they occur running out from the mainland so as to join, within a few yards, the outlying rocks of the Mewstone. The passage left is so narrow and shallow that in the lowest spring tides one can, I am told, wade across. Many of the rock-pools are sandy, and have excellent *Zostera* beds. I do not know any more instructive locality in Plymouth waters for shore-hunting than Wembury Point.

Cystoclonium purpurascens and β cirrhosa,
Rhodymenia jubata and β cirrhosa,
Codium tomentosum,
Dictyota dichotoma,
Mesoglœa vermiformis,

not to mention others, were all found in plenty.

On the rocks east of this reef the marine lichen *Lichina pygmæa* grows abundantly at half-tide. The rock-pools below Wembury Church are also full of interest, and amply repay examination. Here were growing in plenty *Gigartina pistillata* in fruit, *Monospora pedicellata, Corallina rubens* and β *corniculata, Gymnogongrus plicatus, Chordaria flagelliformis, Codium tomentosum.*

Wembury Bay itself abounds with submerged rocks, and a thorough knowledge of its topography, as Roach had, is necessary in dredging. There is no better locality for the *Phæophyceæ* and the *Corallinaceæ* than Wembury Bay. Chief weeds found:

Corallina officinalis, squamata, rubens, and β corniculata.
Gracilaria confervoides.
Rhodymenia jubata.
Fastigiaria furcellata.
Bonnemaisonia asparagoides.
Species of Callithamnion, Rhodomela, Polysiphonia, and Lomentaria.
Delesseria alata, D. sinuosa.
Dictyopteris polypodioides.
Dictyota dichotoma.
Taonia atomaria.
Sporochnus pedunculatus.
Mesoglœa, Sphacelaria, Cladostephus, Punctaria, Leathesia species.

The Mewstone.

The rock-pools of this interesting rock are well worth a visit; protected on the north side and close to the mainland, they are on the south side, for the most part, exposed to and in connection with an open sea. They are richest in the north, north-east, and south-west parts, and, as would be expected, the weeds found in the north and north-east pools are much the same as those found on the mainland opposite. I was pleased to find here a very fine plant of *Codium tomentosum* bearing zoosporanges, the whole plant a single multinucleate cell, weighing at least three pounds!

Polyides rotundus.
Sarcophyllis edulis (in plenty).
Dasya ocellata.
Nitophyllum Hilliæ, N. punctatum.
Rhodophyllis bifida.
Antithamnion plumula.
Gigartina mamillosa.
Nemalion multifidum.
Gelidium corneum, several varieties (four or five in one pool).
Gymnogongrus plicatus.
Several species of Callithamnion (including C. polyspermum), Polysiphonia, Ceramium.
Cutleria multifida, ♀, and Laminaria bulbosa, drifted.
Dictyota, in plenty.
Desmarestia, Sphacelaria, Cladostephus, Ectocarpus, Bryopsis, &c., were found here.

On the south and south-west parts, in addition to most of the foregoing, the following amongst others were found:

Delesseria hypoglossum, D. ruscifolia.
Cystoclonium purpurascens.
Phyllophora rubens.
Spondylothamnion.
Fastigiaria.
Laurencia.
Chylocladia.
Rhodymenia.
Bangia.

Porphyra.	Asperococcus.
Mesoglœa (in plenty).	

On a calm day one can see the bottom of the sea, even to the recognition of particular weeds, in many places in Wembury Bay, north and east of the Mewstone. Circumstances prevented me from carrying out an intention of using the dredge or grapples in these places. Dredging half a mile south of the Mewstone, in seven to nine fathoms, 200—400 yards east of the Black Buoy, revealed the rare (British) weed *Dictyopteris polypodioides* in great abundance, with tetraspores, ♀ and ♂ organs. I read a paper on this genus before the Linnæan Society in December last, in which paper the results of my examination of this Plymouth material were incorporated. I was able to show that the *Dictyotaceæ* are true *Phæophyceæ,* and that they fall into a series in which Reinke's *Tilopterideæ,* of which the Plymouth representative is *Tilopteris Mertensii,* are included. Other weeds dredged here were—

Rytiphlæa fruticulosa.	Gracilaria confervoides.
Scinaia furcellata.	Delesseria sinuosa.
Bonnemaisonia.	Gelidium corneum.
Schizymenia.	Cutleria multifida.
Rhodymenia jubata.	Sporochnus pedunculatus.
Corallina rubens.	Taonia, Dictyota, Cladostephus.

Mouth of the Yealm River.

Dredging in the Yealm in three to six fathoms, off the Coastguard Station and close in, furnished a locality for *Gracilaria multipartita* (*G. polycarpa*), *Halymenia ligulata, Scinaia furcellata, Dudresnaia coccinea* (all in abundance). The following were also dredged:

Spyridia filamentosa,	Asperococcus bullosus,
Gracilaria confervoides,	Sporochnus pedunculatus,

and species of Monospora, Antithamnion, Spondylothamnion, Delesseria, Nitophyllum, Rhodophyllis, Gymnogongrus, Chylocladia, Ceramium, Ectocarpus, &c.

The Breakwater.

I was prevented from examining the Breakwater at all fully. On the inner side the boulders, &c., were seen, at low spring tide, covered with *Fucus, Ozothallia, Laminaria, Halidrys,* growing amongst which were *Gigartina mamillosa,* species of *Callithamnion,* including *C. seirospermum, Ceramium, Chylocladia, Plocamium,* *Rhodymenia, Pylaiella littoralis, Scytosiphon lomentarius, Bryopsis plumosa.*

Middle Fort (behind Breakwater).

Examination of the inter-tidal and extra-tidal surface of this fort brought to light *Spondylothamnion multifida* (very fine plants), several species of *Callithamnion*, including *C. thuyoideum, C. seirospermum, C. gracillimum, Antithamnion plumula*, β, species of *Nitophyllum, Gigartina, Rhodymenia, Delesseria, Chylocladia, Porphyra, Desmarestia, Ectocarpus, Ulva*, &c.

The Buoys.

Examination of the buoys, with which Plymouth waters abound, serves to give one some idea of the migrations of marine plants. It should be remembered that all the buoys are thoroughly cleaned and repainted twice a year (before and after winter—end of September, beginning of April). They might be used, coated with different substances, for experiments having as their object the discovery of the best weed-growing preventatives as applied to ships' bottoms. The weeds were generally healthy, in full fruit, and firmly attached. Those on the White Buoy, south-south-west of Drake's Island, were relatively poor and insecurely attached.

Draystone Buoy (off Penlee Point).

It was of interest to find plants of *Rhodymenia palmata*, for in this species no British fruit-bearing specimen has yet been found, only tetraspore-bearing forms.

Amongst others on the buoy were *Chantransia, Polysiphonia*, including *P. Brodiæi* (the tufted branches of which form nests for *Isopoda*), *Punctaria, Scytosiphon, Sphacelaria, Ectocarpus, Ulva, Enteromorpha.* The weeds growing on the buoys outside the Breakwater, marking the east and west channels for vessels, included those found on the Draystone Buoy, and, in addition, *Bangia fusco-purpurea, Ceramium rubrum, Callithamnion, Laminaria saccharina, Desmarestia ligulata.* The weeds on the Duke Rock Buoy were similar to those on the outer buoys, but less abundant.

Desmarestia.—With the exception of a brief notice in Études Phycologiques by Thuret and Bornet (p. 16) of unilocular sporangia in *Desmarestia viridis*, no description of reproductive organs in any species of *Desmarestia* has yet appeared. On a small plant of *Desmarestia ligulata* I was fortunate enough to find (after examining every plant of *Desmarestia* met with during my stay) unilocular, usually monosporous sporangia in the position in which Harvey nearly fifty years ago suggested, and in the cortex too. I hope to publish shortly a detailed description.

Bigbury Bay.

The rocks south of Yealm River mouth towards Stoke Point, fully exposed to the south-west gales, were generally barren like those between Rame Head and Penlee Point. East of Revelstoke Point, and well protected by it, there are good, well-stocked rock-pools. A short visit to the pools west of Revelstoke Church led me to think the weeds generally comparable to those found on the Renny Rocks, Wembury Point, and the Mewstone. *Cystoclonium purpurascens, Sarcophyllis edulis, Monospora, Griffithsia equisetifolia, Ptilota elegans, Mesoglœa vermiformis,* and many others were seen. The dredge brought up *Phyllophora rubens* with nemathecia, *Spondylothamnion multifida, Antithamnion plumula, Bonnemaisonia asparagoides, Dictyopteris polypodioides, Sphacelaria filicina,* &c.

I propose in a subsequent number of the Journal to continue my observations on the flora, to give a more detailed list of the species met with, and to trace out the distribution, in the different localities, of individual species. I have, I trust, said enough to show that there is no lack of algæ needing investigation. It is impossible for me to give an adequate idea of the details of the flora. I shall be only too pleased to place my knowledge, gained under such great advantages, at the service of algologists.

Report of a Trawling Cruise in H.M.S. "Research" off the South-west Coast of Ireland.

By

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THE cruise, of which the zoological results are given in this report, was undertaken at the suggestion of Capt. Wharton, R.N., F.R.S., hydrographer to the Admiralty, who kindly advised me that H.M.S. "Research" was to make a fresh series of soundings off the entrance to the Channel, and put me in communication with the captain of the ship. To Capt. Aldrich I am indebted for unbounded hospitality and attention whilst I was on board, and I take this opportunity of expressing my most hearty thanks both to him and to the officers on board for the hospitality and kindness which they afforded me, and for the help which they gave me in the trawling operations. The "Research" is a paddle vessel of 520 tons register, built last year for the express purpose of surveying, and provided with a steam winch, deep-sea trawls and dredges, and 1000 fathoms of wire rope, with accumulators and accessory tackle. The available space on board was limited; there was no separate cabin at my disposal, so Capt. Aldrich most kindly made me his guest and gave me a berth in his own cabin, and I was given as much room as could possibly be allowed for storing my bottles and other apparatus.

Having joined the ship at Queenstown, we left the harbour on the evening of Tuesday, July 9th, and stood on a westerly course for Cape Clear. On the 10th, having cleared the Irish coast, the ship's head was turned south, and a line of soundings was made on the edge of the bank which was under survey. During this and the three succeeding days the ship was turned westward for a few hours each day, and the trawl was shot in deep water off the bank. At night we returned to the bank and anchored. On Sunday, July 14th, we remained at anchor at the south-west extremity of the bank, and on Monday we resumed a northerly course on about the meridian of 10° 7′ W. longitude, retracing our course on the 18th to run another line of soundings a little eastward of our previous position. During each of these days the trawl was shot on the bank in from 70 to 80 fathoms. During the expedition I took a number of hauls with the tow-net, both in daytime and at night. On the 19th we made for Queenstown, and arrived in port in the evening, after a very enjoyable cruise, during which we were favoured with remarkably fine weather.

A little more than a week previously the Rev. W. Spotswood Green had undertaken a similar cruise in the "Flying Fox," belonging to the Clyde Shipping Company, and had trawled in considerable depths in nearly the same locality as that in which we began our operations, but he kept further north than we did throughout his trip. Being before me both in his cruise and in the date of publishing his results, Mr. Green has rather taken the edge of novelty off my work; but although I must yield the pride of priority to some of his species, which were new, and were taken immediately after by myself, the interest of the trawling in the "Research" is not in reality diminished by this circumstance. In fact, my cruise may be considered as complementary to that of the "Flying Fox," and continued the line of trawling much further south, giving a fuller and more comprehensive view of the bottom fauna of this part of the sea.

Some of the most interesting results of my cruise were the capture of a second specimen of *Solea Greenii*, Günther, a new species, of which a single specimen only was taken in the "Flying Fox;" the capture of *Macrurus lævis* and *Rhombus boscii*, both new to British fauna before Mr. Green's expedition, and of *Haloporphyrus eques*, which was not taken by him. I also took several specimens of the rare Asterid, *Nymphaster subspinosus*, a single specimen of *Eupagurus carneus*, Pocock, which was first taken by Mr. Green, three fine specimens of *Epizoanthus paguriphilus*, Verrill, and a new species of the genus *Leptothyra*.

The general results of the trawling at the different stations are given below, and the list of the species collected is given in a separate table. I undertook to work out the whole collection myself, which has delayed the publication of my report; but eventually I have had to go to several friends for assistance in some of the groups, and I have received much assistance from Canon A. M. Norman. Professor Jeffrey Bell has kindly given me a separate report on the Echinoderms.

Station 1. July 10th, 1889. Position, 50° 50′ 15″ N., 11° 12′ 30″ W.—The trawl was shot at 4 p.m. in 200 fathoms, and was down an hour and a half. The bottom consisted of fine sand, containing many Foraminifera. A large haul of fish, including many "megrims" (*Rhombus boscii*), two species of *Macrurus* (*M. lævis* and *M. cœlorhynchus*); *Haloporphyrus eques*, a *Phycis*, many *Scorpæna dactyloptera*, and a single large specimen of *Raia batis*; quantities of *Spatangus purpureus* and Holothurians (*H. tremula*), a single specimen of *Asterias rubens,* and a few *Actinauge Richardi,* with other specimens, among which was a hitherto undescribed species of *Leptothyra.*

Station 2. July 11th. Position, 50° 29′ 26″ N., 11° 4′ W.—The trawl was shot at 11 a.m. in 400 fathoms, and was hauled up at 1.12 p.m., taking an hour and twenty-eight minutes in coming to the surface. It contained only one fish, *Haloporphyrus eques,* a great quantity of *Spatangus purpureus,* four specimens of *Nymphaster subspinosus,* multitudes of *Echinus norvegicus* sticking in the swabs; several crustacea, including *Eupagurus carneus, Lipsognathus Thomsoni, Scyramathia Carpenteri, Bathynectes longispinosa,* and *Ebalia nux;* three specimens of *Epizoanthus paguriphilus,* and other forms, among which were two or three specimens of *Actinauge Richardi.*

Station 3. July 12th. Position, 49° 50′ 2″ N., 11° W.—The trawl was shot at noon in 200 fathoms, but capsized and came up empty. A few specimens of *Dorocidaris papillata* and some fragments of *Brisinga* were sticking in the swabs.

Station 4. July 13th. Position, 49° 5′ 40″ N., 11° 14′ W.—The trawl was shot in 217 fathoms, and brought up a single large specimen of *Lophius piscatorius,* half a dozen *Rhombus boscii,* a single *Macrurus lævis,* one *Solea Greenii,* and two small Gadoids. There were, as before numerous specimens of *Spatangus purpureus* and *Holothuria tremula,* and a few *Dorocidaris papillata.* The specimen of *Solea Greenii,* a female, is considerably larger than that taken by the "Flying Fox," and was perfectly ripe, the ova running out on deck when it was brought on board. When alive its upper surface was of a uniform chestnut-brown colour.

Station 5. July 15th. Position, 48° 59′ 42″ N., 10° 7′ 27″ W.—The trawl was shot twice in ninety fathoms. The first time it capsized and came up empty; the second time it was full, and contained among other things four *Rhombus boscii,* two small rays, of doubtful position, large numbers of *Pecten opercularis,* several specimens of *Asterias glacialis* and *A. rubens, Ophiothrix Lütkeni,* numerous Polyzoa, chiefly *Cellaria* and *Cellepora;* several Hydroids, including some fine specimens of *Eudendrium rameum;* several colonies of *Alcyonium glomeratum,* half a dozen specimens of *Polythoa incrustata,* and a *Polythoa* which I have not been able to identify satisfactorily.

Station 6. July 16th. Position, 49° 23′ 54″ N., 10° 8′ 34″ W.—The trawl was shot in seventy fathoms on the spot marked in the chart as the "Great Sole Bank." The trawl came up empty, though to judge from the runners it had been working evenly enough. The swabs contained some Ascidians and a Hermione. The trawl was shot a second time a few miles further on (49° 26′ 36″ N., 10° 10′ W.), and again was unfortunate, as it capsized and came up empty. A few Pycnogonids and many Hydroids and Polyzoa were sticking in the swabs.

Station 7. July 17th. Position, 50° 24′ 45″ N., 10° 7′ 30″ W.—The trawl was shot at noon in seventy fathoms, and hauled two hours afterwards. When it came on board a large hole was found to be torn in the cod end, through which much of the contents must have escaped. The catch included among other things a single specimen of *Luidia* (probably *ciliaris*), several specimens of *Echinus acutus*, and a single specimen of *Porania pulvillus*. Among other Hydroids was a considerable quantity of *Tubularia coronata*.

Station 8. July 18th. Position, 50° 22′ 21″ N., 10° 7′ 30″ W.—The trawl was down for two hours on a gravelly bottom. Depth about seventy fathoms. The contents did not differ much from those of the previous day. A single specimen of *Holothuria tremula* was taken, and the presence of numerous *Ophioglypha albida* and *Adamsia palliata* was the only noticeable feature. A large Actinian, apparently an *Actinoloba*, was also caught, but it was so much damaged as to be beyond recognition.

The following is a list of all the specimens taken in the trawl and identified. It must be understood that not every specimen was brought home for identification. As I was asked not to bring too much baggage on board, I limited my supply of bottles and spirit, and each day after examining the contents of the trawl, I preserved only such specimens as I could not recognise. Naturally enough, I had afterwards to regret not having preserved many specimens which I identified on board and returned to the sea; but, on the other hand, I am satisfied that my actual collections, together with my notes of species observed on board, give a very nearly accurate account of the fauna as exhibited in our trawling.

VERTEBRATA.—Pisces.

Raia batis, *Linn.*

A single large specimen at Station 1, 200 fath. I am not aware that this species has been recorded from so great a depth before. Dr. Günther (Challenger Reports, Deep Sea Fishes, p. 11) says that it has been observed on the Norwegian coast down to 150 fath.

Raia, sp. incert.

Several specimens of a small ray were obtained at Stations 5 and 6. Being unable to identify them with any described species, I forwarded a specimen to Dr. Günther, who kindly examined it and wrote as follows:—"I cannot identify it with any of the known

British species; it comes nearest to *Raia circularis* and *R. miraletus* (from the Mediterranean), but shows differences in the scutellation form of the body, and ornamental colouring. But it would be hazardous to offer a more definite opinion, as we know very little about the amount of variation and of the changes with growth and locality in rays."

All the specimens taken were apparently young.

TELEOSTEI.—*Acanthopterygii.*

SCORPÆNA DACTYLOPTERA, *De la Roche.*

Several specimens in 200 and 217 fath. This species was also taken by Mr. Green, before whose expedition it was unknown to British fauna.

LOPHIUS PISCATORIUS, *Linn.*

A single large specimen at Station 4, 200 fath. The angler, according to Brown Goode, is known to descend to considerable depths.

CALLIONYMUS LYRA, *Linn.*

Many specimens, Stations 7 and 8, 70 fath.

Anacanthini.

GADUS ARGENTEUS, *Guich.*

Two specimens at Station 4, 217 fath. This species was first found in the Mediterranean, and has only once been taken since, by the "Porcupine" in 1869, very close to the station at which I obtained it. (See Günther, Ann. Mag. Nat. Hist., xiii, 1874, p. 138.)

PHYCIS ALDRICHII, n. sp.

Two specimens of this genus were obtained at Station 1, from a depth of 200 fath. After careful examination (they are unfortunately a good deal damaged) I cannot identify them with any described species, and therefore propose to name it, provisionally, *Phycis Aldrichii*, in honour of my host, Capt. Aldrich. This form is very closely allied to *P. americanus*, Schn. (with which it may prove to be identical), differing from it chiefly in the first dorsal, the anterior rays of which are not elongated in *P. Aldrichii*.

The following is the description of the species:

D. 10/52. A. 50.

Length of the head somewhat less than one quarter the total length of the body, excluding the caudal fin. Eye equal in length to the snout. Length of eye rather more than one third the length of the head. Interorbital space less than the height of the eye. Barbel about three quarters the length of the eye. The first dorsal has its origin behind the insertion of the pectoral fin. The third ray of the first dorsal is the longest, but is not as long as the head. Length of the pectoral less than that of the head. Ventrals extend as far back as the third or fourth ray of the anal fin. Vertical and caudal fins edged with black.

The specimens described are 20 cm. long.

HALOPORPHYRUS EQUES, *Günth.*

One specimen was obtained at Station 2, 400 fath. New to Great Britain. Numerous specimens were obtained in the Faröe Channel by the "Knight Errant" in 1880 and 1882.

MACRURUS CŒLORHYNCHUS, *Risso.*

Three specimens from Station 1, 200 fath. This species and the following were unknown to British fauna before Mr. Green's expedition.

MACRURUS LÆVIS, *Lowe.*

Several specimens from Stations 1 and 4.

RHOMBUS BOSCII, *Risso.*

Many specimens from Stations 1, 4, and 7. I at first mistook this species for the "megrim," *Rhombus megastoma*, but the enormous size of the eyes shows it to be *R. boscii*. At Station 1 we trawled nearly a hundred, and ate nearly all of them under the impression that they were megrims. They are very good eating. This, again, is a species found by Mr. Green, and previously new to British fauna.

ARNOGLOSSUS LATERNA, *Günth.*

Many small specimens from Stations 5 and 7, 70 fath.

PLEURONECTES CYNOGLOSSUS, *Linn.*

Stations 1 (200 fath.) and 8 (70 fath.).

Dr. Günther, in the "Challenger" report on deep sea fishes, notes the remarkable fact that this littoral species is sometimes found at considerable depths. The greatest depth recorded is 732 fath.

SOLEA GREENII, *Günth.*

Station 4, 217 fath. I obtained a single specimen of this interesting new species, discovered a week before my cruise by Mr. Green, who also only obtained a single specimen. Mine is a female, larger than the other, being 18·8 cm. in length, and was perfectly ripe when caught, the roe running out on the slightest pressure. When fresh the colour of the upper side was a uniform chestnut brown.

TUNICATA.

ASCIDIA VIRGINEA, *O. F. Müller.*

Two specimens adhering to Serpula tubes.

ASCIDIA FUSIFORMIS, *Herdman.*

Five specimens, adhering to Annelid tubes and Polyzoa, varying in size from three quarters of an inch to an inch and a quarter. The larger individuals contained numerous ova in the peribranchial cavity. These with the preceding species were dredged in 70 fath.

DIPLOSOMA, sp.?

One small colony, attached to a Hydroid stem.

MOLLUSCA.—GASTEROPODA.

LEPTOTHYRA BOURNEI, *Norman.*

Vide addendum by Canon Norman, p. 323.

SOLARIUM MEDITERRANEUM, *Monterosato.*

Vide addendum by Canon Norman, p. 322.

NATICA NITIDA.

Station 7, 70 fath.

CALYPTRÆA SINENSIS, *Linn.*

Station 7. Several specimens.

APORRHAIS PES-PELECANI, *Linn.*

Shell containing *Phascolion strombi* from Station 8.

APORRHAIS PES-CARBONIS, *Brogn.*

Station 1, 200 fath.

MORIO (CASSIDARIA) TYRRHENA, *Chem.*

Two fine specimens of this rare Gasteropod were taken at Station 2, 400 fath.

FUSUS GRACILIS, *Da Cost.*

Several specimens from Station 2.

SCAPHANDER LIGNARIUS, *Linn.*

Several specimens from 70 fath.

NUDIBRANCHIATA.

ARCHIDORIS TUBERCULATA, *Cuvier.*

Two small specimens from Station 8. Mr. Garstang has examined these and finds that they do not differ appreciably from specimens trawled in shallower water near Plymouth.

CEPHALOPODA.

OCTOPUS VULGARIS, *Lamk.*

Two small specimens.

ELEDONE CIRRHOSA, *Lamk.*

One young specimen.

LAMELLIBRANCHIATA.

PECTUNCULUS GLYCYMERIS, *Linn.*

Several specimens from 70 fath.

ASTARTE SULCATA, *Da Cost.*

A specimen from Station 2, 400 fath.

VENUS CASINA, *Linn.*

Station 1, 200 fath.

PINNA RUDIS, *Linn.*

Several specimens from 70 fath.

PECTEN OPERCULARIS, *Linn.*

Common in 70 fath.

PECTEN SEPTEMRADIATUS, *Müll.*

A single specimen from Station 2, 400 fath.

PECTEN TIGRINUS, *Müll.*

From Station 8, 70 fath.

CRUSTACEA. DECAPODA.

ATELECYCLUS HETERODON, *Leach.*

From 400 and 70 fath.

PORTUNUS TUBERCULATUS, *Roux.*

A single specimen. Station 7, 70 fath.

BATHYNECTES LONGISPINA, *Stimp.*

A single specimen of this rare species was taken in 400 fath.

XANTHO TUBERCULATUS, *Bell.*

Station 2, 400 fath.

ANAMATHIA CARPENTERI, *Norman.*

1873. ANAMATHIA CARPENTERI, *Norman.* In Wyville Thomson's Depths of the Sea, p. 175, fig. 35.
1883. SCYRAMATHIA CARPENTERI, *A. Milne Edwards.* Recueil de figures de Crustacés nouveaux ou peu connus, pl. ii.
1885. — — *G. O. Sars.* Norwegian N. Atlantic Expl. Expedit., 1876–8, Crustacea, p. 6, pl. i, figs. 1—7.
1886. ANAMATHIA CARPENTERI, *S. J. Smith.* Rep. Decapoda, "Albatross" Dredgings, p. 21.

Seven specimens from 400 fath.

Canon Norman sends me the following note :—" Mr. Pocock, in his recent paper on the trawlings of the 'Flying Fox,' says that he is not aware that this species had gained a right to be included in the

British Fauna; yet the type specimens, one of which was originally described in The Depths of the Sea, were distinctly recorded as having been dredged on the *Holtenia* ground off the Butt of Lewis."

INACHUS DORSETTENSIS, *Penn.*

LISPOGNATHUS THOMSONI, *Norman.*

1873. DORHYNCHUS THOMSONI, *Norman.* In Wyville Thomson's Depths of the Sea, p. 174, fig. 34.
1881. LISPOGNATHUS THOMSONI, *A. Milne Edwards.* Comptes Rendus, pp. 878 and 932.
1883. — — *A. Milne Edwards.* Recueil de figures de Crustacés nouveaux ou peu connus, pl. iii.
1883. — FURCATUS, *Smith.* Proc. Nat. Museum U.S., vol. vi, p. 18.
1886. — THOMSONI, *Smith.* Report Decapoda, "Albatross" Dredging, 1884, p. 18.

A single specimen from 400 fath. This species was also obtained in the "Flying Fox" expedition. Canon Norman sends me the following note:—"This species, like *Anamathia Carpenteri,* was figured in The Depths of the Sea as one of the inhabitants of the warm area off the Butt of Lewis, yet Mr. Pocock says that he was not aware that it had been recorded as a British species. Moreover, both species were again recorded from the same district in my report of the Crustacea of the 'Knight Errant' Expedition."*

STENORHYNCHUS TENUIROSTRIS, *M. Edw.*

EBALIA NUX, *Norman, MS.*

1880. EBALIA NUX, *Norman.* Notes on the French Exploration of "Le Travailleur" in the Bay of Biscay, Am. Mag. Nat. Hist. and Rep. Brit. Assoc., p. 387.
1883. — — (*Norman*), *Marion.* Annales du Musée d'Hist. Nat. de Marseille, vol. i, mém. 2, p. 36.
1883. — — (*Norman*), *A. Milne Edwards.* Recueil de figures de Crustacés nouveaux ou peu connus, pl. v.
1889. — — *Pocock.* Am. Mag. Nat. Hist., ser. 6, vol. iv, p. 426.

A single specimen was taken in 400 fath. The single specimen of the "Flying Fox" was taken in 315 fath. Canon Norman sends me the following notes on this species:—"Mr. Pocock seems to have been unaware that *Ebalia nux* had been admirably figured by Prof. A. Milne Edwards. The following is the distribution of the species as far as is known to me."

"'Porcupine,' 1869, Stations 1, 3, 6, 11, all off the west and south-west of Ireland, in 90 to 1630 fath.; also Station 46, lat. 59° 23′ N.,

* Proc. Royal Soc. Edinb., 1882.

long. 7° 4′ W., that is to the north-west of the Butt of Lewis, on the margin of the *Holtenia* ground, in 374 fath.

"'Porcupine,' 1870, Station 8, lat. 48° 13′ N., long. 9° 11′ W., 257 fath.; Station 10, off Cape Finisterre, 91 fath., Vigo Bay;* Station 13, off Cape Mondego, coast of Portugal, 220 fath.; Station 26, off south coast of Portugal, 364 fath.; and in the Mediterranean, off Cape de Gatt, 60 to 160 fath., and on the Adventure bank, 92 fath.

"'Travailleur' Expedition, 1880. In this expedition *Ebalia nux* was taken many times in the Bay of Biscay off the Spanish coast. My notes taken on board give me July 17th, 666 metres; July 23rd, 1107 to 1353 metres.

"'Travailleur,' 1881. In this year's expedition Prof. Milne Edwards reports it as again taken in the Bay of Biscay, and also in the northern part of the Mediterranean, 300 metres.

"'Flying Fox' and 'Research' trawlings off the south-west coast of Ireland. Profs. A. Milne Edwards and Marion courteously recognise my MS. name *Ebalia nux*, but if that is rejected it will stand as *Ebalia nux*, A. Milne Edwards."

PARAPAGURUS PILOSIMANUS, *Smith.*

1880. EUPAGURUS JACOBI, *A. Milne Edwards.* Études préliminaires sur les Crustacés, Blake Exped. in Bull. Mus. Comp. Zool., viii, p. 42.

Three specimens in old shells covered by *Epizanothus paguriphilus*, 400 fath. Dr. Norman informs me that the first evidence he had of the existence of this species in the Eastern Atlantic was that of a single arm dredged by the "Triton" Expedition in 1882, Station 13, lat. 59° 51′ N., long. 8° 18′ W., in 570 fath.; and this fragment he was enabled positively to identify by direct comparison with American examples. Its occurrence is now first recorded. He also calls my attention to the fact that the species was in the same year recorded by Prof. Milne Edwards (under the name *Eupagurus Jacobi*, M. Edw.) as having been dredged off the Spanish coast by the "Travailleur." Thus this recently described deep-sea Pagurid is already known to have a most extensive range—Guadaloupe, St. Lucia, Martinique, N.E. America; in the British area north-west of the Butt of Lewis and off the south of Ireland, also extending southwards to the coast of Spain.

EUPAGURUS METICULOSUS, *Roux.*

Several specimens in shells covered by *Polythoa incrustata* in 70 fath.

* So labelled, but probably one of the dredgings off Vigo Bay.

EUPAGURUS PUBESCENS, *Kröyer.*

EUPAGURUS CARNEUS, *Pocock.* Ann. Mag. Nat Hist., 6th series, vol. iv, p. 428.

This species was first taken by Mr. Green in the "Flying Fox." My single specimen, a female, was trawled in 400 fath. It inhabited a large shell of *Fusus gracilis.*

GALATHEA NEXA, *Emb.*
GALATHEA DISPERSA, *Bate.*
MUNIDA BAMFFICA, *Pennant.*

Stations 7 and 8, 70 fath.

PONTOPHILUS SPINOSUS, *Leach.*

A single specimen from Station 2, 400 fath.

ISOPODA.

ÆGA TRIDENS, *Leach.*

Single specimen, 200 fath.

AMPHIPODA.*

AMPHITHOPSIS LATIPES, *M. Sars.*
METOPA BRUZELII, *Goes.*
ERICTHONIUS DIFFORMIS, *M. Edw.*
MELITA OBTUSATA.
STENOTHOË MARINA, *Sp. B.*

COPEPODA.

ARTOTROGUS BOECKII, *Brady.*

A single specimen, 75 fath.

PANTOPODA.

PYCNOGONUM LITTORALE, *Ström.*

Several specimens from 200 and 70 fath.

POLYCHÆTA.

HERMIONE HYSTRIX, *Sav.*

Three specimens from 400 fath.

* Mr. A. O. Walker has kindly looked through and identified my small collection of Amphipoda.

LAGISCA RARISPINA, *Sars.*

70 fath.

AMPHITRITE CIRRATA, *Müll.*

70 fath.

HYALINŒCIA TUBICOLA, *O. F. Müll.*

70 fath.

DITRUPA ARIETINA, *Müller.*

NEMERTEA.

AMPHIPORUS LACTEUS ?

Station 7.

GEPHYREA.

PHASCOLION STROMBI, *Théel.*

POLYZOA.

SCRUPOCELLARIA SCRUPOSA, *Linn.*
CELLARIA SINUOSA, *Hassall.*
CELLARIA JOHNSTONI, *Busk.*
CELLEPORA RAMULOSA, *Linn.*
CELLEPORA DICHOTOMA, *Hincks.*

All the Polyzoa were taken in moderate depths (70 fath.).

ANTHOZOA.

ACTINAUGE RICHARDI, *Marion.*

From Stations 1 and 2, 200 and 400 fath.

CHITONACTIS CORONATA, *Gosse.*

Station 1, 200 fath.

ADAMSIA PALLIATA, *Forbes.*

Many specimens from Station 8, 70 fath.

EPIZOANTHUS PAGURIPHILUS, *Verrill.*

Three specimens of this species, which is here recorded for the first time, I believe, from English seas, were obtained at Station 2, 400 fath. They were associated with *Parapagurus pilosimanus.* Mr. Pocock, in the Report on the Crustacea of Mr. Green's expedition, says that the *P. pilosimanus* obtained were associated with an *Epizoanthus*, but no further mention is made of the latter, which may have been *E. paguriphilus*.

POLYTHOA INCRUSTATA, *Sars*.

Several specimens from Station 5, 70 fath. Associated with *Eupagurus meticulosus*.

POLYTHOA, sp. incert.

The difficulty of identifying the species of this genus from spirit specimens is so great that I have given up the attempt in this instance. The specimen obtained was from 90 fath. at Station 5.

HYDROZOA.

PERIGONIMUS ARENACEUS ?

Growing on a Fucus shell in 200 fath.

EUDENDRIUM RAMEUM, *Pall.*
TUBULARIA INDIVISA, *Linn.*
TUBULARIA CORONATA, *Abild.*
DIPHASIA PINASTER, *Ellis and Sol.*
SERTULARELLA GAYI, *Lam.*
AGLAOPHENIA MYRIOPHYLLUM, *Linn.*
ANTENNULARIA ANTENNINA, *Flem.*

With the exception of *Perigonimus*, all the Hydroids were trawled from moderate depths.

In addition to the trawling I made frequent use of the tow-net, but was somewhat hampered by the necessities of the cruise. At night we were anchored, and the tides were seldom strong enough to keep my net extended; during the day we were working rapidly along the lines of observation, when tow-netting was impossible, or we were trawling, when it was difficult. I did most of my work during the trawling, but whenever the paddles were moved—and they had to be moved pretty often to keep the ship's head up—I ran the risk of losing my net.

I was anxious to make a comparison between the surface fauna outside Plymouth and that at the entrance to the Channel, in order to settle the question whether there is a current setting in towards the Channel, and carrying the numerous southern and Atlantic forms which are from time to time taken on the south-west coast in an easterly direction. Such a current, if it existed, would be a part of

Reynell's current, but in fact it does not exist except as a surface current, due to prevalent westerly winds. This was shown both by the daily observations of Captain Aldrich with current logs, and by the contents of the tow-net. The current log showed that the tides cause a rotatory current moving in the same direction as the hands of a watch, and there is a tendency for the rotating stream to move very slowly eastward. The observations were still in progress when I left the ship, and will be published in another place by Captain Aldrich.

The surface fauna was quite different from anything that I have seen in the Channel. Going from Plymouth to Cork, we passed through shoals of *Aurelia*, but on our stations in the eleventh meridian W. not a single *Aurelia* was to be seen. On July 12th we passed through a shoal, miles in extent, of *Pelagia perla*, Haeckel, a form which I have never seen near Plymouth, and which is only at rare intervals cast ashore at Mount's Bay. Each day the net was full of *Salpa democratica-mucronata*, Forskäl, a form which I have never met with during two summers at Plymouth; and *Doliolum Ehrenbergii*, Krohn, of which only a few isolated individuals are to be found near Plymouth. Of the Copepoda certain ubiquitous species were plentiful enough (*Cetochilus septentrionalis, Clausia elongata, Dias longiremis, Centropages typicus, Oithona spinirostris*, and *Corycæus anglicus*), but more oceanic conditions were indicated by the relatively greater abundance of the first named. I obtained also a large number of *Ectinosoma atlanticum*, Brady and Robertson, a form which I have never seen in the neighbourhood of Plymouth. In addition to these I took two specimens of *Oncæa*, which I am satisfied belong to *Oncæa obtusa*, Dana, as figured by Brady in the "Challenger" Reports, and not to *O. mediterranea*, Claus, which I found near Plymouth in 1889.

The common oceanic Phyllopods *Podon* and *Evadne* occurred in great numbers, as also did *Hyperia galba*, Mont.; and there were a few Zoëa and Megalopa stages of Decapods, but these were far less numerous than in seas nearer land. *Tomopteris* was fairly common, but *Sagitta* was far less abundant than in the seas near Plymouth. On one occasion I obtained several very large *Bipinnaria* larvæ and several later stages in Asterid development. Together with these were Holothurian larvæ (probably of *H. tremula*), the tailed larvæ of *Doliolum*, and a single specimen of *Tornaria Krohnii*, a species which I had previously taken near Plymouth.

Of the Anthomedusæ the species common near the English shores, such as *Obelia, Lizzia*, and *Thaumantias*, were entirely absent, but on two occasions I captured large numbers of a very fragile and peculiar Medusa, of which I have been unable to determine the relations. It seems to be entirely destitute of either a manubrium or radial canals. A few specimens of *Arachnactis albida*, a form not uncommon at Plymouth, were taken in each catch.

Of Siphonophora I only obtained two species. One, a Monophysid which is sometimes found at Plymouth, seems to be *Muggiæa* (*Diphyes*) *Kochii*, Will.; the other is an Anthophysid. The latter broke into fragments in the process of preservation, and I cannot determine its species with accuracy. The palpons bear distinct conical eye-spots, which would point to its being a near ally of, if not identical with the *Athorybia ocellata* of Haeckel. I have never seen a member of the Anthophysidæ in the neighbourhood of Plymouth.

The absence of pelagic Radiolaria at Plymouth has often engaged my attention. In the "Research" I found the following well-known species in tolerable abundance:—*Thalassicolla nucleata*, Huxley; *Collosphæra Huxleyi*, J. Müller; *Sphærozoum punctatum*, J. Müller; *Acanthometron elasticum*, Haeckel. In addition to these were several species of *Ceratium*.

It is apparent from the foregoing that the surface fauna at the entrance to the Channel has a distinct facies, and is different from that nearer the shores of England. A more extended investigation of the surface fauna from the Channel to the Atlantic would probably yield some very interesting results. It may be found that many oceanic species are carried up in mid-Channel, as they are certainly cast ashore in some seasons near Brighton. I have noticed at Plymouth that there is generally a considerable difference between the shore tide and the Channel tide, the latter of which runs three hours later than the former. The Channel tide is almost invariably richer both in amount and variety of pelagic life. There is every reason to believe that the movements of mackerel and pilchards are largely influenced by the distribution of the pelagic fauna, and in proportion as we obtain a more extended knowledge of the latter we may expect to learn more of the still mysterious migrations of these fishes. During the cruise we saw on two or three occasions shoals of fish at a little distance from the ship; probably they were mackerel which were feeding on the abundant surface fauna. The sea, also, was full of the ova and larvæ of Teleostei. Most of the larvæ were Gadoids, but of what species it is impossible to say. Without a much more extended knowledge of facts it is impossible to assert anything about the relations of fishes and surface fauna, but it seems at least reasonable to suppose that the winter pilchards which strike on the south coast of Cornwall, fat and in excellent condition, have come from the rich feeding-ground afforded by the set of the Gulf Stream into the Bay of Biscay.

Addendum by the Rev. Canon Norman, D.C.L., F.L.S.

Solarium mediterraneum, *Monterosato.*

1873. Solarium Mediterraneum, *Monterosato.* Notizie intorno ai Solarii del Mediterraneo, p. 6, figs. 8, 9.

A single living specimen dredged in 400 fath., 50° 29′ 26″ N., 11° 4′ W.

In his "Porcupine" paper Jeffreys considers Monterosato's species to be a variety of *S. pseudo-perspectivum*, Brocchi (*S. discus*, Philippi). It may be so, but I prefer to retain Monterosato's name here because it indicates that the first specimen taken in the British seas is referable to that particular form. It is distinguished from *S. pseudo-perspectivum* as follows: The comparative height is somewhat greater, the umbilicus more contracted, the periphery more acutely keeled, and the mouth consequently more pointedly produced in the position of that keel. The upper surface is much smoother, presenting little trace of sculpture beyond a faint spiral line (the corrugated ribs of *pseudo-perspectivum* being absent); this under surface, on the other hand, is more sculptured, the exterior half of the whorl bearing about ten fine riblets, of which the outer two show some signs of corrugation. Height 7 mm., width 12 mm.

This is a second species of this genus added to our fauna. Two living specimens of *Solarium siculum*, Cantraine, were dredged by the "Porcupine," 1869, lat. 51° 1′ N., long. 11° 21′ W., in 458 fath.

The Mediterranean specimens with which I have compared the Irish specimen of *S. mediterraneum* are accurately represented by Philippi's figure of *S. discus*; but Brocchi's figure of *S. pseudo-perspectivum* represents a shell of which the upper surface is smooth or nearly so, and in this respect like *S. mediterraneum*, but it wants the riblets of the under surface characteristic of the latter form.

Family TURBINIDÆ.

Genus Leptothyra, *P. P. Carpenter, MS.* (Dall, 1871) = *Collonia*, Philippi (non *Collonia*, Gray, 1852) = *Homalopoma*, P. P. Carpenter, 1864 = *Leptonyx*, P. P. Carpenter, 1864 (non *Leptonyx*, Swain, 1821).

Dall, in his Report on the "Blake" Mollusca (Bull. Soc. Comp. Zool., xviii, p. 352), by a slip of memory says in a note, "The name *Homalopoma* was under consideration by Dr. Carpenter as a substitute for *Leptonyx*, but was never published by him." The fact is that *Homalopoma* was the first term used by him (*Supp. Report*

Mollusca West Coast of North America, in Brit. Assoc. Rep., 1863, p. 537); but at a subsequent page (652), when he characterises the genus, he substitutes the name *Leptonyx,* adding "genus = *Homalopoma,* p. 537, nom. preoc." I cannot find that this name has been used, but as no description was given under the name *Homalopoma* it may perhaps be best to retain the name which has been adopted by Dall.

LEPTOTHYRA BOURNEI, n. sp.

Shell shortly conical, whorls six, girt (except at the base) with numerous thread-like riblets, one of which is a little more prominent than the rest, and forms a keel; on the body-whorl there are six riblets below and three above the more prominent riblet; on the penultimate whorl there are four below and four above; no transverse—that is, vertical sculpture; apex rather blunt. Base convex, without any trace of umbilicus or umbilical chink. Shell very solid. Pillar lip slightly longitudinally channelled, the channel interrupted in the middle by a transverse depressed nodule. Colour white; interior of shell and umbilical region highly polished and nacreous with fine prismatic colouring. Operculum calcareous; external surface minutely granulated, rather sunken centrally, exhibiting no trace of spiral arrangement; internal surface chitinous, with central nucleus and multispiral (11—12) whorls, the outermost whorl rapidly enlarging. Lingual membranes have the lateral uncini extremely numerous, hamate; central teeth hamate, ten in number.* Length 18 mm., breadth 20 mm.

A single living specimen was dredged in 200 fath., 50° 50′ 15″ N., 11° 12′ 30″ W.

This is a fine shell, and the largest species known of the genus; its operculum closely agrees in character with that of the type (*L. sanguinea,* Linn.).

From *L. induta,* Watson (Report "Challenger" Gasteropoda, p. 128, pl. vi, fig. 1), it differs in the more shortly conical form, and in the total absence of the longitudinal "infra-sutural puckerings" and beaded riblets of the upper whorls; while, on the other hand, the spiral sculpture of the present form is much more developed. It comes much nearer to the shell described by Dall (*l. c.,* p. 352, pl. xxxviii, fig. 6) as *Leptothyra induta,* var. *albida,* but in that case the riblets are fewer in number but much more pronounced; and it may, I think, be questioned whether Dall's variety is really referable to Watson's species.

* The mounting is not very good, but I am unable to discover the usual central tooth. In that position there seems to be a gap, on either side of which are five teeth.

Notes on the Echinoderms collected by Mr. Bourne in Deep Water off the South-west of Ireland in H.M.S. "Research."

By

F. Jeffrey Bell, M.A., Sec. R.M.S.

Mr. Bourne has been good enough to submit to me most of the interesting specimens of Echinoderms which he obtained during his short stay on board H.M.S. "Research." Coming so soon after the important collection made by the Rev. W. S. Green in neighbouring waters and at greater depths, it will, I think, suffice for me to treat this collection as an appendix to that, and to refer for a general discussion of such points as appeared worth noting to my report in the Annals and Magazine of Natural History for December last.

The great interest of Mr. Bourne's collection lies in the remarkable way in which the depths of some of our more common shallow-water species is increased, in some cases indeed to a remarkable extent; see the cases of *Stichaster roseus, Asterias rubens, A. glacialis,* and *Spatangus purpureus.*

The species which were observed on board ship, but which were not preserved, are indicated by an asterisk.

A list of Mr. Bourne's stations is given on p. 306.

Asteroidea.

Pontaster tenuispinis, *D. and K.*

Taken at several stations from 90 to 400 fath.

*Psilaster Andromeda, *M. Tr.*

Station 2.

*Luidia ciliaris, *Phil.*

Stations 5 and 7.

PORANIA PULVILLUS, *O. F. M.*

Station 7.

*PALMIPES PLACENTA, *Penn.*

Stations 7 and 8. The range given by Mr. Sladen for this species is 2—100 fath.; but, as he also remarks that the "Porcupine" specimens are without exact locality or conditions, it is well to have a definite statement for British specimens.

STICHASTER ROSEUS, *O. F. M.*

Station 1. The depth—200 fath.—is an advance by 150 on any yet recorded.

*ASTERIAS RUBENS, *Linn.*

Stations 1, 5, and 8. Mr. Bourne calls my attention to the depth of 200 fath.; Mr. Green did the same for his depth of 100 fath. This considerable increase in the range of these two species is significant.

*ASTERIAS GLACIALIS, *O. F. M.*

Station 5. The range of this species is increased from 66 to 90 fath.

BRISINGA CORONATA, *Sars.*

Fragments only.

OPHIUROIDEA.

OPHIOCTEN SERICEUM, *Forbes.*

Station 2.

OPHIOPHOLIS ACULEATA, *Linn.*

Station 7. Young specimens.

OPHIOTHRIX PENTAPHYLLUM, *Penn.*

Stations 1 and 5. Mr. Bourne, I notice, has labelled these specimens *O. Luetkeni.* Before long I hope to be able to marshal the evidence regarding the variability of *O. pentaphyllum* which is in my possession in such a way as to justify the doubts which Sir Wyville Thomson always had as to the distinctness of *O. Luetkeni.*

Ophiobyrsa hystricis, *Lym.*

It seems very probable that the remarkable Ophiurid to which I refer in the introduction to my report on Mr. Green's collection belongs to this species, but a close and extended investigation is required. Mr. Bourne's specimen is from Station 2.

Echinoidea.

Cidaris papillata.

Stations 2, 3, and 4.

Echinus acutus, *Lamk.*

Station 8.

*Echinus esculentus, *Linn.*

Station 6.

Echinus norvegicus, *D. and K.*

Station 2. This species was not collected by Mr. Green, and I am very glad to be able to put it with those collected by him.

Spatangus purpureus, *O. F. M.*

Stations 1, 2, 4, 5, 8; very abundant 1, 2, 4. I should, after what I have been able to see of the variations of this species and of *S. raschi*, been particularly pleased had all the Spatangi from more than 100 fath. been preserved. In suggesting the possibility of intercrossing between the two species I felt I was going beyond my record for the time, inasmuch as I had not then evidence that *S. purpureus* lived at depths as great or greater than 100 fath.

Holothurioidea.

Holothuria tremula, *Gunner.*

Stations 1, 2, 4, 8.

NOTE.

Besides the Echinoderms above described I obtained three Asterids which appeared to me to be very similar to *Nymphaster protentus*, Sladen, described by Sladen in the "Challenger" Report of the Asteroidea. But as I thought that I could distinguish some differences in my specimens, I sent them to Mr. Sladen for examination before I had thought of sending the whole collection of Echinoderms to Prof. Bell. Hence they do not appear in the above report.

Mr. Sladen writes to me as follows:—"The two star-fishes you sent are very fine examples of *Nymphaster protentus,* which I described in the Report 'Challenger' Asteroidea. They are larger than the type. One differs in having occasionally a small pedicellaria on the marginal plates like those on the abactinal plates. Their presence in your specimens is probably due to age. The second specimen differs in having a small spiniform granule, the largest about 1 mm. in length, on the infero-marginal plates on the inner two thirds of the ray, and a similar but smaller granule on a few of the innermost supero-marginal plates, not more than five or six being present in each interbrachial arc. This is to the eye a striking difference, but I do not consider it to be essentially of any great importance. I therefore shrink from ranking the example as a distinct variety of *Nymphaster protentus* on the basis of a single specimen, for the character in question is one subject to much variation in other forms, and may be sexual." Since I received this letter Canon Norman has called my attention to the fact that *Nymphaster protentus,* Sladen, is, in its younger condition, indistinguishable from *Pentagonaster subspinosus* of the "Blake" Expedition described by Perrier in 1884 (*Mém. sur les Étoiles de mer recueilles dans la mer des Antilles et le Golfe du Mexique,* Nouv. Archiv. du Muséum d'Hist. Nat., ser. 2, tom. vi, p. 234, plate vi, fig. 1). Perrier's specific name must therefore be adopted, and the range of the species is thus considerably extended. By the "Blake" Expedition it was dredged in 163—209 fathoms, off Havana, Barbadoes, and Cariacon; by the "Challenger" at Station 3, south-west of the Canary Islands, lat. 25° 45′ N., long. 20° 14′ W., 1525 fath.; by the "Flying Fox" off the south-west of Ireland in 315 fath., and by the "Research." For a description of the "Flying Fox" specimens, described as *Nymphaster protentus,* see Prof. Bell's paper, Ann. Mag. Nat. Hist., ser. 6, vol. iv, p. 434.

G. C. B.

Anchovies in the English Channel.

By

J. T. Cunningham, M.A., F.R.S.E.

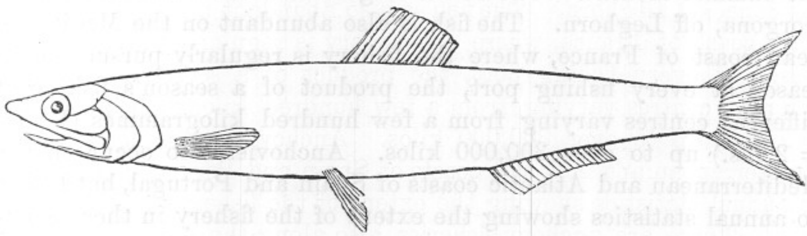
I. Natural History of the Anchovy.

The anchovy belongs to the same family of fishes as the herring, pilchard, and sprat, the family Clupeidæ. But whereas the herring, pilchard, and sprat have so many structural features in common that they are placed in a single genus, namely *Clupea*, the anchovy is in many respects so peculiar that it is placed in the distinct genus *Engraulis*. There are many species of *Engraulis* in various parts of the world, but only one on the coasts of Europe, and that one, commonly known as the anchovy, is called by zoologists *Engraulis encrasicholus*. The origin of these names dates back to a very early period. Both are used by ancient classical Greek authors. The derivation of ἐγγραυλίς is not known; ἐγκρασίχολος is derived from χόλος, bile, and ἐγκράσις, infusion, and was given to the fish on account of its bitter flavour; the name means infused with bile, the taste of the fish suggesting to the ancients that its flesh was infused with bile. It is stated in Yarrell's British Fishes, and in Day's more recent work on the same subject, that the anchovy was in old times said to have its gall in its head. This statement is evidently derived from erroneous interpretations by mediæval zoologists of the name *encrasicholus*. In the French translation of Rondelet's work *Des Poissons*, published at Lyons in 1558, livre vii, chap. iii, it is stated that anchovies " sont nommés Encrasicholi à cause qu'ils ont le fiel en la teste." This shows that Rondelet derived the word from ἐν and κράς, the head; the dative singular of κράς is κράτι, and the dative plural κράσι: the root is κρατ, and the word if thus derived would have been ἐγκρατίχολος. The derivation I have previously given from ἐγκράσις is that given in Liddell and Scott's Greek Lexicon, and is doubtless correct.

The derivation of the modern word anchovy, which under various forms occurs in a number of modern European languages, has not been satisfactorily traced. In the most recent philological English dictionary two derivations are given, but neither seems in the least degree probable. According to Diez the Italian *acciuga* is derived from a Latin word *apya*, which is altered from *aphya*, and this represents the Greek ἄφυη. This last word was applied to small fishes, which may have included the anchovy. The "ga" of the Italian word Diez considers as a suffix. In many Italian dialects the name is *anjova* or *anjoa*. Another theory is that the Spanish *anchova* is derived from the Basque name *anchoa*, which is identified with *antzuia*, meaning dry; so that anchovy means the dried fish. But there is no evidence that anchovies were used in the dried state. It seems more probable that the modern names are all derived from an unknown Latin name.

The identification of the fish called *encrasicholus* by ancient Greek authors with the anchovy is, according to Rondelet, proved by the fact that the modern Greeks in his time still called it *encrasicholus*.

Mediæval naturalists continued to call the species *encrasicholus*. Linnæus placed it in his system as *Clupea encrasicholus*, and Cuvier afterwards removed it to the position it now holds in a separate genus under the name *Engraulis encrasicholus*.



The anchovy is at once distinguished from any species of *Clupea*, from a herring, pilchard, or sprat, by the large and peculiar mouth. The depth of the gape in the anchovy is very large in proportion to the size of the fish. In the species of *Clupea* the angle of the mouth is below the middle of the eye; in the anchovy the angle of the mouth is a long way behind the eye, farther behind the eye than the eye is from the end of the snout. In the species of *Clupea* the apex of the upper jaw is at the end of the snout, so that the mouth is terminal; in the anchovy the mouth is on the lower side of the head as in a shark, and the snout projects forwards beyond the jaws. In the species of *Clupea* when the mouth is opened the lower end of the maxillary bone is drawn forwards, so that the sides of the gape are closed; in the anchovy the maxillary bone does not move in this way, and when the mouth is opened the sides of the long gape are open. The fins of the anchovy are very similar to those of the species of *Clupea*; there is a single dorsal fin as in all

Clupeidæ, and a single somewhat long anal fin. The dorsal fin is at the centre of the back; the pelvic fins are inserted in front of the dorsal fin, as in the sprat; the pectoral fins are close behind the gill openings. The gill openings are very large, their upper angles extending almost to the dorsal edge of the head. There is nothing very remarkable about the scales; they are rather larger than those of the herring, and, as in most Clupeoids, are very deciduous: there are no keeled scales along the ventral edge. The skin is much more delicate than that of any species of *Clupea*, and the flesh also in the fresh state is very tender, though when salted it has considerable firmness. The fish never exceeds 8 inches in length; Risso gives the maximum at Nice as 2 decimetres, or $7\frac{7}{8}$ inches, and Mr. Dunn says he has obtained it 8 inches long off the coast of Cornwall. But 5 to 6 inches is the more usual length. Those I have obtained from the south coast of England are from 5 to $5\frac{1}{4}$ inches long.

The range of distribution of the anchovy extends from the Mediterranean to the south coast of Norway and the entrance of the Baltic. It is common on both sides of the Italian peninsula, and at all the Italian fishing centres there is a regular anchovy fishery in the summer months. One of the largest fisheries is at the island of Gorgona, off Leghorn. The fish is also abundant on the Mediterranean coast of France, where the fishery is regularly pursued in its season at every fishing port, the product of a season's fishing at different centres varying from a few hundred kilogrammes (1 kilo. = 2 lbs.) up to over 300,000 kilos. Anchovies also occur on the Mediterranean and Atlantic coasts of Spain and Portugal, but I have no annual statistics showing the extent of the fishery in these countries. There are anchovy fisheries also along the Atlantic coast of France, on the coast of the Bay of Biscay. In the French official statistics we find that at Bayonne in 1884 the total catch of anchovies was 30,000 kilos.; and at Quimper, at the northern end of the Bay of Biscay, the catch in the same year was 683,000 kilos. On the Channel coast of France anchovies are not mentioned in the French official statistics among the products of the fisheries, and I have found no mention of any anchovy fishing on the coast of Belgium. But on the Dutch coast there is a regular anchovy fishery in the estuary of the Schelde and in the Zuyder Zee. The annual catch in the Zuyder Zee according to the Dutch official statistics varies from 2000 to 100,000 *ankers*, an anker containing 50 kilos.

On the coasts of the British Islands no anchovy fishery has ever been carried on, but the species has long been known to occur on these coasts, especially on the south coast of England. It was first recorded in England by Ray, who obtained specimens from the estuary of the Dee. Donovan, in his British Fishes, published in 1804, gives a figure of the anchovy, and states that he possessed a specimen caught a few years previously on the coast of Hampshire. According to Day, Mr. Peach obtained it from the herring nets off Wick; and there is one in the Newcastle Museum found in 1834 among sprats in the Durham market. It is frequently taken in the stow-nets in the river opposite Lynn, in Norfolk. It has also been recorded from the coast of Essex and the mouth of the Thames. Mr. Dunn, as quoted by Day, says that it is quite a common fish in the autumn from Polperro to Falmouth. The same observer informed Day, and he has also stated the same to myself, that in November, 1871, he witnessed the capture of at least 150,000 in a pilchard seine at Mevagissey; these were sold for almost nothing as manure. In Wales it has been recorded off Glamorganshire, and as abundant in some seasons at Swansea. It has also been taken on the Irish coast. Couch, in his *Fishes of the British Islands,* vol. iv, published in 1864, gives a figure and a chapter on the anchovy. I cannot do better than quote what he says on the subject:—"In the westmost portion of the British Channel these fish are often taken in drift-nets employed in the fishery for herrings and pilchards; but this is only when they are sufficiently large to become entangled in the meshes as these chance to be doubled together; and there is sufficient evidence to show that if nets of finer twine, with meshes of proper size, were employed, sufficient might be taken on the coast of Cornwall to supply the full amount of what is consumed in our own country, the whole of which, as sent to us from the Mediterranean, has been so much as, with a tax on the importation of twopence in the pound, to bring into the Exchequer year by year the sum of £1764. As regards the time when these fish are near us, I have met with an example in March from the stomach of a mackerel; in summer they are found at St. Ives, in the ground seans employed in catching launce."

The mode of reproduction and development of the anchovy was first ascertained by a Dutch zoologist, K. F. Wenckebach, in 1886. The investigation was carried out at the Zoological Station of the Nederlandsche Dierkundige Vereenigung (Dutch Zoological Association) established in the summer of that year at Nieuwediep, which is on the west side of the entrance of the Zuyder Zee. Prof. C. K. Hoffmann had previously ascertained that the anchovies in the Zuyder Zee were sexually ripe in the months of June and July, that the eggs taken from the ripe ovaries were of oval form, about 1 mm. long and perfectly transparent; but he had not succeeded either in finding fertilized eggs undergoing development in the natural conditions, nor in artificially fertilizing them. Wenckebach inferred from the transparency of the eggs that they were probably pelagic, and developed while suspended in the surface waters of the sea. He therefore tried to obtain the developing eggs in the beginning of July, 1886, from the surface of the sea by means of a fine surface tow-net, and at once succeeded. He found that the floating eggs of the anchovy were to be found in July all over the Zuyder Zee. The eggs hatched at the end of the third day after fertilization, but unfortunately Wenckebach does not mention the temperature of the sea from which the eggs were taken nor the temperature of the water in which they were kept under observation. The egg is distinguished by the following characters: the form is, as already mentioned, oval or sausage-shaped, and about 1 mm. in length; this is alone sufficient to distinguish it, for no other pelagic fish egg is known which has an elongated oval form. The whole of the yolk is divided up into a number of polygonal segments, in which respect the anchovy's egg resembles that of the pilchard,* and there are no oil-globules. The blastoderm is situated at one end of the egg, and the larva when hatched is without pigment and extremely transparent, like that of the herring and pilchard.

The Italian zoologist, Dr. Fed. Raffaele, found the ova of the anchovy abundant in the Gulf of Naples from May to September. According to Wenckebach the ova are not to be found in the Zuyder Zee after July 19th, so that we may infer that the period of reproduction lasts longer at Naples than in Holland—in the former extending through the months of June, July, and August, in the latter only through June and the first half of July. Raffaele says that hatching took place after two or three days, but he also neglects to give the temperature of the sea in which the eggs develop.

We have now to consider the conditions of life of the anchovy.

Like other Clupeoids it is a truly pelagic fish, a fish which lives and feeds entirely in the open waters, having no direct relation to the bottom or the shores of the sea. It feeds on other pelagic creatures, probably chiefly on Copepods and other pelagic Crustacea. It swims in shoals, and the shoals are constantly moving about. The important point is to obtain some evidence as to the extent and periods of the movement of the shoals. The theory of the great annual migration of the herrings has been generally abandoned, but we still occasionally find the view expressed that the anchovies which are found every year in the Schelde and the Zuyder Zee travel thither from the Atlantic Ocean through the English Channel and the North Sea. For instance, Professor Ewart, in a letter published in the *Times* on January 21st of the present year, calling attention to the fact that anchovies were caught in considerable numbers in the Moray Firth in December last, says, "Perhaps further inquiries may show that the migration northwards of the

* See my paper on *Teleostean Ova* in this Journal, New Ser., No. 1, 1889.

anchovies is in some way related to the mildness of the winter. It is most desirable to ascertain whether the anchovies have reached the Moray Firth with the warm Atlantic water that during western winds rushes through the Pentland Firth, or by travelling along the east coast through the cold Arctic water that wells up from the bottom in the vicinity of the Dogger Bank." I am inclined to think that further inquiries will show that the anchovies in the Moray Firth come neither the one way nor the other, but that these fish are permanent residents in the North Sea.

The migration theory receives some apparent support from the fact that the anchovy fishery in Holland takes place in the summer months, namely May and June, while the anchovies have only been taken on the south coast of England in the winter, from November to January. But, on the other hand, as we have seen above, anchovies breed in summer from May to September at Naples, and doubtless at other places of the Mediterranean coast of Europe. It is exceedingly improbable that the anchovy should breed only at the extreme north and the extreme south of its range, and not at any intermediate point. Are we to believe that all the anchovies which live in the Mediterranean breed near the north coast of that sea, and never migrate beyond the Straits of Gibraltar, and that all the anchovies which live in the Atlantic Ocean travel to Holland to shed their eggs? Or are we to suppose that all the anchovies after breeding migrate to the ocean, and when the spawning period returns half of them travel to Holland to breed, and the other half enter the Mediterranean and shed their eggs there? Risso, in his *Ichthyologie de Nice* (1810), states that some anchovies reside constantly at the mouth of the Var, while others come in to the neighbourhood of Nice regularly as migrants.

It is probable that the anchovy will be found to breed in summer on all the coasts where it occurs. This has not yet been ascertained—in fact, I have not yet succeeded in finding whether the fishery for anchovies on the west coast of France takes place in summer or in winter. Ripe anchovies have, however, been obtained on the west coast of England. Mr. Jackson, of Southport, on June 9th, 1878, took some dozens in a shrimp trawl off that place, which were distended with ripe ovaries. I have not been able yet to obtain any information concerning the natural history of anchovies, or the anchovy fisheries on the coasts of Spain and Portugal.

Some extremely interesting researches have been carried out by the Dutch zoologist Prof. C. K. Hoffmann,* on the rate of growth of

* *Contributions to our Knowledge of the Life-history and Reproduction of the Anchovy.* Published as Appendix II to the Verslag van den Staat der Nederlandsche Zeevisscherijen over 1885. 'S Gravenhage, 1886.

the anchovy in the Zuyder Zee, and the relation of the temperature of the water to the abundance of the fish and the success of the fishery in different summers. Prof. Hoffmann shows from a comparison of the variations of summer temperature, and of the product of the anchovy fishery from 1857 to 1885, variations which he exhibits graphically by curves in carefully constructed diagrams, that a high temperature in one summer is followed by a large catch of anchovies in the *following* summer. He finds that the anchovy grows very rapidly, and that the reason of the fact just stated is, that in a warm summer more young anchovies are produced than in a cold one, and these returning to the Zuyder Zee in the following year, when they are already adult, afford the fishermen a heavy spoil. The young anchovies are hatched in June, and by October, according to Hoffmann, have reached the length of $4\frac{3}{4}$ inches.

II. The Prospects of an Anchovy Fishery in England.

In November, 1889, paragraphs in various newspapers stated that the fishermen of Dover and Deal had been catching large numbers of anchovies in their nets, and had thrown them overboard through ignorance of their nature and value. Professor Lankester instructed me to go to Dover and make inquiries into this matter, as it seemed to him advisable to ascertain whether anchovies could be regularly obtained in English waters, and if so, to endeavour to establish a trade in them which would benefit both the fishermen and the community generally. Accordingly I went to Dover, and found that the fish believed to be anchovies had been caught by the sprat-fishermen. The nets used at that place for the capture of sprats are drift nets containing sixty-four meshes to the yard, that is, meshes about half an inch square. These nets are worked by open boats rigged with mainsail, foresail, and mizen, the mast being moveable. The nets are usually shot about a mile from the shore near the Admiralty Pier, towards the end of the flood tide, and they drift eastwards. Sprats are only caught in autumn and winter, chiefly in November and December. I was told that some boats had obtained at one shot 4000 sprats and 1000 anchovies. One man said he had seen anchovies among the sprats every winter, but never in such abundance as last season. I was unable to get any specimens of the anchovies on this occasion at Dover, for the sprat-fishing was temporarily suspended; some men had tried for them during the previous week, but had caught none. The reason of this, according to the fishermen, was that the weather was too quiet and the water too clear, so that their nets were visible on account of the phosphorescence on them in the water. They said that the best weather for their fishing was a moderate south-west breeze, because then the water was "thick." However, from the description given by both the fishermen and a dealer whom I consulted, there could be no doubt that the fish called anchovies were really of that species.

I sent a letter to the *Times* describing the results of my visit to Dover, and giving a summary of what is stated in books on fish and fisheries concerning the distribution of anchovies, the condition of the anchovy fishery in various countries, and the occurrence of the fish in English waters. At the conclusion of my letter I asked for information concerning the capture of anchovies at any other parts of the English coast. This letter was published on December 12th, and the *Times* commented on it in a leading article, calling attention to the importance of the attempt to start a regular anchovy-fishery in England.

Among the letters I received in response to my public appeal for information the most important was one from Mr. Whitehead, of Torquay, who informed me that large quantities of anchovies had for some weeks before the date of his letter, December 13th, been taken among the sprats in Torbay. He could not say what proportion the anchovies bore to the sprats, but he noticed in one lot that about one fifth consisted of the former; he did not send me any specimens. On January 3rd, 1890, I received some actual specimens in spirit from Mr. Whitehead, together with another letter, in which he said that they were still being taken in the proportion of one fifth anchovies to four fifths sprats. These specimens placed beyond doubt the identity of the fish described by Mr. Whitehead as anchovies. They were genuine anchovies, and it was thus proved that during last November, December, and January a large quantity of anchovies were landed at Torquay. I shall discuss subsequently the question of what was done with these anchovies.

As Mr. Dunn, of Mevagissey, Cornwall, had previously noted the capture of anchovies at that place, I wrote to him on December 13th asking if any had been taken there this season, and if he could send me specimens. In reply he very kindly sent me eight specimens in spirit, and a letter saying that anchovies were plentiful off that part of the coast in the autumn of every year, that this season they had been present during the three previous months, but that very few were usually caught, only a few being occasionally meshed in the pilchard-nets; the greatest catch amounted to only about a dozen specimens, because the mesh of the pilchard-nets was too large, and the anchovies were only taken in parts of the nets which got entangled. It is evident that the capture of a few specimens in a pilchard-net indicates that the anchovies are present in the sea in large numbers.

In consequence of Mr. Dunn's information I inquired on December 17th of the pilchard-fishers at Plymouth if they ever caught anchovies, and they answered that they frequently caught a few specimens, but always threw them away. They promised in future to bring me all they caught. About the same time I borrowed a sprat drift-net and arranged to have it shot by our own men from our own boat, both inside and outside the Sound, thinking that a sprat-net, having a smaller mesh, might catch more anchovies than the pilchard-net.

As the result of my application to the Plymouth pilchard-fishers a number of anchovies taken in pilchard-nets in the neighbourhood of the Eddystone were brought to me in December, 1889, and January, 1890. These were brought in lots of from one to six specimens at a time. But I caught no anchovies in my sprat-net, from which it may be inferred that anchovies occur off Plymouth at some distance from land, about the Eddystone, but not in the inshore waters either inside the Sound or immediately outside it. The nearest places from which I got specimens were the south side of the Mewstone and a mile or so south of Penlee Point.

It was thus evident that although anchovies might possibly in the future be caught by suitable nets in marketable quantities off Plymouth and Mevagissey, that at the time they were actually landed in marketable quantities only at Torquay. I wrote to Mr. Whitehead at the beginning of January asking him to get me 5000 anchovies and send them to me at Plymouth, where I arranged with an Italian fish-curer to have them cured. But, unfortunately, fishing operations were entirely suspended during nearly the whole of the month of January by continuous stormy weather. On January 29th, when moderate weather at last set in, I went to Torquay to procure if possible a considerable quantity of anchovies. I found there that sprats were not taken with drift-nets as at Dover and Deal, but in large seines worked by means of several boats, one of them, into which the net is drawn, being a large barge-like boat moored in shallow water. The purse of a seine of this kind consists of very small meshes, so that it is impossible that any anchovies escape through the net; the net is as well adapted for catching anchovies as for catching sprats, and the two kinds of fish are caught in the net together. I saw one of these seines worked, and about a dozen bushels of sprats were taken in it, but among them were very few anchovies; I picked out about a dozen, but the total number was too small to make it worth while to sort the two kinds completely. I was told by the fishermen that in the past season as many as thirty bushels of anchovies had been caught at one haul of the seine.

On January 15th I had a letter from a gentleman at Sidmouth asking me to send him some specimens of anchovies in order that he might ascertain whether the fish called by the local fishermen "Caplin," and caught together with sprats, were of that species. I sent him specimens, and he found that the so-called Caplin were anchovies.

On January 21st Professor Cossar Ewart, in a letter in the *Times*, stated that at the end of the previous December anchovies were abundant in the Moray Firth off Troup Head, on the east coast of Scotland, and had been caught in considerable numbers in the herring nets of the Buckie fishermen.

It is evident from these facts that anchovies were during last winter present in large numbers off the south coast of England, from Dover to Mevagissey, and apart from the question whether they could be taken in marketable quantities by the use of nets not now actually in use, it is a fact that they have been taken in marketable quantities at various places by means of nets regularly used every winter for the capture of sprats. The question, therefore, presents itself, why should these anchovies have been wasted while large numbers of imported anchovies are sold in this country at high prices? For these anchovies were practically wasted. When mixed with sprats at Torquay they are usually sold with them at the ordinary price of sprats, and the buyers object to them because they cause the sprats to "turn off." At Dover they were either thrown away or sold with the sprats unsorted. The average price paid to the fishermen for sprats at Torquay is 4*s*. a bushel. Anchovies may not be so plentiful every winter as they were last winter, but even if they only occurred at all once in five years or so, they might nevertheless be used in the proper manner instead of being sold as sprats. For anchovies when properly preserved are a valuable delicacy and always fetch a high price. In order to try to create a market for English anchovies I wrote a letter to the *Times*, which was published about January 10th, asking the importers of foreign anchovies into England whether any of them would be willing to purchase English anchovies. But I did not receive a single answer. I then wrote to Messrs. Burgess and Son, the Strand, London, who supply the English market with the most esteemed anchovies and anchovy preparations. They replied that if I sent them some English anchovies they would report upon them. Accordingly I sent them a few of the fish from Torquay on January 30th, and they reported that such fish would be perfectly useless to them for any of their manufactures. I then called at the warehouse and found that the firm imported all their anchovies from Gorgona preserved in brine, and that they had not found the size and flavour of the Torquay anchovies equal to those of the Gorgona fish.

I also wrote to Mr. Dunn, who is connected with a fish-curing factory at Mevagissey, and he told me that he had been trying experiments on them, but the results were still to be proved. He did not say whence he got the anchovies, but when I was at Torquay on January 30th I was told by a fish-buyer there that he had sent some barrels of anchovies to Mr. Dunn, who was willing to take more, but at that time no more could be got.

I have also examined the different preparations of anchovies sold in England. Anchovy sauce and anchovy paste could be made from English anchovies as well as from imported. Entire anchovies in brine are sold in small bottles; a bottle of those prepared by Burgess and Son costs 10½d. and contains about seventeen fish. French anchovies prepared in Paris are also sold in England. These are preserved in oil and put up in smaller bottles than Burgess's Gorgona anchovies; each bottle contains a smaller weight of fish, but the price is the same. The individual French anchovies are smaller than Burgess's and no larger than those I have obtained at Plymouth and Torquay. Then there is another kind of preserved fish sold as "Norwegian anchovies." These are small fish packed in little wooden barrels, and preserved in salt and bay leaves and pepper. When I was at Torquay, Mr. Slade, who kindly assisted me greatly in my inquiries there, told me that these "Norwegian anchovies" were not anchovies at all. I had never looked at them myself, so I bought a barrel and examined its contents, and to my surprise found that the fish it contained were nothing but sprats. All the fish in the barrel were of the same kind, all were without exception of the species *Clupea sprattus*. I paid 1*s*. 9*d*. for this barrel and found it contained 111 sprats weighing 2 lbs. 5 oz. Fresh sprats are sold retail in England at 1*d*. per lb. I bought another barrel in Plymouth and examined its contents with the same result. So here we have the curious anomaly that at Torquay genuine anchovies are caught and wasted, while sprats brought from Norway are being sold at about 8*d*. per lb. These barrels of "Norwegian anchovies" are labelled merely "Finest selected, C. L. & S." The contents are not otherwise described. But, as far as I understand the Merchandise Marks Act, goods imported into this country must now be labelled with a true and accurate description of their character, and I hope the proper authorities will not be long in compelling the Norwegian exporters to label their pretended anchovies as sprats. When that is done there will be more prospect of obtaining a sale for genuine English anchovies.

It seems to me that the creation of a trade in English anchovies lies with Mr. Dunn, of Mevagissey. His energy and experience will enable him without difficulty to prepare anchovies in such a way as to make them as palatable if not more so than Gorgona or French anchovies. I therefore advise all fish buyers in future who meet with anchovies at Torquay or elsewhere to communicate with Mr. Dunn. Other manufacturers will follow Mr. Dunn's lead, and the time may come before long when anchovies will be sought with special nets along the whole south coast, instead of being taken as now accidentally along with sprats. The anchovies imported by Burgess and Son from Gorgona are somewhat larger than the English specimens I have seen, but I do not believe they have any real superiority in quality. I have eaten the English anchovies boiled in the fresh condition and found them delicious, and I have no doubt that when salted they would be as good as the Italian or French fish. Dutch anchovies are sent in the salted condition to Germany, Belgium, and other countries, but not to England.

NOTES AND MEMORANDA.

Probable Relation between Temperature and the Annual Catch of Anchovies in the Schelde District (with Pl. XXIV).—Mr. C. J. Bottemanne, of Bergen-op-Zoom, the Inspector of Fisheries for Holland, has expressed in tables published *in extenso* in the Verslag omtrent den Toestand der Visscherijen in de Schelde en Zeeuwsche Stroomen for 1888, some very interesting statistics which have been condensed in Pl. XXIV of this journal. The temperature observations were made on the Rinkelaar guardship of the Ijerseke Bank of the Eastern Schelde (see Map, Pl. XXI) ; the amounts of the annual catch are taken from the official returns. It appears probable from these statistics that *the extent of the catch of anchovies in the Schelde district in any year is (at least largely) dependent on the temperature of the water during the midsummer months of the preceding year.* The curves in Pl. XXIV exhibit the temperature on the Ijerseke Bank during the months June to September from 1883 to 1888, the shaded blocks below them represent graphically the mass of anchovies *taken in the succeeding year, i. e.* 1884—1889 (the figures in the bottom line placed after the year indicate the total number of barrels). The only apparent exception is 1886, but, though the highest recorded temperature of this year is not great, the mean temperature in July to September was extremely and unusually high, as will readily be seen in the diagram. As an example of the valuable information which scientific observers may give to those interested in fisheries, Mr. Bottemanne, on receiving the statistics of temperature for 1888, warned the fishermen of the district last year not to go to trouble or expense about the anchovy fishery ; they persisted, however, and justified his advice by realising 12 barrels as against 730 barrels of the previous year.

Even more convincing, because more complete, are the observations made in the Zuyder Zee on the same point, which are tabulated in the Verslag van den Staat der Nederlandsche Zeevisscherijen for 1885 by Prof. Hoffmann, and extend over twenty-eight years, from 1857 to 1885 ; they entirely bear out the same conclusions as those made in the Schelde district.—G. H. FOWLER.

Halosphæra viridis, Schmidt.—This marine alga was found here last spring. It has been observed at Naples, but its life-history is very imperfectly known. It consists of a hollow sphere from a quarter to half a millimetre in diameter, the inner surface of which is covered by a thin layer of protoplasm containing numerous chlorophyll granules embedded in it, and a large nucleus which is surrounded by a mass of protoplasm free from chlorophyll. These spheres float in great numbers close to the surface of the sea, and are carried about by the waves, having no motion of their own. F. Schmitz, the only observer who has recorded any observations on them, states (Mittheil. aus d. Zool. Stat. zu Neapel, Bd. i, 1879) that these spheres always make their appearance at Naples in January or February and remain till June, when they disappear. During that time he observed repeated division of the nucleus to take place, accompanied by spindle formation, as the result of which the contents of the sphere are converted into a large number of daughter-cells consisting each of a nucleus surrounded by a mass of protoplasm, to which the chlorophyll, now diffused, gives a dense green colour. These daughter-cells adhere to the wall of the sphere, which consists of two envelopes, an outer and an inner. The outer one bursts, and the inner one gradually dissolves away, setting free a number of zoospores to which the daughter-cells above mentioned have meanwhile given rise by subdivision. These zoospores are conical cells furnished with a pair of cilia springing from the basal end of the cell. They swim about freely. Beyond this their history has not been traced. Our knowledge of its development is thus insufficient to enable us to determine the systematic position of Halosphæra. Specimens found at Plymouth were sent up to London for examination in April last, but owing to defective conditions it was not possible to keep them alive long enough for observation. I hope an opportunity may be found of studying them under more favorable circumstances next spring.—HERBERT THOMPSON.

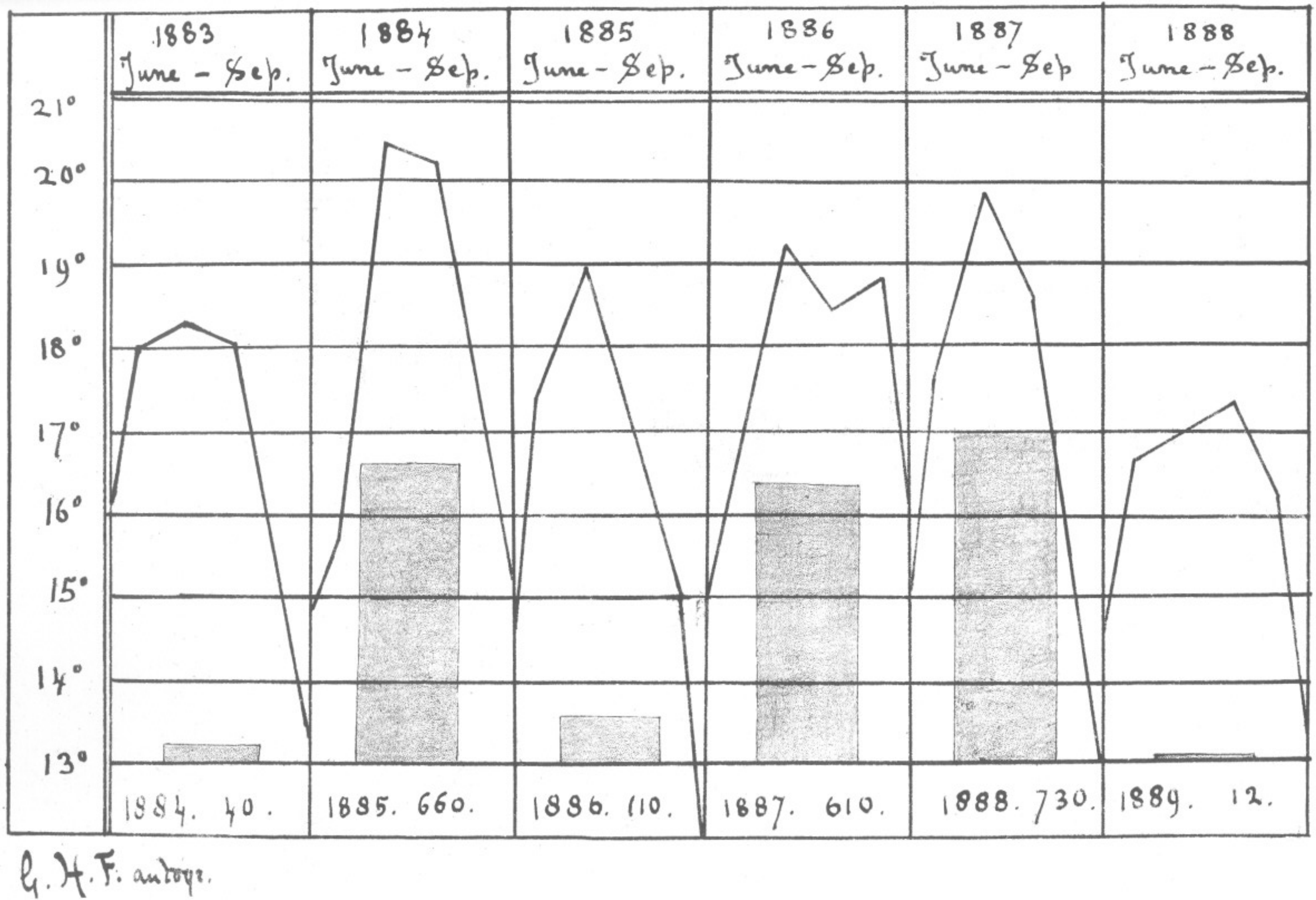


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Plate XXIV.

PRICE LIST OF ZOOLOGICAL SPECIMENS.

THE following specimens suitable for class purposes and dissection are kept in stock at the Plymouth Laboratory, and may be obtained at short notice on application to the Director. Except where otherwise stated in the list, all specimens will be forwarded in alcohol; but those marked with an asterisk can be sent fresh if required, in which case the prices will be correspondingly reduced.

BOTANICAL CLASSES also can be supplied at short notice with fresh specimens of the commoner marine Algæ, *e. g. Ulva, Cladophora, Porphyra, Ceramium, Callithamnion, Polysiphonia, Gigartina, Rhodymenia, Pycnophycus, Cystoseira, Fucus, Halidrys, Laminaria, Himanthalia.*

			s.	*d.*
Protozoa.				
Amœboidea	various, fresh only	per tube	0	6
Thalamophora	,, ,,	,,	0	6
Heliozoa	,, ,,	,,	0	6
Ciliata	ZOOTHAMNIUM and others, fresh only	,,	1	0
Rhynchoflagellata	NOCTILUCA	,,	1	0
Porifera.				
Calcarea—				
Homocœla	*LEUCOSOLENIA *botryoides*, Bow.	,,	1	0
Heterocœla	*GRANTIA *ciliata*, Johns	,,	0	9
	compressa, Flem	,,	0	9
Non-calcarea—				
Cornacuspongiæ	HALICHONDRIA *panicea*, Johns.	per spec.	1/—2	0
Spiculispongiæ	SUBERITES *domuncula*, Ndo.	,,	1	0
	CLIONA *celata*, Grant	,,	1	0
	OSCARELLA *lobularis*, Schmidt	,,	1	0
Hydrozoa.				
Hydroidea gymnoblastea	SYNCORYNE *eximia*, Allm.	per tube	1	0
	EUDENDRIUM *ramosum*, L.	,,	1	0
	*MYRIOTHELA *phrygia*, Fabr.	,,	2	0
	TUBULARIA *indivisa*, L.	,,	1/—2	0
	larynx, Ellis	,,	1/—2	0
(Anthomedusæ)	SARSIA, LIZZIA, BOUGAINVILLEA, SYNCORYNE	,,	1	0
Hydroidea calyptoblastea	OBELIA *geniculata*, L.	,,	0	6
	dichotoma, L.	,,	1	0
	HALECIUM *Beanii*, Johns.	,,	1	0

			s.	*d.*
Hydrozoa.				
Hydroidea calyptoblastea...	SERTULARELLA *Gayi*, Lmx.........	per tube	1	0
	polyzonias, L......	„	1	0
	*SERTULARIA *pumila*, L.............	„	0	6
	AGLAOPHENIA *tubulifera*, Hincks	„	1/—2	0
	ANTENNULARIA *antennina*, L.,	per colony	1/—3	0
	ramosa, Lmk.	„	1/—3	0
	*PLUMULARIA *setacea*, Lam.	per tube	0	6
(Leptomedusæ)	OBELIA, THAUMANTIAS	„	1	0
Discomedusæ	AURELIA *aurita*, M. Edw...........	each	/3—2	0
	**hydra-tuba & ephyræ*...	per tube	1	0
Stauromedusæ..................	HALICLYSTUS *octoradiatus*, Clark (LUCERNARIA *auricula*, Johns.),	per doz.	3	0
Anthozoa.				
Zoantharia	*ACTINIA *mesembryanthemum*, Ell.,	each	/3—2	0
	*ANEMONIA *sulcata*, Penn............	„	/3—1	0
	*ADAMSIA *palliata*, Bohad...........	„	/6—2	0
	Rondeletii, D. Ch........	„	1/—2	6
	*TEALIA *crassicornis*, Müll...........	„	/3—2	0
	*BUNODES *gemmaceus*, Ell...........	„	/3—1	0
	*POLYTHOA, sp.........................	„	/6—2	0
Madreporaria	*CARYOPHYLLIA *Smithii*, Johns. ...	„	/6—1	6
Alcyonaria	ALCYONIUM *digitatum*, L....	per colony	2/—3	6
	GORGONIA *verrucosa*, Pall....	„	2/—3	6
Ctenophora.				
	HORMIPHORA *plumosa*, Ag..........	per tube	1	0
Turbellaria.				
	*LEPTOPLANA *tremellaris*, Müll....	„	2	0
Nemertea.				
	LINEUS *marinus*, Mont.	each	/6—3	0
	AMPHIPORUS *pulcher*, Müll.	per tube	1	6
	TETRASTEMMA, various sp.	„	1	6
Polychæta.				
	*NEREIS *pelagica*, L..................	„	1	0
	EUNICE *sanguinea*, Au. and Edw.	„	1	0
	*EULALIA *viridis*, Oerst.	„	1	0
	*LEPIDONOTUS *squamatus*, L......	„	1	6
	HERMIONE *hystrix*, Kbg.	„	1	6
	*CIRRHATULUS *tentaculatus*, Mont.	per tube	2	0
	*ARENICOLA *piscatorum*, Lam.	each	0	3
	CHÆTOPTERUS, sp.	each	1	0
	SABELLARIA *spinulosa*, Leuck......	per tube	1	0
	*POLYCIRRHUS *aurantiacus*.........	„	2	0
Gephyrea.				
	THALASSEMA *Neptuni*, Gaertn.	each	1	0
	PHASCOLION *strombi*, Theel	„	1	0
Hirudinea.				
	PONTOBDELLA *muricata*, Risso	„	0	6
Chætognatha.				
	SAGITTA *bipunctata*, Q. and G......	per tube	0	6

			s.	d.
Arthropoda.				
Cladocera	Evadne *spinifera*, Kr.	,,	0	6
	Podon *intermedius*, Lilljbg.	per tube	0	6
Copepoda	Cetochilus *septentrionalis*, Goodsir	,,	0	6
	Dias *longiremis*, Lilljbg.	,,	0	6
	Anomalocera *Patersonii*, Tmpltn.	,,	0	6
	Harpacticus *fulvus*, Fischer	,,	0	6
	Corycæus *anglicus*, Lubbock	,,	0	6
	Caligus, sp.	,,	0	6
Cirrhipedia	Lepas *anatifera*, L.	per bottle	2	6
	Scalpellum *vulgare*, Leach	per tube	1	0
	Balanus *Amphitrite*, Darw.	,,	1	0
	Chthamalus *stellatus*, Ranz.	,,	1	0
Amphipoda	*Gammarus *locusta*, Fabr.	,,	0	6
	*Orchestia *littorea*, Mont.	,,	0	6
	Caprella *linearis*, Latr.	,,	0	6
Isopoda	*Idotea *emarginata*, Fabr.	,,	0	6
	tricuspidata, Desm.	,,	0	6
	Ligia *oceanica*, Linn.	,,	1	0
	Bopyrus *squillarum*, Latr.	each	1	0
Schizopoda	Mysis, various sp.	per tube	1	0
Leptostraca	*Nebalia *Geoffroyi*, M. Edw.	,,	1	6
Cumacea	Various	,,	1	6
Decapoda macroura	*Palæmon *serratus*, Penn.	each	0	4
	Pandalus *annulicornis*, Leach	per tube	1	0
	*Crangon *vulgaris*, Fabr.	,,	1	0
	*Homarus *vulgaris*, Edw.	each	2/6—5	0
	*Palinurus *vulgaris*, Latr.	,,	2/6—10	0
Decapoda anomoura	Galathea *strigosa*, Fabr.	,,	1	0
	various sp.	per tube	1	0
	Pagurus **Bernhardus*, Linn.	each	0	6
	Prideauxii, Leach	,,	0	4
	cuanensis, Thomp.	,,	0	4
	**lævis*, Thomp.	per tube	1	0
Decapoda brachyura	*Carcinus *mœnas*, Linn.	each	0	4
	*Cancer *pagurus*, Linn.	,,	1/—5	0
	*Portunus *depurator*, Leach	,,	0	3
	puber, Linn.	,,	0	4
	*Stenorhynchus *tenuirostris*, Bell	,,	0	3
	*Porcellana *longicornis*, Penn.	per tube	1	0
	platycheles, Penn.	per doz.	1	0
Pantopoda	Pycnogonum *littorale*, Müll.	,,	1	0
	Phoxichilus *spinosus*, Mont.	,,	1	0
	Nymphon *gracile*, Leach	,,	1	0
Mollusca.				
Gasteropoda.				
Polyplacophora	*Chiton, various sp.	per tube	1	0
Streptoneura zygobranchia.	*Patella *vulgata*, Linn.	per doz.	2	0
	Helcion *pellucidum*, Linn.	per tube	1	0

			s.	d.
Mollusca.				
Gasteropoda.				
Streptoneura azygobranchia.	*TROCHUS *cinerarius*, Linn.	per tube	1	0
	zizyphinus, Linn.	per doz.	2	0
	*LITTORINA *littorea*, Linn.	per tube	1	0
	rudis, Mat.	,,	0	6
	*BUCCINUM *undatum*, Linn.	each	0	6
	*NASSA *reticulata*, Linn.	per tube	1	0
	incrassata, Ström.	,,	1	0
	*PURPURA *lapillus*, Linn.	per doz.	1	0
Euthyneura opisthobranchia.	APLYSIA *punctata*, Cuv.	each	0	9
	DORIS *tuberculata*, Cuv.	,,	0	6
	bilamellata	per tube	1	6
	GONIODORIS *nodosa*, Mont.	,,	2	0
	ÆOLIS *papillosa*, Linn.	each	1	0
	coronata, Forbes	,,	0	6
	rufibranchialis, John.	,,	0	6
Scaphopoda	DENTALIUM *entalis*, Linn.	per tube	2	6
Cephalopoda.				
Decapoda	*SEPIOLA *atlantica*, D'Orb.	,,	2	0
	LOLIGO *Forbesii*, Stp.	each	1/—3	0
Octopoda	*ELEDONE *cirrhosa*, Lamk.	,,	2/—4	0
Lamellibranchiata.				
Isomya	*CARDIUM *edule*, Linn.	per doz.	1	6
Heteromya	*MYTILUS *edulis*, Linn.	,,	2	0
Monomya	*OSTRÆA *edulis*, Linn.	each	0	8
	*PECTEN *maximus*, Linn.	per doz.	3	6
	opercularis, Linn.	,,	2	6
Polyzoa.				
Entoprocta	PEDICELLINA *cernua*, Pallas	per tube	2	6
Ectoprocta.				
Cheilostomata	BUGULA *plumosa*, Linn.	,,	1	0
	turbinata, Alder	,,	1	0
	*SCRUPOCELLARIA *reptans*, Linn.	,,	1	0
	MEMBRANIPORA *pilosa*, Linn.	,,	0	6
	ALCYONIDIUM *gelatinosum*, Linn.	,,	1	0
	*FLUSTRELLA *hispida*, Fabr.	,,	1	0
Ctenostomata	BOWERBANKIA *imbricata*, Adams	,,	1	0
Cyclostomata	*CRISIA *eburnea*, Linn.	,,	1	0
	IDMONEA *serpens*, Linn.	,,	0	6
Echinodermata.				
Crinoidea	*ANTEDON *rosacea*, Linck	per doz.	3	0
Asteroidea	*ASTERIAS *rubens*, Linn.	each	0	6
	glacialis, Linn.	,,	0	6
	*ASTERINA *gibbosa*, Penn.	per doz.	1	6
Echinoidea	ECHINUS *esculentus*, Penn.	each	1	0
Ophiuroidea	OPHIOTHRIX *fragilis*, Müll.	per doz.	2	6
	OPHIOGLYPHA *lacertosa*, Penn.	,,	2	6

			s.	d.
Echinodermata.				
Holothuroidea	HOLOTHURIA *nigra*, Peach.	each	1	6
	CUCUMARIA *frondosa*, Gunner	„	0	6
	OCNUS *brunneus*, Forbes	per tube	1	6
	PLUTEUS, AURICULARIA, and BIPINNARIA larvæ	per tube	2	0
Chordata.				
Urochorda.				
Ascidiæ simplices	ASCIDIA *scabra*, O. F. M.	„	1	6
	aspersa, O. F. M.	per doz.	2	6
	PHALLUSIA *mamillata*, Cuv.	each	1	6
	STYELA *grossularia*, Van Ben. (LARVÆ),	per tube	2	6
Ascidiæ sociales	CLAVELLINA *lepadiformis*, O. F. M.	„	2	6
Ascidiæ compositæ	BOTRYLLUS, various sp.	per colony	1	6
	LEPTOCLINUM *gelatinosum*, M. Edw.	„	1	6
	MORCHELLIUM, sp.	„	2	0
Eucrania.				
Elasmobranchii	ACANTHIAS *vulgaris*, Risso	fresh, each	0	4
		in spirit „	0	8
	SCYLLIUM *canicula*, Cuv.	fresh „	0	4
		in spirit „	0	8
	RAIA *batis*, Linn.	fresh „	1/—2	0
		in spirit „	2/—10	0
	clavata, Linn.	fresh „	1/—2	0
		in spirit „	2/—8	0
Teleostei	GADUS *pollachius*, Linn.	fresh „	0	6
		in spirit „	1/—2	0
	morrhua, Linn.	fresh „	0	9
		in spirit „	1/—3	0
	PLEURONECTES *platessa*, Linn.	fresh „	0	6
		in spirit „	1/—2	0
	LABRAX *lupus*, Cuv.	fresh „	2	0
		in spirit „	3/—4	0

It must be understood that the above does not pretend to be a complete list, even of the commoner species procurable at Plymouth. A more extensive list is given in No. II (old series) of this Journal. Reference may also be made to special reports on different groups published in this Journal, and application for any particular British species should be made to the Director.

The prices quoted include spirit and ordinary bottles, but not large jars and packing cases. The cost of carriage by rail will not be prepaid except on request, and in that case will be charged for in the account.

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 on 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 MARINE BIOLOGICAL 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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NOTICE.

The Council of the Marine Biological Association wish it to be understood that they do not accept responsibility for statements published in this Journal, excepting when those statements are contained in an official report of the Council.

Persons desirous of joining the M. B. A. can do so on application to the Director, The Laboratory, Citadel Hill, Plymouth. Members pay One Guinea annually, or a Composition Fee of Fifteen Guineas for Life Membership. Founders pay £100. Governors (Life-Members of Council) £500. Members of the Association have the following rights and privileges: they elect annually the Officers and Council; they receive the Journal of the Association free by post; they are admitted to view the Laboratory at Plymouth, and may introduce friends with them; they have the first claim to rent a place in the Laboratory for research, with use of tanks, boats, &c., and have access to the books in the Library at Plymouth.

All letters and other correspondence should be addressed to the Director, the Laboratory, Citadel Hill, Plymouth.

For a statement of the objects and organization of the Association, see page 3 of the wrapper.