27.—FISH-CULTURAL INVESTIGATIONS AT ST. ANDREWS MARINE LABORATORY, SCOTLAND.

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I.—ON THE FISHES DEVELOPED AT THE ST. ANDREWS MARINE LABORATORY (UNDER THE FISHERY BOARD FOR SCOTLAND).

Since 1883 special attention has been devoted at St. Andrews to the subject of the development of marine fishes, an attention which was first stimulated by the absence of reliable knowledge on this subject as well as of the eggs and life-histories of even the commonest and most important of our food-fishes. At this period the greatest uncertainty prevailed as to the floating or sinking of the eggs of such fishes; indeed, among strictly scientific men in Great Britain no attention had been given to the subject, and the most eminent of them thought that the floating or sinking of these eggs might be due wholly to the temperature of the water, just as others deemed it might be due to the oil-globule, overlooking the fact that many are devoid of that structure.

Previous to this period the life-history of scarcely a single marine food-fish had been studied in Great Britain. It was known that Sars had observed the development of the cod in Norwegian waters, and that Agassiz, Ryder, and others in the United States of America had paid considerable attention to those of their shores, but the field was almost untouched in this country. A commencement was made during the trawling expeditions of 1884, and, with the aid of Lord Dalhousie and the Fishery Board for Scotland, a systematic examination of such forms as were available was begun at the St. Andrews Marine Laboratory, and it was fortunate that, shortly afterward, the aid and coöperation of Prof. E. E. Prince, now Commissioner of Fisheries in Canada, were available.

On the present occasion I shall devote my remarks to the mention of those fishes which for the first time have been hatched at the St. Andrews Marine Laboratory—the oldest institution of the kind in Great Britain.

No pelagic egg is more abundant on the east coast than that of the grey gurnard (*Trigla gurnardus*), and it is quite easy to fertilize ripe eggs from the females and hatch them in the tanks. The larvæ are hardy, and in open-air tanks communicating with the sea could readily be reared to the young stages. The minute characters of the egg, larvæ and young stages have been described and figured in the publications emanating from the laboratory, and the same remarks apply to the subsequent forms.

The armed bullhead (*Agonus cataphractus*) deposits its demersal eggs on the bottom of the bay and on stones, while the larvæ and young are only common in the bottom nets. The ova are easily hatched in the laboratory, and the bright colors of the young are characteristic.

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The floating gelatinous ribbands containing the ova of the frogfish (*Lophius piscatorius*) are less frequently encountered on the east coast than one would expect. It is possible, however, that the constant destruction of the adults in the stake nets and in trawls may account for the comparative rarity of the ova. Isolated eggs are occasionally obtained in the tow nets, but the best examples of the developing ova were procured from the salmon stake nets off the east rocks, and the larvæ have been carefully figured and described by Prof. Prince.

The demersal eggs of the spotted goby (*Gobius minutus*) have occasionally been found on stones, and more frequently in the valves of *Solen siliqua*, *Lutraria*, and other mollusks. They have been described by Mr. E. W. L. Holt, who has also carried on able researches at the St. Andrews Laboratory. The young are very abundant.

The small but beautifully reticulate pelagic ova of the dragonet (*Callionymus lyra*) are not uncommon in the tow nets all along the eastern and western shores. They were first described in 1885, and have frequently been hatched in the tanks. The larvæ have been described both by Prof. E. E. Prince and Mr. Holt. The very young stages are frequently observed in the bottom tow nets; indeed, all stages have been thus procured. The abundance of black pigment on the ventral surface of the young forms is one of the most striking features.

The masses of the demersal ova of the lump-sucker (*Cyclopterus lumpus*) are very abundant in spring off the rocky shores, and the remarkable devotion of the males in guarding the eggs is not surpassed by any other form. Many so expose themselves amongst the tidal rocks close to the eggs at low water that crows pierce their sides and devour them alive after picking out their eyes. The eggs are easily hatched in the tanks, and the larvæ and young are very hardy. They likewise abound in the tidal pools and in the inshore waters amongst floating seaweeds. Instead of being thrown away as manure, the multitudes of adults might be utilized for making mock-turtle soup. Their thick gelatinous skins are well adapted for this purpose.

One of the earliest demersal eggs of the season is that of Montagu's sucker (*Liparis montagui*) which occurs in clusters on *Delesseria* and other seaweeds and on zoophytes all along the east coast. The larvæ in the tanks are as lively as those of the lump-sucker—shooting through the water like swarms of ephemeræ in the air.

The largest marine demersal egg hitherto met with in Great Britain is that of the wolf-fish (*Anarrhichas lupus*) a huge mass of which was brought to the harbor by a local trawler early in 1886, and subsequently hatched in the laboratory. The ova are only a little less than those of the salmon—for which the local fishermen mistook them, but they differ wholly from that species, not only in regard to the single large oil-globule, but in the fact that the ova are fixed to each other in masses. The large larva is one of the most interesting forms in the group. The skins of the adults should be utilized for leather, as in the case of the Norwegian species.

The eggs of the gunnel (*Centronotus gunellus*) are often met with in spring as masses in holes of the rocks near low-water mark, the female fish generally enveloping them in a coil of the body, and the same feature is observed when the eggs are deposited in the tanks. They are hardy, and the larvæ and the young are also easily kept in confinement.

The demersal ova of the 15-spined stickleback occur in nests formed of seaweeds in the higher littoral parts, and they also are readily hatched in confinement, as detailed by Prof. E. E. Prince.

The pelagic ova of the cod—procured during the trawling expeditions of 1884—were among the earlier forms treated at the laboratory, and every year since have been under observation. The same may be said of the eggs of the haddock and whiting.

The pelagic eggs of the poor cod (*Gadus minutus*) have also been frequently under observation, but fertilized eggs about which there could be no doubt have only recently been obtained, as detailed in the accompanying pages.

The pelagic ova of the ling have been fully described and the larvæ and subsequent stages figured. The ripe ova and milt were obtained from the distant offshore waters by the long-liners, and though the surroundings of the jars were by no means favorable in the fishing boats no difficulty was experienced in conveying them to the laboratory for hatching.

The pelagic eggs of the torsk (*Brosmius brosme*) in a fertilized condition were only recently procured from Shetland, and are distinguished by their pinkish oil-globules, as described in the following pages.

Great uncertainty prevailed concerning the eggs of the sand-eels, both larger and smaller, but it has been found that the ova are demersal and adhesive, probably sticking to sand or other substance in the sites frequented by the adults. The eggs of the larger sand-eel (*Ammodytes lanceolatus*) have a deep-greenish oil-globule, that in the eggs of the lesser sand-eel being paler and with a pinkish hue. The larvæ have long been known, and occur in great numbers in the bottom tow nets. They also, however, at a somewhat later stage are occasionally found at the surface.

The pelagic eggs of the long rough dab (*Hippoglossoides limandoides*) have been familiar since 1884, and every season have been hatched at the laboratory. The egg is remarkable for the size of the perivitelline space, which gives it a large diameter.

The pelagic ova of the brill have been successfully hatched, and the boldly colored larvæ described. The difficulty is to get a sufficient number of ripe ova and a suitable male for fertilization. The egg has a single oil-globule.

The pelagic eggs of the sail-fluke (*Arnoglossus megastoma*) also have a single oil-globule, and they and the larvæ are described in the following part of this paper.

The large pelagic ova of the plaice have long been familiar at the laboratory as one of the earliest captures of each season. The ova are hardy and the larvæ are easily reared. The growth of the young is comparatively rapid.

Large numbers of the pelagic ova of the lemon dab (*Pleuronectes microcephalus*) have frequently been hatched, and the larvæ reared to the late stages. There should be little difficulty in rearing this species in suitable open-air tanks.

The small but ubiquitous pelagic ova of the dab (*Pleuronectes limanda*) have been familiar every season since 1884. They are hardy and so are the larvæ. The same remarks apply to the eggs of the flounder (*Pleuronectes flesus*), which can survive considerable changes in the temperature of the water.

The pelagic ova of the sole (*Solea vulgaris*) were first observed in the trawling expeditions of 1884, and have been found every season in the bay when carefully looked for. The eggs and larvæ are very hardy, and experiments on a larger scale at Dunbar will soon be made with both.

The transparent pelagic eggs of the sprat (*Clupea sprattus*) occur in enormous numbers every season. They are easily hatched in the tanks.

The eggs of many other fishes have, moreover, been examined and most of them described, such as those of the short and long-spined *Cottus*, bimaculated sucker,

shanny, Yarrell's blenny, viviparous blenny, 3-spined stickleback, bib, green cod, pollack, the rocklings, halibut, turbot, Müller's topknot, salmon, gar-pike (ovarian), minnow, conger (ovarian), twaite-shad (ovarian). Further information has been gained about eggs which had been hatched elsewhere, such as the lesser weever, rockling (*Motella mustela*), little sole, herring, and others, besides the young of various skates, dogfishes, and the viviparous blenny.

Besides the study of the living eggs, larvæ, and young fishes, large collections of preserved pelagic ova, larvæ, and young fishes have for several years received special attention. They are made by the *Garland*, the ship used by the Scotch Fishery Board for scientific observations, according to special instructions, and the ova are preserved in 4 parts alcohol, 4 parts acetic acid (2 per cent), and 1 part camphor, after being killed in a saturated solution of picric acid in 5 per cent hydrochloric acid; the larvæ and young fishes are killed by a saturated solution of corrosive sublimate, washed, and then placed in methylated spirit, and changed if many are in one tube or bottle. By careful study and comparison the nature of many of the ova can be made out, and the numbers of each in the respective areas determined. The nets of course, are kept down for a fixed period, and both surface and bottom nets are used simultaneously. By summing up the results of the trawl and of the contents of the tow-nets, the condition of the several areas in regard to food and other fishes is determined with considerable accuracy, while the occurrence and distribution of ova are also observed.

II.—ON THE HATCHING OF MARINE FISHES IN RELATION TO THE FISHERIES.

Though from the foregoing remarks it will be seen that most of the important food-fishes have been hatched at the St. Andrews Marine Laboratory, yet it can not be said that in this country the hatching of such fishes has been carried out on a large scale. The Fishery Board for Scotland have nearly completed an establishment of this kind at Dunbar (see pp. 257–262), and fishes have been collected for next season, but no actual hatching on a large scale has occurred. The importance of the issue demands that a thorough trial be made, though it has not yet been proved that the artificial hatching of sea fishes will be beneficial to the fisheries generally. In performing experiments of this kind it is best to select a fish not only suitable and hardy, but one comparatively rare in the vicinity of the hatchery, if not entirely foreign to the area. The increase of such a fish after the operations can not thus be mistaken. For example the sole (*Solea vulgaris*) has been selected as the best fitted for experiment at Dunbar, since comparatively few exist in the neighborhood, and the larvæ and young are hardy. The same species has been chosen for experiments in transporting the adults and adolescents into new areas, such as St. Andrews Bay, into which several hundred were placed this autumn. The plaice (*Platessa vulgaris*) will also be hatched at Dunbar. For experiments of the first-mentioned kind the fjords of Norway are admirably adapted, since constant fishing has greatly thinned the native cod (a small variety). If, therefore, Capt. Dannevig can show that his millions of larvæ, which for some years have been sent into the water, have had the effect of increasing the number of cod captured by the fishermen of the locality, a strong case will have been made out.

So far as we in this country can judge, the American experiments have not resulted in anything very definite in regard to sea fishes. It is doubtful, however, if the scale on which such experiments have been conducted has been sufficiently large to merit confidence. Again, we are in want of accurate data to guide us in regard to

the period at which the fishes ought to be freed; that is to say, whether they should be placed in the sea just before the yolk-sac is absorbed or retained in large open-air inclosures until they are adolescents. The difficulty of making the inclosures precisely resemble the open sea in their pelagic fauna and flora (both of which are so closely related to the well-being of the fishes) is well known; indeed, no perfect substitute for the open sea can be found. Further experience, however, may enable us to overcome many of these difficulties.

III.—FURTHER REMARKS ON THE DEVELOPMENT AND LIFE-HISTORIES OF THE FOOD-FISHES AT THE ST. ANDREWS MARINE LABORATORY.

ON THE EGGS AND LARVÆ OF THE POOR COD (GADUS MINUTUS).

Raffaele* briefly alludes to the egg and larvæ of this species, which seems to be one of the most ubiquitous gadoids, ranging from the Mediterranean to the North Sea, remarking that the former (eggs) agree in general structure with those of the cod, but that the larvæ differ in the arrangement of the pigment. Marion † also found a large number of ova in the Gulf of Marseilles, on the 7th March, which he considered were those of the capelan (*Gadus minutus*), and he gives a figure of the larva. Lastly, Mr. Cunningham states that in April he found this species ripe at Plymouth, the diameter of the ova 1.02 mm., and the perivitelline space small. He did not hatch them.

For several years the spawning of this species has been under consideration, but a more or less complete account has only been obtained recently. In 1884 and 1885 many ripe females were seen, but no ripe male was available at the same time. By the skill and care of a fisherman at St. Andrews (James Gourlay) numerous fertilized ova were brought from the neighborhood of the Bell Rock in June last year (1892). The nearly ripe ovarian egg has, as usual, a denser capsule, which, moreover, is wrinkled. In diameter the ripe eggs ranged from ·9906 mm. to 1·0287 mm., sizes extending on both sides of the average given by Mr. Cunningham. And the series of ova procured in the open sea off Aberdeen were from ·9525 to ·9906 mm., and were thus somewhat less than the preceding. Only a very few reached 1·0287 mm.

The development was comparatively rapid, as might have been anticipated in the warm weather. Ripe ova fertilized at 9 a. m. on the 6th June were in the multicelled condition at 5.45 p. m., with a well-marked perivitelline space. The temperature at this period rapidly increased, so that considerable mortality ensued. Indeed, the mere handling of the water containing them under the miscroscope killed the embryos, which on the 7th were outlined and the optic vesicles indicated.

The eyes of the advanced embryos are silvery (one of the most characteristic features of the egg), and yellowish pigment is scattered over the head, body, and yolk. The young larva somewhat resembles the whiting in coloration and measures from 2·2 to 2·4 mm. The eyes are silvery greenish, and the entire head and body are dappled with minute yellow specks, invisible under a lens, but seen by transmitted light under a low power of the microscope. Black chromatophores occur along the ventral border of the muscle-plates, the tip of the tail alone being free. A less distinct series lies along the dorsal edge, and a few finely branched specks exist on the head. The rectum terminates blindly at the posterior and upper part of the yolk, which seems

* Mittheilungen Zool. Stat. Neap., VIII Bd., 1 Heft, sep. abth., p. 36, tav. I, f. 25, et tav. 2, pp. 20, 21, 1888.

† Ann. du Musée d'Hist. Nat. de Marseilles, Zoolog., IV, p. 188, pt. 2, fig. 14.

to be comparatively large. Thus in a specimen with the tail slightly shortened (by curvature) the total length was 2·4 mm., while the yolk-sac from its anterior to its posterior border was 1·2 mm.

Five days after hatching stellate black chromatophores appear on the yolk-sac and along the sides of the body, only terminating near the tip of the tail. The yellow chromatophores are also more evident on the yolk-sac. The otocyst shows a double border. The position of the rectum is almost unchanged. The yolk-sac soon diminishes and the growth of the branchial arches, gill-slits, pectorals, and other parts is apparent, while the mouth opens.

Two days later the yolk in some had quite disappeared, and the mouth is widely open, though the mandible is as a rule rigid. The pectorals are large fan-shaped blades and are carried upward. Even before the yolk has been absorbed the larvæ swim on edge, resting afterwards on the side. The eyes are silvery on the bottom by reflected light, but have a gorgeous bronzed hue by transmitted light. In the older examples the yellow pigment seems to be less conspicuous, for it is present only on the head and anterior region, with a few specks on the pectorals. The increase of the black pigment over the abdomen is noticeable. The circulation of the colorless blood is visible in the dorsal aorta and the cardinal veins. The swim-bladder is well marked. They constantly dart about with open mouth, seldom resting more than a second or two, so that delineation is difficult.

At a slightly later stage the yellowish pigment had disappeared except from the cheeks, and the pectorals had increased in size. The marginal fin became vesicular; indeed the specimens were comparatively delicate, often perishing if placed in water on a slide. A few survived till the 24th June without presenting any noteworthy change except the appearance of a dorsal and a ventral skeletal bar representing the shoulder girdle.

ON A PECULIAR EXAMPLE (HYBRID?) OF THE POOR COD (GADUS MINUTUS).

A fisherman procured by a hook on the 24th March a fish which he and others supposed to be a hybrid between the whiting and the bib, or between the former and the poor cod, and he sent it to the laboratory.

The extreme length of the specimen was 7½ inches, and the greatest depth 1½ inches. In general outline it somewhat approached the whiting, though the dusky bronzed pigment of the dorsum and dorso-lateral regions, the somewhat coarser scales, together with the shape of the head, the presence of a barbule, and the condition of the pelvic fins leaned to the poor cod. Yet it distinctly differed from the latter in general aspect, and in the much more silvery infero-lateral regions and abdomen.

In regard to the shape of the body and the course of the lateral line it most nearly approached the poor cod, though it was more elongated. Moreover, the curve of the lateral line kept at a nearly uniform height, or even with a tendency upward till beyond the tip of the pectoral, and the downward curve was decidedly more abrupt. It differed in this respect not only from the poor cod, but from the whiting and the bib. This curvature may be related to the marked depression in the dorsal outline from the posterior border of the first dorsal fin to the middle of the second, but it is not connected with any abnormality of the vertebral column.

The fins agreed more or less with those of the whiting, the first dorsal especially differing from that in the poor cod and bib, and corresponding rather with that

in the whiting, since it was much less acutely triangular and much less elongated. It possessed 14 rays (Day attributing 12 to 15 to the poor cod). The second dorsal corresponded generally with that in the last-mentioned species, and it had 22 rays (Day giving 19 to 25). The fin rays, however, were less uniform. The third dorsal had 25 rays (Day, 17 to 22) and resembled that in the poor cod. The first anal commenced in a line with the posterior border of the first dorsal, and extended slightly beyond the commencement of the third dorsal. The longer rays anteriorly, and its general shape, approached the condition in the poor cod. It had 27 rays (Day, 25 to 28). A vertical line from the posterior border of the first dorsal touched the commencement of this fin, whereas in the whiting a considerable portion of the first anal was in front of the line. The second anal had 26 rays (Day, 25 to 29).

The caudal had a somewhat larger "bite" in the middle than usual, and had 30 rays (Day, 26). The pectorals require no special remark, except that the black spot at the base was more pronounced than in the poor cod, but corresponded neither with the bib nor the whiting, being less distinct than in the former, and larger than in the latter. It proceeded nearly to the middle of the base, instead of being confined to the region above the base. There were 18 rays in the pectorals (Day, 13 to 16). The pelvic fins agreed with those in the poor cod, each having 6 rays.

When viewed from the dorsum the snout was considerably narrower than in a poor cod of the same length. In profile, also, the head was more elongate, the mandible especially differing, since it projected in front beyond the premaxillaries. The eyes were considerably smaller than in an average example of the poor cod, and the loose corneal covering was less developed. The barbel was comparatively small.

The specimen was a female, with the ovaries even more advanced than in an ordinary example of the species, and it would certainly have spawned this season. The ova ranged from ·3810 mm. to 1·1430 mm.

The teeth differed from those of the poor cod and the bib, being nearly uniform; that is, the larger teeth of the outer row, usually so characteristic, were not distinctly differentiated. They diverged still further from the teeth of the whiting. There were 37 gill-rakers in the outer gill, 24 in the next, 23 in third, and 18 in the inner, all thus diverging from the average condition in the poor cod.

On the whole the differences warrant notice, especially as these became even more marked after preservation in spirit. Instead of the pale-brownish and somewhat loose, wrinkled skin of the dorsum and lateral regions of an ordinary preparation of a poor cod, this presented slightly darker pigment on a smoother surface (smaller scales). The region below the lateral line was also much smoother, and, moreover, the firm surface had a sheen as silvery as in the whiting.

ON THE EGGS OF THE COALFISH (GADUS VIRENS).

Some remarks were made last year* on the unfertilized eggs of this species, and the continued exertions of Dr. Fulton and the staff of the Fishery Board have enabled me to add to our knowledge of this species. In a ripe female the ovaries are characterized by walls of considerable thickness, so that at first sight they resembled those of the wolf-fish, more especially as they were very distinctly connate. In section the ovarian wall appeared to have a well-marked circular coat, then a thick layer of longitudinal fibers, followed by a somewhat mixed inner series, chiefly circular, but

*Tenth Annual Report of the Fishery Board for Scotland, III, p. 287.

also containing numerous longitudinal fibers. The belly in this sex at maturity is prominent (a feature specially noted by Mr. Holt), as in the cod, pollack, and others.

On March 31 Mr. R. Duthie, assistant fishery officer at Lerwick, Shetland, skillfully fertilized a series of ova at 4 p. m. and transmitted them to St. Andrews. At 6 p. m. on April 3 all seemed to have perished, but a more careful survey of the demersals showed that there were some living eggs on the bottom. These had a diameter of 1·0287 mm., whereas others from the same fish, imperfectly preserved in weak picric and spirit, had a diameter of 1·1430 mm. The general appearance of the egg resembled that in the cod, and the micropyle agreed with that of the haddock. The blastopore was still open, and the optic vesicles had formed. The perivitelline space varied in size.

On April 4 the blastopore had closed (with radiate streaks) and Kupffers' vesicle had formed. The muscle plates were defined and the notochord more evident. The yolk presented a faintly granular aspect, perhaps from indications of the future pigment corpuscles. The pectoral folds are large and show many granules. The radiate strands of the latter region had become only distinct on April 6, and black chromatophores had appeared over the yolk, while indications of similar pigment were present along the body. The black chromatophores had generally increased on April 7, though there were variations in this respect. On the 8th the sides and yolk-sac of the embryo had a series of conspicuous black chromatophores, and the tip of the tail now reached the head. The arrangement of pigment thus prominently differs from that in the cod and foreshadows the more general distribution of the chromatophores so characteristic of the species in the young condition. One hatched on April 9, the color being similar to that described in the advanced embryo. All the eggs remained throughout on the bottom of the vessel, but retained vitality.

It is remarkable that so few opportunities of seeing the fertilized ova of this species have occurred, and yet it is a common form on the eastern and western coasts.

REMARKS ON THE EGGS AND YOUNG OF THE HALIBUT.

The ripe females of this species seem to have been met with chiefly toward the end of April and beginning of May. Those observed last year* were procured on the former date, those of this year on the latter, viz, on the 5th of May. It was thought last year, from the condition of the specimens, that the *zona radiata* of the eggs in this species was delicate; such, however, is not the case.

In size they are among the largest pelagic eggs known, ranging from 3·0861 to 3·8 mm. Raffaele, in the Bay of Naples, appears to have found none over 3 mm. in diameter, though Wenkebach subsequently procured one of 4 mm. The capsule (*zona radiata*) shows faint scribbled markings, as first mentioned by Mr. Holt, who obtained the eggs at Grimsby about the beginning of May last year. In those from Bergen Bank the markings resembled fine creases or folds, which sometimes even assume a stellate arrangement like those of the lemon dab or brill. The usual minute punctures occur all over the surface. The folded edge of the *zona radiata* is marked by closely arranged striæ, an appearance often seen in the shriveled eggs of other species. A simple micropylar orifice only occurred, without surrounding lines, and it generally presented a pinkish hue, probably from refraction, as in the large pores in the egg of the torsk. This form has been included under the pelagic eggs, both from its appear-

*Tenth Annual Report of the Fishery Board for Scotland, part III, p. 285.

ance and structure, but since it has never been obtained in a tow net in the neighboring seas it is possible it may be less buoyant than the smaller eggs.

The larval and post-larval stages of the halibut have hitherto escaped notice. A form procured by the *Garland*, on Smith Bank, in June, 1889, off the coast of Caithness, however, approaches what is conceived to be the type of this genus. It is distinguished by the great thickness of the body (the depth of which, moreover, is comparatively moderate), by the character of the head, and the presence of branchiæ projecting behind the opercula. It is not a very young fish, to judge from the thickness and firmness of the body and the condition of the branchiæ, yet the embryonic tail (opisthure) is still present. The total length is 9·5 mm., and the greatest depth is about 3·8 mm. The vent is situated a little in advance of the median line of the body, which is speckled with minute brownish-black points (in spirit) on the head and lateral regions, and by similar specks over the abdomen, the latter chromatophores, however, having undergone considerable change from the spreading out of the marginal pigment, while a black speck remains in the center. The chromatophores on the lateral region are somewhat regularly arranged. Indications of two pigment-touches occur in the dorsal (marginal) fin, viz, one above the tip of the pectoral, and the other about the center of the first abdominal region of the body. Ventrally a single patch is situated midway between the anus and the hypural region. The pigment invades the fin, and thus resembles that in the pleuronectids generally. On viewing the dorsum from above, the cephalic and the two marginal touches, which extend to the fin, are best seen. Ventrally a little pigment over the abdomen and the patch in the anal fin are noticeable, while chromatophores are dotted round the anus. The pigment is alike on both sides.

The eyes are of considerable size and are lateral in position. The marginal fin is injured, but seems to have been of moderate depth, traces of true rays appearing both dorsally and ventrally, and particularly in the caudal. The terminal curve of the notochord is pronounced, but does not taper much, and the embryonic fin forms a shorter lobe than in the pleuronectids hitherto examined. A few black specks occur inside the abdominal cavity.

The thickness and elongation of the body of this specimen suggest its relationship to the halibut, yet nothing in its structure would militate against its being another form. I am inclined, however, to connect it with the species mentioned.

Specimens of the young halibut are extremely rare, perhaps because they are found only in deep water on the great fishing-grounds. The smallest examples hitherto examined here were two from St. Andrews Bay, the larger being a foot long. They were obtained by a local trawler, but similar specimens are occasionally caught on lines. Last year a specimen, apparently of this species, was procured in the deeps about 50 miles from Norway on May 31, measuring 97 mm., or a little over 3¾ inches. It had been swallowed by a green cod. The fin formula is D. 97, A. 73 (?), caudal 19, pectoral 11, pelvic 6, though it must be stated that digestion had considerably affected the fins.

The chief differences between this and an example 1 foot long are the proportionally larger size of the eyes and their proximity to the anterior border of the snout—the smallness of the gape—the posterior angle of the mouth being somewhat in front of the eye; whereas in the larger (1 foot) it passes to the anterior fifth of the eye, and the maxilla is boldly marked. The arch of the lateral line behind the eye on the right side is much more pronounced in the larger specimen, for in the smaller it is gently curved upward and runs forward with a very slight declivity. On the left side the

arch is more distinctly curved. Variations, however, are frequent in the larger examples. The caudal rays proceed from a nearly vertical line in the smaller specimen, but from a semicircle (*i. e.*, a line convex backward) in the larger. The opercular region also differs, but the action of the gastric juice had made changes in the small specimen. The thickness and narrowness of the body are more or less diagnostic at this stage.

ON THE EGGS AND LARVÆ OF THE TORSK (BROSMIUS BROSME).

The literature on the spawning and development of the torsk is very meager. Thus, Couch says it comes from deep water near the coast at the time of spawning, which is in January and February. Parnell, again, states that it spawns in April and May amongst the seaweeds along the coast. Day, like Parnell, seems to have copied this remark without query. Brook, in the Report (1886) of the Fishery Board for Scotland gives, on the authority of the fishery officers, March at Wick, May and June at Peterhead, and the same two months at Berwick. Dr. Fulton, who examined two very fine specimens of 34 inches, and weighing, respectively, 15 pounds 5½ ounces and 15 pounds, calculated that the partially developed ova in the former were about 2,283,979 in number, whereas in the latter, which, he thinks, had discharged part of them, the ovaries contained 790,064. In the latter example, 40 or 50 in 3,612 ova which were counted were large clear eggs, having a diameter of 1·4 to 1·32 mm.

Little was known of the breeding of the species, though from its relationship with the ling and the rockling it was supposed to have an egg with an oil-globule. Various attempts had been made by the Fishery Board for Scotland and others to secure ripe examples, but without success. The energetic efforts of Dr. Fulton and the fishery officers (among whom must specially be mentioned Mr. Mackie, assistant officer at Peterhead, and Mr. Duthrie, assistant officer at Lerwick) at last solved the difficulty. Mr. Mackie procured ovarian eggs, the latter a fine series of fertilized ova. In the ovarian ova a number of unripe were mingled with others more or less ripe, the diameter of the latter in a fluid consisting of one-half saturated solution of picric acid and half spirit, ranging from 1·2573 to 1·3335 mm., the latter being approximately the average of ripe eggs after preservation. The ripe fertilized eggs, the securing of which under many difficulties reflected great credit on Mr. Duthrie, were got on the 25th of May. He had less trouble in obtaining females; it was the condition of the males which puzzled him; for the spermaries are small, reaching in the proportions only from 2 to 3 inches in a male of good size, and having the form of a small frilled cord or ribband. They thus differ materially from the condition in the cod and its allies.

The ova on their arrival from Shetland were almost dry, and their hardihood was, perhaps, partly due to the fact, so often seen in other forms, that they had reached a certain stage of development, viz, the fourth day. They had an average diameter of 1·3335 mm., so that the preserved examples from Peterhead must have been exceptionally fine or had been slightly dilated. The large oil-globule, which had a diameter of 0·2286 to 0·2667 mm. appeared, under the lens, of a pale reddish-brown hue, but by transmitted light of a pale red; indeed, no pelagic egg, with the exception of the sand-eel, has presented a more distinctive color. In some a series of minute fatty granules were also present under the large globules. The *zona radiata* is remarkably tough and resistant, and the egg can only be ruptured by the exercise of considerable force. A series of boldly marked punctures are present and they have in some views

a slightly pinkish hue from refraction, while under a high power they give the capsule a minutely punctured appearance. If a fragment of the *zona* be dried on a slide, each of the punctures enlarges and becomes the center of a curiously wrinkled margin with numerous processes, such as might have been due to protoplasmic environment. This appearance was, however, probably due to the wrinkles or folds of the dried *zona*. The latter in the fresh examples is further marked by faint lines or creases, which in some are crossed by another series of similar lines, so that it resembles the *zona* of the brill, lemon dab, and sail fluke. The micropyle is very evident and after the plan of that in the haddock; the external aperture, which is in the center of a depression, is smaller than the internal.

On the fourth day, when the eggs reached the laboratory, the blastopore was closing or closed, the optic vesicles formed, and a broad alar expansion was present on each side. The perivitelline space was small. Development proceeded normally, so that two days later a number of myotomes were formed laterally, besides lenses and otocysts, while slight contractions occurred in the heart. A considerable portion of the tail was free, and a few simple pigment-specks were scattered over it. The embryo jerks body and tail. Next day (May 28) black chromatophores were studded along the sides of the body and the head, and some on the latter and in the proximity of the pectorals were slightly stellate. Each otocyst had two otoliths. The pectorals projected outward as rounded lobes. The tail was much elongated and had a group of black chromatophores at the tip. The perivitelline space was larger. All the ova lie on the bottom of the vessel.

Before hatching, a greenish yellow hue (by transmitted light) appeared on the head and the tip of the tail. Some emerged on May 30 before noon (ninth day after fertilization). The larva measures about 4 mm. and is characterized by the large pinkish-brown oil-globule, which is generally fixed at the posterior border of the yolk. In some, however, the oil-globule was freely movable, a feature which had not hitherto been observed in such larval forms. By depressing the tail of the larva the oil-globule glides forward to the middle of the yolk, and by elevating the head it mounts to the highest point, viz, the anterior border of the yolk. Nothing could better illustrate the features formerly pointed out in regard to the movement of the oil-globule in the gurnard,* and the passage of the brightly colored globule through its yolk (and not merely at the surface of the yolk as some thought) was in this instance easily followed.

The free condition of the oil globule of the larval torsk in these instances was probably abnormal, but it is worthy of note. Five conspicuous black touches or bars further distinguish the larva, viz, one on the head and four on the body. The chromatophores on the head are somewhat irregularly scattered, though a front view of the head in the egg shows that a more or less symmetrical series occur over each eye. The first patch or bar on the trunk is placed rather behind the middle of the yolk, though a little variation exists, and it is rendered the more conspicuous as the black pigment of the subnotochordal region exists beneath. The chromatophores in this and the other areas are very finely ramose. The next patch or bar lies on the muscle-plates behind the yolk; the last is at the tip of the tail, while a less definite one is intermediate. As already mentioned in connection with the embryo, the larvæ have a slightly yellowish hue (greenish by transmitted light) on the head, yolk-sac, and the tip of the tail. The rectum is high up on the marginal fin, with the lumen just

*Trans. R. Soc. Edin., vol. 35, p. 687.

within the tip. The urinary vesicle is distinct. The notochord is multicolumnar. The surface of the yolk-sac, the pectorals, and the marginal fin are minutely vesicular. A little black pigment appears in the eye. The healthy larvæ are active.

Next day (May 31) the chief feature was the increase in the greenish-yellow hue on the under surface of the head, on the yolk sac, and the tip of the tail, this hue being due to the development of the cutaneous vesicles formerly mentioned, and it makes a bold contrast with the pinkish oil-globule. The ramifications of the black chromatophores have everywhere increased, those at the tip of the tail having a radiate arrangement like fin-rays. The liver appears on the ventral border of the gut, while the rectum has moved downward a little and often contains a round mass. The pectorals and otocysts are larger. In one a peculiar abnormity occurred, viz, the presence of a long narrow process—resembling a diverticulum—in the rectum, which in this instance had reached the somewhat defective border of the fin.

The changes which were visible on June 1 consisted of the projection of the cartilages of the mandible, increase of pigment in the eyes, and the passage of the rectum, with the urinary vesicle near the fin-margin. The little fishes are restless, and the use of the pectorals in balancing is more evident. The yolk has considerably diminished. Next day the eyes showed a greenish silvery luster, and peristaltic movements occurred in the gut. Moreover, though the mouth is still closed, spasmodic movements of the mandibular region take place. As in the cod, rockling, and other forms, the black chromatophores, when seen against a dark background under a lens, look brownish.

June 3 the larvæ were characterized by their activity, and especially by the rapid vibration of the pectorals. Only a small anterior portion of the yolk now remained, while the reddish-brown oil-globule has been drawn forward and almost concealed under the greatly increased black pigment of the upper region of the abdomen.

About a week after hatching (June 6) the larvæ swam more readily, and the mouth had opened—the mandible being moved up and down with the hyoidean apparatus. The yolk was almost absorbed, only a trace of the oil-globule being visible. The rectum had not yet reached the border of the marginal fin, but it was close to it and its margin was papillose. Little change had taken place in the pigment of the body, but the caudal patch had spread out in a characteristically fan-shaped manner (coincident with the development of embryonic rays in the tail) and the yellowish tint of the marginal fin in the same region had somewhat increased. The caudal region of the marginal fin seemed to have diminished. They are hardy larvæ, and could without much difficulty be reared in large numbers in a suitable inclosure.

ON THE DEVELOPMENT OF THE SAIL-FLUKE (ARNOGLOSSUS MEGASTOMA).

The earlier ichthyologists do not appear to have seen a ripe sail-fluke or "megrim," as it is often termed by the Scottish fishermen. No information on the subject is given by Parnell and Couch. Day observed that "Thompson, on October 31, at Belfast, procured one which had just shed its ova, only a few mature ones remaining." Raffaele* pointed out that the ova of *Arnoglossus* have a single oil-globule, and his figure on the whole resembles the present species, except that he does not show the minute structure of the *zona radiata*. His figure of the larval *Arnoglossus* (tav. 4, fig. 20), however,

* Le nova galleggianti, etc., Mit. a. d. Zool. Ital. zu Neap., III Bd., 1 Heft, 1888, sep. abd., p. 49.

differs materially from that of *A. megastoma*, both in structure and coloration; and it is unknown whether the careful Italian author refers to *A. laterna* or another form. He represents the post-larval *Arnoglossus*, again, with a long ray like a flagellum anteriorly.

Mr. Holt*, who found ripe forms of both series in March, April, and May, states that the eggs are very translucent, have a diameter of 1·08 to 1·13, and possess a single oil-globule, ·30 mm. in diameter. He thinks, from his observations off the west coast of Ireland, that spawning takes place only in moderately deep water, and necessarily therefore at some distance from shore, always at a great distance from the coast when the declivity is very gradual. On the eastern shores of Scotland the species is an inhabitant of the deeper water.

Three series of ova reached the laboratory in May, 1892, but it will be sufficient to allude only to the last, which were at an early stage of development on the 28th of May at 11 a. m. They had a diameter of 1·1430 mm., while the oil-globule measured ·3048 mm. All the living eggs were remarkably buoyant and had a perivitelline space. The *zona radiata* conforms to the type seen in the brill and lemon-dab, being covered with raised lines or ridges with very fine striæ between them. The usual minute punctures densely cover the surface. The micropyle is difficult to distinguish, but it appears to be sometimes situated in the center of a radial series of lines in a space bounded by other ridges. It is best seen by setting several eggs together in a cell, so that they support each other and give special positions unattainable when each is free.

On the 29th May (next day) the rim had either reached the equator or extended beyond it, and a dimple was often present on each side (in optical section) where the rim constricted the yolk. The following day (30th May) the embryo was fully half round the yolk and the perivitelline space had increased. The lenses are now present, and black chromatophores appear under the oil-globule and in the caudal region.

Further changes before hatching were the increase in the perivitelline space from the diminution of the yolk, the ramifications of the chromatophores under the oil-globule and on the tail. Black pigment also appeared along the sides of the embryo. Larvæ were hatched on the 1st June, perhaps prematurely. They possess only black pigment, which is somewhat uniformly scattered over the body with a few specks on the head, and it also occurs both dorsally and ventrally in the marginal fin. Thus five or six V-shaped chromatophores are found near the margin of the dorsal fin behind the yolk-sac—almost intermediate between it and the tip of the tail, and two similar or somewhat triangular ones opposite the former ventrally. The large oil-globule lies at the posterior and inferior part of the yolk. The otocysts are simple sacs. No pigment exists in the eyes. The notochord is multicolumnar. The solid strand of the rectum comes to the edge of the marginal fin, and a pre-anal portion of this fin is present. The urinary vesicle shows only a small central chamber. The oil-globule in lateral views is somewhat elliptical.

Two days afterward (June 3) yellow pigment was apparent amongst the black in the marginal fin, and along the sides of the body posteriorly. The yolk-sac, as a rule, has no chromatophores, one or two only occasionally being situated at the upper part of the region. The enlargement of the otocysts, liver, and other organs is considerable, and the skin is minutely vesicular. In larvæ which only escaped at this date (June 3) the yellow pigment was not noticeable on the caudal region.

* Report of Council, Roy. Dub. Soc., 1891, p. 238.

The mouth seemed to open comparatively early, since it formed a conspicuous aperture on June 6. It differs considerably from that of the gadoids, as the mandibular cartilages are much less developed, yet it is proportionally large and the movements extensive. The pericardial chamber was very large in the eyes on the 7th. The large pectorals are used for balancing. Black pigment was developed. The skin is minutely vesicular, and the canary-yellow pigment is conspicuous in the posterior part of the body.

REMARKS ON THE DEVELOPMENT OF THE BRILL.

Some remarks were formerly made* about the development of the ova of the brill fertilized with the milt of a turbot. A further series fertilized with a male of the same species was obtained on May 22, 1892. They had a diameter of 1·3335 mm., the oil-globule measuring ·2286 mm. The latter behaved as in the gurnard, rolling under the periblast and beneath the disk, and passing through the yolk when suddenly inverted. Without going into minute details it may be stated that on the 27th the embryo had lenses and otocysts, the tail projected from the yolk, while a yellowish hue pervaded the head, body, and yolk-sac from the development of numerous chromatophores. So numerous are these over the yolk-sac that it seems to be densely speckled all over with minute yellow grains. Black chromatophores are likewise present on this as well as on the body. The remarkable development of the deep brownish-yellow pigment is one of the characteristic features of the species, and the fact was elicited that the milt of the male turbot did not seem to have made any striking variation in hue, so far as could be observed in the embryo and larva.

LIST OF PAPERS.

The following list of papers published in connection with the St. Andrews Marine Laboratory might properly include the work on the Invertebrate Marine Fauna and Fishes of St. Andrews† and numerous papers published since 1861:

List of published papers dealing with work done at St. Andrews Marine Laboratory from the opening of the Laboratory in 1884 up to and including 1892.

1. Report I to the Fishery Board for Scotland, 1884.
2. Report on Trawling at the request of Lord Dalhousie, chairman of the Trawling Commission, 1884–85.
3. Report II to the Fishery Board for Scotland, 1885. (1 plate.)
4. Report III to the Fishery Board for Scotland up to 31st December, 1885.
5. Report IV to the Fishery Board for Scotland (year 1886), 1887. The foregoing by Prof. McIntosh.
6. On the Occurrence of *Lumpenus lampetriformis* off the east coast of Scotland; by Francis Day. Proceedings Zoölogical Society, 1884, p. 445. (1 plate.)
7. Notes from the St. Andrews Marine Laboratory, I. *a.* On the British species of *Cyanea*. *b.* On the Reproduction of *Mytilus edulis*. Prof. McIntosh, Ann. Nat. Hist., Feb., 1885.
8. Notes from the same, II. On the Spawning of certain Marine Fishes (Herring, Viviparous Blenny, Catfish, Short-spined *Cottus*, Armed Bullhead, Bimaculated Sucker, and Montagu's Sucker); On Pelagic Ova, the Young of the Ling and the Eel. (1 plate.)—Ibid, Ann. Nat. Hist., June, 1885.
9. Lecture on the Ova of Fishes.—Ibid, Nature, April, 1885.
10. The Phosphorescence of Marine Animals, the Presidential Address to the Biological Section of the British Association, Sept., 1885. Ibid.
11. Notes from the St. Andrews Laboratory, III. *a.* On the ova of *Callionymus lyra*. *b.* On a new British *Staurocephalus*. *c.* On certain Processes formed by *Cerapus* on *Tubularia indivisa*. *d.* On certain Peculiar Ova from the Forth. *e.* On a Female Porpoise. (1 plate.) Prof. McIntosh.
12. Note on the Chemical Composition of the Milk of the Porpoise. Prof. Purdie, Ann. Nat. Hist., December, 1885, and Chemical News.
13. On the Development of the Food-Fishes at the St. Andrews Marine Laboratory. E. E. Prince, Rep. Brit. Assoc., 1885, p. 1091.

*Ninth An. Rept. Fishery Board for Scotland, III, p. 317. †A. & C. Black, 1875.

14. On the Nest and Development of *Gastrosteus spinachia* at the St. Andrews Marine Laboratory. E. E. Prince, Rep. Brit. Assoc., 1885, 1093; printed in full with 1 plate, Ann. Nat. Hist., Dec., 1885.
14*a* and 15. On the Reproduction of the Common Mussel. John Wilson, Rep. Brit. Assoc., 1885, p. 1094, and Report Fishery Board for Scotland, 1886.
16. On *Golfingia M'Intoshii*, a new *Sipunculus* from the Neighborhood of St. Andrews. Prof. Ray-Lankester, M. A., LL. D., F. R. S., etc., Trans. Lin. Soc., vol. II, part 16. (2 plates.)
17. Notes from the St. Andrews Laboratory, IV. On the Structure of the Tunny. (1 plate.) Prof. McIntosh, Ann. Nat. Hist., April, 1886.
18. On the British Weevers, the Bib, and the Poor Cod. Ibid, Ann. Nat. Hist., May, 1886.
19. Early Stages in the Development of the Food-Fishes. E. E. Prince, Ann. Nat. Hist., May, 1886.
20. Further Remarks on the Tunny. Prof. McIntosh, Ann. Nat. Hist., June, 1886.
21. Remarks on the Eggs of Marine Fishes. Ibid, Nature, 1886.
22. On the Presence of Oleaginous Spheres in the Yolk of Teleostean Ova. E. E. Prince, Ann. Nat. Hist., Aug., 1886.
23. Points in the Development of the Pectoral Fin and Girdle in Teleosteans. E. E. Prince, Rep. Brit. Assoc., 1866, p. 697.
24. Some Remarks on the Egg Membranes of Osseous Fishes. Dr. R. Scharff, Ibid, p. 698.
25. Note on a Peculiar Medusa (*Thaumantias*) from St. Andrews Bay. Prof. McIntosh, Ibid, p. 710.
26. On the structure of the Tail in *Myxine*. Prof. Cleland, M.D., LL.D., F.R.S., Report Fishery Board, 1886, p. 211.
27. Report of the Committee for the Purpose of Continuing the Researches on Food-Fishes and Invertebrates at the St. Andrews Marine Laboratory. Report Brit. Assoc., 1886.
28. Notes from the St. Andrews Marine Laboratory, V. On the Paternal Instincts of *Cyclopterus lumpus*, etc. Prof. McIntosh, Ann. Nat. Hist., Aug., 1886.
29. Notes from the St. Andrews Marine Laboratory, VI. On the very Young Cod and other Food-Fishes. Prof. McIntosh, Ann. Nat. History, Oct., 1886.
30. On some experiments in Preserving Mussels for Bait. Report Fishery Board for 1886 (published 1887).
31. On the Intra-ovarian Eggs of Osseous Fishes. Dr. R. Scharff, Proceed. Roy. Soc., 1887, and Quart. Jour. Micros. Sci., Aug., 1887. (1 plate, 4to.)
32. On the Pelagic Fauna of our Shores in its Relation to the Nourishment of the young Food-Fishes. Prof. McIntosh, Ann. Nat. Hist., Feb., 1887.
33. Notes from the St. Andrews Marine Laboratory, VII. *a*. On the Occurrence of Peculiar Gelatinous Bodies in Profusion. *b*. On *Syncoryne decipiens* Dujardin. *c*. On the Commensalistic Habits of the Larval Forms of *Peachia*. *d*. On the Presence of Swarms of Appendicularians. *e*. On the Occurrence of *Clione borealis*, Pall. Ibid, Ann. Nat. Hist., Aug., 1887.
34. Notes from the St. Andrews Marine Laboratory, VIII. *a*. On a Post-larval *Labrus*, with Remarks on the Color of Pelvic Fins. *b*. On the Post-larval Condition of *Liparis*. *c*. On a Peculiar Teleostean Yolk-sac. *d*. General Remarks on Post-larval Food-fishes. Ibid, Ann. Nat. Hist., Oct., 1887.
35. On some Rare and Remarkable Forms at St. Andrews Marine Laboratory. Prof. McIntosh, Meeting Brit. Assoc., 1887.
36. On the Development of the Ovary and Oviduct in Certain Osseous Fishes. E. E. Prince, Ibid, 1887.
37. On the so-called Luminous Organs of *Maurolicus pennantii*. E. E. Prince, Rep. Brit. Assoc., 1887, p. 769.
38. On the Ova of *Tomopteris onisciformis*, Esch. E. E. Prince, Rep. Brit. Assoc., 1887, p. 769.
39. On the Ciliated Organs of *Tomopteris*. E. E. Prince, Ibid, p. 769.
40. The Emigration of Amœboid Corpuscles in the Starfish. Herbert E. Durham, B. A., lately Vintnor Exhibitioner, King's College, Cambridge, Proceed. Roy. Soc., vol. 43, p. 327 (1 plate).
41. Note on the Madreporite of *Cribrella oculata*. Ibid, Proceed. Roy. Soc., vol. 43, p. 330.
42. On the Reproduction and Development of the Common Mussel. (3 4to. plates). John Wilson, B.SC., Demonstrator of Zoölogy, St. Andrews University, V, Report Fishery Board for Scotland, p. 247, 1887.
43. The Significance of the Yolk in the Eggs of Osseous Fishes. E. E. Prince, Ann. Nat. Hist., July, 1887. (1 plate.)

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44. Further Remarks on the Development and Life-History of the Food-fishes. Sixth Annual Report. W. C. M.
45. On Annelids and other Forms used as Bait. Sixth Annual Report.
46. Pelagic and other Fauna of St. Andrews Bay. Sixth Annual Report.
47. Report of the Committee for the purpose of continuing the Researches on Food-Fishes at the St. Andrews Marine Laboratory. Report British Association, 1888.
48. Note on the Bib and the Poor Cod. Ann. Nat. Hist., Oct., 1888.
49. Notes from the St. Andrews Marine Laboratory, No. IX. W. C. M.
    1. On *Lesueuria*, a Ctenophore new to Britain.
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    3. On a Post-larval Pleuronectid (Sole).
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50 On the Embryology of the Retina of the Teleosteans. Dr. Marcus Gunn. Ann. Nat. Hist., Sept., 1888.

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51. The Life-History of a Marine Food Fish Illustrated. Lecture to the Royal Institution of Great Britain, Feb., 1889. W. C. M.
52. The Pelagic Fauna of St. Andrews Bay during the months of 1888. (4 plates.) Seventh Annual Report of the Fishery Board, 1889. W. C. M.
53. On the Life-History of the Herring. Ernest W. L. Holt, Ann. Nat. Hist., 1889.

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    1. On Abnormal Hydromedusæ.
    2. On the occurrence of the Ctenophores throughout the year.
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55. Notes from the St. Andrews Marine Laboratory, No. xi. Ann. Nat. Hist., April, 1890. Ibid.
    1. On the occurrence of the *Hydromedusæ* and *Scyphomedusæ* throughout the year.
    2. On *Arachnactis*.
56. On the Pelagic Fauna of St. Andrews Bay during the months of 1888. No. ii. Eighth Annual Report, 1890. Ibid.
57. Report on the Pelagic Ova and Young Food Fishes collected by the *Garland*. Ibid, 1890.
58. Notes from the St. Andrews Marine Laboratory, No. xii. Ann. Nat. Hist., Aug., 1890. Ibid.
    1. Preliminary Note on the occurrence of the Pelagic Annelids and Chætognaths in St. Andrews Bay throughout the year. Ibid.
    2. On the British species of *Spinther*.
    3. On the Young Stages of the Gunnel.
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60. On the Ova of *Gobius*, with plate. E. W. L. Holt, Ann. Nat. Hist., 1890.
61. On the Larvæ of *Zoarces viviparus*. E. W. L. Holt. Ibid, 1890.
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65. Further Observations on the Life-Histories and Development of the Food and other Fishes. (Plates x–xiii.) Ninth Annual Report Fishery Board for Scotland. W. C. M.
66. Further Note on the *Medusæ* of St. Andrews Bay (Aug., 1890–May, 1891). Rev. J. H. Crawford, F. L. S.
67. On the Occurrence of *Halistemma* in British Waters (St. Andrews Bay). Rev. A. D. Sloan, M. A., B. SC., Ann. Nat. Hist.
68. Some Features in the Eggs and Larva of the Skulpin. Prof. Prince, Ninth Annual Report Fishery Board for Scotland.
69. Further Observation on the *Hydromedusæ* of St. Andrews Bay. Rev. J. H. Crawford, Ann. Nat. Hist.

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70. Additional Observations on the Development and Life-Histories of the Marine Food-Fishes and the Distribution of their Ova. Proc. Roy. Soc. Edin., Feb., 1892.
71. Contributions to the Life-Histories and Development of the Food and other Fishes. (Plates xiv–xvii.) Tenth Annual Report, 1892, Scotch Fishery Board. W. C. M.
72. Notes from the St. Andrews Marine Laboratory, No. xiii. Ann. Nat. Hist., July 1892. Ibid
    1. On the Eggs and Young Stages of the Sand Eels.
    2. On the Ova and Larvæ of certain Pleuronectids.
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73. A Brief Sketch of the Scottish Fisheries, chiefly in their Scientific Aspects, during the past decade, 1882–1892. Nov., 1892. Ibid.
74. On the Preservation of Teleostean Ova. W. E. Collinge, St. Andrews Marine Laboratory, Ann. Nat. Hist., Sept., 1892.