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Experiments and Observations made at the Plymouth Laboratory.

By

J. T. Cunningham, M.A.

I. Diagnostic Characters in Flat Fishes.

One of the objects of zoological study is to ascertain more completely and more accurately the peculiarities by which one kind of animal (species, variety, genus, &c.) is distinguished from another. The advance of our knowledge in this direction depends on the more minute examination and more accurate distinction of known forms, the examination of larger numbers of specimens from familiar localities, and the examination of specimens from localities previously unsearched. There is scarcely any family so thoroughly investigated that it does not yield new discoveries on a renewed examination of more abundant material. It is found possible to recognise finer distinctions, and so split up one species into several, or convert what was considered a species into a genus. New material—that is to say, examination of a large number of specimens—often shows, too, that distinct species are more or less connected by intermediate forms. But in all this work the part played by these minute peculiarities in the life of the animal usually receives little attention. It is not the object of systematic zoology to ascertain the uses of characters, or to explain their origin. These objects require different methods, and are usually pursued by different investigators. But among the various methods employed there is one which has seldom, if ever, been followed—that of surveying the various characters of different grades,—specific, generic, family, &c. —in order to find whether it is possible to trace a connection between them and the habits of the animals which exhibit them, and generally to consider how far the principles which have been suggested in explanation of the evolution of species are applicable to the diagnostic characters of a particular family. On the present occasion I propose to consider the family of flat fishes. This Journal is, I think, not the place for a paper entirely devoted to developing arguments or presenting evidence in support of particular views or conclusions of a theoretical character. Therefore, although my inclination to certain views may be obvious in the following remarks, I have no desire to press these views on this occasion; but my object is merely to describe certain observations and studies I have recently made, and to point out what an immense field of interesting inquiry is afforded in the relations and development of those characters by which the subdivisions of a single family of fishes are distinguished.

My own observations have been for the most part confined to British specimens of the family of flat fishes; and for a general survey of the characters throughout the family, and their relations to one another, I shall rely chiefly on a valuable paper by the American ichthyologists, Jordan and Goss, published in 1889.* Certain kinds of flat-fish are distinguished by the fact that the dorsal and ventral fins are prolonged on to the lower side of the body at the base of the tail, the attachments of these accessory portions being transverse to the axis of the body. One of the fish that present this character is not uncommon round all the coasts of Britain; at Plymouth specimens are frequently obtained, either in the Sound in summer, or on more distant grounds. This is the *Zeugopterus punctatus* of Collett, the *Muller's topknot* of Couch, *Rhombus hirtus* of Yarrell. The chief other characteristics of this fish are its almost rectangular shape, the posterior region of the body being much broader and less triangular than in other flat fishes, the roughness of the upper side of the body, due to the character of the scales, and the presence of a large foramen in the septum between the gill-cavities. The great breadth of the body posteriorly is due partly to the breadth of the body proper, partly to that of the dorsal and ventral fins, in which the fin-rays are longest near the posterior end, so that the outer edges of the fins form a straight line transversely across the base of the tail. The snout is obtuse, and the trunk and dorsal fin rise steeply behind it, giving

* *A Review of the Flounders and Soles (Pleuronectidæ) of America and Europe*, by David Starr Jordan and David Kop Goss; Rep. U.S. Fish Commission for 1886 (1889).

the rectangular form anteriorly. The scales are short from before backwards and broad transversely; the exposed portion is short, and projects outwards from the skin at an angle with the embedded portion; at the edge is a single row of spines, of which the central one is considerably the longest. These spines are not of the same length in all the scales, but longer ones occur at scattered points over the skin.

Only two other kinds of flat fishes are known in which what may be called subcaudal finlets are present; or, to put the same fact in other words, the fishes in which this character is present are separated by other differences into three species. The other two are *Zeugopterus unimaculatus*, Steenstrup, and *Zeugopterus norvegicus* (Günther). The former is distinguished by the fact that the first ray of the dorsal fin is produced into an elongated filament, while in the latter this character is wanting, and the pelvic fins are separate from the ventral, not united with it as in *punctatus*. The other specific characters consist in minor differences in the generic characters themselves. The perforation of the branchial septum exists also in *Arnoglossus megastoma*, commonly called the megrim at Plymouth; and in consequence of this Steenstrup included this species with the three previously mentioned in the genus Zeugopterus. But as this last species does not possess the subcaudal prolongations of the dorsal and ventral fins, nor the other characters which unite the first three, it is best to confine the name Zeugopterus to these three species.

The three species of Zeugopterus, then, have what may be described as a continuous distribution. No two of them are geographically separated, and they have not been found anywhere beyond a limited region on the coast of Europe. All three occur on the British coasts. *Punctatus* is, as has been stated, frequently taken in Plymouth Sound; it occurs all along the south coast of England, and also on the east coast. It has been taken on the east coast of Scotland as far north as the Orkneys, on the west coast of Scotland in the Firth of Clyde, and on the east coast of Ireland. Northward the species extends to the north coast of Norway, southward to the northern shores of France, but it is absent from the Mediterranean. *Norvegicus* is likewise a northern form, not ranging to the Mediterranean. I have taken several specimens at Plymouth: one specimen was taken during the survey of fishing grounds on the west coast of Ireland, 1891–2; three specimens have been taken in the Clyde. It is somewhat rare on the Scandinavian coasts. *Unimaculatus*, on the other hand, is a Mediterranean form, occasionally but rarely taken on British and northern coasts. I have never obtained a specimen at Plymouth. On the south-west coast of Scotland it is more abundant than at any other part of the British coasts, several specimens having been taken in Loch Fyne and the Firth of Clyde. It has been taken on the coast of Denmark, but not on that of Norway.

Peculiar habits, differing from those of other flat fishes, have been observed in living specimens of two species of Zeugopterus, namely, *punctatus* and *unimaculatus*. The fish are seen in aquaria to be nearly always adhering to the vertical sides, remaining in one place for a long time, and keeping themselves suspended in this way in a vertical position without any difficulty. Other flat fishes occasionally assume this position, but are unable to retain it for more than a few seconds or minutes. This habit was studied by the late Mr. George Brook, F.Z.S., who described his observations in two papers.* In the first of these he refers only to *Zeugopterus unimaculatus*, of which he took several specimens in Loch Fyne in a small sandy bay. They usually adhered to the sides of the tank in which they were placed, although found on this sandy ground overgrown with Zostera or sea-grass. The body was slightly raised from the glass with the lower surface of the unpaired fins tightly pressed against it. A current of water is stated to have passed from the branchial chamber of the lower side along the space between the body and the glass and out behind, this current being caused by a rapid vibratory movement of the accessory portions of the dorsal and anal fins. The accessory portions of the fins appeared, therefore, "to be specially constructed to aid in the respiratory function." In his later paper Brook states that he was inclined to think he laid too much stress on the action of the accessory flap. "The basal portions of the vertical fins are kept in constant motion, but this motion is more vigorous in the rays immediately in front of the tail than in the accessory flaps situated underneath it." Brook did not attempt to explain the method by which the fish was enabled to adhere to the glass or other vertical surface and maintain itself in a vertical position.

My own observations in the Plymouth Laboratory have been made on *Z. punctatus*, and my object was to ascertain what force kept the fish in a vertical position against a vertical surface, and how the force was produced. The fish lives well in confinement, and is not timid or violent in its movements when disturbed. It is not difficult, therefore, to guide it to the glass front of the tank and persuade it to adhere there, so that observations and experiments can be made with it. It was evident that the adhesion of the fish was not produced by ordinary sucker action—in other words, by hydrostatic pressure, because the space beneath the body was freely open to the outside water in front dorsally

* *Ichthyological Notes*, Fourth Ann. Rep. Scot. Fishery Board; *Notes on the British Species of Zeugopterus*, Proc. Roy. Phys. Soc. Edinb., Session 1886–7.

and ventrally to the head. The posterior parts of the fin-fringes were in constant motion, moving in a series of vibrations from before backwards, together with the part of the body to which they were attached, and the effect of this motion was to pump out the water from the space between the body and the glass, its place being supplied by water which entered in front. The subcaudal fin-flaps were perfectly motionless, and tightly pressed between the base of the tail and the surface of the glass, so that any movement of them was impossible. The question arose, however, whether the tail and these flaps formed a small sucker which helped in the adhesion. To test this I removed the flaps with a snip of the scissors, an operation which caused very little pain to the fish, and it adhered afterwards quite as well as when the flaps were in their natural condition. The subcaudal flaps are therefore certainly not necessary to the adhesion, nor to the pumping action of the muscles and fins, which went on as before. It seemed probable, therefore, that the pumping action was itself the cause of the adhesion. But the difficulty in accepting this view was that there was a distinct though gentle respiratory movement of the jaws and opercular flaps; and if the pumping of the water from beneath the body caused a negative pressure there, and a positive pressure on the outer side of the body, it seemed equally certain that the respiratory movement must force water into the space beneath the body, and so cause a positive pressure there which would tend to force the fish away from the glass. The currents of water were now examined by means of the suspended particles in the water, and by putting carmine from a pipette at any spot at which it was desired to see the rapidity and direction of the flow. Particles were seen to pass in at the mouth and out at the lower respiratory orifice, but particles and carmine were also seen to pass into the space beneath the body above and below the head without passing through the respiratory channel. It was, therefore, satisfactorily proved that the amount of water pumped out in a given time at the sides of the tail was greater than the amount passed in anteriorly by the respiratory movements; and considerably greater, for the velocity of the stream above and below the snout as shown by the movement of the particles of carmine was by no means insignificant. It follows that the pumping action of the fins, continually withdrawing water from the space between the body and the surface to which it is applied, causes a negative pressure greater than the positive pressure due to the respiratory movements, and this keeps the body pressed against the vertical surface sufficiently to prevent its falling. The negative pressure is continually being neutralised by the water entering in front, and therefore the pumping action must be constantly kept up, as it is observed to be.

The direct resistance which prevents the fish from falling under the action of gravity is, of course, friction; but unless there was some force to press the fish against the solid surface there would be no friction. In testing the currents with carmine it was seen to pass in at the mouth and out at both gill openings and nothing was observed which indicated a special part played by the perforation of the gill-septum.

To test the validity of the explanation I had arrived at concerning the adhesion of the fish, I constructed a model in the following manner. I took a rectangular piece of flexible thin sheet india rubber. In the middle of each of the shorter sides I fastened, by a few stitches of sewing cotton, a short piece of glass tubing. On to one of these pieces I adjusted a long piece of rubber tubing. I placed the apparatus in a tank, bringing the tubing out over the edge of the glass front, and allowing it to act as a siphon, drawing water out of the tank. While the siphon was running I placed the india-rubber flap gently against the glass inside the tank under water, and it remained adhering to the surface. The front piece of glass tube now represented the respiratory channel of the fish, and above and below it were apertures between the front of the tank and the rubber flap, representing the apertures above and below the snout in the case of the fish. The action of the siphon represented the pumping action of the muscles and fins in the fish. There was nothing in the model to represent the respiratory movements of the fish, but that does not invalidate the comparison. When the siphon was stopped by pinching the rubber tubing outside the tank, the rubber flap fell away from the glass and sank slowly to the bottom of the tank. I think with this confirmation the evidence I have now given in support of my explanation of the adhesion of the fish to vertical surfaces is amply sufficient. I have observed that when other kinds of flat-fish cling to the vertical surface of the glass front of an aquarium they move the posterior parts of the unpaired fins in the same way as Zeugopterus, but these parts of the fins and the muscles adjacent being less developed, the action is neither so powerful nor so long maintained.

There can be little doubt that the explanation above given applies to *Z. unimaculatus*, in which the habit of adhesion was observed by Brook, as well as to *Z. punctatus*. It probably applies also to *Z. norvegicus*, but I have not yet ascertained whether this species has the same habit. We do not know at present whether there are any other important differences in mode of life between Zeugopterus and other genera,—such, for instance, as kind of food. We know that these flat fishes are not entirely confined to rocks, but are also found on sandy bottoms with other flat fishes. There is no doubt that when adhering to a rock, one of these fishes accommodating its colour to that of the rock surface is well concealed from observation, and in this way its habit is an advantage to it, just as the habit of covering itself with sand is of advantage to a sole. But according to the present state of our knowledge the only generic character which is necessary to the peculiar habit is the great development of the posterior muscles and fins, which is the chief factor in the characteristic shape of the body. It is possible that the roughness of the upper surface, due to the spines of the scales, adds to the concealment of the fish by aiding in the resemblance to a rock surface. But no use has yet been found for the subcaudal prolongations of the fins or the perforation of the gill-septum.

With regard to the specific characters, nothing is known of peculiarities in mode of life which would give an importance in the struggle for existence to the concrescence of the pelvic fins with the ventral in *punctatus,* to the absence of this character and the elongation of the first dorsal ray in *unimaculatus,* or to the absence of both characters in *norvegicus.* No use is known, in fact, for any of the other specific characters, of which a brief review may be here given. The characters tend to form a series. Thus, in size, *norvegicus* is smallest, *unimaculatus* larger, and *punctatus* largest, the last reaching a length of 8½ inches. The subcaudal fin-flaps are least developed in *norvegicus;* most in *punctatus;* each has four rays in *norvegicus* and *unimaculatus,* six in *punctatus.* The shortening and spinulation of the scales are greatest in *punctatus,* least in *norvegicus.* In *punctatus* there are teeth on the vomer, in *unimaculatus* none, in *norvegicus* they are very small.

According to the studies of Jordan and Goss, the flat fishes form three well-marked sub-families, including the most numerous and important forms, and sundry other sub-families of less importance. These three are those whose familiar British representatives are the turbot, the plaice, and the sole; they may be called the Rhombinæ, Pleuronectinæ, and Soleinæ. I do not follow the American authors in their application of the names. The Rhombinæ have the following principal distinguishing characteristics.

The body is sinistral. The mouth is symmetrical, the dentition nearly equally developed on both sides, and the teeth acute. Pectorals and pelvics usually well developed, and the pelvics asymmetrical, that of the left or eyed side inserted on the extreme edge of the abdomen, its rays more or less wide apart; that of the right side inserted on the right side. Caudal fin rounded or subtruncate. Vertebræ in moderate or small number. Species chiefly tropical or subtropical.

It is to this division that Zeugopterus belongs. The nearest relative of Zeugopterus is certainly the megrim, which has the perforation in the gill-septum. This fish was united with Zeugopterus by Steenstrup, with Arnoglossus by Day. Günther places it as a sub-genus of Rhombus, with the name Lepidorhombus, and in my opinion it is best to separate it altogether under this name. The only other species of the genus is *Lepidorhombus Boscii.* I do not know whether the latter has a perforated gill-septum, but think it probable. The chief characters of Lepidorhombus are the very large mouth, thin body, and skin with little pigment and ciliated deciduous scales. *Citharus linguatula*, Günther, closely resembles the megrim, but has unequal teeth, and is destitute of the perforation of the gill-septum. Arnoglossus is a fairly well-marked genus, of which several species have been described, but only two (*laterna* and *Grohmanni*) are definitely known to myself. The scales are small and feebly ciliated, very deciduous, the skin also being very thin and weak, so that it is easily torn and detached. The mouth is comparatively small, much smaller than in Lepidorhombus. The fish are of somewhat small size. The presence of secondary sexual characters must be regarded as characteristic of this genus, some of the anterior median fin-rays being elongated in the male. All these forms are confined to the coast of Europe. Two species from deep water in the Gulf of Mexico have been assigned to Arnoglossus, but there is little probability that they rightly belong to it.

Rhombus is a genus which is distinct from all those above mentioned. It has a broad, usually strong body, with a thick skin; a broad interorbital area, whereas in the preceding forms it is narrow, and scales small, cycloid, or wanting. The mouth is large and the jaws strong; the teeth small, in bands, and nearly equal. The specific differences consist chiefly in the character of the dermal armature. In the brill (*Rhombus lævis*) the scales are cycloid and imbricate on both sides of the body, and there are no bony tubercles; the anterior rays of the dorsal are somewhat prolonged and much branched. In the turbot (*Rhombus maximus*) there are no scales, but bony tubercles scattered over the upper surface, absent on the lower; and the anterior dorsal rays are not prolonged, or distinguished in any way. These two are confined to Europe; on the American coast of the Atlantic there is a species resembling the brill called *R. maculatus*, known commonly as the window-pane, from its thinness. It is scaled on both sides, and the anterior rays are more prolonged than in the European brill. Transitional forms between the brill and the turbot have long been known, and were originally described as a separate species under the name *R. mœoticus* by Pallas in Zoogr. Ross. As. in 1811. Specimens from the Black Sea have been frequently described since, and they seem to be more abundant there than elsewhere. Steindachner (Ichth. Berichte, 1868) states that a complete series of gradations between the ordinary turbot, in which the scales are obsolete, and the scaly turbot, which is more or less completely scaly, is to be observed. He obtained one of the most completely scaled specimens from the Baltic. Whether these specimens are to be regarded as variations, a variety, or as hybrids, we do not know. If they breed true, so that a scaled specimen is derived from scaly parents, then they form a variety, but this seems unlikely; it seems more probable that scaled forms occasionally develop from ordinary parents.

Another interesting genus in the Rhombinæ closely allied to Rhombus is Rhomboidichthys, called Platophrys by Jordan and Goss. In this genus the scales are small and ctenoid, and not deciduous. The interorbital space is very broad, and the peculiar position of the dorsal eye gives a curious appearance to the fish. There is a slight difference between the sexes, the pectoral of the left or upper side being filamentous in the male. Many species have been described from the West Indies and east coast of South America, and one from the Pacific coast.

It is unnecessary at present to refer to any of the remaining genera or species of the Rhombinæ which are less known. The principal characters by which the best known forms are distinguished have been mentioned, and what do we know of the functions of those characters? No one has hitherto been able to suggest a reason why the scales are more useful to the brill and tubercles to the turbot. We do not know why the male Arnoglossus requires elongated fin-rays, a kind of piscine moustache, a masculine ornament which is developed in several other species of fish. We can say with truth that the Rhombinæ are for the most part predaceous flat fishes which seize active prey, and to this habit of life the large symmetrically developed mouth and teeth are adapted. It is quite possible, too, that if we knew the habits of particular species more exactly and more completely, we should see that the whole muscular system and shape of body, as well as the particular size of mouth, were adapted to the particular habits and surroundings. But this leaves some of the features most important in diagnosis, such as the scales and the secondary sexual characters, unexplained.

A different set of characters offering similar difficulties occurs in the sub-family Pleuronectinæ. The common features of this sub-family as diagnosed by Jordan and Goss are the following:

Mouth small, asymmetrical, the jaws on the eyed side with nearly straight outline, the bones on the blind side strongly curved; dentition chiefly developed on the blind side; eyes large; edge of pre-opercular not hidden by the scales; pectoral fins well developed;

unpaired fins well separated; pelvic fins nearly or quite symmetrical; body dextral. Species arctic or subarctic in distribution.

In this sub-family Jordan and Goss make our common dab the type of a genus. The characters are—

No accessory branch to the lateral line, but a distinct arch in it over the pectoral.

Scales rough, ctenoid, and imbricated.

Vertebræ forty in number.

The authors recognise four species. One of these is doubtful, founded by Prof. Goode on certain specimens taken in deep water off the southern coast of New England. *Limanda limanda*, the European form, has no rugose prominences above the operculum behind the interorbital ridge. The fin-rays are—dorsal 65 to 78, ventral 50 to 62; scales along the lateral line 86 to 96, teeth in an irregular series. This species extends from the Atlantic coasts of France along all the coasts of Northern Europe, and on the coast of Iceland: it is absent from the Mediterranean.

Limanda ferruginea is the dab of the American side of the Atlantic, extending from New York to Labrador. It differs from ours in having more numerous teeth in a more regular close-set series, a more projecting snout, and rugose prominences above the operculum. The fin-rays are a little more numerous, namely, D. 85, A. 62. The scales are smaller and more numerous, namely, lateral line 100.

Limanda aspera is the dab of the North Pacific. It is distinguished by somewhat marked characters, of which the principal are that there is no angle between the snout and the profile of the head, and the scales of the blind side are more or less rough, those of the upper side rougher than in the other species. Specimens have been taken on the coasts of both Alaska and Kamtschatka. It seems, therefore, that while the species on opposite sides of the Atlantic are different, those on opposite sides of the Pacific are the same. This case offers an instance of geographical races. The differences are not great, but if they are constant it matters little whether we call these forms, species or varieties or races. The case affords a contrast to that of Zeugopterus; in the latter we have three species in the same area, separated by no barriers except those which are physiological: in other words, they do not interbreed. In the case of the three forms of Limanda interbreeding is physically impossible, except where the ranges meet. We have no evidence that the differences are adaptational.

Closely allied to Limanda is a species in the Pacific called by Jordan and Goss *Lepidopsetta bilineata*. Only one species is placed in the genus, the establishment of which seems superfluous. The form is distinguished from Limanda by the presence of an accessory branch of the lateral line, which starts from the anterior portion of that line, extending in all members of the family above the eyes, and runs backward along the base of the dorsal fin. It is a curious fact that this variation is known as a constant character only in the Pacific, and that there it occurs in a large number of species: of the thirteen species of this sub-family in that ocean distinguished by Jordan and Goss it occurs in eight; and it also occurs in one genus, also in the Pacific, in the quite distinct sub-family Hippoglossinæ. A fact of this kind cannot be explained simply as an adaptation; it cannot be supposed that there is some common peculiarity in the habits and surroundings of all these species which renders this particular extension of the lateral line useful.

The plaice (*Pleuronectes platessa*) is distinguished from *P. limanda* by wanting the arch to the lateral line, having cycloid reduced scales and tubercles on the post-ocular ridge. The flounder has differentiated scales, most of them being reduced and cycloid as in the plaice, but those along the bases of the longitudinal fins, along the lateral line, and on the head being enlarged to form rough spiny tubercles. *Pseudo-pleuronectes americanus*, the representative of the plaice on the east coast of America, approaches the dab in having imbricated ctenoid scales. In *Liopsetta Putnami* the spinulation of the scales is a sexual character, the scales in the male being rough and strongly ctenoid, in the female smooth and almost completely cycloid. This species ranges from Cape Cod to Labrador. Mr. Holt, in the last number of the Journal, has described specimens of the plaice from the Baltic in which ciliation or spinulation of the scales, although varying in different individuals, was distinctly a sexual character more strongly developed in the males. Möbius, in his Fishes of the Baltic,* mentions these ciliated plaice, and observes that they form a transition to unusually smooth specimens of the flounder. The smooth flounders, although occurring on the south coast of England, are stated to be commonest in the Mediterranean, where they seem to occur exclusively. It appears, therefore, that there is a northern rough variety of the plaice and a smooth variety of the flounder in the south.

We have at present no evidence that these differences are adaptational, nor can we trace them to preceding or determining causes. But, on the other hand, we must admit adaptation in many of the characters of the sub-family. For instance, the small size and asymmetrical shape of the mouth correspond to the general habit of these fish of feeding on invertebrate slow-moving creatures on the sea bottom. The fish seize their prey from above with the lower side of the

* IV[te] Bericht der Comm. zur Unters. der Deutschen Meere.

jaws. But many of the characters of the sub-family cannot definitely be proved to be adaptive, *e. g.* the narrow symmetrical pelvic fins and the slight anterior extension of the dorsal fin.

II. The Development of the Egg in Flat Fishes and Pipe-fishes.

Since my paper in Vol. III, No. 2, p. 154, of this Journal was written I have been continuing my studies of the development of the eggs in the ovaries of fishes. My attention has been given principally to the history of a definite body in the yolk known as the vitelline nucleus, but quite distinct from the proper nucleus of the egg or germinal vesicle. I hope to be able at some future time to publish a full account of my observations with adequate illustration, but in the meantime some account of the subject in the Journal of the Association may be useful.

In the fresh state it is almost impossible to perceive any trace of the vitelline nucleus, only a faint indication of it can be made out after familiarity with it has been gained by the study of its structure in preparations which have been subjected to the action of reagents. In fishes in which the eggs before the development of yolk are extremely transparent the structure can be easily seen after treatment with dilute acetic acid, in a small portion of the ovary simply spread out on a slide. In those eggs in which the development of yolk has made considerable progress the body in question can only be seen in prepared sections. In a piece of the ovary of a flat-fish in which there is no yolk—for instance, a flounder or plaice,—on the addition of acetic acid the transparent protoplasm of the egg gradually coagulates, and the first change to occur is the appearance of the vitelline body as a spot which is more opaque than the surrounding substance. In the larger ova (Fig. 1, *b*) this body is round and of considerable size, somewhat larger than one of the nucleoli of the germinal vesicle, and it is situated between the germinal vesicle and the surface of the ovum. Examined with a high power it is seen to consist of a spherical collection of minute granules. In the smaller eggs (Fig. 1, *a*) those about ·118 mm. in diameter, the vitelline nucleus is somewhat smaller and close to the surface of the germinal vesicle. In still smaller eggs, only ·10 mm. in diameter, the body can just be discerned as a few granules just outside the membrane of the germinal vesicle, and in ova smaller than this no trace of it is visible. I have not been able to see any indication that the vitelline body is situated on a particular side of the egg. The egg is approximately spherical; the question whether the radius of the sphere which is determined by the presence of the vitelline body has any particular position in the subsequent history of the egg will be considered later.

It will appear, then, that the body in question, judging from examination of entire fresh ova treated with acetic acid, is not present in the youngest ova, but becomes visible when they have reached a

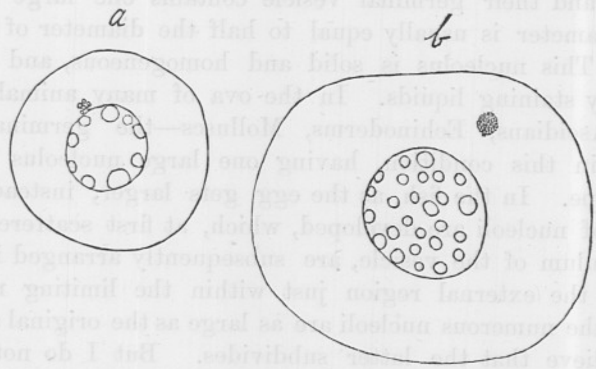

FIG. 1.—Developing eggs from the ovary of a plaice $8\frac{3}{4}$ inches long, examined August 30th, 1894; treated with dilute acetic acid. Seen with Zeiss E, oc. 3.

certain definite size; that it makes its appearance in the form of a few granules close to the wall of the germinal vesicle, and as the egg becomes larger is gradually more and more separated from the latter, at the same time increasing in size and opacity. This suggests that the body is formed from the germinal vesicle by the expulsion of granules; but no direct evidence of this can be seen, and, moreover, it is not supported by the fact that the vitelline body increases in size after it is separated by a layer of protoplasm from the germinal vesicle. In eggs in which the yolk has begun to appear at the surface of the cell-plasma the vitelline body is seen beneath the layer of yolk granules, and it never actually reaches the surface of the egg.

After the character of the vitelline body has been studied in ova treated with acetic acid, it is possible sometimes to make it out in living ova without the addition of any reagent. It is seen then as a group of faint granules whose opacity and refringent power are very slightly different from those of the surrounding cell-plasma.

There is, therefore, a stage in the development of the ova in a flat-fish in which neither the vitelline nucleus nor the yolk have appeared or commenced to develop. It would be interesting to have a satisfactory account of the whole history of the ovum, and particularly of this early stage, but at present there are many passages in the history not yet elucidated. In prepared sections of an ovary from an immature fish—for instance, a plaice $7\frac{1}{2}$ inches long killed in March—the youngest ova are seen beneath the surface of the germinal lamellæ. The lamellæ are covered by a very thin membrane containing nuclei. This membrane represents what is known as the germinal epithelium, but it is so thin that it is difficult to see much of it in transverse sections. The smallest ova are rounded, and their germinal vesicle contains one large nucleolus, whose diameter is usually equal to half the diameter of the whole vesicle. This nucleolus is solid and homogeneous, and is darkly stained by staining liquids. In the ova of many animals—for example, Ascidians, Echinoderms, Molluscs—the germinal vesicle remains in this condition, having one large nucleolus until the egg is ripe. In the fish, as the egg gets larger, instead of one a number of nucleoli are developed, which, at first scattered through the reticulum of the vesicle, are subsequently arranged in a single layer in the external region just within the limiting membrane. None of the numerous nucleoli are as large as the original single one, and I believe that the latter subdivides. But I do not think all the new nucleoli are produced by subdivision of the original one, because in the younger and smaller ova there are to be seen very minute nucleolar granules together with a large undiminished nucleolus, so that it is to be inferred that many of the additional nucleoli are produced by the increase in size of these minute granules.

In very young fish none of the ova contain a vitelline nucleus; for instance, in sections from a plaice 3 inches long, killed in March and probably a year old, it is not to be seen. In these sections the largest ova have a diameter of ·07 mm. The production of young ova in this ovary was evidently going on rapidly; nests of them are present at numerous spots in contact with the germinal epithelium. But even at this early stage nuclear division figures are not to be seen, nor have I detected such figures in sections of the ovary at any stage. It may be that even in the young ovary the youngest ova seen have passed beyond the division stage and entered upon the period of growth, and that division only takes place in the flat germ-cells of the epithelium, and cannot be seen in sections. But even when examining the germinal epithelium from the surface I have seen no division figures, nor am I aware that other observers have described any. It is a point which requires further investigation.

In sections from a plaice $7\frac{1}{2}$ inches long, fixed with chromic and osmic acids, the vitelline nucleus is distinctly visible in the larger ova, whose diameter has a maximum of ·14 mm. The appearance of the nucleus is quite different from that of the nucleoli in the germinal vesicle; its outline is not so definite, and it is seen to be a group of refringent granules. It does not stain so deeply as the nucleoli. The younger stages of it described above as seen in fresh preparations are not visible in the sections, but only the later stages in which it is situated near the surface of the ovum.

The vitelline nucleus persists in the ovum during the development of the yolk. To obtain satisfactory sections of the yolked ova, as a rule other reagents must be used than those which succeed best with the ovaries in which yolk has not begun to develop. Picro-sulphuric acid is one of the reagents which give good results. I have some sections prepared with this reagent from a large plaice taken from the aquarium and killed in August. In these many of the smaller yolkless ova are collapsed and shrunken, and the connective tissue between the ova is distended and broken, but the yolked ova are in many cases wonderfully perfect. The stain used was hæmatoxylin, and the yolkless ova are over-stained, but in this respect also the yolked ova are very satisfactory. The yolk forms an external layer of varying thickness according to the size of the egg; and between it and the germinal vesicle is a layer of finely reticulate protoplasm. The vitelline nucleus has a shape which suggests that of an octopus: towards the centre of the egg it is rounded and has a definite outline, although it is not separate from the surrounding protoplasm, but continuous with it. It lies on the inner boundary of the layer of yolk, which consists of small yolk spherules. On the outer side the vitelline nucleus gives off a number of diverging processes which run into the yolk layer, becoming continuous with the protoplasmic strands which separate and enclose the yolk spherules. The substance of the vitelline nucleus is deeply stained (in hæmatoxylin), and in structure is finely granular, not as in the younger stage composed of a small number of refringent granules.

As the thickness of the yolk layer increases it at lasts passes the vitelline nucleus, so that the latter comes to be situated entirely within the yolk-containing layer of the egg, and can be seen as an island of granular protoplasm surrounded by the yolk spherules. In this condition it is not so conspicuous, and is relatively smaller. My preparations showing this stage are from a large plaice killed in August, and the largest eggs in the sections are about ·28 mm. in diameter. In these most advanced eggs there is still a layer of protoplasm containing no yolk between the layer of yolk and the germinal vesicle.

During the development of the yolk the germinal vesicle exhibits changes. The chief of these is that the nucleoli are no longer almost always arranged in a single row at the outside of the vesicle, but are seen scattered in the central regions. In many preparations the membrane or outline of the germinal vesicle is much wrinkled and contracted, but this is to a certain extent due to the action of reagents. It occurs in preparations made with corrosive sublimate and acetic, and with picro-sulphuric acid, but in some preparations made with chrom-osmic acid it is less marked. On the other hand, in a piece of the ovary from a flat fish just killed and placed on a slide beneath the microscope, without the addition of water or any reagent, the wrinkling of the membrane of the germinal vesicle is very frequently observed in the larger transparent ova and in those in which yolk is commencing to develop. It is probable enough, therefore, that this wrinkling of the membrane is, to some extent, a natural phenomenon occurring during life, although there can be no doubt that in many preparations the nucleus has been further altered and contracted by the action of the reagents.

This wrinkling of the membrane is the same condition which is described by Scharff * as the formation of peculiar protuberances all over the outer surface of the germinal vesicle in eggs of the gurnard. His fig. 9 agrees closely with the appearance presented in many of my own preparations. But he gives an extraordinary interpretation of the changes taking place, which I am quite unable to accept.

He states that the protuberances containing nucleoli are separated off, carried towards the exterior of the egg, and there form the yolk spherules, having the appearance of cells containing a nucleus. I am unable to trace any direct connection between nucleoli and yolk spherules. I have failed to find after long and careful scrutiny the slightest evidence that the nucleoli migrate at all. It is true that occasionally a nucleolus in a prepared section appears to be outside the nuclear membrane, but I find this is always due to one or other of two causes; either the nucleolus has been bodily pushed out of its place by the edge of the razor which failed to cut through it immediately, or the pouch of the wrinkled membrane has been cut in such a manner in the section that it is separate from the interior of the main germinal vesicle. In the latter case the connection can be seen in the next section. In the former case the artificial nature of the occurrence is easily proved by observing that the direction in which the nucleolus has moved is the same as that of other striæ in the section caused by the razor. The nucleoli become very hard after the action of chromic acid, and it is in preparations from tissue hardened with this reagent that such dislocations usually occur. The hypothesis that the nucleoli give rise to the yolk spherules is untenable from the nature of the case, for the spherules are very numerous, and as the egg ripens form a bulk

* Quarterly Journal Micr. Sci., vol. xxviii.

many times greater than the germinal vesicle, or than all the nucleoli put together. There is no indication of a rapid formation of nucleoli, and at the end in the egg almost ripe there are still a number of nucleoli remaining. It is practically certain, therefore, that the yolk spherules are formed *in situ*, first on the outside of the egg and then progressively inwards.

Another point in which I am unable to agree with Scharff's description is his account of the division of the protoplasm of the egg into two layers. In this case again, in my opinion, he has been misled, as many others have been in microscopical researches, by alterations due to method of preparation and the action of reagents. Scharff states that the ovaries from which his sections were prepared were hardened with weak chromic or with picro-sulphuric acid, both excellent reagents which I have largely used myself. But he states that his preserved material was prepared not by himself, but by Professor McIntosh; and it is not certain whether the ovaries were perfectly fresh when preserved—a very important point. My experience is that when preparations are made from fish obtained in the market which have been dead several hours, the preserving liquid used being Perenyi's mixture, a division of the protoplasm into two zones is seen. The ovary when examined fresh appears perfectly unaltered, but after preparation produces a result different from that obtained from an ovary taken from a fish just killed. The outer lighter zone is frequently separated from the inner. In all my successful preparations from ovaries preserved immediately after the death of the fish there is no division of the protoplasm into zones in the yolkless ova, and in the older ova the only distinction is that between the outer layer containing yolk granules or spherules, and the inner layer where there is no yolk. In young yolkless ova, whether in sections from immature ovaries in which all the ova are in this condition, or in sections from ovaries in which the majority of ova are larger and developing yolk, the whole of the protoplasm is deeply stained, almost as deeply as the nucleoli, while the rest of the germinal vesicle is scarcely stained at all. In fact, the protoplasm of the ovum from its earliest appearance is distinguished by its affinity for stains, which causes young ova to contrast vividly with the connective tissue of the sections. The staining is less after the action of chromic acid, but after corrosive sublimate or picro-sulphuric acid it is usually intense. Yolk substance, on the other hand, does not stain at all, and hence in older eggs the contrast between the unstained yolk layer and the inner protoplasmic layer is marked. In the older eggs, however, the inner unyolked protoplasm does not stain so intensely as the protoplasm of the young unyolked eggs. In some preparations the protoplasm of the unyolked ova is much vacuolated; this occurs only when some preserving agent containing much nitric acid has been used, such as Perenyi's mixture or picro-nitric acid, and is due to the action of the nitric acid.

Several investigators have expressed the conclusion that the vitelline nucleus is connected with the formation of the yolk,—is the centre, in fact, at which this process takes place. This is a suggestion which one would be glad to accept if possible, because it would afford a satisfactory explanation of the presence of this body, otherwise so difficult to understand. A very interesting and useful examination of the problem from this point of view is contained in the account given by Professor Emery of the history of the egg of Fierasfer in his monograph on that genus published by the Zoological Station of Naples. In many respects I find Professor Emery's observations and views much more in agreement with my own than those of other authors who have considered the development of the egg in fishes. In my judgment he shows a sounder and more comprehensive grasp of the succession of appearances to be interpreted, and has no inclination, like many others, to form extraordinary conclusions inconsistent with the general view of the nature of the egg, and supported by scarcely any evidence.

Emery's description of the earlier history of the vitelline nucleus agrees, to a great extent, with mine. It appears, he says, as a small mass of granulations excentrically situated, and then becomes larger and denser, but never acquires a definite boundary. Its ultimate history consists in its gradual disintegration with the formation of the vitelline spherules. The granular vitelline nucleus assumes an irregular form, more or less stellate, and often shows in its interior one or two small clear vacuoles. Around the nucleus extends an obscure zone, semilunar in section, of very minute granules, the beginning of the formation of the vitelline globules. This zone continually extends and surrounds the whole ovum, and as the yolk-globules get larger the vitelline nucleus becomes merely a small clear space in the layer of formed yolk. Emery goes on to say that it is not clear from these facts whether the yolk-globules are formed exclusively at the expense of the vitelline nucleus, or in part from this and in part directly from the plasma of the ovum, or if, lastly, the vitelline nucleus is formed and disappears without its substance contributing to the production of the yolk.

Emery, then, was not able to decide in what way the vitelline nucleus is connected with the formation of the yolk-globules, but he states that the development of these globules commences in Fierasfer in the immediate neighbourhood of the nucleus and extends outwards. It should be noted that the eggs of Fierasfer are, when mature, transparent and pelagic like these I have studied. I have been unable to find any indication that the yolk commences first in the neighbourhood of the vitelline nucleus. As I have already stated, the yolk layer is at first wholly external to the nucleus, and there are no yolk-globules or granules at the side of the latter. When the formation of granules begins it appears as a thin layer round the whole of the outside of the plasm of the egg, and is not thicker near the vitelline nucleus than elsewhere. In most ova the layer of yolk in sections is of uniform thickness, but occasionally it is thicker on one side than the other, and then the vitelline nucleus is not at the thickest part. In spite of the fact that the largest yolk-globules are those of the inner part of the yolk layer, it seems certain that the increase of yolk takes place by the new formation of globules added to the layer on the inner side. Forming globules are seen at the inner edge of the layer. After the yolk layer has so increased that its inner border is internal to the vitelline nucleus, it is clear that the new formation of globules can have nothing to do with that body.

The most recent published paper on the yolk nucleus is that by Jesse W. Hubbard, of Indiana University, U.S.A.* This investigator studied the eggs of *Cymatogaster aggregatus*, a viviparous fish of the coast of California, and his conclusions closely agree with my own. Cymatogaster belongs to the family Embiotocidæ, which is allied to the wrasses. The eggs of Cymatogaster are small, ·3 mm. in diameter, and being developed within the ovary the quantity of yolk in them is naturally small. The preserving reagent used by Hubbard was Flemming's strong mixture, the effects of which I have found in my own experience to be destructive to many parts of the egg. Like myself, Hubbard could see no trace of the yolk nucleus in very young fish, in those under 4 cm. in length. It was present in the ovaries of specimens over 7 cm. The smallest egg in which the body was observed was ·02 mm. in diameter, and it appeared as a cap of stained protoplasm fitting round one side of the nucleus.

In a slightly larger egg the yolk nucleus is separate from the germinal vesicle, and it gradually moves away from the latter. Hubbard concludes that the yolk nucleus originates from the germinal vesicle not by division, but by a general extrusion of substance. It passes to the external region of the egg, and when the yolk is formed and the egg is ripe it is situated at the yolk pole of the egg, opposite the blastodisc. It remains visible in the same position in the yolk after the egg is laid, and during segmentation until the closing of the blastopore, when it breaks

* *The Yolk Nucleus in* Cymatogaster aggregatus, Proc. Amer. Philos. Soc., vol. xxxiii, 1894.

up and disappears. Hubbard considers that there is no direct evidence in support of the view that the yolk nucleus is the centre of yolk formation; he has seen no indication that it gives rise to yolk. When the yolk forms it is distributed uniformly about the centre of the egg. Perhaps Hubbard's most important result is that the yolk nucleus passes to the opposite pole of the egg to that occupied by the germinal vesicle, and so defines the yolk pole, or, as it is sometimes called, the vegetative pole, long before the germinal vesicle has passed to the surface of the egg from the central region. I have not yet examined the last stages of maturation of the eggs of flat fishes. I have never detected the yolk nucleus in the eggs of these fishes after fertilization, when, if it is to be seen at all, it would be found in the thin layer of protoplasm which encloses the continuous mass of yolk. In my sections of the ova of conger nearly ripe, taken from females which have died in our tanks with enlarged and much-developed ovaries, in which ova the yolk is fully developed, I have not been able to detect the yolk nucleus.

The wrinkling of the membrane of the germinal vesicle already mentioned is an indication of its degeneration. In the later stages of maturation, as the limit of the yolk layer approaches the germinal vesicle, the membrane gradually disappears, and the nucleoli become scattered in the reticulum of the vesicle. At the same time this reticulum appears to become denser, and although it still remains unstained it has a more solid continuous appearance. In eggs nearly ripe—for instance, in preparations from a plaice killed in January, in which some of the eggs were becoming transparent—the whole body of the ovum is crowded with large yolk spheres, and the germinal vesicle forms an unstained round island in the midst of these, containing a number of stained nucleoli. No membrane, separating the nucleus from the protoplasm in which the yolk spheres are contained, can be seen. The later changes by which the nucleus of the egg, and especially its nucleoli, pass from a central to an external position in the ripe egg when extruded I have not yet studied.

The description given shows the history of the ovum in a flat-fish from the time of its first origin in the germinal epithelium to the stage in which it is almost ready for extrusion. The history is probably almost exactly similar in all fishes which produce pelagic eggs and have an annual spawning season. As I pointed out in my previous paper, the great majority of the eggs pass through the whole of this history in the course of a year, between one spawning season and the next. I have made preparations from ovaries in which spawning had just taken place, spent ovaries, with the following results.

In my previous paper I described the condition of the spent ovary of the plaice, as seen when microscopically examined in the fresh condition, and expressed the conclusion that all the unripe eggs containing yolk remaining in the ovary were destined to degenerate and be absorbed. The chief characteristic of sections of a spent ovary consists in the number of empty follicles seen. These are the collapsed receptacles in which the ripe ova were developed, and from which they have been expelled. The mode of expulsion is constant and of some importance. The follicle bursts at the surface of the germinal tissue, the egg therefore escaping through a rupture of the so-called germinal epithelium. When this takes place the wall of the follicle becomes continuous with the external covering of the germinal tissue,—that is to say, with the germinal epithelium and the connective tissue which supports it. Such an empty follicle corresponds with what is called a corpus luteum in the mammalian ovary. In the fish its walls are thick, and contain many blood-vessels: it may be regarded as an elastic membrane, which, having been stretched round the large ripe egg, becomes thickened and contracted when the latter escapes. In the cavity of the follicle are always seen the separated and broken follicular cells, but there are indications of cells on the surface of the interior of the follicle, so that perhaps not the whole of the follicular epithelium perishes. The appearance of the empty follicles, opening by an aperture at the surface of the germinal tissue, and of their walls, continuous with the membrane at the surface, strongly suggests the idea that a follicle is simply a pocket formed in the germinal membrane and temporarily constricted off from it, being restored to it again when the mature egg is expelled. But whether the wall of the follicle becomes again a part of the germinal membrane and begins again to produce new ova, or whether it is gradually absorbed, is a question I am unable to answer at present. In the larger of the young yolkless ova in the spent ovary the vitelline nucleus is present.

I have now to describe some observations on ovaries in which the history of the ova presents considerable differences from that which is characteristic of flat fishes and other fishes with pelagic ova.

Henneguy,* in a recent paper on the vitelline nucleus, states that among all the Teleosteans whose ova he examined, those of the pipe-fish (*Syngnathus acus*) gave him the most interesting facts. These facts are described thus :—There are four stages of the development of the vitelline body : (1) The smallest ova have no vitelline

* *Le corps vitellin de Balbiani dans l'œuf des Vertébrés*, Journ. de l'Anat. et de la Physiol., No. 1, 1893.

body; (2) in ova more advanced than the youngest the germinal vesicle has a number of nucleoli round its circumference within the membrane, and a granular mass in the centre; the protoplasm of the ovum contains a round refringent body deeply stained in safranin, the vitelline nucleus; (3) in ova about ·06 mm. in diameter the vitelline nucleus has become elliptical in shape, and at its outer border is a larger rounded mass formed of a homogeneous substance full of granulations; (4) the whole is transformed into a mass of granules, such as that observed in the ova of the majority of Teleosteans. The outer rounded body is described as formed by a modification of part of the refringent body, by a process of disintegration which finally invades the whole of the latter, and transforms it into a mass of granules. Unfortunately Henneguy omits to state what is the condition of the yolk corresponding to these stages, and the only indication of the size of the eggs is that in stage 3 they are ·06 mm. in diameter.

My observations do not completely agree with Henneguy's, but before pointing out the differences I wish to say something of the ovary. This organ in the pipe-fish is an elongated narrow cylindrical tube. There is one on each side of the body. It has a salmon-pink colour, due to the colour of the yolk in the eggs. The inner lining of the tube, the germinal tissue, only projects into the cavity of the tube in one fold or lamina, which is longitudinal. In this lamina alone are the young eggs formed, and they are pushed away from it as they become larger.

A long series of stages of the developing ova can thus be studied in a single ovary, and the production of new ova seems to go on nearly all the year round,—at least, I have not yet seen evidence of a limited spawning season, and specimens with ripe ova or just spent have been opened by me from June to October. I believe that several batches of ova are produced in one season in succession. The number of ova produced is small, and, as is well known, they are received by the male into a skin pouch, and there hatched.

It is not difficult to open the ovary and examine the proliferating lamina on a slide. In the fresh state the young yolkless ova are not very transparent, and it is impossible to make out any other structure than the germinal vesicle. But on the addition of dilute acetic acid the protoplasm of the eggs begins to coagulate, and in it there appears in most cases (Fig. 2) a single oval body, which in the smaller ova is in contact with the membrane of the germinal vesicle, in the larger is between it and the exterior of the egg. This body is of considerable size, both it and the nucleoli in the germinal vesicle being relatively larger than in the egg of the flat-fish. Another peculiarity of this vitelline body is that it has a most distinct and definite outline, and a refringent homogeneous interior. Occasionally a few granulations appear in its centre. The body is not much unlike a nucleolus, but the nucleoli, under the action of acetic acid, show internal vesicles and the vitelline body does not; the latter has also a pale yellowish colour, while the nucleoli are colourless.

FIG. 2.

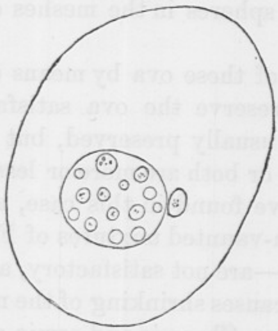

FIG. 3.

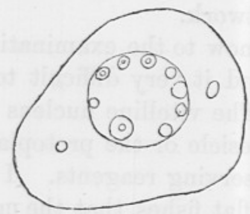

FIG. 2.—Egg in the germinal ridge of *Syngnathus acus* examined fresh with addition of 1 per cent. acetic acid. Shows the vitelline body close to the germinal vesicle.
FIG. 3.—Another egg in the same preparation, showing two vitelline bodies on opposite sides of the germinal vesicle.

The most remarkable fact about the vitelline nucleus in the ova of the pipe-fish is that there are often more than one of them in a single egg, frequently two, and I have seen as many as four. In the latter case the four were in a cluster, as though produced by the division of one, but when there are two they may be both on one side of the germinal vesicle, or one on one side and one on the other (Fig. 3). Henneguy examined the ovary of the pipe-fish apparently only in sections, and would not be so likely in that case to recognise the presence of two vitelline bodies in one ovum. The bodies can be well seen and studied in preparations of portions of the germinal lamella mounted whole. My best preparation of this kind was fixed in a mixture of chromic, osmic, and acetic acid, and stained with hæmatoxylin. The presence of two vitelline bodies in some ova in this preparation is easily confirmed. It should be noted that when two are present they are smaller in size than when there is only one. The structure certainly persists unchanged in ova in which yolk has begun to form. I have been able to distinguish it clearly in such ova of a diameter up to ·29 mm., and in these it is unchanged, showing no signs of the conversion into a granular mass which Henneguy describes as commenced in ova only ·06 mm. in diameter. The vitelline nucleus is entirely unstained and homogeneous, and has an appearance very different from that of the nucleoli, which are somewhat shrunken, and are stained. In ova larger than ·3 mm. I am unable to distinguish the vitelline nucleus in the yolk. The latter forms in the eggs of Syngnathus in a manner different from that described in the plaice. It does not form a definite external layer gradually thickening towards the centre of the ovum, but appears uniformly throughout the protoplasm in small, not very distinct or refringent granules, which increase in number and size. In the larger ova the yolk appears as large rounded spheres in the meshes of a protoplasmic network.

To turn now to the examination of these ova by means of sections. I have found it very difficult to preserve the ova satisfactorily for cutting. The vitelline nucleus is usually preserved, but either the germinal vesicle or the protoplasm or both are more or less destroyed by the preserving reagents. I have found in this case, as with the ovaries of flat fishes, that the much-vaunted mixtures of Flemming—namely, chromic, osmic, and acetic—are not satisfactory, and that the fault lies in the acetic acid, which causes shrinking of the nucleus and destruction of its delicate reticulum. Chromic and osmic alone, when the chromic is not too strong, have a good effect, but have the disadvantages of contracting the nucleoli, preventing staining, and making the yolk hard and brittle. Corrosive sublimate, either alone or with acetic acid, produces quite disappointing results on the ovaries of pipe-fishes.

In none of my sections have I seen the modifications of the vitelline nucleus described by Henneguy, although I have used the preserving reagents and stains which he employed, namely, Flemming's mixture and safranin or hæmatoxylin. I have also used the triple stain safranin, gentian violet, and orange G. After some modes of treatment the vitelline nucleus is stained, but never granular. The largest egg in which I have seen the body is ·36 mm. in diameter, and in this it is as definite in outline and as simple in structure as in the small unyolked ova. I have seen no indication of modifications tending to the breaking up or disappearance of the nucleus; in the larger eggs I can find no trace of it. As to its earlier history, it is seen in eggs ·06 mm. in diameter in direct contact with the exterior of the germinal vesicle. In one egg there are two of these bodies at different parts of the membrane of the vesicle, one smaller than the other. In smaller eggs I have seen no trace of it. These smaller eggs form a cluster or nest at the very apex of the germinal lamella. As to their origin, I have not been able to get sections which show them as perfectly as I should wish, but I have seen primordial ova in the epithelium covering the apex of the lamella, and that is the source from which they all spring.

III. A Piebald Plaice.

In the memoir by Dr. MacMunn and myself on the *Coloration of Fishes* (Phil. Trans., 1894) specimens of flat fishes are described in which some portion of the upper side is abnormally destitute of pigment. Thus abnormalities consisting in the pigmentation of part or whole of the lower side are balanced by abnormalities consisting in the absence of pigment from areas on the upper side. I have recently received a living specimen of the plaice exhibiting the latter kind of abnormality. It was caught in the Hamoaze, and brought to the Laboratory on October 3rd. It is still living in one of the tanks. The anterior third and the caudal third of the upper or right side in this specimen are pigmented as in a normal plaice, the red spots having the usual appearance and position; but the middle third is white like the whole of the lower side. The white unpigmented area is bounded by two definite irregular lines, the anterior passing transversely across the body just behind the pectoral fin, the other in the posterior region of the body. There is an isolated round patch of normal pigment within the white area dorsally.

Mr. Holt, in the previous number of this Journal (p. 188, *et seq.*), gives reasons why my rejection of atavism as an explanation of the abnormal coloration of the lower side cannot be held to be valid. But I can see no reason why the principle which explains the occurrence of pigment on the lower side should not also explain its occasional absence on the upper. If it is atavism in the one case it is atavism in the other, and the occurrence of piebald plaice, or flat fishes white on both sides, is as good an indication that this family of fishes is descended from ancestors that were unpigmented on both sides, as the occasional presence of pigment on the lower side that they are descended from ancestors coloured on both sides. Thus it is obvious that atavism fails to explain both kinds of abnormality, whereas the explanation adopted by Mr. Bateson and myself applies equally well to either case. That explanation is that in certain cases one side, instead of developing normally, partially or completely imitates the other. It does not require much consideration to see that Mr. Holt's reference to what he terms ambi-ciliation, tends to support my views, and not his own. For it is difficult to connect the varying conditions of the dermal armature in different kinds of flat fishes with an original ancestral condition. If the ciliated scales of the brill are ancestral, then the tubercles of the turbot are new, and *vice versâ*; but when the lower side is pigmented, it is also provided with scales or tubercles like the upper, thus proving that the lower side has in the abnormal specimen formed itself after the pattern of the upper side, and not after the pattern of a remote ancestor. It has never been maintained, as Mr. Holt suggests, that this unusual development of dermal armature on pigmented lower sides has anything to do with the action of light; on the contrary, I have always maintained that abnormalities of coloration occurring in nature are independent of the action of light on the individual.

The subject is too complicated to be discussed at any length here, belonging as it does to the intricate problems of ontogeny. But one interesting consideration may be mentioned. In a piebald plaice, such as the specimen here recorded, the unpigmented area is exposed to light as much as the rest of the upper side, and yet it remains unpigmented. How then, it may be asked, can it be maintained that pigment is developed on the lower side of a normal specimen by exposing that side to the light? Some may be inclined to believe that the two things are incompatible, and that therefore the pigment which appeared in my experiments is due to some factor other than the action of light. But it seems to me that, as far as the experiments are concerned, all other factors were excluded; and the explanation in the other case seems to be as follows:—I have said that the white area on the upper side is an imitation of the lower side, and I think that there is probably some peculiar connection between this area and the lower side, so that it may be regarded, in a sense, as an extension of, and continuation of, the skin of the lower side. Therefore, so long as the lower side remains white, this area of the upper side will also remain white. Possibly, if the lower side became pigmented, this white area on the upper side would also become pigmented, and it would be a curious experiment to expose the lower side to the light, and see if both it and the white area on the upper side would develop pigment.

IV. Growth and Distribution of Young Food-fishes.

In April, 1893, I had the pleasure of undertaking some experiments with young flounders for the late Dr. Romanes. I procured the specimens as usual from Mr. Dunn, of Mevagissey. They were the young of the year in process of metamorphosis, and among them I received five young soles a little more advanced in development. I placed these five soles in one of the table tanks in the Laboratory, a tank 5 feet long, 2½ feet wide, 1½ feet deep. When received these soles were about 1·5 cm. long, or nearly ⅝ inch.

During the following summer a number of young fish of different kinds were put into the same tank, and they have been fed and watched with some care ever since. The following is an account of their growth and history.

In June a few young turbot and brill in the pelagic transformation stage were put into the tank.

On July 5th a plaice 6·9 cm. ($2\frac{3}{4}$ inches) was put in ; it was taken in Cawsand Bay.

On July 21st a turbot 3·5 inches long was put in, taken at the surface in the Sound.

On July 28th I put in six plaice, 6·5 to 8·5 cm. ($2\frac{1}{2}$ to $3\frac{3}{8}$ inches). These plaice were judged to be of the brood of the year; *i. e.* hatched the preceding January, February, or March.

On September 2nd I took out one of the soles which was dead ; it was 9·6 cm. long, or $3\frac{3}{4}$ inches, and must have been not much more or less than six months old.

On October 19th I emptied the tank and measured all the fish in it. The inventory was as follows :

7 plaice: 7 cm. ($2\frac{3}{4}$ inches), 12·3 cm., 12·8 cm., 13·0 c.m., 14·1 c.m., 14·4 cm., 14·8 cm. ($5\frac{3}{4}$ inches). 1 sole, 9·9 cm. long. 3 brill: 8·0 cm., 8·5 cm., and 10·4 cm. 3 turbot: 6·5 cm., 9·5 cm., 9·9 cm.

There were also three pollack, about 12·3 cm. long, one red mullet and one bream, all young fish of the year.

On April 4th, 1894, several of the fish died, in consequence of a temporary stoppage of the circulation. They were 1 turbot, 10·8 cm. long ($4\frac{1}{4}$ inches.) ; 1 brill, 11·3 cm. long ($4\frac{1}{2}$ inches) ; 1 plaice, 16·7 cm. long ($6\frac{3}{4}$ inches).

I have not been able to give sufficient attention to this tank during the past summer to record the size of each specimen that died in it. I examined all the fish in it on December 31st, 1894, and found only the following remaining :—1 sole 14·7 cm. long ($5\frac{3}{4}$ inches) ; 1 plaice 21 cm. long ($8\frac{1}{4}$ inches) ; 1 plaice 18·5 cm. long ($7\frac{1}{4}$ inches).

This experiment is obviously a very small contribution to the study of the growth of fishes. Plaice, sole, turbot, and brill evidently do not bear confinement so well as flounders, and it would be better to have a larger number of specimens in a larger tank. Nevertheless the results show observed sizes at known ages, and there can be no doubt that some fish in the sea grow no faster or slower than those. It is shown that a sole may reach from $3\frac{3}{4}$ to 4 inches when six months old, and may not exceed $5\frac{3}{4}$ inches when about twenty months old. It is clear, therefore, that soles not differing much from 4 inches in length in spring are probably a year old. This year I had an opportunity of examining a large number of soles of about this size.

In the course of some work on which I was engaged for the Essex Technical Instruction Committee I made as careful a study as possible in May and June, 1894, of the fish and marine fauna of the estuary of the Colne and the neighbouring sea channel called the Wallett. On June 8th I went out for a trip in one of the shrimping smacks belonging to Brightlingsea. The boat was 35 to 40 feet long, cutter-rigged and very low in the water. She carried a shrimp trawl of 25 feet beam, with a mesh at the cod end of about ½ inch square. We ran down the Colne with a fair breeze and shot the trawl just beyond the bar, towing eastward, and afterwards took two other hauls further eastward and further from the shore, the last being finished when we were a little to the east of Clacton.

In each haul there were a large number of interesting things besides the shrimps which were the object of the fishing. The red shrimp (*Pandalus annulicornis*) was most abundant, but there were some brown (*Crangon vulgaris*) also. The ground at the second haul was hard cultch; the dredge put over for a few minutes brought up only empty oyster-shells. The depth was 2 to 5 fathoms at low water.

A few fair-sized fish were caught, but none mature. They were plaice, small soles, and dabs. A great number of very small fish were caught. The smallest were dabs and plaice, the latter from 2 to 6 inches long. The most noticeable feature was the very large number of lemon soles 4 or 5 inches long, and doubtless a year old; hundreds of these were culled out from the first haul, and they were almost as numerous in the second and third. Soles of the same range of size, 3 to 5 inches, were also very abundant, but not quite so numerous as the lemon soles. I have never met with so large a collection of yearling soles and lemon soles. I was unable to give my attention to a thorough investigation of this ground to find out what the fish were feeding on, and what their prey was feeding on,—in fact, to obtain an explanation of the abundant life in this channel. I opened a young dab 4 inches long, and found it contained a small Amphipod, probably Gammarus. I found a *Gadus luscus* had its stomach distended with the red shrimp Pandalus.

V. Notes on Rare or Interesting Specimens.

During last August mackerel were unusually plentiful in Plymouth Sound, and several large hauls of them were made by means of seines close to the shore below the Laboratory, in the little cove known as Tinside. The Laboratory fisherman, watching the hauling of a seine in Barnpool, saw eight shad caught with the mackerel, and these, together with some of the "britt" which escaped from the net, he secured and brought to the Laboratory. I made a careful examination of these fish, and found that they belonged to the species *Clupea alosa*, having the slender numerous gill-rakers of that species. But in most of the specimens there was a row of dark spots on the side behind the shoulder-spot. Such spots are constant in the other species, *C. finta*, but, according to Day, have been recorded especially in the young of *C. alosa*. My notes on the specimens are as follows:

(1) Male: 14½ inches long; single row of nine rather large spots. Gill-rakers in first arch about 107, seventy on the horizontal portion.

(2) Male: length 13¾ inches; gill-rakers on horizontal portion of first arch, seventy. Nine spots on side in single row.

(3) Male: 13¼ inches; spots in single row, not very distinct; counted six behind the shoulder-spot.

(4) Female: 13½ inches; double row of spots on each side, counted twenty-one altogether; spots of one row opposite spaces of the other.

(5) Female: a double row of spots; nine in the upper row, two in lower.

(6) Female: counted seven spots.

(7) Female: five spots.

(8) Female: no spots.

In some cases the spots were symmetrical on the two sides, but in others they were scarcely to be distinguished on one side of the body, although well marked on the other.

In the stomach of one specimen were three half-digested britt, doubtless from the shoals, some of which were taken by the seine and brought up with the shad. These were young sprats, and it was for the sake of feeding on these that both the shad and mackerel were in the Sound.

The weight of the largest shad was 1 lb. 1½ oz.; of the smallest, 9½ oz. As far as I could judge the specimens had previously spawned: the breeding season is stated to be May and June, and it probably spawns in the Tamar.

On September 8th four more specimens of the same species were brought up, taken in a seine on the west side of the Hamoaze.

Auxis Rochei, Günther.—A specimen of this species was obtained on August 13, having been taken with mackerel in a seine at Mount Batten. It was 16 inches long, sex female. The stomach was empty, the ovaries small. Under the microscope the eggs were found to be small, transparent, and yolkless; probably the fish had recently spawned. Specimens are stated by Day to have been taken occasionally on the east coast and the south coast of Britain, but not very frequently. He mentions the record of one taken at Looe in 1843, of two in Mount's Bay in 1844, and of one at a later date at Mevagissey by Mr. Dunn. This fish resembles the mackerel in many respects, the chief difference being that the scales are confined to a distinctly limited region behind the head, forming what is called a "corselet."

Orcynus thynnus, Lütken, *Thynnus thynnus*, Günther.—A specimen of the common tunny 3 feet long was brought to the Laboratory on September 19th. It was caught in mackerel drift-nets some miles from Plymouth Sound, only 18 mackerel being caught in the same haul. It was 3 feet long, and female. The ovaries were small, in an inactive condition, spawning having probably recently occurred. The eggs were very young. Dr. Bassett Smith examined the specimen for parasites, and found *Brachilla thynni* behind the pectoral fins, and a large number of Trematodes on the gills. The capture of a specimen of this species is not an unusual occurrence off the south-west coast in summer and autumn.

Myliobatis aquila, Cuvier.—A single specimen of this species was brought to the Laboratory on November 1st, probably taken by a trawler, but the exact locality of its capture was not ascertained. It measured 62·5 cm. (2 feet 1 inch) across the pectorals, 40 cm. (1 foot 4 inches) from the snout to the end of the conjoined pelvic fins, and 65·5 cm. (2 feet 2 inches) was the length of the tail.

I examined the viscera. The left lobe of the liver was of great size and thickness, and covered the whole abdominal cavity ventrally, the right lobe was much smaller, and dorsal to the left. The stomach, intestine, spleen, and pancreas were as in other Elasmobranchs. The contents of the stomach were much digested, but showed remains of molluscs: an operculate foot, apparently of Buccinum, a proboscis of the same, and some pieces of Pecten shell were recognised. The absence of claspers indicated that the specimen was female. The ovaries were smooth, extending nearly the whole length of the body cavity, broad and flat, and joined at their bases across the middle line. The eggs in process of maturation were visible, the specimen being apparently immature. The anterior ends of the oviducts with their openings were very distinct along the sides of the root of the liver just behind the pericardium, but the rest of the tubes were concealed beneath the pericardium. The posterior ends were dilated, and lay over the large kidney (metanephros). There was no distinct egg-shell gland. The species and the other members of the family are generally stated to be viviparous, and Couch's account of the purse which he attributed to *Myliobatis* is too vague and defective to be regarded as important evidence. Members of the allied family Trygonidæ have been recently shown not only to be viviparous, but to nourish their young in the uterus by means of long glandular papillæ of the wall of the uterus, which pass through the spiracles into the stomach of the fœtus.

In my specimen of Myliobatis the abdominal pores were distinct and open behind the aperture of the cloaca.

The Larva of the Eel.

By

J. T. Cunningham, M.A.

Le Leptocefalide e la loro trasformazione in Murenide. Nota preliminare del Corr. G. B. Grassi e del dott S. Calandruccio. Atti d. R. Accad. d. Lincei, Ser. v, vol. i.
Soluzione di un enigma antichissimo ossia. Scoperta della metamorfosi dell' anguilla. Grassi e Calandruccio. Neptunia, 15—30 Sett., 1894.

FROM the time of Aristotle many naturalists have desired, and a large number have attempted, to discover something about the breeding and development of the common eel, but until the present time it has remained a baffling mystery. At last the mystery is to a great extent penetrated; the larva of the eel has been discovered, and turns out to be a creature which was known before. Until the present year absolutely nothing was known of the history of the eel between the disappearance of the parents in the sea in autumn, and the appearance of the young transparent elvers in early spring. Professor Grassi and Dr. Calandruccio have now discovered that one of the larval forms called Leptocephali is the larva of the common eel. This form was described and distinguished as *Leptocephalus brevirostris,* but it was not suspected that it belonged to the eel.

In my paper on the *Reproduction and Development of the Conger,* in No. 1, vol. ii, of this Journal, 1891, I gave some account of what was known at that time concerning the habits and history of the Leptocephali. I mentioned there that only one kind of Leptocephalus was known on the British coasts, namely, L. Morrisii, and that the transformation of a specimen of that kind into the conger had been observed at Roscoff, by M. Yves Delage. Leptocephali are most frequently captured at Messina, and it was largely from specimens obtained there that a number of different kinds were defined and described. In 1856 the Catalogue of Apodal Fish, drawn up by Professor Kaup, of Darmstadt, was published by the trustees of the British Museum. Its object was to give a description of all the genera and species of apodal fish, *i. e.* fish destitute of pelvic fins, existing in the various English and Continental collections. In this work the family Leptocephalidæ was defined as comprising small, compressed, transparent fish, entirely devoid of scales, and having a very imperfect cartilaginous skeleton. The forms were distinguished into four genera,—Esunculus, Hyoprorus, Tilurus, and Leptocephalus. It must be remembered that in this work of Kaup's, as in much work of a similar kind, the method is purely empirical; specimens are described simply as they appear, and different forms are called different species without any consideration of the relations they may bear to each other, without regard to such questions as: are the specimens adult or larval? or: may not many of the different forms be the same animal at different ages or in different sexes? But even from the empirical descriptive point of view the inclusion of Esunculus in the Leptocephalidæ, or even among the apodal fishes at all, was a mistake, for it has distinct pelvic fins, and Kaup gives the number of fin-rays in these as five. It has short dorsal and ventral fins, nearly opposite to each other, and a forked caudal fin. It is obviously the larva of some fish belonging to a family other than the Murænidæ. It resembles somewhat a young Clupeoid, but not very closely; the head is smaller, the dorsal fin farther behind the pelvic. There were a large number of specimens of this form in the Paris Museum, but the place of their capture is not recorded.

Hyoprorus is a genus of which only one species was known, *H. Messinensis,* discovered by Gegenbaur at Messina, originally described by Kölliker. Kaup describes a single specimen, obtained like the others from Messina. The specimen was 4·96 inches long, and had a murænoid continuous median fin extending round the body posteriorly, the extremity of the tail being pointed. The peculiarity of the genus is the sudden broadening of the body in the vertical plane immediately behind the head. The jaws are elongated and straight, with mere traces of teeth. Mr. Gill in his paper on the relations of the Leptocephalids in 1864 expressed the conclusion that Hyoprorus was the young stage of *Nettastoma melanurum,* a Mediterranean species of marine eel with a long and depressed snout, no pectoral fins, open gill apertures, and a tail twice as long as the body, tapering to a point. Dr. Günther in 1870 expressed his entire concurrence with this view.

Tilurus, of which two species were described by Kaup, is a much-elongated transparent compressed fish, also found at Messina. One specimen was 12·21 inches in length. The anus is situated near the end of the attenuated tail, which is as thin as a hair and coiled at its extremity. Dr. Günther was unable to refer Tilurus to any known fish, and thinks it does not belong to the Murænidæ.

Of Leptocephalus Kaup distinguished the following species:

Morrisii.—A blunt head, scarcely visible teeth; lateral line, belly, and anal fin dotted with black points; tail pointed; greatest height one ninth of the total length.

Spalanzani.—Blunt head, almost imperceptible teeth; body narrower in proportion to length.

punctatus.—A round vermiform body; points along the lateral line, oblique pairs of dots along the edge of the belly; anus before the middle of the body, and a row of indistinct points on the anal fin. Specimen came from Messina.

diaphanus.—Anus nearly in the middle of the total length, dorsal fin commencing somewhat before the anus; 4·37 inches long. Also from Messina.

Kölliker i.—A blunt caudal fin with distinct rather long rays; body not higher vertically than the head. Also from Messina.

Gegenbauri.—Has a similar tail, but the height of the body is greater. Also from Messina.

Bibroni.—Similar to the last, but anus behind the middle of the body. From Messina.

Yarrellii.—Similar, but anus still further back. From Messina.

stenops.—Stout teeth and large eyes closely approximated to one another. Probably from Messina.

longirostris.—Has long jaws and distinct teeth, and the body broadening suddenly in the vertical plane behind the head. From Messina.

tænia.—A round head, large projecting globular eyes, short snout, much-elongated broad body. Specimens from India and the Maldives.

brevirostris.—No dots; fourteen teeth in each jaw; small slender tail sustained by visible rays; eyes black; total length 3·15 inches. Locality Messina.

He also distinguished *acuticaudatus, Dussumieri, dentex, marginatus, lineo-punctatus,* and *capensis.* In a later paper, published in 1860, Kaup identified *L. Spalanzani,* Risso, with *Morrisii,* and described two other species of Leptocephalus under the names *Haeckeli* and *Kefersteini.*

Kefersteini.—Seven roundish spots composed of points along the intestine; anus a little behind the middle of the body; head extremely small, with very fine teeth. From Messina.

Haeckeli.—Head small and pointed, tail only one eighth the length of the body. Resembles *brevirostris,* but the snout is longer, the body not so high, and the tail less pointed. From Messina.

In my former paper I referred to the remarks concerning Leptocephalidæ contained in Dr. Günther's Catalogue, vol. viii, p. 138. It is there suggested that Myrus, Ophichthys, and perhaps also Muræna have their Leptocephaline forms. Pointing out that the question whether the Leptocephali were normal or abnormal larvæ could only be decided by investigation of living specimens, Dr. Günther abandons the practice of distinguishing different species among them, and merely groups together the known forms which appear to have a common origin, or which by their general similarity appear to be closely connected together. Thus he groups together *L. Morrisii, diaphanus, Bibroni, Gegenbauri, Köllikeri,* and *punctatus.* We shall see that in recognising *punctatus* as the more developed stage of *Morrisii,* Günther is proved by the researches of Grassi and Calandruccio to have been right, while many of the other forms grouped with *Morrisii* by Günther turn out to be the larvæ of adult forms closely allied to the conger.

It is a curious fact that Leptocephali which are rarely observed or captured in other places are not uncommon at Messina. Commenting on this fact in 1883, Bellotti, an Italian naturalist, maintained that it gave support to the view that these creatures were not normal larvæ, but abnormal overgrown individuals whose proper development had been arrested by exceptional conditions. This investigator had only been able to capture a few rare specimens at Genoa, Nice, and Naples, and none at all at Palermo, Catania, or Siracusa, which are near Messina. He surmised that the impetuous currents and the numerous whirlpools of the narrow Straits of Messina were the exceptional conditions which caused the larvæ of congers, &c., to pass through an abnormal course of development. Until the normal development was known, arguments of this kind, as I have remarked in my previous paper, were of little importance.

Signore Grassi is an Italian naturalist who lives at Catania. He is one of those who devote themselves chiefly to the application of rigid scientific method to investigation in the department which used to be called natural history, and which it has been proposed to distinguish by the term bionomics. He has made himself famous recently by his marvellous discoveries concerning the life histories of the termites or white ants. In 1892 he published a brief account of some researches which he and Dr. Calandruccio had made on the Leptocephali. For five years they had noticed that these forms were common enough at Catania, being captured at all times of the year and sometimes in abundance. They were most plentiful in the harbour, and were caught by the nets called tartarene and sciabica, nets which are dragged over a sandy or muddy bottom. In these authors' opinion this abundance of Leptocephali at Catania is peculiar to the period mentioned, and to be attributed to the volcanic eruptions which have sent much lava into the sea, and so compelled certain Murænidæ to leave their usual haunts among the rocks or at great depths and seek shallower water. It is obvious that this suggestion has no great air of probability.

The careful experimental investigation of the Leptocephali was carried on by these naturalists in the year 1891–2, and the following were the results. In the development of the conger (*Conger vulgaris*) three stages can be distinguished :—First, a tænioid form resembling *L. Morrisii*, except that the dots on the lateral line are limited to the posterior extremity of the body; second, *L. Morrisii* itself; and third, the form which had been previously distinguished as *L. punctatus*: from this the perfect conger is directly developed. The first tænioid form has long and fine larval teeth; these are wanting in *Morrisii*, in which the permanent teeth begin to develop in a position internal to that of the larval.

During the metamorphosis there takes place a gradual reabsorption of the gelatinous skeleton, much pigment develops, the anus passes into a more anterior position, and so much diminution in size takes place that from larvæ 12½ cm. long (5 inches) are obtained congers only 7½ cm. (3 inches). During the transformation, which may not take more than a month, the Leptocephali take no food or only minute particles. The transformation may be followed without any difficulty in specimens kept in any aquarium, or even in tubs; the authors observed it in 150 individuals. This is surely a sufficient confirmation of the isolated observation of Delage. All the various stages observed in captive specimens were also seen in specimens taken from the sea. In the aquaria the larvæ hid away in groups, threaded through the crevices under stones, the eggs of Aplysia, &c.; they also sought the darkest corners of the aquaria and avoided the light.

L. diaphanus of Kaup was found to develop into *Congromuræna balearica*. This is a Mediterranean species of Congromuræna, a genus very similar to Conger, but distinguished by the presence of large muciferous cavities in the front part of the skull, and the dorsal fin commencing at a more anterior point, namely, nearly above the gill opening. *L. Köllikeri* proved to be the larva of *Congromuræna mystax*, the only other Mediterranean species of the genus; and *L. Haeckeli, Yarrellii, Bibroni, Gegenbauri,* and probably *brevirostris* were found to be merely different stages in the development of the same form. The investigators have now come to a different conclusion concerning *brevirostris*, but with regard to the others reference to Kaup's original descriptions and figures shows that they resemble one another in the truncated, rather broad form of the tail and its distinct rays. In the course of development it appears that the post-anal or caudal portion of the body continually grows longer in proportion to the pre-anal or anterior portion. It thus appears that the Leptocephaline forms grouped with *Morrisii* by Günther are larval stages of Conger and Congromuræna, and his view of their close connection is shown to have been remarkably sound.

L. Kefersteini was found to be a somewhat rare form at Catania, but it was easily kept alive in aquaria, where it buried itself in the sand at the bottom and changed into *Ophichthys serpens.* Ophichthys is distinguished chiefly by having the extremity of the tail free, not surrounded by the median fin, and a pointed snout projecting beyond the lower jaw. *L. stenops* was found to be the larva of *Myrus vulgaris,* whose characters are—nostrils on or close to the margin of the upper lip, caudal rays very short, tail twice as long as the trunk, white lines across the occiput, and white pores on the face and lateral line. *L. longirostris* was similarly connected with Muræna, which has narrow gill openings, and a body suddenly becoming very thick just behind the head. This character is markedly exhibited by the larva. *L. tænia* is probably the larva of Sphagebranchus, which is allied to Ophichthys (united with it by Günther), but has the gill openings convergent on the ventral surface of the head.

The same naturalists, pursuing their researches on the Leptocephali, have now satisfied themselves that the species *L. brevirostris* is the larva of the common eel. They have not, it is true, been able to follow the entire transformation on one and the same specimen, but they have verified the most important changes in several individuals, and have compared all the organs in these stages and in the perfect form, and have traced a gradual transition from the structure and characters of *brevirostris* to the fresh-water eel. *L. brevirostris* (Fig. 1) is a comparatively small Leptocephalid,

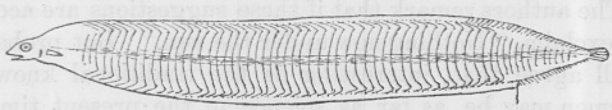

FIG. 1.—*Leptocephalus brevirostris,* after fig. 15, pl. xviii, of Kaup's Catalogue of Apodal Fish in the British Museum, 1856.

scarcely reaching the maximum length of 8 cm. ($3\frac{1}{4}$ inches), with a maximum vertical height of 1 cm. The reduction in length during the metamorphosis may be somewhat more or somewhat less in different individuals, but never exceeds 3 cm.; that is to say, a fully transformed young eel, which is still very transparent, may be as short as 5 cm. (2 inches), but not less, and it is very slender.

L. brevirostris has not hitherto been found anywhere else except in the Straits of Messina. Is it possible, ask the Sicilian naturalists, that eels undergo a metamorphosis only in that place, and elsewhere have a different history? The hypothesis is exceedingly improbable. They have made investigations, and convinced themselves that nowhere can young eels be obtained which are less than 5 cm. long. Contrary assertions are to be found in literature. It has been asserted that there are eels only 2 or 3 cm. long, or even as small as 7 mm. (about ⅜ inch), but critical examination shows that no such statements rest on direct observation. The *Leptocephali brevirostres,* which are the larvæ of the eel, have hitherto escaped observation in other places on account of their habit of hiding themselves in the bottom of the sea.

The authors add some curious remarks concerning the history of the knowledge of the subject. They tell us that it is a fact that the fishermen of Augusta know by tradition the metamorphosis of the Murænidæ, by which we presume is meant that they have a tradition that Leptocephali are the immature or larval forms of congers and eels. It is also a fact that at Catania the Leptocephali are commonly called *Morenelle,* or little Murænæ. It is to be inferred that from time to time some observant fishermen have noticed similarities or transition stages which led them to express this conclusion among their fellows.

Aristotle states, in his History of Animals, that eels have no sexes, nor eggs, nor semen, and that they arise from *γῆς ἔντερα,* the entrails of the earth. By this expression some have understood earthworms, others have maintained that the Greeks applied it to all sorts of creeping, limbless creatures living in soil or mud, and believed that these were spontaneously generated. At Palermo the Leptocephali are called *lombrici* or *vermicelli di mare,* and Grassi and his colleague suggest that perhaps the belief that these *lombrici* gave rise to Murænids reached Aristotle in some form or other, and so caused him to write that eels arose from the entrails of the earth. The authors remark that if these suggestions are accepted we may well exclaim, "Nothing new under the sun." But probably most people will agree that, interesting as the traditional knowledge of the fishermen may be, as far as science in the present time is concerned, the knowledge of the transformation of the eel and other Murænidæ is due to the patient and fruitful investigations of Grassi and Calandruccio.

Considering that eels are so common, it will be a matter of much interest to make renewed attempts to discover their larvæ and those of the conger at Plymouth, and at other places outside the Mediterranean. The subject suggests two interesting questions : firstly, are Leptocephali pelagic or not, or are some pelagic and some not? secondly, are the eggs of the Murænidæ pelagic, or some pelagic and some not, as in other families of fishes? It appears from the account given by Grassi and Calandruccio that the Leptocephali at Catania are captured on the bottom, and we have just seen that these authors conclude that the larva of the eel has escaped capture in other places from its habit of hiding or burrowing in the sea bottom. In captivity the larva of the conger was found to hide at the bottom and avoid the light. *L. Kefersteini*, the larva of *Ophichthys serpens*, lived in the aquarium buried in the sand; and the larva of *Congromuræna balearica* also burrowed into the sand, although, singularly enough, it could only be kept alive on a naked marble bottom. We are not told whether these larvæ came out at night and swam about freely. That the larvæ of the conger and common eel are not constantly pelagic at night seems proved by the fact that they have never been taken in abundance in nocturnal tow-netting expeditions. I conclude, therefore, that these Leptocephali, and all those known from the Mediterranean, are not truly pelagic, but live on or in the sea bottom, and that the reason they are found in the open water or at the surface at Messina is that there the strong tidal currents and eddies stir up the bottom and carry their light bodies about as scraps of paper are lifted and borne along by the wind. Reference to my previous paper, and the records which are there cited, will show that in two cases *L. Morrisii* has been taken in a hand-net near the surface of the water, but in other cases it was taken from the bottom,—for instance, in the process of fishing for prawns. There can be little doubt that the larvæ of the conger and of the eel exist around our coasts in great abundance, under stones or buried in sand or gravel, and that we do not catch them because we do not know the right way to go about it.

But, on the other hand, we find constantly in narratives of oceanic zoological researches that Leptocephali were taken in abundance in ordinary tow-nets worked near the surface. This, it is to be remarked, occurs always in the tropics. For instance Giglioli and Issel, in their volume Pelagos, published in 1884, state that twice only during the voyage of the "Magenta" they found specimens of Leptocephalus in the pelagic net, once in sight of Java, once in the South Pacific.

In the "Challenger" narrative the occurrence of pelagic Leptocephali is only mentioned twice, once in the account of pelagic animals observed between Fernando Noronha and Bahia, off the coast of Brazil, 5° to 15° south latitude, the second time among those captured on the voyage from the New Hebrides to New York, in about the same latitude to the eastward of Australia in the Pacific. In the former case the Leptocephali were accompanied by the Pleuronectid larva of Rhomboidichthys, the larva originally known as Plagusia, characterised by the peculiarity that the lower eye reaches the upper surface by passing through the base of the dorsal fin. Dr. Günther gives the following account of the Leptocephali in his Report on the Pelagic Fishes of the "Challenger." He says that singularly few specimens were collected during the expedition, and these throw no new light on the question of origin. Six specimens obtained in mid-Atlantic belong to the form which has received the name *pellucidus* and other names. These other names are those associated by Grassi with *Congromuræna mystax*. One specimen obtained on the west coast of Africa at the surface belonged to the form *L. Morrisii*. Another, from a station near the Admiralty Islands, belonged to the form *L. tænia*. Lastly, a specimen from the North Atlantic had the characters of *L. brevirostris*. It is much to be regretted that no further description or any figures are given. If the comparisons are correct, it would follow that the larva of both the common conger and common eel were taken in the open Atlantic in a pelagic condition.

A. Agassiz remarks in Three Cruises of the "Blake," vol. i, p. 121, that we may trace the northern course of the Gulf Stream by the presence of Sargassum, Porpita, Leptocephali, &c., which are carried each year to the coast of Southern New England.

It seems evident that in tropical regions of the ocean truly pelagic Leptocephali are of constant occurrence and fairly abundant. It will probably be found that these are the larvæ of species of Murænidæ other than those whose larvæ have been traced by the Sicilian naturalists. But in the present state of our knowledge it seems impossible to distinguish satisfactorily the oceanic pelagic forms from those of the Mediterranean, or from those which are not pelagic. Thus Grassi and Calandruccio suggest that *L. tænia* is the larva of species of Sphagebranchus, of which species occur both in the Mediterranean and the East Indies. But the names *tænia, marginatus, lineo-punctatus,* and *capensis* are grouped together by Günther as applying to much-elongated forms which appear to have been taken at the surface of the open ocean: some specimens reach a length of 25 cm., or nearly 10 inches. The specimens named *L. tænia* by Kaup came from India and the Maldive Islands, but we are not told whether they were pelagic; probably they were. If so, the question arises whether the form called *L. tænia* by the Sicilians is also truly pelagic, or if it belongs to a different species. It would scarcely be profitable to pursue these speculations further. What has been said is sufficient to suggest strongly that the characters and history of the Leptocephali still offer a most promising field of study and investigation, alike in the Mediterranean, in the tropics, and on our own coasts. It is much to be hoped that Drs. Grassi and Calandruccio will publish a complete account of their observations with satisfactory figures, in order to satisfy the interest and curiosity excited by their preliminary communications. It is worthy of remark that there is some similarity between the cases of the Leptocephali and the larval Pleuronectid originally described by Steenstrup as Plagusia, and probably belonging to the genus Rhomboidichthys. This larva is a conspicuous pelagic form in tropical seas on account of its large size, and in this respect and in its oceanic distribution differs from the smaller larvæ of other genera which are abundant on temperate shores, but whose pelagic life is but little prolonged. In like manner it will probably be found that the oceanic Leptocephali are peculiar to certain special genera among the Murænidæ. In the article printed in Neptunia, the Sicilian ichthyologists make no mention of the well-known oceanic Leptocephali, and have overlooked their existence in formulating their general conclusion that these larvæ escape notice and capture by their habit of hiding at the bottom, except at Messina and Catania.

With regard to the pelagic condition of the ova of Murænidæ, Grassi and Calandruccio state that they have been able from their own observations to confirm with complete certainty the suggestion of Raffaele that certain pelagic eggs described by him belong to this family. But they do not assert that they have identified particular eggs with particular species. If the eggs of the conger and common eel are really pelagic, it is an inexplicable fact that they have not been identified in the course of the careful and long-continued researches made on pelagic ova at Plymouth and other places on the Atlantic coasts of Europe.

North Sea Investigations.

By

Ernest W. L. Holt.

On the Destruction of Immature Fish in the North Sea.

I subjoin the results of statistical inquiries into this question, continued from the point at which they were left in the last number of this Journal. Having been permitted by the Council of the Association to undertake a series of lectures along the coast of Yorkshire on behalf of the North-eastern Sea Fisheries Committee during the present autumn and winter, I find it necessary to restrict the present paper to the smallest possible compass, reserving practically everything except the mere statement of figures until more time shall be available for the deduction of results.

I regret to have to say that the statistics for the month of May are by no means complete. Bibliographical work in connection with several scientific papers on which I was then engaged necessitated my absence from Grimsby during the early part of the month, and the sudden illness of my subordinate during the same period interfered with the arrangements I had made for keeping up the records. The statistics as to plaice are, therefore, a blank for the first week of May; Mr. Clark unfortunately remained unwell for the rest of the month, while a serious break-down in the circulating apparatus of the Cleethorpes aquarium made great demands upon the time which I should otherwise have been able to devote to market observations; and, though I was able to keep account of all plaice landed, my statistics as to haddock and cod are too meagre to be worth insertion. The gas-engine for water circulation was finally restored to good working order, but, to guard against any future temporary break-down, I have fitted the entire series of sea-water tanks with an apparatus for air circulation, on a pattern communicated to me by Dr. G. H. Fowler.

It has proved that this air circulation is quite sufficient to keep the tanks properly aërated throughout the night, and we have thus been able to save the excessive labour and expense (for gas) which the smallness of our reservoir had hitherto entailed in pumping by night as well as by day.

Plaice.—The statistics are continued from the end of April, 1894; as stated above, the eight days missed in May were at the beginning of the month.

Month.	Total No. of Boxes.	North Sea.			Iceland.	
		Total.	"Large."	"Small."	No. of Boxes.	No. of "Voyages."
1894.	I.	II.	III.	IV.	V.	VI.
May (less 8 days)	12,729	9,612	5,393	4,219	3,117	25
June	15,939	13,181	8,439	4,742	2,758	21
July (less 3 days)	14,304	11,295	9,034	2,261	3,009	19
August (less 1 day) ...	16,616	15,950	14,617	1,333	666	5
September (less 3 days)	15,503	15,503	14,663	840	...	...

In the last number of this Journal (p. 171) I entered at some length into the question of the diversion of fishing power from one point to another, which is revealed by comparison of the different columns in the above table. The same reasoning is of course applicable to the present season; and while we note from the close similarity of column IV in 1893 and 1894 that the "small" fish grounds were worked to about the same extent in the two years, the great diminution of column VI in July and August of 1894 shows that considerably more power was available in those months for the augmentation of column III. There is an actual increase of about 3000 boxes in the aggregate of the two months in 1894; but such an increase is of no great significance when we take into account not only the number of boats available from the diminution of column VI, but also the steady annual increase in trawling power generally. It will have been gathered from my previous remarks that the Iceland grounds are worked by steam vessels only (as far as trawling is concerned), while the "small" fish are chiefly contributed in the later part of the summer by fleets of sailing smacks. During the present year the usual practice of forming a large fleet, to land fish by steam cutters at London, has been discontinued, so that during the fleeting season the number of vessels landing at Grimsby has been proportionately greater. A very large Fishing Company belonging to the port habitually "fleets" throughout the year, its fish being landed in London, and therefore finding no place in my records.*

The Iceland trawl fishery cannot be said to have been satisfactory during the present season. In the early part, especially in May, boats had for the first time a difficulty in finding their fish. In previous years the only difficulty had been in getting a fair price for

* A cutter occasionally lands at Grimsby when coming in for stores or other purpose, but I do not include the fish in these returns, since to do so would tend to confusion in the deduction of results.

them, but, out of twenty-five "voyages" in May, twenty averaged but little more than 100 boxes each. Later on matters improved somewhat, but at no period were the fish to be found in the same abundance as last year, while, as I am informed, some of the best grounds were practically "cleaned out." To some extent, no doubt, on this account, but largely also on account of the higher price obtainable for the smaller inshore fish, there appears to have been a very general disregard of the territorial regulations of the Danish Government, with the result that one or two vessels were seized and heavily fined. This had the effect of bringing the season to an earlier close than last year, and, as the Iceland Parliament passed a bill early in September enforcing still heavier penalties on territorial trawling, it may be supposed that the inshore grounds will be little molested in future years. The penalties under the new law are as follows:

For the first offence . . .	2,000 crowns, £100 each.
For the second offence . . .	10,000 crowns, £500 each.
For the third offence . . .	Confiscation of the vessel.

On a coast where the declivity is rapid the three-mile limit is far from being the natural one, but no fault can be found with the authorities for availing themselves of all the protection which international law allows them.

Haddock.—The appended figures show the total number of "small" fish landed during the months specified:

June (less 1 day) . . .	5570 boxes.
July	6039 "
August (less 2 days) . .	6798 "
September	6587 "

Comparison with the same months of last year (*supra*, pp. 128 and 174) shows a large increase for the present year, which increase, it may be mentioned, is being maintained in the later part of the season. Indeed, I am given to understand that haddock are now more plentiful than they have been for a great number of years, and there has certainly been a steady augmentation ever since these statistics were commenced. My figures deal only with "small" fish, but I have no evidence of any diminution in the supply of fish of all sizes, and however the haddock may have suffered from over-fishing in the past, it apparently holds its own at present. The exceptionally large catches of the autumn and winter of this year may possibly be to a great extent dependent on the favorable weather of 1893. Bottemanne has clearly established the dependence of the anchovy supply of any year on the temperature of the previous year;* and though there exists no series of observations to

* Cf. Dr. Fowler's epitome of Bottemanne's researches (*supra*, vol. i, N.S., p. 340).

support the same conclusions with regard to any other fish, it is at least possible that the principle is capable of a wider interpretation. Fishermen hold the opinion that a warm spring means a good supply of fish of all sorts in the autumn of the *same* year, but the experience of 1893 can hardly be said to have given any very great support to this view. It must be remembered, however, that the advantages of a good supply of fish may be seriously discounted by weather unfavorable to their capture; while, on the contrary, as during the present autumn, an open season permits of catches which may make the supply appear *relatively* greater than it actually is.

Cod.—Trawled codling, of the size explained in previous records, have been landed in the following numbers:

June (less 1 day) . . .	354	boxes.
July	1708	„
August (less 2 days) . .	2140	„
September	2636	„

The most noteworthy feature is the lowness of the returns for June. April (*supra*, p. 175) was also somewhat unproductive, and fish were certainly scarce in May. I have already alluded to the general opinion that codling are comparatively scarce (in the trawl) in summer, and comparison of the different months shows that the least productive period of each year has been from April to June (inclusive).

Inshore Fisheries.—I referred in my last report to the unusually large catches of prawns (Pandalus), shrimps and small plaice, &c., made in the Humber last summer. It was attributed by fishermen to the fine warm weather, and I considered it probable that the good effects of such weather would continue to be felt in the summer of the present year. There has been, however, at the best only a moderate supply of prawns and shrimps this year, while "flat-fish," *i. e.* young plaice, have been remarkably scarce, though the same cannot be said of soles. Indeed, from observations which I was able to make on board the s.s. "Garland," both this year and last, I believe that there has been a distinct improvement in the supply of soles in the river. Comparatively few were brought to market, owing to the energetic action of the local fisheries authorities in enforcing their bye-laws with regard to fish trawling in the river, and to this action the increase may to some extent be due. It may be explained that soles are likely to receive the most protection from this legislation, because they are the fish to which the fish trawlers were wont to devote the bulk of their attention as long as they were permitted to do so, and the greatest number of soles are found in parts of the river not much frequented by other flat-fish.

mandible and none on the maxilla or the prominent parts of the gill-cover, while the fin-rays are only feebly scaled.

Dimensions.—Of the three specimens two were measured after preservation, the third being measured both in the fresh and preserved conditions.

Note on some Supposed Hybrids between the Turbot and the Brill.

By

Ernest W. L. Holt.

THE specimens conform to a type which appears to be fairly well known to Grimsby fishermen and fish merchants, and which is always regarded by them as the offspring of the parents mentioned in the title. The object of the present note is to discuss the probabilities of the correctness of this diagnosis as fully as the material allows. The form can hardly be said to be rare, since within two years I have secured three specimens, while I have heard of several others having been present in the market. In some old manuscript notes kindly lent me by my friend Mr. G. L. Alward I find descriptions which apply to two fish of the same type, while Dr. Günther tells me that he has received several from London fish merchants.

Notes of apparently similar fish have from time to time appeared in both scientific and sporting publications, since Day (Fish G. Brit., ii, p. 13) refers to specimens described in the Proceedings of the Zoological Society and the Field, while Smitt has recently given both description and figure (Hist. Skand. Fish., ed. 2, p. 446).

Description of Specimens.

The specimens which have come under my own observation are three in number; they were trawled in the North Sea, one in June, 1892, and the others in the same month of the following year.

Colour.—In the fresh condition they presented so close a resemblance in colour to brill that they might easily have been mistaken for a fish of that species. The brill, as is well known, is of a reddish-brown colour on the ocular side, diversified with sundry lighter markings, which markings are retained to some extent after death. The turbot, on the other hand, as it appears in the market, is of nearly uniform olive-brown colour, the lighter markings conspicuous in living examples being rapidly masked by post-mortem expansion of the darker chromatophores. Specimens of the two species may certainly be found to approach each other in general coloration, but it will be conceded that the broad distinction which I have laid down holds good in the majority of cases. Preservation in alcohol rather emphasises the distinction in the case of brill and turbot, but, of the three hybrids, one acquired after preservation a colour corresponding to that of a turbot similarly preserved, while the other two retained the reddish tinge of the brill.

Scales.—The character of the scales forms the most striking feature in the three specimens, and is practically identical in all. In place of the imbricating scales of the brill or the isolated tubercles of the turbot, both sides of the body are beset with large more or less oval, cycloidal scales, which, though never actually imbricating, are placed fairly close together. On the ocular side of the body each scale is very thin and slightly convex, the most prominent part being at the central point of the concentric system of faintly marked ridges situate behind the middle line of the scale. The larger scales exhibit a number of faint grooves for insertion anteriorly, but there is no free edge. The whole scale is between two pigmented layers of dermis, but the upper layer on the ocular side is in most cases incomplete at the greatest convexity of the scale, so that the latter is, to that limited extent, exposed. The skin is so thin that it might readily be abraded, and to what extent the partial exposure of the scales may be due to artificial causes (*e. g.* injury in the trawl, &c.) it is impossible to say. The largest scales occur on the lateral parts, especially on the caudal peduncle, and anteriorly in the neighbourhood of the lateral line. In a specimen of 43·3 cm., one of the largest from this region measures 5 by 3·5 mm. Towards the abdominal region the scales become smaller and irregularly rounded, as also on parts of the interspinous ridges. On the jaws they are small and circular, rather small and nearly round on the head, except on the malar part, where they become larger and elongate. On the fin-rays the scales are very small, and here alone they show some attempt at imbrication. On the blind side the scales are essentially similar to those of the ocular side, but are less convex and almost invariably veiled by skin. They correspond in distribution, with the exception that there are only a few on the mandible and none on the maxilla or the prominent parts of the gill-cover, while the fin-rays are only feebly scaled.

Dimensions.—Of the three specimens two were measured after preservation, the third being measured both in the fresh and preserved conditions.

	Total length.	Total without caudal.	Length of head.	Greatest height.
A.	$17\frac{3}{8}$ in.	14 in.	$4\frac{5}{8}$ in.	$9\frac{19}{32}$ in.
B.	$18\frac{1}{8}$ in.	$15\frac{1}{4}$ in.	$4\frac{7}{8}$ in.	$9\frac{1}{2}$ in.
C (*preserved*)	$18\frac{3}{4}$ in.	$15\frac{13}{16}$ in.	5 in.	$10\frac{3}{8}$ in.
C (*fresh*)	19 in.	16 in.	5 in.	$10\frac{1}{2}$ in.

Fin-ray Formula :

A.	D. 69	A. 52.
B.	D. 72	A. 54.
C.	D. 76	A. 54.

Comparative.—The foregoing description will probably suffice, minor details of character being more conveniently treated only in comparison to those of the species to the union of which the forms before us have been imputed. It may at once be said that all three examples are females, but not one of them is sexually mature. It is significant that all three were caught in the month of June, a period at which the ovary would certainly be enlarged (or evidently recently shotten) in either brill or turbot, and fish of either species as large as those before us (viz. $17\frac{1}{8}$ to 19 inches) would as a rule be sexually mature. In fact, an immature female brill of even the smallest size quoted is decidedly rare. Apart from the scales, turbot and brill are most readily distinguished by the proportion borne by the height to the length of the body, the turbot being the deeper fish of the two. The proportions laid down in ichthyological works, however, are of no great service, since the size of the individuals on which such proportions are based is never forthcoming, and it is well known that the proportions of a fish are subject to constant change with the growth. Therefore, in comparing our supposed hybrids with the brill and turbot, it appeared best to give the proportions of a series of forms of either species agreeing as nearly as possible with them in size, as in the appended table. The total length, without the caudal, given in the first column is taken as the unit, and the other dimensions are expressed in decimals of this unit.

	Total length without caudal, in inches.	Length of head.	Greatest height of body.
Hybrid A	14	·330	·685
„ B	$15\frac{1}{4}$	·336	·622
„ C*	$15\frac{13}{16}$	·316	·656
„ C†	16	·312	·656
Brill i	$10\frac{1}{8}$	·358	·679
„ ii	11	·295	·608
„ iii	11	·295	·586
„ iv	$11\frac{1}{4}$	·288	·600
„ v	$11\frac{3}{4}$	·295	·675
„ vi	12	·291	·562
„ vii	$14\frac{7}{8}$	·302	·571
„ viii	$15\frac{1}{2}$	·306	·516
„ ix	16	·281	·562

* Fresh. † Preserved in alcohol.

	Total length without caudal in inches.	Length of head.	Greatest height of body.
Turbot i	13¼	·349	·660
" ii	13¼	·339	·688
" iii	13½	·342	·750
" iv	13½	·351	·722
" v	14	·357	·732
" vi	14¼	·333	·719
" vii	14⅜	·347	·695
" viii	14⅝	·341	·700
" ix	14¾	·336	·711
" x	14⅞	·344	·710
" xi	15	·358	·766
" xii	15½	·354	·677
" xiii	15¾	·349	·730
" xiv	16½	·333	·666

The details of proportion of brill and turbot given in the above table show how easily a diagnosis based on these features alone may be vitiated by individual variation; but, on the whole, the condition exhibited by the hybrids appears to be an intermediate one, not inclining very strongly to either species. It must be remarked that the measurements from which the proportions of the brill and turbot are deduced were taken in the fresh condition, but comparison of the two series of proportions of hybrid C shows that the figures are not greatly affected by preservation in alcohol. The variation which is exhibited by the hybrids amongst themselves is evidently not greater than is met with in perfectly normal examples of either species.

The fin-ray formula given above is certainly intermediate in character, but inclines, among material collected from the same locality, rather to the brill than the turbot. Thus nine turbot give D. 60—67, A. 42—48; the three hybrids D. 69—76, A. 52—54; and four brill D. 77—81, A. 57—62. The first dorsal ray is in each case shorter than the second, as in turbot, but its extremity is divided, as in the brill.

The number of vertebræ is an important distinction between the turbot and the brill. The only hybrid in which I have counted these structures agrees in this respect with the last-named species.

In certain minor characters of doubtful importance the hybrids appear to be intermediate. The vomerine teeth are rather more numerous in the brill than in the hybrids, and much more numerous than in those turbot which I have examined. In the teeth of the upper jaw the hybrids agree best with the brill, the teeth being more slender than those of the turbot. The peculiar papillation of the lips is probably a very variable character. Such turbot as I have examined have an outer row of semicircular pigmented labial tags or papillæ; this feature was slightly represented in the hybrids, but absent from the brill. A strong inflection of the dorsal profile behind the snout is noticeable in all turbot. It is, at best, but slightly marked in the brill, and in this the hybrids agree with the last-named species.

As will be gathered from the description, the scales of the supposed hybrids differ at first sight very markedly from those of either the turbot or the brill, resembling rather the smaller non-imbricating skin-clad scales met with in the plaice, and especially in large examples. The resemblance to either brill or turbot only becomes apparent when we come to consider the real nature of the dermal apparatus of the last-named species. The turbot, as is well known, is clad in a deeply wrinkled skin, the wrinkles, on close inspection, being the depressions or sulci which separate a very irregularly arranged series of rather vesicular papillæ. Scales are only represented by a series of tubes, with very imperfect dorsal and ventral flanges, in connection with the sense-organs of the lateral line, and by large isolated tubercles, the apices or bosses of which are naked, while the bases are deeply embedded in the derma by a series of twisted irregular radical processes. Such tubercles in British examples are present only on the ocular side, except in "cyclopean" or in partially ambicolorate fish, in which they occur also to a greater or less extent on the blind side. In Norwegian fish, however, the tubercles, which are as a rule more numerous on the ocular side than in examples from our own seas, occur not infrequently on the blind side without any accompanying pigmentation. The skin papillæ and wrinkles are equally present on either side in all examples.

On the general surface of the body there is no very striking resemblance between the papillæ of the turbot and the scale capsules of the hybrid, but at the base of the interspinous ridges the skin of the two forms presents a fairly close resemblance, and I was led by this to institute a comparison of the skin armour of the two forms, which led me ultimately to the conclusion that the papillæ of the turbot's skin were undoubtedly scale-capsules, in which the scales had failed to develop. This view I believed to be novel, but on the appearance of Professor Smitt's edition of Fries, Ekstrom, and Van Wright's History of Skandinavian Fishes I found it set forth (p. 434) that the skin is furnished with "soft verrucose closed scale-sacs." This interpretation of the papillæ may either be original, or, since the work in question is largely a compilation, may be collated from the observations of some earlier Skandinavian ichthyologist. I am entirely in accord with it, but, if it is set forth for the first time in the work referred to, it runs the risk of rejection for want of evidence, since the matter is nowhere alluded to in the context. I propose, therefore, to discuss the question very briefly in this note.

In the appended woodcut, Fig. 2, *a* is a group of scales and capsules from the lateral line of a hybrid (blind side), and the resem-

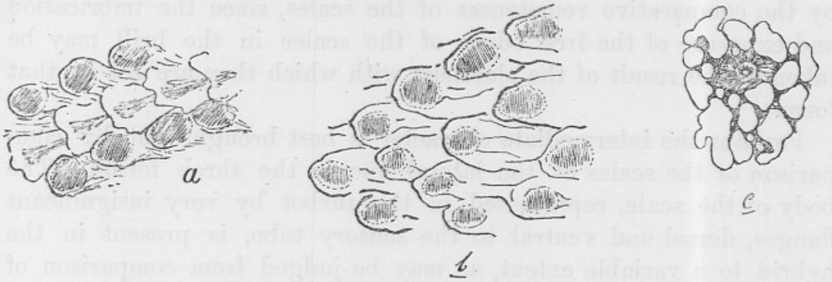

FIG. 2.—*a*. Group of scales from region of lateral line of hybrid (blind side). *b*. Group of scales from base of interhæmal ridge of hybrid (blind side). *c*. Tubercle and surrounding papillæ of turbot (ocular side); pigment omitted from papillæ.

blance to true scale capsules of the lateral line of the normal turbot is sufficiently noticeable. The surrounding scale capsules, however, are far more regular than the papillæ of the turbot, besides enclosing a very conspicuous ovoidal scale. In a group of scales (*b*) from the base of the interhæmal ridge of a hybrid (blind side) we find that the sulci, in this case obviously in connection with true scale capsules, present an appearance closely similar to those met with between the papillæ of the same region in the turbot. *c* shows a single tubercle of a nearly adult turbot (ocular side) surrounded by a group of papillæ, the apex of the tubercle projecting through the skin in precisely the same manner as I have described in the case of some of the scales of the ocular side in the hybrids. The smallest turbot ($4\frac{7}{8}$ inches) in which I have found the tubercles visible to the naked eye has these structures in the form of blunt cones, the bases of which are elongated anteriorly, but entirely destitute of radical processes. Radial insertion sulci are also absent, but such is also the case in some scales of the hybrid. In fact, save that it is much thicker in proportion, the young tubercle of the turbot is not distinguishable in structure from the scale of the hybrid. The tubercles of the turbot, as is well known, have no regularity either of disposition or of number, and I think that there can be little doubt but that the intervening papillæ are merely barren scale-sacs, which become to some extent broken up and anastomosed with the growth of the fish. If this is the case the intermediate nature of the scales of the hybrid becomes apparent.

More sparingly distributed than those of the brill, though more numerous than in even the most thickly tubercled Norwegian turbot, the scales retain characters which closely resemble a very early condition in the development of a turbot's tubercle, as well as the perfect condition of the scale of a brill. The persistence of the skinny covering has probably no greater significance than is explained by the comparative remoteness of the scales, since the imbrication and exposure of the free edges of the scales in the brill may be taken as the result of the closeness with which they are set in that form.

Perhaps the intermediate character is best brought out by comparison of the scales of the lateral line in the three forms. The body of the scale, represented in the turbot by very insignificant flanges, dorsal and ventral to the sensory tube, is present in the hybrid to a variable extent, as may be judged from comparison of *b* and *c* (Fig. 3). In no case is it so well developed as in the brill (*a*), nor so insignificant as in the turbot (*d*).

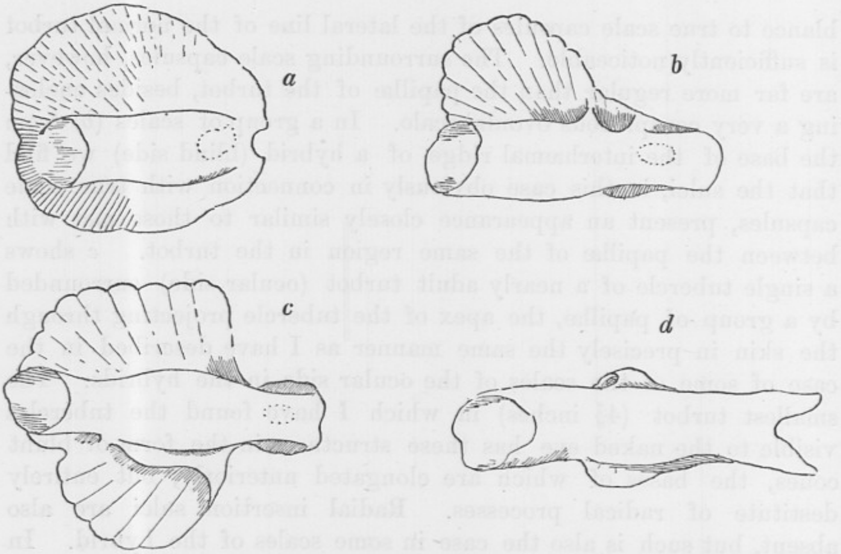

FIG. 3.—*a*. Scale from lateral line of brill (blind side). *b*, *c*. From hybrid (blind side) *d*. From turbot (blind side).

Conclusions.—In discussing the parentage of these forms it appears to me that there are only two alternative theories, since it is not likely to be seriously contended that they belong to a distinct species. They may be either hybrids, or "sports" of either the turbot or the brill. If the latter is the true explanation it is at least remarkable that the variation should in so many points tend towards the typical characters of another species, and I cannot but think that the sexual immaturity of all three specimens (considering their large size) is strong evidence of hybridity. As to whether the female parent was brill or turbot there is little evidence, but perhaps the preponderance of brill-like characters seems to point to the former species. Within the limits of a single species (*e. g. Salmo levenensis*) it is the characters (of size and pigmentation) of the female parent that are reproduced in the offspring (Sir J. Gibson Maitland, Bart., *in litt.*), and it is not unreasonable to suppose that the species of that parent may be predominant in determining the characters of a hybrid. Ova of the brill have been successfully impregnated with the milt of the turbot by Professor M'Intosh, and although the larvæ proved delicate, they do not appear to have been less hardy than pure-bred turbot larvæ which have come under my own observation.

Of the several instances of supposed hybrids collected by Smith (*op. cit.*, pp. 444 and 446) all seem to have been somewhat turbot-like in shape, and the author's conjectures as to the parentage seem to be based chiefly on the number of fin-rays and the relative thickness of the scales. The form which appears to correspond most nearly to those which form the subject of this note is suggested to be the result of the union of the male turbot and female brill, and on the whole I am inclined to think that this interpretation of the parentage is correct.

The Migration of the Anchovy.

Summary of a Report to the Council of the Association.

By

J. T. Cunningham, M.A.

The facts gathered up to the present time with regard to the occurrence of anchovies in the English Channel are briefly as follows:

In November, 1889,* large numbers of anchovies were reported to have been taken at Dover in the drift-nets used for sprat fishing. During the same month also numbers were taken by the sprat fishermen in Torbay, in seines.

In the following November, 1890, numbers of anchovies were brought in at Plymouth by pilchard fishermen, fishing to the south of the Eddystone. On November 26th one boat took 584, and on November 27th one took 500. During this autumn nothing was heard of anchovies at Torquay, and Mr. Matthias Dunn could not obtain any at Mevagissey.

The only anchovies brought to the Laboratory in the autumn of 1891 were caught on November 9th. On this occasion twenty-one fish were counted. No anchovies were reported from Torquay. Anchovy nets purchased by the Association were shot twenty-four times between September, 1891, and April, 1892, and thirty-one anchovies were taken, the largest catch being twenty on November 20th.

During the winter 1892–3 the number of anchovies obtained from fishing boats at Plymouth was sixty-one, of which number thirty-three were caught in November and December. The Association's nets were shot six times in November and December, and five anchovies were taken, all at one time (November 28th).

During the winter 1893–4 only eight anchovies were obtained from the Plymouth fishermen. The nets of the Association were

* This Journal, vol. i, N.S., p. 334.

shot once, but no anchovies were caught. No anchovies were reported from Torquay.

In November and December, 1894, twenty-seven anchovies were obtained from Plymouth fishermen. The Association's nets were shot five times in November, but no anchovies were caught, and it was definitely ascertained that none were taken at Torquay.

My general conclusions from the facts known concerning the anchovy are as follows:

It seems at present most probable that the anchovies which spawn on the Dutch coast in June and July are those which are found in the English Channel in autumn and winter. We do not know of any spawning places of this fish on the west coast of Europe, except the east side of the North Sea. The spawn has been observed in the Zuyder Zee and in the open sea near Nordeney by Ehrenbaum. We have not seen any anchovy spawn in the neighbourhood of Plymouth, and there is no evidence of the presence of anchovies in that locality in summer. But anchovies are caught on the French shore of the Bay of Biscay, at any rate in the southern part. We do not know if they spawn there. If, then, the anchovies in the Channel move north in summer when they spawn, how is it that their place is not taken by other anchovies coming up from the south?

The reply to this question is probably given by the peculiar distribution of summer and winter temperature. There is a much greater range of temperature in the shallow estuaries and basins on the coast of Holland than in the deeper water at the entrance to the English Channel. On the chart of temperatures of the Atlantic, published by the Meteorological Office, the August temperature near Plymouth is 61° to 62°, and outside the Frisian Islands it is marked 62°, 63°, and near Heligoland 65°. The temperature in the Zuyder Zee is higher in summer than that of the sea outside. We know from the Dutch observations that in 1887 the seven days' mean temperature at 7 p.m. in the Zuyder Zee in July varied from 62·6° to 66·2°. According to observations published by Mr. Dickson in this Journal, vol. ii, p. 276, the ten days' mean off Plymouth in July, 1891, was 57·2° to 57·4°. In the same year the seven days' mean of the surface water in the Zuyder Zee was in July 62·2° to 63·3°.

In 1892 the surface temperature in February, ten days' mean, according to Mr. Dickson, was 44·1° to 46·4°. In the Zuyder Zee for the same month it was 33·9° to 39·0°.

It is clear, therefore, that the water on the coast of Holland is warmer in summer and colder in winter than that of the English Channel. This explains why anchovies do not spawn in the Channel. A temperature equal to that on the coast of Holland in summer is only obtained further south on the French coast, where anchovies are taken in summer, and where they probably spawn. We know that there are anchovies in autumn and winter at the western end of the English Channel; these, in order to reach a temperature high enough for spawning, must go either north or south. It seems probable that all these anchovies come from Holland and return thither.

In relation to this probable migration it is interesting to compare the statistics of the Dutch fishery with the evidence we have obtained of the varying abundance of anchovies in the neighbourhood of Plymouth. The following are the temperatures in July in the Zuyder Zee, and the total yield of the anchovy fishery in that sea in successive years:

	Temperature in July.	Ankers of Anchovies salted.
1882	14·7° to 16·7° C.	18,736
1889	16·8° to 18·9°	1,676
1890	15·4° to 18·3°	194,096
1891	16·8° to 17·3°	45,914
1892	16·2° to 17·7°	6,854
1893	17·7° to 20·1°	13,908

Now we first heard of anchovies in connection with the M. B. A. in November, 1889, when large numbers were seen at Dover, large numbers were taken in the sprat seines at Torquay, and samples were brought to the Laboratory by the pilchard fishers at Plymouth. In the previous summer very few had been caught in the Zuyder Zee, although the temperature in that summer was high. But in the following summer, with a similar temperature in the Zuyder Zee, one of the maximum catches was made there. In the winter of 1890 anchovies were abundant in the Channel; I obtained 1000 from pilchard-nets in two days in November, and again in the following summer a fairly large catch was made in the Zuyder Zee. In the winter of 1891 and 1892 anchovies were not plentiful off Plymouth, and in the following summers the catch in the Zuyder Zee was small.

The fact that so few anchovies were taken in the Zuyder Zee in 1889, while in the following autumn they were so abundant in the Channel, is difficult to reconcile with the theory that the winter anchovies in the Channel come from the coast of Holland. It is possible that there is another explanation, namely, that in warm winters the anchovies come northward to the Channel, and in a warm summer following pass up to the warm waters of the Dutch coast, where they are crowded together in narrow waters, and so give opportunity for a fishery. If this suggestion were correct the prosperity of the Zuyder Zee fishery would depend not, as Prof.

Hoffmann supposed, on the warm summer of the year before, but on the mildness of the winter in the Channel. This suggestion can be tested by an examination of the meteorological conditions during past years in comparison with the statistics of the Dutch fishery.

I would suggest that in future a careful record should be kept of the meteorological conditions, temperature of the sea, and number of anchovies obtained at Plymouth, in order that the law of the anchovy fisheries might be ascertained. I would further suggest that endeavours be made to obtain data concerning the natural history of the anchovy on the west coast of France, and north and west coasts of the Spanish Peninsula. We do not know at present whether the fish spawns there, and in what abundance it occurs at different seasons. If these matters have not yet been ascertained, it would not be difficult by communications in the proper quarters to get observations on them made by competent naturalists in the countries concerned, or it might even be advisable to send a naturalist from England for the purpose.

In conclusion I would say a few words on the question of an English anchovy fishery. As far as our evidence goes—and it is fairly extensive—there has been no possibility of a profitable fishery except in the years 1889 and 1890. In the former year a considerable number of anchovies could have been cured at Torquay, and in the latter a smaller number at Plymouth; but there is no indication that enough anchovies could be caught in the Channel to recompense the employment of special nets for their capture alone. My own opinion is that the fish are either too much scattered or too far from the coast to be caught in very large numbers. In Holland it is different; the fish are there crowded into a small area.

On the other hand, I think it would be advisable to ascertain whether small pilchards occur off the Cornish coast in summer in sufficient numbers to support a sardine industry like that of the west coast of France. The pilchard fishery is unprosperous, the market for large salted pilchards is bad. There is a factory at Mevagissey where large pilchards are imperfectly preserved as sardines, but the flavour of sardines depends on the size, as lamb is more delicate than mutton. If small pilchards are to be caught on the Cornish coast in large numbers in summer, there is no reason why the French sardine industry should not be extended to Cornwall, and prove a great boon to the population, whose resources in mining and fishing have been much reduced. To this end I would advise that our small-meshed nets be shot regularly throughout the months of April, May, June, July, August, and September, and all the results examined and recorded.

On the Oxidation of Ammonia in Sea Water.

By

G. P. Darnell-Smith, B.Sc., F.C.S.

Whilst working at the Laboratory this summer on the function of iodine in Algæ, it was suggested to me by the Director that I should study the influence of Algæ on the ammonia in sea water. I here tender my thanks to Mr. E. J. Bles for his kind advice and assistance.

Before commencing experiments with Algæ the effect of keeping sea water in the light and in the dark was tried. Neither daylight nor darkness appears to have any effect on the amount of ammonia in the water. Thus—

Sea water containing .	·002	grm. NH_3	per 100 litres,
After standing in the dark twenty-four hours contained .	·0025	,,	,,
After standing in the dark forty-eight hours contained	·002	,,	,,
Sea water containing .	·001	,,	,,
After standing in the light eight hours contained .	·001	,,	,,
After standing in the light sixteen hours contained . . .	·001	,,	,,

After a few days, however, whether standing in daylight or darkness, ammonia is produced by the decomposition of organic matter.

In order to test the efficiency of Algæ in oxidising the ammonia, sea water which had been in an inverted bell-jar seven days, with a fair quantity of Ulva, moderately illuminated, was analysed.

It contained	·0376	grm. NH_3	per 100 litres.
After being placed in the window twenty-four hours it contained .	·010	,,	,,
After being placed in the window forty-eight hours it contained .	·009	,,	,,

This rapid reduction of ammonia is probably due to the oxygen given off by the Ulva. To check this conclusion, water containing ·008 grm. NH_3 per 100 litres was placed in a bell-jar in the dark and a quantity of Ulva placed in it.

After twenty hours it contained .	·008	grm. NH_3 per 100 litres.
After forty " " .	·008	" "

Thus when assimilation was not proceeding the quantity of ammonia remained stationary. Decomposition then commenced, for—

After standing in the dark sixty-four hours it contained .	·012	grm. NH_3 per 100 litres.
After standing in the dark eighty-eight hours it contained . .	·030	" "

The jar was now placed in the window, and after standing there forty-eight hours it contained ·007 grm. NH_3 per 100 litres. That the reduction of ammonia in sea water by Ulva depends upon the assimilation of the latter is further shown by the following experiments. Water, into which some Ulva had been put, had stood seven days in a position moderately illuminated.

It contained	·037	grm. NH_3 per 100 litres.
After standing in the window twenty-four hours it contained . .	·009	" "
After standing in the window forty-eight hours it contained . .	·010	" "
After standing in the window seventy-two hours it contained .	·015	" "

The available carbon dioxide had apparently been used up after the first twenty-four hours, and the plant was unable then to keep down the ammonia. A small quantity of carbon dioxide was now blown through the water, and after twelve hours it contained ·009 grm. NH_3 per 100 litres. A further quantity of carbon dioxide was blown through overnight, and after standing seven hours in daylight the water contained ·006 grm. NH_3 per 100 litres. That the reduction in the amount of ammonia was not due to the agitation of the water is shown by the following experiment. Water containing much ammonia was placed with Ulva in bright sunshine.

It contained at the commencement	·009	grm. NH_3 per 100 litres;
" after five hours	·003	" "
" after forty-one hours	·006	" "

showing the same series of changes as in the previous experiment. Carbonic acid gas was now blown through it, and it was still found to contain ·006 grm. NH_3 per 100 litres. After standing one night and six hours in daylight, however, it contained ·002 grm. NH_3 per 100 litres. The preceding experiments show that when Ulva is assimilating rapidly and oxygen is given off, the ammonia in sea water is very quickly reduced. The amount of carbonic acid gas, however, available for purposes of assimilation is not clear; from the "Challenger" Reports there does not appear to be any free carbonic acid gas in sea water, and Algæ, therefore, must depend upon that which is in a state of "loose" chemical combination.

An experiment was now made to test the rapidity of action of a current of air blown through the water. A current of air at the rate of 400 c.c. per minute was blown through sea water which contained—

At the commencement	·030 grm.	NH_3	per 100 litres.
After five hours	·023	,,	,,
After twenty-six hours	·013	,,	,,
After fifty hours	·008	,,	,,

A second experiment gave similar results, and it appears, therefore, that the oxygen given off by Algæ is very much more efficacious than that of the atmosphere, which is probably due to its being in the nascent condition.

Remarks on Trawling.

By

Professor M'Intosh, M.D., LL.D., F.R.S., F.R.S.E.

FIRST SERIES.*

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I. General Remarks.

Fully ten years having elapsed since the Report on Trawling on the eastern shores was presented to the Trawling Commission (composed of the late Earl of Dalhousie, chairman; Right Hon. Edward Marjoribanks, M.P., now Lord Tweedmouth; Prof. Huxley; Mr. W. S. Caine, M.P.; and Mr., now Sir, T. F. Brady), it appears to be desirable to review the statements contained therein in the light of the information which the impetus given by the Commission has produced. Moreover this examination of results is all the more necessary, since last year another important body—viz. the Select Committee of the House of Commons on Fisheries, presided over by Mr. Majoribanks, M.P.—issued a new blue-book containing the finding of the Committee, and a mass of evidence.

In criticising this Report on Trawling, it is necessary to bear in mind that certain definite instructions were given by the Commission in regard to the hauls of the trawl. These fall under Section 6, and are as follow:—" The results of each haul of the trawl, so far as regards food-fishes, should be carefully registered, in order that positive data may be obtained.

" (*a*) As to the proportional quantity of immature fishes taken at various seasons.

* I have to acknowledge, in the preparation of the " Remarks," the courtesy of Mr. Esslemont, Chairman of the Board; of Dr. Fulton; of Mr. W. C. Robertson, the secretary; of Mr. Couper, Fishery Officer, Aberdeen; of Messrs. Joseph Johnston and Sons, Montrose; of Mr. Scott, of the General Steam Fishing Company, Granton; and of the owners and captains of the various vessels, who invariably exerted themselves to furnish information. It was especially interesting to find some of the captains of the General Steam Fishing Company's ships, with whom I had worked in 1884, still at their posts.

"(*b*) As to the destruction of the spawn of food-fishes.

"(*c*) As to the proportion of live and dead fishes."

It is important to remember, also, that the choice of ground lay with the trawler in almost every case, and that the most productive ground, so far as could be ascertained, would in all probability be selected.

In the Report of 1884 the fishes were grouped into "saleable," "unsaleable," and "young," the latter term being synonymous with that now in general use, viz. "immature"—a term, indeed, which was introduced prominently in this Report. These three heads are well understood, and need cause no ambiguity, since even the fishing community are quite able to understand them—a size limit, of course, in every case having been considered. To the Royal Commissioners the fact that a young or immature dab was under 7 inches was not of great utility, but the number of such young forms was of the utmost importance in view of the statements then prevalent. Due care was taken to see personally that every example was authenticated, and if any weight is to be attached to the statement that the "great defect of the Report* is that no information whatever is given as to the limit of size dividing the saleable fish from the immature," there will be little difficulty in remedying it. Besides, it was not the scientific observer who regulated the sizes of the saleable fishes, but fishermen engaged in an industrial pursuit, and who had to bear in mind the demands of the public. Moreover a fish of a size that was saleable at St. Andrews might not be so at Aberdeen, and *vice versâ*, though, as a rule, the variation under this head was not great. According to the state of the market, again, fishes—*e.g.* gurnards—that were saleable at one season were unsaleable at another. As pointed out in the Report, "it is remarkable that so good a fish should be liable to variation in this respect, and that it should not always be taken to market, even during the height of the herring season." Frog-fishes even occasionally found a ready sale in the great central towns of England after the head, skin, and fins were removed; and in the Outer Hebrides dog-fishes formed, and still form, an important item in the crofters' diet-roll, the piles of skins in front of their huts being characteristic.

To take the fishes in the order in which they are mentioned in the Trawling Report, the following sizes formed the lower limit of the saleable fishes:—Skate (including grey, thornback, starry, sandy, &c.), 10—12 inches across the pectorals; herring, 7—8 inches, but those obtained were all much larger; codling (young cod), 8—10 inches, but no example so small occurred in the series;

* Prof. Ray Lankester, *Sea Fisheries*, Chicago Exhibition, 1893, p. 64.

haddock, 8—9 inches,—when so small their price is insignificant, about 1s. per box; whiting, 8—9 inches; poor-cod, 7 inches; bib, 6—7 inches; coal-fish, 1 foot; hake, 1 foot, though seldom seen below 15 inches; ling, 15—20 inches; halibut, 13 inches; sail-fluke, 8 inches; craig-fluke (witch), 7 inches; long rough dab, 7 inches; turbot, 6—7 inches; brill, 7—8 inches; plaice, 7 inches; dab, 7 inches; lemon-dab, 7 inches; sole, 7 inches; flounder, 7 inches, rarely sold; grey gurnard, 9 inches; bream, 9—10 inches; cat-fish or wolf-fish, 15 inches, though all those obtained were large. By the term "saleable," of course, saleable in the food market is meant, since much smaller examples of every species might be utilised for manure, either as landed or after preparation in a factory.

In regard to the unsaleable round fishes, the remarks of the Commissioners of 1866 were—"It has never been alleged that ling, cod, and conger, in which the line fishermen are so largely interested, or mackerel, pilchards, or herrings, upon which the seine and drift fishermen depend, are caught by the trawl in an immature and uneatable condition." "Whiting and haddocks of small size, thought marketable, are taken by the trawl; but fish of similar dimensions are also captured by the liners, against whom, indeed, the charge of taking immature cod has especially been brought."

In the Report of 1884 it was stated that "a considerable number of young cod were present in most of the good hauls, but all were saleable fishes. Quite as many immature cod (codling) were caught by the liners in the same waters; and off the Bell Rock perhaps the proportion is even greater." The same state of matters exists at this moment. On the other hand, the number of very small haddocks caught by the liners, *e. g.* last year off the east coast of Scotland, far exceeded anything of the kind captured by trawlers. The one mode of fishing was as destructive to these immature forms as the other. The small fishes swarmed on the ground, and were caught in every haul of the liners just as they were swept into the trawl, but many of the smaller forms escaped from the latter through the meshes, while they were held fast by the hooks and so injured that, although they had been returned to the water, it is doubtful if they would have survived.

The remarks made then (1884) on the capture of very young cod and very young haddocks, therefore, remain suitable for to-day; and the same may be said of those on whiting, ling, hake, gurnards, coal-fishes, pollack, bib, and poor-cod. In the Trawling Report it was stated that large cod and other adult fishes were now seldom caught within the limits of the Bay of St. Andrews, and this was in accordance with the evidence then obtainable. The use of anemones as bait, together with the closure of the bay, shows that as many as sixty or eighty good cod are occasionally caught by a single boat, the lines being buoyed and left in the water all night. Some fine congers are also occasionally obtained off the east rocks. Moreover excellent haddocks are procured in the same area early in the year, and for two years small haddocks have abounded. Large green cod also occasionally leap out of the water in pursuit of their prey, and are captured on the beach, while a few pollack are got in the salmon-stake nets or on hooks. It would thus appear that further experience leads to a modification of the statement in the Trawling Report. How far the increase in numbers has been due to the closure and the absence of molestation, and how far to the fixed and extensive lines and special bait, are open questions.

The closure of the inshore waters—*e. g.* St. Andrews Bay—must have conduced to the prosperity of the turbot and the brill of that neighbourhood, most of the turbot (ranging from 9—11 inches) which formerly were captured by the trawlers (sailing and steam) now being unmolested, and reaching the outer waters when of some size. The salmon stake-nets, however, on the west sands still prove destructive to many turbot from $5\frac{1}{4}$ inches upwards. These small examples of this valuable fish are only used as bait for crab-pots. It is true the trawlers sweep the outer waters into which the young turbot and brill pass, but the area is wider, and the size of those captured considerably larger.

No fish formed the subject of greater solicitude in the Trawling Report than the plaice, both from its wide distribution and its great abundance, as well as from the supposed view that this was a form specially destroyed by the trawl, which had cleared out of St. Andrews Bay, for example, all the full-grown adults, and left only the smaller forms. It is apparent, therefore, that during the past nine years such inshore waters have had sufficient time for recuperation—at least to some extent—if these views can be maintained. The results of the trawling-work of the "Garland" up to 1892 have already been dealt with in this connection,* so that other observations, and the statistics of fishes captured by the liners in this area, have only to be considered. Without at present going into detail, it is found that comparatively few full-grown plaice are captured in the enclosed waters of St. Andrews Bay. Most of the large specimens that have occurred have been either diseased—*e. g.* blind or emaciated—or injured. An enormous number of immature or half-grown plaice, however, are reared in the area, and are captured by the liners, chiefly with lobworm, their lines being buoyed and left in the water for such periods as they please, relays

* A Brief Sketch of the Scottish Fisheries, 1882–92, p. 6.

of lines being often used. The success with which the local fishermen ply their trade in early spring amongst the plaice is indicated by the fact that a single haul of the lines of a small fishing-boat last February produced a sum of £9, and that a larger "catch" was procured by the same boat within the week. The closure of the inshore waters, therefore, while it places the trawl-fishermen at a disadvantage, benefits the line-fishermen, and does not deprive the public altogether of the supply of flat-fishes from the enclosed area. It does not, however, produce many large flat-fishes, for as these get older they appear to seek the deeper waters outside the limit, either from a natural habit, or as the result of constant interference by man. This habit, indeed, was noticed in the Report when dealing with the question of instituting the closure within the three-mile limit—thus :—"The flat-fishes, such as turbot, brill, plaice, soles, dabs, and thornback (skate) would certainly be left in comparative security in certain bays, as at St. Andrew's, the larger only, perhaps, seeking the grounds in the offing." These larger flat-fishes, many of which are mature (that is, spawning) are captured outside the three-mile limit in great numbers, and thus the supply of ova and young fishes for the inshore waters is affected, for, as previously pointed out, the latter waters depend to a large extent on the former in this respect. Few or no spawning plaice (none within our experience) are ever captured within the bay, though eggs and young in various stages are not uncommon. It is stated, however, that adult ripe plaice were formerly procured by hook and line off the rocky shore towards the mouth of the bay between Boarhills and Fife-Ness, on hard ground on which no trawl could work. The adult spawning plaice in greater numbers occur in the offshore waters, and, so far as known, there is no passage of these from the outer to the inner area for the purpose of discharging their eggs—as was formerly believed in regard to many fishes. If it had been for the advantage of the eggs and larval plaice that the adults should only spawn close inshore in the shallow water, there is no reason to doubt that such would have been the arrangement. It is apparent, however, that it is otherwise. Before reaching the shallow water of the bays the scattered ova have advanced towards hatching or have hatched, the majority probably in the latter condition, the open water being perhaps better suited for their safety. The yolk-sac of the larval fish is soon absorbed, the symmetrical post-larval condition is reached, by-and-by transformation occurs, and the little fish takes to the bottom, swarms being found in the muddy rock-pools towards the end of April and beginning of May. The life-history of this species would seem to show that—in dealing artificially with the eggs and larvæ—the most natural method is to place the larval fishes—just before the yolk-sac is absorbed—some distance from shore. They are more or less transparent, and will escape many of the dangers they run in such waters, and, before being carried close inshore, will either be transformed or about to be transformed, and more capable of escaping by their own exertions from their enemies. If the larvæ are placed in the sea close to a rocky beach or stretch of tidal sand or gravel, it is possible that many would be stranded by the tide. Therefore, though the observation that the young plaice (with eyes now on the right side) abound in spring in the shallow rock-pools and elsewhere is perfectly correct, it is no argument for placing the larval fishes in their neighbourhood, when in a truly pelagic condition. In the same way the spawning ling are found far from the inshore waters, their minute eggs being hatched in the open ocean, and the young stages passed long before reaching the margin of low water. The ling has not, indeed, been found in inshore waters till it reaches about 3 inches ($3\frac{1}{2}$) in length, and then in very limited numbers. It is more frequently secured when from 6 to 8 inches in length—at extreme low water at the margins of the rocks. As it gets larger it seeks the offshore, and thus, as in the plaice, there is a double migration—the wafting of the eggs, larval and young fishes shorewards, and the return of the adolescent and the larger forms seawards. A similar life-history appears to be present in many of the food-fishes—*e. g.* the turbot, brill, and halibut, though in the case of the dab, long rough dab, and some others there are marked exceptions, as pointed out in the Trawling Report. Thus, "the large proportion of immature dabs found 15 miles off St. Abb's Head is interesting, and shows that such are not confined to shallow bays like that of St. Andrew's. Moreover, the occurrence of relatively small specimens at this and even greater distances from land would raise a doubt as to whether all such young forms have been reared on a sandy beach inshore."* Since the foregoing was written, opportunities, by aid of the "Garland," for using the special trawl-like tow-net and the mid-water net near and at the bottom on the grounds 15 to 20 miles south-east of the Island of May, have been afforded, and great numbers of larval, post-larval, and young dabs, long rough dabs, and other forms have been obtained, thus confirming the opinion formerly expressed. Moreover, the trawling work of the "Garland" on its various stations from the Moray Firth to the Forth bear out the same conclusion. Again, the deeper water is the home of the post-larval frog-fish, even the pelagic eggs being rather uncommon near shore. The adolescent and adults, on the other hand, are frequent in shallow sandy bays like St. Andrew's.

* Report, Royal Commission on Trawling, p. 361.

It is apparent, from certain remarks in the preceding paragraph, that it is a mistake to say that the trawl alone can capture flat fishes. If the bait be suitable the lines are tolerably effective in regard to plaice, lemon-dabs, dabs, and flounders. Again, halibut-fishing (by hook) is the most productive method off the coasts of Iceland, Faröe, and elsewhere, and even the turbot and the sole are occasionally caught by the liners.

II. Changes in the Trawling-Vessels and their Apparatus.

With the exception of a few small sailing vessels and boats, trawling in Scottish waters is carried on, as it was in 1884, almost exclusively by steam-vessels; but, whereas at the latter period many of the vessels were old tugs or modified paddle-steamers formerly used for other purposes, most of the modern vessels, *e.g.* sailing from Granton and Aberdeen, are specially built for the purpose. The finest vessels do not cost much more than the serviceable vessels of the General Steam Fishing Company did in 1884, viz. £4,500, but very considerable improvements have occurred in the arrangement and equipment. Some of these iron ships are 100 to 120 feet between the perpendiculars, and considerably more on deck, with a depth of 10 to 12 feet. The paddle-ships at Montrose* are 116 feet between the perpendiculars, 21 feet broad and 10 feet deep; while the fine screw vessel is no less than 120 feet between the perpendiculars, 21 feet broad, and 11 feet 6 inches deep. The three latter have comparatively low bows, like many of the ships from Granton. The newer ships at Granton have also increased in size. Moreover, greatly increased height is given to the bow of the vessels at Aberdeen, so that the foot-hold on the fore-deck must be very uncertain, especially if slippery; but the water is kept out of the ship by such an arrangement. The after-part of the ship, however, is more or less flat, so that the trawls can easily be worked. These vessels range from 140 to 180 tons burthen, with engines from 40 to 65 horse-power.

Instead of having the steam-winch near the fore-cabin, in the newest ships it is placed on deck close to the engine-room, so that the steadiness of the ship is increased, and the bow kept out of the water. The screw-vessel at Montrose has two winches, one being behind the foremast, the other (smaller) behind the mainmast. The latter is very useful in discharging fishes and in working the dandy. In general, the Granton ships have the steam-winch in front, with the capstan behind, just before the engine-room—a different arrangement from that at Aberdeen. Moreover, a decided improvement is introduced by the presence of a "brake" in connection with this

* Messrs. Joseph Johnston and Sons.

apparatus. In 1884 reliance was placed on the old hawser fixed to the trawl-warp in the case of the net being held by a sunken wreck or a rock. Now, the moment the net is fixed, the "brake" (which is secured to a moderate degree) permits the trawl-warp to run out, and thus save the net from serious rupture or total destruction while the ship is being stopped. In the Granton ships an iron wire rope is used instead of a hawser from a hook on the mainmast, to save rubbing on the rail. This is fixed to the trawl-warp by spun-yarn. The length of the trawl-warp, which is of steel-wire rope, ranges from 200 to 240 fathoms. The warp has six outer and a central strand. The older warps had a Manilla centre, but the newer have wire. A change has also been made in the teeth of the wheels of the winch, for instead of being transverse, they are now helical or oblique in such ships as the "Belcher." The warp is run round a capstan in rear, and out by a slit with rollers in the bulwarks of the ship. The large ends of the winch are used, as formerly, for winding the bridles and all ropes and tackle, the latter being still the method of hoisting on board the bag of the trawl. Instead, however, of the snatch-blocks being fixed to the deck, they now are attached to the top of the engine-room. A considerable number of the paddle-ships still use a 9-inch Manilla hawser as trawl-warp, and it is wound round a capstan from wheels beneath the deck. These also have the piece of old hawser (at Montrose of about 13 fathoms) as a guard during trawling, but, as indicated, the best screw-trawlers have the "brake" on the winch. In one or two of the older trawlers at Granton, the narrowness of the ship has caused the winch to be placed on the fore part longitudinally, not transversely.

In some of the ships at Aberdeen the steering or wheel-house has a roof, with side-panels and panes, so as to protect the men, and it occupies the same position, viz. in the centre of the vessel. Others have simply a canvas shelter above the wood. In one of the newest vessels at Aberdeen, the steering-house is open, as it is stated the men are apt to sleep in the covered houses, and prefer to be in the open air during their watches, while it is interesting to note that the Granton General Steam Fishing Company's ships have always had open wooden wheel-houses. Besides a spirit-compass on a stand, a new vessel has an inverted one on a wooden pole, so that two are available in steering. Coals are still carried in the side-bunkers, which in the best ships have a floor of cement, so as to minimise the danger from fire. At Aberdeen small English coals are largely used,* and instead of being piled loosely on deck at starting, as in some of the vessels from Granton, the extra coals are stored in bags, and are thus more easily handled. The finest vessels carry about 60 tons of coal in

* At 11*s*. per ton.

the side-bunkers adjoining the engine-room, and burn about $2\frac{1}{2}$ tons per diem, with surface-condensing boilers; but fairly good ships often exceed this quantity.* The consumption of coal in such cases is, of course, a vital point in the economy of the trade, and a vessel which will consume 60 tons in 12 days is seriously handicapped. Some think that the larger vessels, which require more coal, are less fitted for remunerative work, since they catch no greater number of fishes. They might, however, be safer at sea. An improvement is the placing of the iron water-tank, which will hold about 270 gallons, under the deck, thus economising space and avoiding accidents. It is filled by a hose-pipe fixed to a screw-hole on deck. In the large screw-vessel from Montrose the tank is placed behind the bulk-head of the engine-room, and a hand-pump raises water to the deck. In the newest ships an oil-tank, to hold from 40 to 50 gallons, is filled beneath deck in the same way.

The bulwarks of the new ships have self-acting scuppers for heavy seas, besides the usual small permanent ones, but no cement gutters are now present at the sides, as it was found that they were rather a disadvantage, for, in such as have seen service, the cement becomes dilapidated. In 1884 the ships working off Aberdeen usually carried their fishes in covered compartments at the bulwarks in front, or even permitted them to lie loosely on deck. This arrangement is now seldom seen, probably owing to the use of ice and the greater distances traversed. The bag of the trawl containing the fishes is emptied in the Aberdeen ships in a series of pounds (about 5 in number), formed by passing stout planks into upright grooves on deck in front of the winch, and in these the fishes are sorted and "gutted," preparatory to being placed in the fish-hold in ice. The labour involved by this method is a contrast to that of previous years off the eastern Scottish shores. Hence, when the catch at night includes haddocks of from 8 to 10 inches in length, these are considered unremunerative to treat in this way, and are thrown overboard.

In the ships of 1884 the stout boat of the trawler was either carried on deck or suspended from davits at the sides. They can be easily launched from the latter, but may be carried away, and, besides, the top weight of the vessel is increased. At Granton the vessels formerly described have now placed their boats on strong iron rails, 6 feet 6 inches high, on the starboard side, and bolted to the engine-room on one hand and the bulwarks on the other. Now a larger boat in the newer vessels is placed on rests in the centre of the ship over the engine-room, while in the most recent it occupies the centre of the stern, and the front "stock" or support

* This is much less than the quantity consumed by some of the old paddle-ships in 1884, *e.g.* about 35 tons a week.

has a swivel. Moreover, in the "Belcher" the hook of the chain-lashing is jointed and fastened with a ring, so that the boat can be made ready in a minute. The modern boat is considerably larger, and is covered with canvas.

In connection with the fittings on deck, the use of raised or projecting figures or letters of sheet-iron on the funnel is one of the modern changes; they are very easily seen at a distance. The initial letter of the owner is sometimes added. Each vessel is, of course, marked likewise on quarter and bow.

The ice-house, which had just been introduced in 1884, is now an important part of the vessel, usually in front of the fish-hold. Five tons of broken ice are taken in the larger vessels to the distant grounds. It is sent from the stores in barrels, and passed from the cart to the hold by a funnel. So important has this feature become, both for liners and trawlers—in Aberdeen, for instance—that special factories have been erected for the manufacture of ice by the ammonia system, about twenty tons being made daily in one* near the harbour at present, and extensions are in progress to manufacture forty tons daily. On the distant grounds, where most of the work of the larger vessels occurs, the ice is placed over the fishes after they are "gutted" and consigned to the hold, as was done by the English trawlers from the distant grounds in 1884. The price of ice (at present 17*s.* 6*d.* per ton) is thus an item of moment in the trawling expenditure. On discharging the fishes from Iceland, Faröe, or the Great Fisher Bank, the old ice is thrown overboard, and, though it might seem economical to keep it for use in a subsequent voyage, *e. g.* for the preservation of the offal, for which 10*s.* per ton is got from the manure companies, yet it is certainly the safer method. No wind-sails are now employed.

The fish-hold in the best ships is from 9 to 10 feet in height, divided into compartments, each with two shelves. In the "Southesk," a screw-vessel at Montrose, there are two holds. When fishes are stored with alternate layers of ice, the front of the compartment is closed with planks, unpainted or coated green with enamel-paint, which is readily purified by washing. The shelves, again, in each division, are useful in diminishing compression. This alone is a marked change on the Granton trawling-vessels of 1884, for the newest ships then had only an ice-chamber surrounding a central compartment in which the fish-boxes were placed. The smacks from Grimsby and other parts in England, it is true, used ice in the manner now described in 1884 and previously, but it was comparatively rare in Scotland at that period. It is necessitated now by the lengthened voyages to the more distant grounds.

* Mr. Lang's.

During the voyage the water which collects from the fishes and the melted ice is carefully pumped out by a "donkey" engine, so as to keep the fish-hold dry. The hold will contain about 700 boxes of fishes, and great care is taken to keep it pure. In the Granton General Steam Fishing Company's ships ice is not used during the winter, for the fishes can be carried fresh to the market by means of one ship acting as "carrier" daily. In the warmer weather, however, ice in bags is taken on board each vessel. Few ships at Granton, indeed, have the compartments for packing the fishes in ice, with the slips of board for closing them. This shows that the majority fish in the less distant waters.

In some of the newest vessels the accommodation for all the crew is in the aft-cabin, the fore part of the vessel being relegated to the fish-hold and stores. This appears to be a decided improvement in regard to the maintenance of a cool temperature and pure air near the fishes, especially when long voyages are undertaken. Formerly the crew had a fore-cabin, and the captain and mate an aft-cabin, and in many vessels the same arrangement still occurs.

The engine-room of the newer vessels is better ventilated, and the arrangements for the working of the engines facilitated. Even the ventilators are utilised for the hoisting of cinders from the hold by the aid of a small windlass. Moreover, in one the engine-room has an entrance from the galley as well as from the side—a convenience in stormy weather. A feature in contrasting the ships at Granton and Leith with those at Aberdeen is the small elevation of the engine-room above deck in the former.

In some ships the shrouds from the mizzen-mast are fastened to the deck about a yard from the bulwarks, so as to leave a clear space for working the trawl. In the larger ships, however, this is not necessary, the space in rear of the shrouds being sufficient for the trawl, or shrouds are altogether dispensed with, as in the Montrose paddle-ships, which have only a foremast.

The galley for the cook is in many under the bridge in front of the engine-room, or in some in the forecastle peak;* but in the Montrose paddle-ships it, with the water-tank, is at the side near the paddle. These also have two tow-rails, one in front of the cabin for the crew, and one behind the cabin for the captain (aft), as the vessels are used for towing. A hand-windlass for raising the anchor is also present.

The average length of the trawl-beam in the best ships is 54 feet, it being found that a longer beam does not work so satisfactorily or catch so many fishes. At Montrose the beam is 52 feet. As before, it is composed of two or three pieces of oak or French

* The presence of a water-closet opposite, in one instance, appears to be objectionable.

elm, though occasionally it is in a single piece, and has a diameter varying from 10 inches to a foot. The shape of the iron trawl-head is scarcely altered, the posterior iron plate in a few being somewhat more abrupt than in 1884, thus conforming to the English type of trawl. The height of the beam from the ground varies from 3 feet 8 inches to about 4 feet. The "Athole," one of the General Steam Fishing Company's ships, is at present provided with an "otter" trawl with gigantic wooden ends about 12 feet long by 5 feet broad, which takes the place of the "hammer" of the pole-trawl described by the Commissioners of 1863,* and which are simply the much enlarged wooden ends in use in the otter-trawls in the Forth in 1858. These huge wooden (door-like) ends have on one side in front two powerful iron bars meeting to form a V, and supported by two accessory stays, the whole forming a projecting apparatus to which the chain connected with the warp is fixed. Towards the rear a perforated iron plate gives passage to two chains (one from each of the powerful iron bars above mentioned) for the attachment of the swivel for the trawl-net. The lower edge of the wooden end is weighted anteriorly with a heavy bar of iron, which occupies nearly half the length of the apparatus. A special and powerful rectangular frame of wood, with a top snatch-block, is fixed at the port-bow and taffrail for hoisting the ends on board; and they form a striking feature from a distance, as—with the boards—they project 6 or 7 feet above the bulwarks. The foregoing trawl is said to capture cod more freely than the beam-trawl, as many as 20 score having been secured in April. It is, however, still on its trial, having only been introduced about six months ago.

It was formerly pointed out that, when the iron trawl-head was dislodged, great difficulty was experienced in repairing it—especially in rough weather. The new trawls at Aberdeen have a broad band of iron, which bends round the end of the beam, and on which the loop of the trawl-head goes. It is secured by an iron pin and safe. This sheath protects the end of the beam, and must save much time at sea. At Granton the ends of the trawls are guarded by flat iron plates, but they do not form a loop over the ends. The trawl-heads are secured by a pin, as already mentioned. In the finest ships the length of the trawl-net is about 118 feet, and the arrangement is as follows:—For the first 56 feet next the beam the mesh of the net is 3 inches from knot to knot; the next 38 feet has at first a 2½-inch mesh, diminishing to 2 inches towards the posterior end, while for 24 feet the bag or "cod"-end of the trawl-net has 1½-inch mesh. At Montrose the trawl-net consists of 44 feet of 3-inch mesh next the beam, then 44 feet ranging from 2½ inches

* Report, Sea Fisheries of the United Kingdom, vol. i, Appendix, p. 3.

downwards, while the last 14 feet has $1\frac{1}{2}$-inch mesh. There is thus no diminution of the mesh at the "cod"-end. Moreover, no improvement in the shape of a "bonnet" or apparatus for preventing the compression of the fishes has been found serviceable. The net has various rubbing pieces of old net and "bass" ropes, and the usual pockets internally. The ground-rope is variable in composition. The majority have this part of the trawl composed of rope only—an outer layer being wound round a central rope. The ground-rope of the Montrose ships is of Manilla soaked in tar, 8 inches in circumference, and made up to 13 with others twisted round; and in the finest ships elsewhere it is 124 feet long. In some, two pieces of chain are inserted at the ends, thus making three divisions of the ground-rope, viz. a central, entirely of rope, and two lateral, with a centre of 18 feet of chain, each being tied to the other with spun-yarn. Ground-ropes with chain throughout are not now used. In certain ships the ground-rope has a centre of wire-rope with a series of wooden rollers, with occasionally here and there a pair of metal rollers (12 in all—Gunn's patent). The rope is also in three divisions, and costs about £6 10*s.*, or 30*s.* more than the ordinary form composed only of Manilla ropes. This arrangement is thought at Aberdeen to give an increased catch of fishes—sometimes about 5 or 6 baskets more than by the ordinary ground-rope. In some ships, again, the port and starboard-trawls have each a different ground-rope; in the one the rope is all of one piece, whereas in the other three breaks occur, viz. two of wire and one of chain. In one ship the ground-rope had only 8 feet of chain at each end, while the centre had rope. All, however, do not think that the rollers are so satisfactory as a ground-rope with pieces of lead in the centre. Moreover, one of the features which contrasts strongly with the condition in 1884 is the fact that the newest ships, with the exception of the Montrose vessels, now carry two trawls—a starboard and port-trawl—complete in all respects. This arrangement has been in force for at least four or five years, and probably was introduced from England. At Aberdeen, however, the second trawl is, as a rule, used as a reserve apparatus, and is not put into requisition until the first has received damage. The mode of working the two trawls would thus appear to differ materially in the respective countries, since, according to an interesting paper by Mr. W. L. Calderwood,* as soon as the contents of the first trawl are placed on the deck, the second is immediately "shot" overboard. The same arrangement has been found at Grimsby by Mr. Holt, who mentions, however, that the reserve-trawl is shot while the "cod"-end with its fishes is still hanging from the tackle.

* *British Sea Fisheries and Fishing Areas*, Scottish Geogr. Mag., Feb. 1894, p. 73.

The General Steam Company's ships at Granton (nine in number) have not varied in regard to the single trawl-beam, but they carry a second net. Consequently the large snatch-block and rollers occur on the port-side only. As before, the net is attached to the trawl-beam by grummet-lashings or by cord. The other parts, comprising the dandy and bridles (each about 25 fathoms) and the chain for the former do not differ materially from previous descriptions. The steel-wire rope is about the same length, viz. 200 to 240 fathoms, and lasts about ten months. The aluminium trawl-warp does not seem to have met with favour in Scotland. In some ships it is not, as formerly, left on deck after the check of wire-rope is fixed to the mizzen-mast, but carried outside the bulwarks, so as to avoid accident to the men. Those which, like the Montrose ships, use a Manilla rope (generally about 180 fathoms), require a new one every six months, the old one being utilised in preparing ground-ropes.

The shooting of the trawl is carried out in a similar manner to that of 1884, only there are no trawl-davits at the taffrail in the best Aberdeen ships; and, instead of the snatch-block then in general use, more convenient "dandy" scores (snatch or tumbling blocks), of which Sudron's or Scisson's patent are the best. At Granton and Montrose the trawl-davits are still in use, with snatch-blocks on deck. The lid of the block is opened during trawling. The trawl-warp leaves the drum, passes round a capstan, and out through rollers, either on the port or starboard-side, according to the trawl in use. Blocks on the mizzen-mast are still employed to hoist the stern-end of the trawl, and the foremast has a derrick. In "shooting" the trawl the ship goes at full speed. When the "cod"-end of the trawl is unshipped, the mate at the same time orders the fore-trawl-beam lashings to be freed, and when the beam is at right angles to the ship the "stopper"-rope is let go, and the order "ware forward" then sends off the trawl-warp from the drum.

A better arrangement now exists for assisting in unshipping the heavy trawl-heads, for these rest on a stout wooden platform about 18 inches high, and thus are easily swung over the rail; and, besides, the deck is saved from injury. In one or two ships at Granton larger platforms for the fore-end of the trawl have been fitted. In a new vessel, indeed, a square of plate-iron has been put on the deck at the point most injured by the trawl-head. In rough weather a chain fastens the trawl-head to the nearest iron stanchion at the bulwarks, and is used in bringing the front trawl-head on board. In the same way an additional chain at the stern-end is sometimes useful. In the Montrose paddle-ships the wheels for winding the trawl-warp (a Manilla rope) are below, and only the capstan is on deck. The latter (capstan) in some trawlers is made too high, and is wrenched out of its fastenings.

The trawl is usually down for five hours on the "Great Fisher Bank" and other grounds, though trawlers working near home regulate the time rather by the nature of the bottom than anything else, in some cases spending as much time (three hours) in mending the net as in trawling on hard ground, or where wrecks and anchors occur. The trawling period, indeed, on hard ground is about three hours, on soft ground five hours. When productive ground is discovered, a "dan," or buoy, with a red or black flag by day, and a white globe-light, close to the surface, at night, is put in the water to mark the spot, though it is liable to be carried away by other ships, and the lamp broken. This buoy has a pole, with heavy iron bars, at one end, and towards the other about ten flat pieces of cork, upwards of a foot square. In one or two ships floats of skin—such as the liners use in herring-fishing, with pole and flag, were substituted for the cork buoys, or small pieces of cork on a string. The rate of speed when trawling is, as formerly, about $2\frac{1}{2}$ knots an hour, though on muddy ground a higher rate is sometimes maintained. In sailing, the best ships go about 11 knots. At night the captain and mate take watch alternately with one of the crew.

The crews on board the trawling ships remain very much as in 1884, the usual number being eight, though there are only seven in the Montrose paddle-ships, one of whom is cook. The latter may be either an old man or an adolescent. Each is furnished in the newest ships with a life-jacket of cork, and there are besides two life-buoys on deck. Only two at Aberdeen, the captain and mate, now have a percentage on the amount of fishes captured. The rest of the crew have ordinary wages. At Montrose the captain and two fishermen have a share in the "catch;" the rest have wages. There are seven men on board the ships of the General Steam Fishing Company at Granton, instead of eight as formerly. The percentages given to each remain almost as in 1884, a graduated series running from the "deck-hands" to the captain. The first engineer gets 5*s.*, and the second 3*s.* 4*d.* per ton of fishes.

In 1884 the Granton General Fishing Company's ships used "cringles" in transferring, during stormy weather, the fish-boxes to the "carrier" for the day. This practice has now been abandoned, and the ships either run to quiet water, and place the boxes on the deck of the "carrier," or they are at once transferred by boarding. It is during the latter operation that considerable injuries occur to the bulwarks and rail of the ships, the former having the stays bent, and the latter being frequently driven in.

One of the newest ships* at Aberdeen is a steel vessel—with a well—for fishing at Iceland and Faröe. It is 103 feet between the perpendiculars, and 114 feet on deck, 21 feet broad, and 12½ deep. The well is one of Houston and Mackie's patent fish-wells, and occupies the entire centre of the ship, the roof of the well sloping inward about half-way up the side of the ship, and leading to the hatches—the opening thus being much smaller than the bottom. The water accordingly will be somewhat steadied during the motion of the ship, though, as the cod will have a roof to rub against as well as walls, injuries may readily occur. The water is driven in during the voyage, rises to the surface of the well, and overflows by an opening in the side of the ship. A constant current is thus kept up. A grating at one end (the lower) permits the removal of refuse from the bottom of the well. While the cod swim freely in the tank, the halibut are tied, as usual, by the tail to the iron rail at the margin. The vessel has been specially fitted for the capture of these by hook and line; and at present no trawl is aboard, though such can be shipped at any time, and the newest apparatus (*e. g.* steam-winch and Sudron's patent dandy-score) is in readiness. The foremast has a derrick-boom, and the anchor-winch is worked by steam. The boat rests on a swivel-stock on the port bow, and is intended to be used as an accessory well. The cabins for the crew (viz. captain, two engineers, and nine men) are at the stern, while in the high bow is a store, and behind a convenient hold for fixing on the bait (herring). An ice-house, fish-hold, and all the newest fittings in the engine-room and other parts show the care that has been bestowed on the construction of the vessel. The consumption of coal is estimated at 3 tons daily.

Similar ships to the foregoing have been employed for some years at Grimsby for line-fishing in Iceland, but several improvements have been introduced in the new ship. Moreover, it can also be used as a trawler when required.

III. The Present State of the Beam-Trawl Fishery in Relation to the Fishing-Grounds and the Fishes.

In 1884, under the head of "General Remarks," a careful survey of the situation of the fisheries in connection with both line-fishing and trawl-fishing was drawn up.† In reading over these remarks at the present time the position does not seem to have been misunderstood; indeed, there is little at variance with the condition as now shown by ten years' experiments and observations. Amongst other remarks it is stated that "steam-trawlers at present can only

* "Ocean Bride"—Mr. Drummond's.

† Vide Report of the Commissioners, pp. 377–380.

fish profitably within a moderate distance of the land; and were the fishes to become so thinned that, with all the skill and energy shown in managing the ships, the returns proved unsatisfactory, trawling might voluntarily disappear. There is no reliable evidence, however, that before such a result would happen irreparable injury would have been done to the sea-fisheries."

Now, at that time there were in Scotland a total of 61* trawling-vessels—of which probably about one-half were steamers, the other half being sailing boats or vessels used for trawling. The exact numbers cannot be obtained, but there were from 12 to 20 boats used in trawling at St. Andrew's, 6 to 8 came from Broughty Ferry, 2 or 3 each from St. Monan's and Cellardyke, and others existed in the Moray Firth. Trawling, indeed, at St. Andrew's was an old custom, the Buckhaven fishermen having introduced it early in the century, and subsequently the local fishermen carried it on more or less regularly, generally trawling in September and October, and in March and April, though occasionally much longer. The frequent presence, however, just before the period of the Trawling Commission, of 10 or 12 powerful steam-trawlers to compete with them on their own ground quite altered the aspect of affairs. The energy with which the steam-trawlers generally worked—for trawling went on by night as well as by day, and in weather unsuitable for the liners—introduced in Scotland a new era into the department. Fishing was to be carried out no longer by more or less independent crews, bound together by blood-relationship or other ties, and whose working hours were largely regulated by the weather and tides, or their own convenience and necessities. Moreover, their whole domestic life was interwoven with the time-honoured pursuit. Their wives and daughters laboriously baited the hooks and arranged the lines in the baskets for "shooting," they gathered the "bent" grass for separating the layers of the line, and with the sons dug lob-worms or procured mussels for bait. In the olden time, indeed, their wives and daughters were likewise their fish-merchants, and disposed of their captures to the best advantage. Now (1883) active and powerful vessels, propelled by steam, and thus more or less independent of the weather—manned by a captain responsible to owners or their manager, a crew bound together only by discipline and pay, and whose fishing apparatus required no bait, appeared on the field. Further, instead of following the pursuit on grounds familiar to generations before them, the new fishermen not only ranged over these, but sought new and sometimes more distant fields. Capitalists took up the question, and fitted out powerful

* The numbers are taken from the Report of the Select Committee of the House of Commons, 1893, p. 396.

ships in both Scotland and England, and sent them into Scottish waters, so that the liners met with most formidable rivals. The complaints of the line-fishermen at this period (1883) and subsequently necessarily attracted much attention, and great sympathy has always been expressed in regard to their condition, for undoubtedly the larger and more regular supply of fishes had a tendency to diminish prices, and this caused a reduction of income to the liner, and the fishes on certain of the nearer grounds were thinned, and perhaps rendered more wary. In the Report of 1884 it was said that "two competitors are in the field instead of one, and for the liner it may take closer work, even with all the help improved modern appliances in boats and material can give, to keep pace with his rival;" and, further, that it would be a great calamity if any mishap should befall such a fine race of men—hardy, willing, and adventurous. Complete destruction, or, at any rate, most serious interference with the fishing-grounds, and the destitution of the fishing population, was then predicted, and many anxious eyes watched the development of events, since about 45,000 men at least were dependent on the net-and-line-boats of the country, whereas only a few hundred—perhaps between 200 and 300—were at that time engaged in the trawling industry.

Since 1884 the trawling vessels have steadily increased in number, so that within the ten years they have been considerably more than doubled, the returns for 1893 showing that there are no less than 142 vessels and 720 men thus employed,—the total value of vessels, exclusive of gear, being about £240,737. Or, to go more minutely into details, of this number 72 are steam-trawlers, having a tonnage of 2,625 tons, and valued at £237,004, to which has to be added the fishing gear, £10,746—making a total of £247,750. These vessels are manned by 544 men. The rest (70) are sailing trawlers, having a tonnage of 423, and valued at £3,733, while their gear is estimated at £1,332—making a total of £5,065, with 176 men on board.

In addition to the foregoing there were 39 steam-trawlers belonging to English owners, fishing regularly from Scottish ports, and the tonnage of which was 959 tons, valued £92,100, and value of gear £3,850—making a total of £95,950. These had 296 men on board. The disproportion between the number of men employed and the cost of the material is chiefly brought out when it is mentioned that for 1892 the liners and net-fishermen were 45,629, while they had 13,865 boats, valued at £680,000. It will thus be seen that, while the average is about £1,695 for each trawling ship, for the liner it is about £49. The disproportion, again, in the trawling vessels, between the first-class and the small sailing-boat, *e. g.* of the Clyde, is very great, the former being about £5,000, the latter under £40.

If the returns of round, flat, and other fishes landed, irrespective of herrings, sprats, sparlings, and mackerel, which do not prominently bear on the present question, be considered, it is found that in 1892* the liners brought to shore 1,229,809 cwts. of round fishes, viz. cod, ling, torsk, saithe, whiting, haddock, and conger, which realised, at 8*s.* per cwt., £516,524; the trawlers landed 261,200 cwts. at 10*s.* 11*d.*, or £143,062; the liners produced 100,228 cwts. of flat-fishes, viz. flounders, plaice, brill, skate, halibut, lemon-dabs, and turbot, at 10*s.* 9*d.*=£53,973; the trawlers, 77,649 cwts. of flat-fishes at 25*s.* 4*d.*=£98,295; while of other kinds of fishes, which include hake, bream, gurnard, cat-fishes, and sillock, the liners had 61,224 cwts. at 4*s.* 9*d.*=£14,646; and the trawlers, 41,256 cwts. at 4*s.* 7*d.*=£9,410. The total in each case are, for the liners 1,391,261 cwts. and £585,143; for the trawlers 380,105 cwts. and £250,767.

In glancing at the returns (1892) of the board, which were handed in by the Chairman to the Select Committee last year, it would seem that one fish, viz. the green cod or coal-fish, is included both amongst the round-fishes and the "other kinds of fish," in the former having the name of "saithe" (adult), and in the latter "sillocks" (young); but this is not a point of much importance in regard to the results. As might be expected, the liners, and notably the long-liners, have the predominance in the round-fishes, especially in regard to cod, ling, and conger, the latter being apparently seldom caught in a trawl on the Eastern coast. These large fishes, moreover, would appear to protect themselves to a considerable extent from this apparatus, especially when it is in frequent use, so that it is only in water that is disturbed by gales or by working at night that they are caught in numbers under these circumstances. Nor is this surprising, since even a tiny cod, of little more than one-eighth of an inch, can avoid the forceps intended to capture it. The cod and saithe are also largely caught by gill-nets on the West coast; while the great lines, with hooks baited with herring, are the chief means of capture used in the case of the conger. Further, it has to be remembered that the trawlers, both near and distant, as a rule, throw overboard their small haddocks (8 to 9 and 10 inches), in both cases because it is not worth their trouble to bring them to market and pay dues for the trifling sum obtained for them; and in the instance of the distant trawler, to avoid, in addition, the labour of "gutting" and the expense of ice. Yet the liners bring these to market and they are included in their returns. It

* The full value of the labours of the Royal Commission of 1883, and especially of the late Lord Dalhousie, in establishing a series of proper statistics for the fisheries of Scotland, cannot be over-estimated.

is an interesting fact that, notwithstanding the recent remarks concerning the condition of the trawled fishes, that the price of the latter surpasses that of the former by 2*s.* 11*d.* per cwt. It is true the trawler can more readily reach the market with his fishes, but against this has to be placed the great number of local fishing-boats which have only brief distances to traverse, and the fact that the trawlers who go to distant banks bring fishes "gutted" as well as preserved in ice, and the appearance of which is not always in their favour.

When the flat-fishes are considered, it is found that though the liners produced considerably more in weight, yet the price obtained per cwt. is not half (by 3*s.* 10*d.* less) that got by the trawlers, so that the total value of the flat-fishes procured by the latter is nearly double that of the former.* Yet we know that halibut are largely caught by the liners, and that the three-mile limit and the closed waters in addition are at the disposal of the latter for relays of lines wherewith to capture plaice, dabs, and flounders. In all probability, however, it is the plaice, the witches, and especially the lemon-dabs and the turbot which prove so advantageous to the trawlers.

Of the "other kinds of fish" little need be said except that comparatively few hake come into the trawl, whereas the liner perhaps obtains a larger number; that while the liner brings the gurnards to shore and often eats them, they are frequently thrown overboard by the trawler; and that the cat-fish (wolf-fish) is caught by both in considerable numbers, but whereas, in certain trawlers, this fish is taken to port on the Tuesdays, it is thrown overboard at the end of the week.

In 1893 the equivalent returns show that the liners brought to land 1,136,389 cwts. of round-fishes=£466,399, this being 93,419 cwts. and £50,125 less than last year. The most marked deficiency has been in haddocks, 69,766 cwts. and £35,092; cod, 54,260 cwts. and £20,661; and whiting, 15,381 and £5,741. An increase had taken place both in line- and trawl-fishing in the other round fishes, viz. ling, torsk, saithe, and in the conger caught by line. How far this diminution was due to the unfavourable weather of 1893 is an open question. It certainly must have had some influence. The abundance of very small haddocks is another fact to be remembered, since many were not brought to shore, and they occupied hooks on which larger fishes might have been caught. The trawlers landed 309,862 cwts. of round fishes=£178,304, or 48,662 cwts.=£35,242 more than last year. With regard to flat-fishes, the liners produced 57,149 cwts. =£43,306, or 4,685 cwts. and £48 more than last year; the

* At Montrose, for instance, the flat-fishes landed by trawlers realised nearly 20*s.* per cwt., while those caught by line produced only 9*s.* 11*d.* per cwt. But turbot alone was sold at £3 6*s.* 2*d.* per cwt., so that the trawlers had the advantage in this respect.

greatest increase, 5,594 cwts. and £566, having been in halibut, but these apparently were largely caught in distant waters, such as off the coast of Norway, Iceland, Faröe, and elsewhere, so that they confuse the returns from British waters. An increase also exists in soles (lemon-dabs?) of 50 cwts. and £120. A slight decrease, again, occurs in flounders, plaice, and brill. The trawlers landed of flat-fishes 71,024 cwts. = £89,781, a decrease of 604 cwts. and £7,243 on last year, this decrease being largely due to the deficiency of lemon-dabs, viz. 6,133 cwts. and £8,448, and a deficiency in turbot of 94 cwts. and £762, while an increase occurred in halibut and a larger increase in flounders, plaice, and brill, 5,197 cwts. and £1,597. This year skate form a separate return, which shows that the liners produced 52,626 cwts. and £10,725, or 4,862 cwts. more than in 1892, yet with only a trifling excess of income over that year, viz. £9 10*s.*—a result probably due to diminished prices. The trawlers landed 5,383 cwts. = £1,015, or 637 cwts. and £253 less than in 1892. Of "other kinds of fishes" the net fishermen brought 3,517 cwts. = £891, or 102 cwts. and £731 more than in 1892, while the liners landed 46,461 cwts. = £10,726, or 11,347 cwts. and £3,160 less than in 1892. The trawlers again caught 39,418 cwts. = £9,215, or 1,838 cwts. and £195 less than in 1892.

The price of the round fishes in 1893 is respectively for the liner 8*s.* 2½*d.* per cwt., and the trawler 11*s.* 6*d.*, or a balance of 3*s.* 3½*d.* in favour of the latter, and therefore a higher proportion than in 1892. In regard to flat-fishes the inclusion of skate makes a considerable difference; thus the average price for flat-fishes, inclusive of skate, is for the liner 9*s.* 10*d.*, for the trawler 23*s.* 9*d.* per cwt., whereas, when the skate are excluded, it is for the liner 15*s.* 2*d.*, for the trawler 25*s.* 3*d.* In the former case the trawler receives no less than 4*s.* 1*d.*, more than double the amount obtained by the liner; in the latter case the trawler receives 10*s.* 1*d.* per cwt. more than the liner. The disproportion in any case is marked. In connection with prices, however, it has to be borne in mind that in many cases the liner is compelled to sell his fishes in remote districts or unfavourable markets, whereas the trawler takes care to put his fishes into the best market, and in quantity.

Again, the grand total of all kinds of fishes landed in 1892 was 5,436,138 cwts. If herrings, sprats, sparlings, and mackerel (viz. 3,664,771) are deducted, 1,771,367 cwts. are left, of which 1,391,262 cwts. were caught by liners, and 380,105 cwts. by trawlers, or, in other words, the liners caught more than three times the quantity of fishes landed by the trawlers. In 1893 the grand total of all kinds of fishes notably exceeds that of 1892, and is no less than

6,208,018 cwts., or 771,880 cwts. more than in 1892. The greater proportion of this, however, is made up of herrings, viz. 4,486,187 cwts.,—that is to say, a fish which is more or less unprotected at all stages of its life is apparently able to hold its own against its destroyers. It is, however, a purely pelagic form, and depends on the pelagic or floating fauna for its food. If the herrings, &c., are deducted a balance of 1,721,831, cwts. is left for the liners and trawlers, being 49,536 cwts. less than in 1892. Of this 1,296,144 cwts. were the produce of the liners (less by 95,118 cwts. than in 1892), and 425,687 cwts. the quantity landed by trawlers (45,582 cwts. more than in 1892). While the liners, therefore, showed a marked diminution in their total, the trawlers showed a considerable increase.

When the returns, however, of the fishing-boats of all kinds (other than beam-trawlers) are considered, it is found that there were in 1893, 363 fewer boats and vessels than in 1892, and a decrease of 1,689 fishermen and boys. This condition of things is sufficient to account for a considerable diminution of line-caught fishes, without regarding the unfavourable weather of the season. Moreover, it has to be remembered that fishery statistics are far from being complete, for though the returns show that the quantity of fishes mentioned has certainly been landed, they do not indicate those fishes which have been landed and not reported. On the other hand, the number of the trawlers has increased by two (probably powerful steam-vessels) and eighteen men during the year.

In 1884 trawling was carried on within a "reasonable distance" of land, so that the paddle-ship could deliver the catches of the night in time for the market next morning, or the daily "carrier" of the fleet of steam-trawlers from Granton, by leaving the fishing-grounds in the afternoon or evening with the united catch, could reach that port early next morning. The vessels from the Moray Firth could land their fresh fishes at Macduff or Aberdeen, and the vessels from Montrose and Dundee carried fresh fishes to those towns.

For ten years the trawl-fishery has been prosecuted with vigour, and it is interesting now to see what areas the ships frequent, and with what results. To commence with the most northerly, viz. Aberdeen, at which trawling has made great progress since the former date (1884), it is found that, whereas the chief supplies were brought fresh from the adjoining sea by the older paddle-ships, or from the Moray Firth by the more powerful vessels, the main supply of the present day comes from the "Great Fisher Bank" or from Iceland. Instead of the activity displayed in 1884 in the strip of sea from 10 to 20 miles off the coast, between

Aberdeen and Montrose, only a few vessels are now seen at work here and there in good weather. Fishes are by no means absent from this area, and at certain times occur in considerable abundance, but the individual catches at other times are limited; and on the rough ground 10 or 11 miles off, in 33 fathoms, it sometimes happens that, after three hours' trawling, about the same time has to be spent in mending the net. Yet lemon-dabs and sail-flukes or "megrims" (*Arnoglossus megastoma*) in the deeper and softer parts, with the larger haddocks and other forms, render the work there still worthy of attention. If small haddocks brought fair prices, the work would, indeed, be tolerably remunerative, as they are at present in very great numbers. The liners work on the same ground and catch chiefly the latter fishes. There is no indication that fish-food has been seriously interfered with on this ground, but, on the contrary, invertebrate life of all kinds is in great abundance. Moreover, the enormous numbers of pelagic sand-eels, from 15 to 33 mm. in length, intermingled with swarms of young flat-fishes, on these grounds, and on which many of the fishes were feeding in May, is a feature of moment. In 1884 the captures on the northern part of this area during the summer months were comparatively limited, and it was only the advent of the herring in autumn that caused a notable increase of white fishes. To-day, at the distance from land just mentioned, each haul in daylight produces from a basket to a basket and a half of lemon-dabs, about three-fourths of a basket of large haddocks, and 4 to 5 boxes of small haddocks. At night, a few ling, cat-fishes, and cod are added to the catch. Few whiting are procured, and the same feature was occasionally seen in 1884, for the whiting are often in the upper parts of the water. Very few cuttle-fishes occurred in May. The "catch" just mentioned is not a heavy one, and is probably surpassed by other ships, but it at any rate shows that fishes are still present in considerable numbers. This is further demonstrated by examining the "catch" of a liner with six men on board, and which had been at sea about 32 hours, fishing on the 28th and 29th of May, probably from 28 to 30 miles off Aberdeen, viz. 9 boxes of large haddocks, the largest fish reaching the length of 20 inches, the rest smaller (at 24*s*. per box), 3½ boxes of small haddocks, a few cod, dabs, one lemon-dab, and a few whiting—making a total of about £12 for the six men. In the same market lately the large haddocks brought 29*s*. per box, so that the above is probably not an unusual price.

At the southern end of the ground just mentioned, viz. off Montrose, a trawler working, three years ago, about 25 miles off, in August, landed the very high catch of 500 boxes of haddocks in a single night. At present the takes range, per week, from 100 to 140 boxes of haddocks and flat-fishes, besides cod, coal-fishes, and gurnards. Plaice are said to be rather scarce, even lemon-dabs being more abundant. For the night of the 29th May 18 boxes of haddocks and flat-fish were landed, besides cod and ling. For each box of good haddocks (7 stones) 16*s.* were obtained—a much lower price than in Aberdeen, where, however, the box was heavier (8 stones or more). The "catch" for the night was about a ton in all. A small liner, with five men on board, which went out between 9 and 10 A.M. on the 29th, landed at 5 P.M. (*i.e.* in 8 hours) ¾ box of large, ½ box of medium, 2 boxes of small haddocks, many about 9 inches long; 1 lemon-dab, 2 very fine cod, and 4 codling, and this though their lines were "shot" in broad daylight. The fishing-ground was from 8 to 10 miles off. This is a small "catch," but the circumstances under which it was made were not favourable. There can be no doubt that the entire Eastern coast abounded with multitudes of small haddocks, and that these have been captured in immense numbers by both liners and trawlers.

The best trawling ships, which are about 30 in number, at Aberdeen at present chiefly frequent the Great Fisher Bank, about 200 miles off, and from 30 to 40 fathoms in depth, it being a general opinion amongst fishermen that this, and up to 60 fathoms, is the most favourable depth for their pursuit, for they think that in deep water (100 to 175 fathoms) they get only conger, halibut, and skate; and elsewhere, as off the coast of Portugal, only sharks are procured at 500 fathoms. Yet the Rev. W. S. Green, off the west coast of Ireland, got "witches," ling, haddocks, and conger at 170 fathoms, and skate and forkbeard at 500 fathoms. On this ground (Great Fisher Bank), which is about 120 miles from east to west, and from 60 to 80 miles from north to south (a larger area than the enclosed region of the Moray Firth), the "catches" of these trawlers vary from 80 to 180 boxes or more, consisting of plaice, haddocks, turbot, and other fishes, which are procured in from 8 to 13 days, including the time spent on the voyage. Since the Moray Firth was closed, these ships, therefore, find it remunerative to undertake this long journey, and bring their fishes preserved in ice to the market in Aberdeen. They do not seem, however, to find it so profitable to fish in the waters near the Scottish shore. In the same way, the powerful ships which proceed to Iceland bring from 200 to 400 boxes of fishes in about 14 days. The plaice procured in this region are recognised by the dark spots; and as these, the haddocks, cod, and other forms have been "gutted" and preserved in ice, they do not have so attractive an appearance as those caught by the liners.

Besides the areas just mentioned, some trawlers proceed to Blacksod Bay, off County Mayo, on the West coast of Ireland, for soles and turbot, while in February and March others go to ground 20 to 40 miles off Scarborough, where, perhaps, 20 score of cod are caught in a night. Some, again, work on the turbot-ground, from 80 to 90 miles off Aberdeen, and others find on the Dogger Bank catches of from 18 to 20 boxes of plaice.

When the trawlers from Granton and Leith are considered, it is found that, notwithstanding the closure of the Forth (for 3 miles beyond the Island of May), these ships have increased in number, have been improved in equipment, and have been able to overcome the difficulties with which they were handicapped—in comparison with the liners. In the case of the General Steam Fishing Company's ships, and probably in others, however, very definite instructions—based on carefully-recorded data, compiled during the last twelve years—are issued to each captain as to the distance to be traversed (by the log), and the direction on every occasion. No haphazard selection of fishing-grounds is made. Thus in December, besides the ordinary fishes, numerous cuttle-fishes (so valuable for bait) are procured off the Isle of May. In January, February, March, and April they work from 5 to 10 miles S.E. of the Isle of May, viz. more or less on the grounds frequented in 1884. In March and April the cod are captured, as before, in considerable numbers as they congregate during the spawning season, and in the earlier months as they follow the herrings. In June, July, August, September, October, and November they take to the more distant grounds off the Forth—about 40 miles E. by N.E.

The opinions somewhat freely expressed by some in 1884 as to the decline of the trawling industry in the Forth and the adjoining area—notwithstanding all the advantages of a free area from inshore to offshore then possessed—do not seem to have been borne out by further experience. Even with the entire area of the Forth and St. Andrew's Bay closed, these vessels, now considerably increased in numbers, have found fishing profitable on the more distant grounds. They work on a certain area, either by means of a flag-buoy or otherwise, and strictly in accordance with the instructions given from headquarters. If the captures are observed to be decreasing, either from the thinning of the fishes or their being scattered, they change ground, as, indeed, was very noticeable in 1884, returning after an interval to the same area, to find that an increase has taken place. In connection with this filling up of areas over which trawling has been assiduously carried on, it is an interesting fact that the local boats—from 12 to 20 or more in number—found for many years that, on the whole, their best ground in St. Andrew's Bay was a line about 2 miles from shore ("Scooniehill," in a line with "the steeples"), and about 4 fathoms in depth. Boat after boat trawled along that line, wind and weather permitting, for four months of the year, and sometimes longer, and to the closing day it maintained its position as the best area for plaice. The same observation has been made at Brixham, where trawling has been in operation about a hundred years. It is quite evident, therefore, that other fishes took the place of those captured, and that this continued month after month and year after year. The whole question, therefore, in the larger areas outside the 3-mile limit is—Can the supplies from the neighbouring waters keep pace with the rate of capture now going on by both liners and trawlers? These supplies consist of the growth of the young from eggs on the area itself, and the immigration of eggs, young, and adults from other areas or the open water beyond. It is seen that, so far as human observation can go, the supplies of herrings are as plentiful as formerly, notwithstanding the absence of restriction and the great waste that annually takes place in this fishing. On the other hand, it is a matter of observation that the first hauls of the trawl on virgin ground are the most successful, and that by-and-by the catch diminishes, and the same occurs with the liners on their new "banks" or "reefs." Yet it cannot be said in either case that the fishes have been extirpated, but they probably have become more wary as well as diminished in numbers, and, moreover, they may have changed their ground, for fishes are constantly roaming. It has to be remembered that the food-fishes are not altogether confined to the shallower water in which they are usually followed, but they likewise extend into the deeper water beyond. Such deeper water and unfrequented regions, therefore, form reserves, in which the species is reproduced, the eggs, young, or adults passing into those areas in which the food-fishes have been more or less thinned.

The area last mentioned, viz. that off the Forth, is perhaps one of the most important in Scotland, in regard to the number and variety of its fishing-grounds. For the present purpose the area may be defined as that bounded by a line drawn eastward from Arbroath on the north, and a similar line from St. Abb's Head on the south. Between these points the Tay and the Forth pour considerable bodies of fresh water into the sea, while the Eden debouches into St. Andrew's Bay between them. The amount of microscopic food—both plant and animal—as well as of the smaller invertebrates which are carried to sea in this area, is very considerable, and in all probability is closely related with the richness of invertebrate life both in the waters and on the bottom. The enormous numbers of pelagic mussels swept from the Tay and the Eden alone form a remarkable feature. It is not surprising, therefore, that the fishing-grounds in this region still continue fairly prolific, notwithstanding the increased demands on their resources. In the same way the Moray Firth is another rich fishing-area on the East coast, though the rivers entering it are smaller.

The steam-liners and trawlers frequent the more distant grounds, not because the fishes are absent from the nearer grounds, but because their "catches," as a rule, far exceed in bulk those obtained on the latter. While, therefore, the present statistics show no serious diminution, it may be truly said that the total is kept up only by the supplies from Iceland, Faröe, and the Great Fisher Bank. But the nearer grounds would have produced a considerable supply if they had been perseveringly worked; and it cannot be doubted that they contained, at any rate, an immense number of small haddocks.* Moreover, these small haddocks had migrated from the distant waters, for it is a remarkable fact that, so far as ascertained, no great shoals of very small haddocks (*i. e.* less than 3 inches) have been encountered in inshore waters. The life-history of the haddock, indeed, between its post-larval condition and the adolescent stage of between 2 and 3 inches, is still comparatively unknown. Before the appearance of these hordes of small haddocks, it was generally asserted that the haddock had been more or less extirpated; hence the necessity for caution in dealing with such subjects. Again the question as to the completeness of the statistics of fishes caught round the Scottish shores has to be considered, and there are some who think much improvement is required in this direction. Indeed, the only satisfactory method would be for every liner, trawler, net-, crab-, or other fisherman to hand to the official on reaching the port a slip stating the amount and kind of the "catch," and the ground on which it was made, as indicated in the Trawling Report of 1884. Taking all these circumstances into consideration, therefore, there is no reason for despairing of the fisheries, especially when the enormous powers of reproduction of the round and flat-fishes, their transparent, floating eggs, and the vastness of the medium which encircles our shores are remembered.

The condition of the inshore waters (within the 3-mile limit) has elsewhere been dealt with,† and will again form the subject of future remarks. All that need be said at present is that, so far as can be ascertained, it would not appear that the closure of the inshore waters

* An idea of the numbers of these may be given by stating that a trawler brought on board, in two hauls, about ten tons of small haddocks, which were, however, freed. Many were probably killed.

† A Brief Sketch of the Scottish Fisheries, 1882–92, p. 6.

has made any marked increase in the fishes of the offshore waters, yet the younger fishes have now had time to pass outward and become mature; nor have the larger fishes been driven shorewards by the more frequent interference with the more distant areas. No change, however, could be expected if the scarcity were due to general over-fishing.

(*To be continued.*)

NOTES AND MEMORANDA.

Virgularia mirabilis.—The following letter has been received from Mr. W. P. Marshall:—I return you herewith the Eddystone specimen of *Virgularia mirabilis* that you lent to my late son and myself when we were at the Plymouth Biological Station, and am very sorry that the investigation we were engaged upon was not sufficiently worked out before his death for the report to be given upon this specimen.

The point under consideration was the development of the polyps in the early stages of growth of the colony, on which valuable information was given by this Eddystone specimen, which led us to a further examination of the younger specimens that had been obtained in the Oban dredging by the Birmingham Natural History Society.

The general result was as follows. In the *adult* specimens there are in the most matured portion—

8 polyps per leaf (or group).

$7\frac{1}{2}$ polyps per inch pitch of leaves (or $7\frac{1}{2}$ leaves in each inch length of specimen).

In the Eddystone specimen there are—

3 polyps per leaf in the lower portion.
4 ,, ,, in greater portion of length.
16 ,, per inch pitch at the lower end.
10 ,, ,, ,, at the upper end.

And the appearance of the specimen suggests that it is at the stage when the fourth polyp begins forming.

In the Oban young specimens there are—

3 polyps per leaf throughout in 3 specimens.
4 ,, ,, ,, 4 specimens.

These correspond closely with the Eddystone specimen in the number of polyps per leaf, but there is a wide difference as regards the pitch of the leaves, namely (Oban specimens)—

56 to 96 pitch with 3 polyps per leaf.
64 to 75 ,, ,, 4 ,, ,,

The *adult Oban* specimens have a general pitch of about 48 at the lower end, and the pitch 16 at the lower end of the Eddystone young specimen is so exceptional as to suggest another species or variety.

The English Channel is not a recorded habitat for Virgularia so far as we know, except for this Eddystone specimen and a smaller fragment obtained off Falmouth in a former dredging excursion of the Birmingham Society in 1879.

Coryphella smaragdina.—On Friday, May 11th, a small Eolid was dredged near the Asia buoy. On subsequent examination it proved to be *Coryphella smaragdina*, A. & H. Alder and Hancock described the species from a single specimen found at Whitley, in Northumberland. It is also found in the Mediterranean. It is, therefore, curious that the species has hitherto never been found at Plymouth. The body of the specimen is about half an inch long and pure white in colour, the tentacles are equal in length, and the anterior angles of the foot are produced out into two tentacular-like processes. The branchiæ are disposed in five transverse bands, and are a vivid green in colour. Though the specimen has been nearly a fortnight in spirit the green is as bright as when the animal was alive. Alder and Hancock in their description of the species mention that they found it on the common *Fucus vesiculosus*. They go on to say that "this position was most likely accidental; at least, it must not be taken as a proof that this species is less carnivorous than its congeners." The Plymouth specimen was found crawling on a stone amongst a mass of Hydroids, so that Alder and Hancock's surmise is fully borne out.—J. C. Sumner.

Director's Report.

Important changes have taken place in the staff of the Plymouth Laboratory, owing to the resignation of Mr. E. J. Bles and the transference of Mr. Cunningham to the North Sea, to continue the fishery investigations carried on there. It is with great regret that I have to report that, owing to the unsatisfactory state of his health, Mr. Holt is unable to continue the valuable work which he has been doing for the Association.

Two naturalists are at present visiting the Laboratory—Mr. J. C. Sumner, who has occupied since the beginning of January a British Association Table, and is engaged in a study of the Echinoderm fauna of Plymouth, and Mr. Richard Assheton, M.A., who is studying the development of Elasmobranchs.

An important alteration is in contemplation in the system of supplying sea-water to the tanks in the Laboratory, which it is hoped will lead to more satisfactory results than have previously been attained. In addition to this, arrangements are being made to bring in water from the open sea in sufficient quantity for delicate experiments, and a definite study of the conditions necessary for the healthy life and development of marine organisms in confinement will be attempted. In this connection I may draw attention to the interesting results contained in the paper by Mr. Darnell-Smith, published in the present number of the Journal. Mr. Darnell-Smith purposes continuing this work during the summer.

I am glad to be able to announce also that the Council have authorised the expenditure of a considerably larger sum for boat-hire during the present year than has been spent in previous years, and it will now be possible to extend the regular dredging and trawling work along the coast, and to visit the rich outlying grounds. It is fully recognised by zoologists that the work of the Association has been very greatly hampered by the want of a larger boat, and it is, in part, to make it clear to all that this is the case that the extra money is to be spent on boat-hire for this year. I would, therefore, make a special appeal to naturalists for support *during the present year*, as I am fully convinced that the results which are attained will have an important bearing on the question of our having a suitable boat of our own. A general scheme will be set on foot to map out the fauna and flora of the neighbourhood, and to arrange types for the museum ; and the Council has directed that tables be placed at the disposal of naturalists who will be willing to assist in this work. I shall be glad to hear from any workers, either zoologists or botanists, who would render help in such faunistic work. An exceptionally good opportunity is thus offered to young men who have recently finished their University course, and are anxious to gain experience in the outdoor work of Marine Natural History. At the same time increased advantages in the supply of material will be afforded to all naturalists who visit the Laboratory, and it is hoped that an exceptional effort will be made to do so by all who are interested in the prosperity of Marine Biology in this country.

Special attention is being paid to the reagents supplied to workers in the Laboratory, and all stains and more delicate chemicals are being obtained from Dr. Grübler's Laboratory, which offers the very best guarantee of their suitability for the purposes for which they are required.

The unexpected loss of Mr. Holt's services, and the fact that Mr. Cunningham has taken charge of the work in the North Sea, render it impossible for me to indicate at the present moment the definite plan of fishery work which will be adopted at Plymouth for the year. This will, however, be arranged with as little delay as possible, and no effort will be spared to carry it to a successful conclusion.

E. J. Allen.

February, 1895.

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, the late Professor MOSELEY, the late Mr. ROMANES, and Professor LANKESTER.

The Association owes its existence and its present satisfactory condition to a combination of scientific naturalists, and of gentlemen who, from philanthropic or practical reasons, are specially interested in the great sea fisheries of the United Kingdom. It is universally admitted that our knowledge of the habits and conditions of life of sea fishes is very small, and insufficient to enable either the practical fisherman or the Legislature to take measures calculated to ensure to the country the greatest return from the "harvest of the sea." Naturalists are, on the other hand, anxious to push further our knowledge of marine life and its conditions. Hence, the Association has erected at Plymouth a thoroughly efficient laboratory, where naturalists may study the history of marine animals and plants in general, and where, in particular, researches on food fishes and molluscs may be carried out with the best appliances.

The Laboratory and its fittings were completed in June, 1888, at a cost of some £12,000. Since that time investigations, practical and scientific, have been constantly pursued at Plymouth. Practical investigations upon matters connected with sea-fishing are carried on under the direction of the Council; in addition, naturalists from England and from abroad have come to the Laboratory, to carry on their own independent researches, and have made valuable additions to zoological and botanical science, at the expense of a small rent for the use of a working table in the Laboratory and other appliances. The number of naturalists who can be employed by the Association in special investigations on fishery questions, and definitely retained for the purpose of carrying on those researches throughout the year, must depend on the funds subscribed by private individuals and public bodies for the purpose. The first charges on the revenue of the Association are the working of the sea-water circulation in the tanks, stocking the tanks with fish and feeding the latter, the payment of servants and fishermen, the hire and maintenance of fishing boats, and the salary of the Resident Director and staff. At the commencement of this number will be found the names of the gentlemen on the staff. In no case does any one salary exceed £250.

The Association has at present received some £20,000, of which £5000 was granted by the Treasury. The annual revenue which can be at present counted on is about £1820, of which £1000 a year is granted by the Treasury, the remainder being principally made up in Subscriptions.

The admirable Marine Biological Laboratory at Naples, founded and directed by Dr. Dohrn, has cost about £20,000, including steam launches, &c., whilst it has an annual budget of £7000.

The ASSOCIATION IS AT PRESENT UNABLE TO AFFORD 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. Funds are urgently needed in order that this section of the work may be carried out with efficiency. The purpose of the Association is to aid at the same time both science and industry. It is national in character and constitution, and its affairs are conducted by a representative Council, by an Honorary Secretary and an Honorary Treasurer, without any charge upon its funds, so that the whole of the subscriptions and donations received are devoted absolutely to the support of the Laboratory and the prosecution of researches by aid of its appliances. The reader is referred to page 4 of the Cover for information as to membership of the Association.

CONTENTS of NEW SERIES, Vol. III, No. 4.

NOTICE.

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

TERMS OF MEMBERSHIP.

		£	s.	d.
Annual Members	per ann.	1	1	0
Life Members	Composition Fee	15	15	0
Founders		100	0	0
Governors		500	0	0

Members of the Association have the following rights and privileges: they elect annually the Officers and Council; they receive the Journal of the Association free by post; they are admitted to view the Laboratory at Plymouth, and may introduce friends with them; they have the first claim to rent a place in the Laboratory for research, with use of tanks, boats, &c., and have access to the books in the Library at Plymouth.

All correspondence should be addressed to the Director, The Laboratory, Plymouth.