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REPORT ON THE REPRODUCTIVE ORGANS OF *SPARUS CENTRODONTUS*, Delaroche; *SPARUS CANTHARUS*, L.; *SEBASTES MARINUS* (L.); AND *SEBASTES DACTYLOPTERUS* (Delaroche); AND ON THE RIPE EGGS AND LARVÆ OF *SPARUS CENTRODONTUS* (?), AND *SEBASTES MARINUS*

(WITH 5 PLATES).

BY

H. C. WILLIAMSON, M.A., D.Sc., F.R.S.E.

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ON THE REPRODUCTIVE ORGANS OF *SPARUS CENTRODONTUS*, Delaroche; *SPARUS CANTHARUS*, L.; *SEBASTES MARINUS* (L.); AND *SEBASTES DACTYLOPTERUS* (Delaroche); AND ON THE RIPE EGGS AND LARVÆ OF *SPARUS CENTRODONTUS* (?), AND *SEBASTES MARINUS*.

BY

H. CHAS. WILLIAMSON, M.A., D.Sc., F.R.S.E.,
MARINE LABORATORY, ABERDEEN.

(*Plates I.–V.*)

Sparus centrodontus, Delaroche.

This species, Cuvier and Valenciennes* state, was named by Delaroche *Sparus centrodontus*. According to the French authors, there is doubt as to the identity of the fish named *Sparus orphus*, L. Day† gives the name *Sparus orphus*, Lacép, as a synonym of *Sparus centrodontus*, Delaroche. Cuvier and Valenciennes proposed to change the name to *Pagellus centrodontus*. But there is, in my opinion, no necessity for removing this species and *Sparus cantharus*, L., from the genus Sparus.

This species is landed at Aberdeen by trawlers during the greater part of the year. In September, 1910, it was being captured in especially large quantities.

It is known as the Jerusalem Haddock, Bream, Silver Haddie (Loch Fyne).

A description of this fish is given below.

Specimens‡ have been examined during each month of the year for the purpose of studying the development of the reproductive organs. In no instance was the ovary ripe. It seems probable that when spawning these fishes may retire to places where they are not taken by the trawl.

The Reproductive Organs.

This species is hermaphrodite. A pair of testes and a pair of ovaries are present in each fish, but the testis and ovary are not always functioning simultaneously. The testis and ovary are intimately combined on each side of the fish.

* Cuvier et Valenciennes—"Histoire Naturelle des Poissons." T. vi. Paris, 1829.

† Day—"The Fishes of Great Britain and Ireland." 2 vols. London, 1880-1884.

‡ Mr. Eunson, fish merchant, Aberdeen, has very kindly given me most of the examples of this and the other species dealt with in this paper.

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While in some fishes both the testis and the ovary may be found developing, in others only the testis or the ovary is developing. In the latter case the portion of the organ belonging to the other sex may be so small that it may escape notice ; but, so far as my experience goes, it is present. All are *potential hermaphrodites*, but only a proportion are *functional hermaphrodites*.

The fishes have been arranged in the table in the following classes :—(1) predominant males, (2) predominant females, and (3) sexes equal. The predominant male or female indicates that the testis or the ovary is large, while the organ of the opposite sex is very small. The number examined during each month, with their range of length, is given. The length of the fish is the distance from the anterior tip of the snout to the extremity of the longer tail ramus.

The range in size of the ova found in the fishes is entered in the last column.

A number of the fishes were spents.

The fishes entered opposite each month do not all belong to the same year. The observations were carried on over a period of three and a half years.

Month.	Predominating Male.		Predominating Female.		Sexes Equal.		Spents.				*Range of Size of the Ovarian Ova. Diameter in *mm.*
							Predominating Male.		Predominating Female.		
	Number.	Range, *cm.*	Number.	Range, *cm.*	Number.	Range, *cm.*	Number.	Range, *cm.*	Number.	Range, *cm.*	
Jan. -	27	31–37	33	32–42	7	32–34	..	..	..	..	·07, ·15, ·25, ·35.
Feb. -	3	34–43	1	35	5	32–34	1 (?)	37	..	..	·35, ·37.
March -	1	37	2	33, 35	2	Small.	..	..	..	..	——
April -	..	..	1	38	..	..	..	..	..	..	·45.
May -	9	34–47	14	33–48	1	33	..	..	..	..	·25–·4.
June -	6	32–36	9	34–45	1	36	..	..	1	38	·17.
July -	9	34–43	32	32–48	6	35–39	3	34–39	3	39–45	·15, ·27.
Aug. -	8	34 43	31	34–49	2	33, 37	..	..	..	..	——
Sept. -	36	34–50	44	33–49	7	31–40	5	37–46	4	39–46	·17, ·2.
Oct. -	10	32–44	26	34–49	1	34	..	..	1	39	——
Nov. -	8	34–46	26	32–47	1	34	..	..	..	..	·06, ·17, ·2, ·35.
Dec. -	2	34, 35	10	33–43	5	35–37	..	..	..	..	·12 ·22, ·25, ·3.

*The sizes given include all the samples from all the groups that were measured during the month. Sample eggs from every ovary were not measured. But the ovaries were examined for any indication of ripening ; it is not therefore likely that in any of the fishes there were eggs of greater diameter than ·45 mm.

Out of 404 fishes, 38, measuring from 31 to 40 cm., had the sexes equal, while 128 predominant males measured from 31 to 50 cm., and 238 predominant females measured from 32 to 49 cm. It may be noted that the fishes having the sexes equal did not appear among the specially large individuals.

A number of reproductive organs were obtained from a collection of fishes captured off the west coast of Orkney in January.

The hermaphrodite condition is indicated when a testis and an ovary are combined in one organ. They may be of equal size, as, for example, in Fig. 21, or the testis or the ovary may be much the larger, as, for example, in Figs. 3a and 19 respectively. In the latter division the very small sexual organ seems to be quite normal, and is, I consider, functional. These are the conditions where the sexual organs are not specially large, *i.e.*, in small bream (*e.g.*, Figs. 3a, 9, 19, 38, which are of natural size). But when one sex predominates in the reproductive organ of a big Centrodontus, the other sexual organ is so much reduced as hardly to be recognised; it seems, indeed, to be exhausted. This condition is seen in Fig. 40 (natural size), where, while the ovary is large, the testis is reduced to a thread. In the previous case the fishes were, I think, preparing to spawn for the first time. In the latter case the ovary had been ripe before.

The conclusion, then, is that the organ when it first ripens is hermaphrodite; at the next spawning it may be unisexual. I do not know whether the hermaphrodite condition may persist in the second spawning. It seems not improbable that where in the hermaphrodite condition one sex specially predominates, that will be the sole functioning sex at the next spawning.

Organs in which two sexes were equally represented are given in Figs. 17 and 21. The testis was white, ripe. It was possible to make out the heads of the sperms, but not their tails. The ovary had an amber tinge. In one specimen, Fig. 21, the eggs measured up to ·1mm. in diameter, while in the other they reached a diameter of ·15mm. A section of the latter reproductive organ is given in Fig. 18.

Where the male predominated the testes were nearly all large and white. In one case the testis was ripe. It was pasty in consistency; the heads of the sperms, but not their tails, were made out. The ovary was very small and colourless; it was enclosed in a deep groove in the edge of the testis. The ovary was 4mm. broad, and it was sunk flush, almost out of sight. In Fig. 3a the groove has been opened out to expose the ovary (*ov.*). It is quite a normal immature ovary, with ridges filled with minute eggs, measuring about ·05mm. in diameter. In another fish the ovary was only partly sunk in the groove (Fig. 9). The eggs measured from ·05mm.–·07mm. in diameter. They were colourless, non-yolked, and clear. These ova have a distinct round nucleus.

Sometimes the ova ·05mm. in diameter, although translucent, are not perfectly clear, as the substance of the egg is granular; they have an exhausted appearance.

The dorsal mesentery (*dm.*, Fig. 38), which supports the organ to the roof of the abdominal cavity, runs along the ovary. The testis forms the free ventral border of the united organ. Sometimes the side of the ovary is attached to the testis; in other cases the attachment is very slight (*e.g.*, Fig. 25).

A section across a predominating male organ, at a quarter of its length from its posterior extremity, is shown in Fig. 8. The ovary is a sac, on the inside wall of which are arranged ridges filled with ova. The ridges run longitudinally. In some cases, *e.g.*, in a fish 43·5cm. long, the egg-ridges rose little, if any, above the surface of the ovary. The eggs were clear and nucleated, the largest measuring ·06mm. in diameter. Part of the inside wall of the ovary is without ova, *i.e.*, the oviducal part.

The ovary and the testis do not communicate. Between the two there is a layer of lacunar, or spongy honeycomb tissue, which extends into the wall of the ovary (*sp.*, Fig. 8). This lacunar tissue acts as the *vas deferens.*

The testis is of an honeycomb structure. A surface view of a portion of the ripe testis is shown in Fig. 16. It is seen from the outside. The spaces are occupied with sperms. The internal structure of a whitish developing testis consists essentially of tubules (*cf.*, Fig. 11).

This drawing represents a transverse section of a portion of a testis. The tubules, which are arranged in a columnar form, are in some cases branched, and they appear to connect directly with the series of ducts occupying the core of the lobe. Each tubule is enclosed at the surface of the testis in a loculus formed by partitions arising from the outside wall (*sk.*, Fig. 10). The skin of the testis when torn tends to split longitudinally.

Some testes were mottled. The yellow mottling is seen in the core of the testis (*mt.*, Fig. 24). May this mottling indicate that the fish has spawned before?

The egg-ridges vanish in the posterior part of the ovary, which becomes the plain-walled oviduct (Fig. 39). This figure represents a view of the two organs in a predominating female. The ovaries are large, and the testes (*T*) are very small. On the side of the ovary next the wall of the abdomen there is a digitiform region of the wall of the ovary without egg-ridges. It is the oviduct (*ovd.*).

The testes do not unite.

The general arrangement of the organs in the abdomen of a predominating male is shown in Fig. 6. The external aperture of the *vas deferens* is omitted.

A series of transverse sections, not drawn to scale, illustrate the arrangement of the parts. Fig. 24 is a section of a functional male organ near its anterior end. The ovary has only a small attachment to the testis. A section made near the junction of the ovaries exhibits a similar condition (Fig. 25). Large lacunæ are visible in the wall of the ovary. Egg-ridges are present, but not on the portion of the wall next the lacunæ. In a section further posteriorly, but where the ovaries are still separate (Fig. 26), the lacunar tissue in the wall of the ovary is very extensive. Ova are present on part of the wall of the ovary. The testis had already ended at this point. A small lobe was, however, found in a section of the single oviduct (Fig. 27) posterior to the union of the ovaries. The junction of the ovaries is shown in Fig. 28. In the section of the oviduct (Fig. 27), the lacunar tissue in its wall represents the two *vasa deferentia*, which it was not possible to separate. The lacunar tissue is apparently present throughout all the wall of the oviduct. Further posteriorly the lacunar tissue is very much increased (Fig. 32). It is present in the whole of the wall of the oviduct, the mesentery forming a break or division. The lacunar tissue was broader on one side than on the other, but that may be simply due to unequal contraction. The strands which form the network of the lacunar cavities appear to be muscular. A surface view of the inside of the last portion of the oviduct is shown in Fig. 35. The duct has been slit open along its dorsal (*i.e.*, posterior) side. The lacunar tissue can be seen in parts through the lining skin of the oviduct. It has a different appearance in different parts.

Near the end of the oviduct the lacunar tissue (*la.*) forms very large cavities (Fig. 33) on the dorsal side, and in a section made close to the external aperture, *i.e.*, next the ventral wall of the abdomen, spaces are seen to have grown into a definite tube on the dorsal edge, the *vas deferens* (VD., Fig. 34). The posterior mesentery cuts the lacunar tissue into two.

The further relationship of the parts is shown in a longitudinal section through the cloacal region (Fig. 31). It is shown upside down. The lacunar tissue on the posterior side is seen to open out into a wide *vas deferens*, which finds exit on the top of the urogenital papilla. The opening of the *vas deferens* is immediately in front of that of the urethra (*urth.*), the two apertures being separated by a thin, soft septum. On the anterior side the outer and inner skins of the oviduct wall join together to close the lacunar space, which communicates round the neck of the oviduct.

On the end of the urethra there is a bulbous gland-like swelling. When the papilla (*pap.*, Fig. 29) is examined from the outside, the single crater in its tip is seen to be divided by a transverse septum. The papilla is not large; it is larger in the male than in the female; sometimes it is inconspicuous. It is well supplied with blood, and is formed of very fine spongy tissue. The sides of the crater are sometimes soft and gauzy; this condition makes it difficult to separate the two small apertures.

The oviduct (*ovd.*, Figs. 29, 31) opens in front of the *vas deferens*, between it and the anus. The aperture appears to be partly closed sometimes by the cohesion of its soft lips. The urogenital papilla and the anal and oviduct apertures are sunk in the cloacal slit. The slit is longitudinal and it closes neatly.

When the female sex predominated the ovary was large, and pink in colour. The testis was small, in some cases so reduced as to be hardly visible. The ova, when ·3mm in diameter, were just visible to the naked eye. When magnified they were opaque, and were enclosed in a swollen follicle (Fig. 20). Some eggs from another ovary measuring ·3mm in diameter were not quite opaque. The nucleus (germinal vesicle) was visible, and it was pigmented. Eggs which are storing up yolk have orange-coloured pigment in them. The pigment is located in the nucleus as a rim of oily opaque corpuscles (*pi.*, Fig. 44). The size of the germinal vesicle varies (*cp.* Fig. 51). It is possible that it has the power of expanding and contracting. The clear eggs measured ·15mm. in diameter. A few specks of red colouring matter were made out in some clear eggs of that size.

The general arrangement of the organs in the abdominal cavity is shown in Fig. 2. The ovary was large and orange-coloured. The testis (*T*) was rendered visible by some brown mottling along its extent. The colouring matter is in little traces as well as in comparatively big patches.

A fine yellow mottling is to be seen scattered through some of the ovaries. The ovarian ridges on the oviduct region of the ovary are covered with a delicate cuticle, which can be easily dissected off in a piece.

The mesentery (*dm.*, Fig. 40) attaches the ovary to the swim-bladder. The principal blood-vessel is situated on the side facing the other ovary.

The ovaries unite posteriorly, and end shortly thereafter. The longitudinal egg-ridges, seen in section, tend to radiate from the large blood-vessels. On the ridges are developed blunt villiform processes full of ova. A developing ovary, which had been a spent, is shown in Fig. 40. The testis, which is a very narrow fold, is in some parts flush with the skin of the ovary. It could be traced right up to the anterior end of the organ. The oviduct region (*ovd.*) is well marked. In some cases, however, the testis began some distance short of the anterior end of the ovary (*cp.* Fig. 22).

The testis is sometimes hardly visible; that appears to be the case especially in ovaries that have been ripe before. The testis in Figs.

19 and 38, although small, is functional and readily seen, while in Fig. 40 the testis is so much reduced as to be probably non-functional, and might be easily passed over. In the last ovary old egg-capsules were present, the remains of a previous spawning. The two classes of reproductive organs differ also in the amount of empty space in the early developing ovary (*cp.* Figs. 42 and 45).

Three sections were made across the organ shown in Fig. 40, viz., at the points A, B, and C. The point A is near the anterior extremity: the section is given in Fig. 45. The testis is visible as a little projecting fold: the oviduct is absent. No part of the wall of the ovary is free from eggs, but the ridges are narrow on the dorsal and ventral sides. In a section at B, viz., across the beginning of the oviduct, Fig. 46, the oviducal part is very narrow internally; there is little, if any, clear space. The testis is flush with the outer skin. The ovary has a big lumen. In the posterior part of the ovary at C, the oviduct is broader; the testis is a little fold (Fig. 47). Near the union of the ovaries, viz., at D, the outside breadth of the oviduct is not equalled by plain surface on the inside. The plain surface of the oviduct inside an ovary is shown in Fig. 23. It exhibits a quantity of minute white granules, which are thickly arranged about the middle and gradually get fewer towards the egg-ridges at the sides. Minute muscle-fibres are visible in the wall.

In the small ovary, Fig. 38, which is probably ripening for the first time, the oviduct can be traced further anteriorly than in Fig. 40 (*cp.* the cross sections, Figs. 42 and 43).

A section across the union of the ovaries of another fish shows the posterior end of the septum (Fig. 49). In this case the testes were dorso-lateral in position, while in another example they were ventro-laterally placed. At a short distance posterior to the above point, Fig. 50, the wall of the oviduct was spongy, thick, extensile, all round except at the ventral region. The testis was present on one side only.

The oviduct is wider than in the male. On the last part of the oviduct I observed two lacunar areas, one bigger than the other, with intervening plain areas, which exhibited straight longitudinal fibres.

The external opening of the oviduct is large; the lips are sometimes broad and leaf-like.

The urogenital papilla in the female is small. The opening on its tip is crater-like, and on first examination it appears to be a single aperture. But if a section be made across the papilla the two ducts are found. The urethra has a thick wall, and its lumen diminishes somewhat near the aperture. The *vas deferens* is a slit which is closed (Fig. 41). The two ducts meet just at the aperture. The papilla is formed of spongy material.

It is an interesting problem whether a fish which becomes unisexual will remain always of that sex. It seems probable that it will do so, for in several developing predominant females I have found the old capsules of ripe eggs which had been retained in the spent ovary. (*Vide* also p. 10.)

Notes on the Reproductive Organs.

The stage of development of the ovary in the fishes examined in each month is indicated by the size of the eggs entered in the last column of the table on page 4.

In January, February, March and May some of the testes were ripe.

In June, July, and August, while there were small ovaries and testes, some spent ovaries were found.

In September the fishes presented large and small testes, developing ovaries, and spent ovaries and testes.

In October the testes and ovaries were small and developing; one ovary was spent.

In November fairly large testes and ovary were found. The fishes had much abdominal fat.

In December a small testis was growing white; an ovary was developing. A considerable quantity of abdominal fat was present.

The Ripe Eggs.

No ripe ovary was obtained, but in several fishes the old capsules of ripe eggs were still present. The eggs were crushed and dried. Only a little white amorphous matter remained inside. An opaque circular mass, sometimes stained yellow, could be detected in the amorphous material. The yellowish mass measured about ·27 and ·3 mm. in diameter. In two cases when the egg was dissected a little white coherent irregular body, measuring about ·2 mm. in diameter, was found. This, I think, may be the remains of an oil globule. In September a quantity of unspawned crushed ova remained in an ovary. A bright golden oil globule was present in the egg. In one it measured ·25 mm. in diameter.

The crushed capsules were oval and the eggs had evidently been oval. Several of these capsules were measured; the sizes were as follows:—1·35 × ·8, 1·2 × ·75, 1·2 × ·75, 1·2 × ·75, 1·1 × ·9, 1·0 × ·85, 1·0 × ·7 mm.

Undescribed Pelagic Fish Egg.

An egg which appeared in the surface tow-net collections made in 1903 by the Fishery Board, in connection with the International Investigation of the North Sea, was remarkable in that it was oval in shape and had an oil globule (Fig. 13).

The eggs were measured after preservation in formaline solution. The oil globule varied from ·17 to ·12 mm. in diameter. The following are the sizes of the eggs in which the oil globule measured ·17, ·15, ·12 mm. respectively:—Oil globule ·17 mm.—eggs, 1·4 × 1·12, 1·37 × 1·1, 1·32 × 1·17, 1·3 × 1·05 mm. Oil globule ·15 mm.—eggs, 1·37 × 1·1, 1·35 × 1·2, 1·35 × 1·07, 1·35 × 1·05, 1·32 × 1·1, 1·32 × 1·07, 1·32 × 1·05, 1·3 × 1·07, 1·27 × 1·1, 1·25 × 1·1. 1·25 × 1·07 mm. Oil globule ·12 mm.—egg, 1·35 × 1·1 mm.

I consider that this egg is that of *Sparus centrodontus*. It was captured in May at points about 40 miles east and 15 to 20 miles west of Shetland respectively. The embryos were all early, except one which extended for about two-thirds round the yolk. One egg was obtained in June, about 20 miles west of Shetland. The embryo was in the disc stage. In August a large number, 84 in all, was obtained off Kinnaird Head, Moray Firth. The exact position was—Troup Head, S.W. by W.; Kinnaird Head, S.E. ¾ S. The eggs were all recently spawned, the embryo being in the disc stage. A very deep hole (100 fms.) occurs in this vicinity, about six miles off-shore.

During the same month one egg was got between Orkney and Shetland, viz., ten miles E. of Fair Isle. The embryo was about three-quarters developed. Thirty-eight eggs were captured 40 miles E. of Shetland in this month. The embryos were about ready to hatch (Fig. 5). The embryo dissected out of one of the eggs is shown enlarged in Fig. 12.

Abnormal Reproductive Organs.

A fish measuring 47 cm. in length had a normal reproductive organ on the left side (*l.*) and an abnormal organ on the right side (Fig. 1). The latter contained several dark-coloured concretions (*c.*), while a small concretion (c'''') was attached to the testis of the left organ. The concretions are collections of unspawned eggs. The concretion c'' is hard and dark-coloured. It is situated in the ovary. It cuts like a hard cheese, and shows in section a conglomerate of eggs. The eggs in the lighter-coloured balls, *c.* and c', appear to be formed of the eggs of a later spawning than c''.

The quashed eggs measured 1·5 mm. in greatest length. The capsules were flattened and the yolk had disappeared from many altogether, although still present in some. The old eggs had a single oil globule ·22 mm. in diameter.

The honeycomb structure of the testis was well seen in the right organ. Clean oval holes were observed in the septa of the honeycomb tissue.

The left ovary was developing, while the other remained in a state of quiescence. The presence of the ball of unspawned eggs had evidently inhibited the development of a new crop of ova. Will the formation of the new ova be prevented if the ovary is in a state of compression?

In another fish the anterior portion of the ovary was detached from the remainder (Fig. 19). No testis was observed attached to the isolated portion.

A Fish with a Second Anus.

A fish which measured 42 cm. in length had a second anus. The gut was attached to the wall of the abdomen, which was perforated by a pore that opened into the gut (Fig. 3).

The usual condition of the gut is as follows:—After leaving the stomach the gut (*d*) passes back to the end of the abdominal cavity; it then turns round and comes forward to the anterior end of the cavity. It then returns posteriorly and proceeds directly to the anus. The three portions of the gut are looped together by mesentery. The middle portion of the gut is the part which was connected to the second anus (*an*). An enlarged drawing, Fig. 7, shows the gut and the part of the abdominal wall (*w*). A fat-fold is attached to the mesentery. Two encysted parasites (*c*) were located in the mesentery. The continuation of the gut through the body wall is shown in Fig. 15. The antero-posterior direction is indicated by the letters *a–p*. The secondary anus was 2 mm. long. Two little processes were present on one side (Fig. 14).

It seemed as if very little matter could have found exit by this aperture.

Description of *Sparus centrodontus*, Delaroche.

This fish is coloured a bright red or pink. Over the abdomen there is a golden red sheen. Small specimens show little red on the body; they are more silvery. The snout, cheeks, and sides are silvery with a golden tinge. A prominent black patch is present on the shoulder, on the beginning of the lateral line. The lateral line is prominent. The dorsum has a metallic appearance. The top of the head is pinkish. The inside of the mouth, and the inside surface of the gill-cover, are pink and orange-red respectively.

The *scales* are ctenoid (Fig. 60); they are large and hard. The general arrangement of the scales is indicated in the drawing Fig. 4; the scales themselves are represented diagrammatically. The scales are arranged in parallel rows. This gives rise to the longitudinal rows (or lineation) which are made out on the side of the fish. The large semi-circular scale situated immediately over the opercular cleft is noteworthy. Alongside the base of the ventral fin one or two scales are elongated into a sharp triangular form, which resembles a short spine. The scales are, however, thin and flexible. On the ventral surface the scales between the ventral fins are extended posteriorly in a triangular projection.

All the *fins* are red. The exact number of fin-rays is not entered in the drawing. The number of fin-rays in the dorsal and anal fins is shown in the following table:—

Length of Fish. *cm.*	Dorsal.		Anal.	
	Spines.	Soft Rays.	Spines.	Soft Rays.
36	(25	Fin-rays).	3	13
37	12	13	3	13
37	13	12	3	13
38	12	13	3	13
42	12	12	3	13
42	12	13	3	13
45	12	13	3	13
46	12	13	3	13

The dorsal fin is composed of spines and soft rays. Of the former there are usually 12, and of the latter 13. The first of the soft rays ends in a single tip as a rule; in one fish the tip was split. The remaining soft rays are split. The dorsal fin stands in a groove in the dorsal edge of the body. The front half of the fin, consisting of the spinous rays, can be laid down into the groove. The last two rays are close together at their bases. The first two spines and the last two rays arise from a single interspinous line in each case. The lip of the hind portion of the groove is formed by large thin scales which rise up from the dorsal edge on each side of the fin. The scales are continued upon the bases of the last two rays as a process similar to that shown for *Cantharus* in Fig. 113.

The anal fin, like the dorsal, stands in a groove, the lip of which is formed posteriorly of scales which are continued in a process upon the proximal part of the last two rays. The first three rays are spines. The last two rays are close together at their bases. The first two spines and the last two rays arise from a single interspinous bone in each case. The angle between the last ray of the dorsal and anal fins respectively and the edge of the body is not filled up with a membrane.

The pectoral fin has 16 rays.

The ventral fin has 6 rays; the first of these is a spine. Only a very small portion of the angle between the last ray and the ventral surface of the body is filled up with a membrane.

The anus and the apertures of the genital organs and urethra are in a slit-like depression on the ventral edge—the cloacal slit. It is indicated at *a*.

The teeth in a *centrodontus* 40 cm. in length were small. They were of two distinct kinds. On the premaxillæ there were at the symphysis about four rows of small curved sharp teeth. Posteriorly there were three rows; of these three the outer row were tusk-like, while the inside row consisted of rounded-topped molar-like teeth. In the lower jaw (Fig. 37) two rows of teeth were made out in the dentary at the symphysis; the outer row of curved teeth, the inner row of teeth with blunted tips. All the teeth were small, but the outer row contained the largest. Posteriorly the inner row showed the rounded molar-like teeth.

The upper lip is papillated; the papillæ dip in between the teeth of the outer row. The papillation occurs in the lower jaw only to a slight extent.

Inside both upper and lower jaws there is a pouch formed by a horizontal membrane joining the premaxillæ and dentaries respectively.

A longitudinal strip of red muscle is present on the side just beneath the skin.

The peritoneum is black.

The urinary bladder is in a little chamber cut off from the end of the abdominal cavity by a septum of peritoneum crossing the cavity between the oviduct and the urinary bladder. The chamber is lined with peritoneum. The urinary bladder is wide; it is sometimes covered with a layer of fat. A mass of fat is sometimes found in the posterior end of the abdominal cavity. The ureter (*ur*, Fig. 6) comes down medianly in front of the first hæmal spine, and crosses over the left side of the swim-bladder to join the urinary bladder.

The swim-bladder is large. A thick yellow matter was found in the hind end of the swim-bladder of a fish 46 cm. long in November. Posteriorly the swim-bladder is firmly attached to the first hæmal spine. The first hæmal spine ends the abdominal cavity and also the swim-bladder. The first and second hæmal spines touch one another. The interspinous bones are long (*int.*, Fig. 2).

The number of vertebræ in one specimen was 23. The first hæmal arch was on the tenth vertebra.

Sparus cantharus, L.—The Black Bream.

This species is landed by trawlers at Aberdeen from time to time. One example examined in November in the fresh condition measured

40·5 cm. in length. It was a silvery fish, with a slight bluish tinge on the dorsum. The cheeks were silvery. The top of the head was of a purplish colour. The inside of the mouth and the inside surface of the gill-cover were white.

The lateral line is prominent (Fig. 30). The scales, which are ctenoid, are large, and are arranged in parallel rows. A series of longitudinal rows is prominent. A golden sheen is observed in the rows sometimes. The large semi-circular scale situated immediately over the opercular cleft is noteworthy.

The mouth is small, with prominent lips; it resembles the mouth of *Labrus*. The teeth are comparatively large. They cover a broad area in the jaws (Fig. 36). There are at least six rows of teeth in the front of the lower jaw. The outside row of teeth are the largest. They are sharp-pointed. The teeth gradually decrease in size towards the inside of the jaw. No round-topped molar tooth was made out. There is in both jaws a pouch formed by a horizontal membrane joined to the premaxillæ and dentaries respectively.

A strip of red muscle is present along the middle of the side.

The peritoneum is white.

The urinary bladder is large. Its attachment in the hind end of the abdominal cavity is median, but it extends forward on the right side of the body in the form of a broad lobe. It reaches to the rectum. It is very vascular.

No urogenital papilla was observed. The apertures of the urethra and *vas deferens* were sunk in three cases examined.

All the fins are dusky in colour. The fins are composed of spines and soft rays.

The dorsal fin is dark, but the web between the rays was blotched with pink. There were 11 spines and 13 soft rays in this fin in three cases, 10 spines and 14 soft rays in one case, and 11 spines and 12 soft rays in another case. The first of the soft rays had a very fine stiff but flexible point. The last two fin-rays arise close together. This fin stands in a groove. The first half of the fin can be laid down and almost hidden in the groove. The hind part of the groove has thin, soft edges formed of scales, and these run up on to the last rays, in a free process (Fig. 113). A similar arrangement is present in connection with the anal fin, but here there are two processes on each side, one a little anterior to the other. The anal fin had 3 spines and 11 soft rays in five cases. The first two spines arise from the first interspinous bone. The last two rays arise close together from a single interspinous bone. This fin had its base, both fin-rays and web, whitish; its distal half is blackish. In one fish the fin was bluish. The anal fin, all but its last three rays, stands in a groove. When the dorsal and anal fins are distended the spinous and soft-rayed portions of the fins are not marked off from one another. The fin has the appearance of a single fin, not of two fins joined together.

The pectoral fin is almost colourless. It had 16 rays, and reached to the level of the anus in one fish.

The ventral fin is dusky; the rays were bluish in one. It had six rays. The first ray is a spine. Alongside the base of this fin an elongated but thin scale is present. At the ventral surface between the ventral fins the scales project in a triangular process. In a fish 42 cm. long the dorsal ramus of the tail was the longer.

The number of vertebræ in three cases was 24. The first hæmal spine was on the eleventh vertebra.

The otolith is convex on one side and concave on the other. Views of both sides and also an edge view of the otolith are given in Figs. 52, 53, and 54.

Comparison between Centrodontus and Cantharus.

The two species may be confounded. They resemble one another in the general shape of the body. If the upper jaws of *Cantharus* be retracted and the mouth shut, a specimen of this species might be taken for a pale-coloured example of *Sparus centrodontus.* Sometimes the smaller *Centrodontus* (*e.g.*, 20 cm. long) show little red colour, and they may be mistaken for *Cantharus*, *i.e.*, when the colour is taken as a guide.

The longitudinal rows are rather more marked in *Cantharus.* The eyes of that species are smaller than those of *Centrodontus.*

Cantharus has a smaller mouth, and more and larger teeth, than *Centrodontus.* They both have a prominent dorsal ridge in front of the dorsal fin : that of *Cantharus* is the more acute. They differ in the shape of the head, seen in profile. *Centrodontus* has a more rounded and fuller snout, but the difference is not always easily gauged.

Cantharus has less body thickness, from side to side, than *Centrodontus.*

The two species differ in the colour of the inside of the mouth, gill-cover, and peritoneum ; *vide* pp. 11 and 13.

The Reproductive Organ of Sparus cantharus.

The reproductive organ resembles that of *centrodontus* : it is hermaphrodite. In a fish 40·5 cm. long, a predominant female, the ovary was orange-coloured. A little testis was present along the lower border of the ovary. The ovarian folds filled up the ovary (Fig. 48). These folds are composed of digitiform processes filled with eggs. The organ does not appear to have been ripe before. The yolked eggs measured ·35 mm. in diameter. Most of the eggs were small and clear. There was a slight pink sheen in the yolked eggs when they were examined with the microscope. The egg filled the follicle almost completely. There were little masses of opaque yellow pigment throughout the ovary.

A fish 42 cm. long was a predominant male. The testis was small and mottled. It had, I think, been spent. The ovary was a wide sac. Some small eggs were seen in the wall of the ovary. The lacunar tissue in the wall of the ovary was very open. The external aperture of the oviduct was closed. The urethra and *vas deferens* opened by the same external pore. In a second predominant male, 39 cm. long, the ovary was a wide sac, and a quantity of yellow glandular-like bodies projected from the internal surface. In the anterior region they were located all round the ovary, but in the remainder of the organ they were restricted in distribution; in the posterior part they were merely dorsal in position. They were arranged in a manner generally resembling the distribution of the egg-ridges. Small eggs are associated with these yellow bodies. They are evidently the yellow glands that are seen in the developing ovary.

The January fish 42 cm. long had yolked eggs ·37 mm. in diameter.

Sebastes marinus (L.).

According to Cuvier and Valenciennes,* Linnæus included this fish, and *Perca scriba*, L., under the name *Perca marina*, L. Müller named it *Perca norvegica*. The two French authors said that "its form is nearly that of the Perch or of the large Serranus;" and further, "it is not a Perch, but a Sebastes similar to the form described by Delaroche under the name *Scorpæna dactyloptera*." Cuvier and Valenciennes gave it the name *Sebastes norvegicus*. Smitt, in "Scandinavian Fishes," uses the name *Sebastes marinus* (L.).

This fish is undoubtedly a Perca. It resembles *Perca fluviatilis* very much in general shape, colouration, and external characters. The chief difference lies in the dorsal fin, which is here a single long fin having two distinct parts. In *Perca fluviatilis* these two parts are separate fins. The exclusion of *Sebastes marinus* from the genus Perca does not appear to me to have been justified. The question is, however, complicated by the other members of the genus Sebastes, and especially by *Sebastes dactylopterus*, which is described in another part of this paper.

This fish, which is known as the Norway Haddock, or Runkie, is landed regularly by trawlers at Aberdeen. Large quantities are brought from Iceland, but some are also got in the North Sea.

Among the adult specimens examined there was a great difference in size, so much so that there appeared the possibility that two species were included under the same name. A comparison which was instituted between the two lots of fish revealed no structural difference of importance. This question is referred to below.

The general external appearance of the fish is shown in Fig. 56. The exact number of fin-rays has not been introduced into each fin.

The fish is red or pink coloured externally. It exhibits a large black blotch on the operculum, and a small blotch on the lower angles of the operculum and sub-operculum. Dark-red or brown bars cross the dorsum and extend down on to the side to a greater or less extent. The bars are five in number. The first is over the opercular region, the second and third are under the spinous portion of the dorsal fin. The fourth is under the soft-rayed portion of the dorsal fin. The fifth is on the root of the tail. In the small specimens the bars extended down to and past the lateral line; they were of irregular shape, broadened out in one part and narrowing at another. The fins are of a brilliant red; the lower half of the pectoral fin and the ventral and anal fins are especially so. The inside of the mouth and pharynx is white or pink-coloured. The red colour gradually fades away after preservation. The black blotch on the operculum is sometimes absent in some of the large fishes landed (*e.g.*, 38 cm. in length), and the bars can hardly be traced in some examples; these fishes had probably been iced. The inside surface of the operculum has a small amount of black pigment. The teeth in the jaws are numerous and small. Teeth are also present on

* "Histoire Naturelle des Poissons,' T. IV. Paris, 1829.

the vomer and the palatine ridges. Horizontal membranes join inside the mouth, the premaxillæ, and the dentaries respectively. The number of fin-rays in the several fins is given below. The hind edge of the tail fin is slightly concave. The dorsal and ventral edges of the base of this fin form somewhat sharp ridges.

The lateral line is slightly bent.

The head is adorned externally by a number of teeth. In two fishes, 48 and 49 cm. long, the teeth on the top of the head were arranged as follows:—One tooth projected over the orbit. A ridge over the top of the orbit ended posteriorly in a little tooth. Two isolated teeth were found further back on nearly the same line. On the head still further behind a prominent plain ridge runs backwards and outwards on each side: it may end in a little tooth. Between the ridges the top of the head is flat or very slightly hollowed. The interorbital space is flat or slightly depressed. The teeth on the side of the opercular bones, and at the beginning of the lateral line, are indicated in the figure.

A marked feature in the appearance of the fish is the hump immediately in front of the beginning of the dorsal fin. The lower jaw is prominent.

The eye is large: the cornea is loose. The cornea is a translucent portion of the skin of the head. The orbit is round.

The scales are ctenoid (Fig. 61). No attempt was made to introduce the exact number or size of scales into the drawing (Fig. 56), but their general distribution is indicated. The outside of the lower jaw is covered with scales. They are well seen in large specimens, *e.g.*, 48 and 49 cm. in length. In small examples, *e.g.*, 20 cm. long, they were detected on the posterior half of the jaw only.

The peritoneum is black. The swim-bladder is large. The ureter is median.

The pyloric cæca were 8 or 9 in number in both large and small fishes (three specimens of each).

The first hæmal spine is forked at its extremity (Fig. 97). The angle varies in depth. The point of the first interspinous bone of the anal fin enters and is bound to the fork of the first hæmal spine. The interspinous bone forms the hind border of the adominal cavity.

A comparison was instituted between 54 fishes measuring from 17·4 to 24 cm., and 4 Iceland fishes measuring 39 and 42 cm. in length. The small fishes were, with two exceptions, pregnant females. They showed the dark bars more prominently. The characters selected for comparison were (*a*) the horizontal diameter of the orbit, (*b*) the distance from the tip of the mandible—when the mouth was closed—of the following points, viz., the beginning of the pectoral, ventral, dorsal and tail fins, the anterior edge of the orbit and opercular cleft. The numbers of fin-rays and vertebræ were also a basis for comparison. The fish was laid on a centimeter scale, and the distances were marked off on the scale by means of a needle. The distances are taken along the longitudinal axis of the fish. Agreement was found in respect to the measurement characters between the two lots of fishes except in three characters, viz.:—The orbit in the smaller fishes was the larger. It measured in horizontal diameter 9·2 to 11·3 per cent. of the length of the fish. The length of the fish in this case is the distance from the tip of the mandible, when the mouth is closed, to the end of the middle rays of the tail fin.

In the Iceland fish the orbit was 7·6 to 8·5 per cent. of the length of the fish. Then the distance from the tip of the mandible to the anterior edge of the orbit was 5·7 to 7·3 per cent. of the length in the small fishes, while in the large specimens it was from 8 to 8·7 per cent. of the corresponding distance. The ventral ramus of the tail of the Iceland specimens was a little longer than that of the small fishes. I do not think that these differences are of specific value.

The details of the measurements expressed in percentages of the length of the fish are given in the following table. Certain measurements were made on the Iceland fishes alone. They are included here, as they may be useful for comparison with other specimens:—

[TABLE.

Species.	District.	Date.	Length. (cm.)	Maturity.	Horizontal Diameter of Orbit. No. of Variants.	Horizontal Diameter of Orbit. Range.	Length of Fins. Pectoral. Variants.	Length of Fins. Pectoral. Range.	Length of Fins. Ventral. Variants.	Length of Fins. Ventral. Range.	Distance from the Tip of Mandible. Anterior Edge of Orbit. Variants.	Distance from the Tip of Mandible. Anterior Edge of Orbit. Range.	Distance from the Tip of Mandible. Opercular Cleft. Variants.	Distance from the Tip of Mandible. Opercular Cleft. Range.
Sebastes marinus .	Iceland .	Jan., 1908	37 to 41	Mature	4	7·6–8·5	4	21·5 22·3	4	16·7–17·2	4	8–8·7	3	25·4–26·4
,, ,, .	North Sea	June, 1910	17·4 ,, 24	*—	54	9·2 11·3	–	—	–	-	54	5·7–7·3	53	23–26·4
,, *dactylopterus*	,,	Jan., Feb.	36·4 ,, 44·5	—	9	9·4 11	10	20·3–24	8	16·4–18·9	10	5·7–6·6	10	23·3–25·5

Species.	District.	Distance from Tip of Mandible. Base of Pectoral Fin. Variants.	Base of Pectoral Fin. Range.	Base of Ventral Fin. Variants.	Base of Ventral Fin. Range.	Anus. Variants.	Anus. Range.	Dorsal Fin. Beginning. Variants.	Dorsal Fin. Beginning. Range.	Dorsal Fin. End. Variants.	Dorsal Fin. End. Range.
Sebastes marinus . . .	Iceland — *continued* . . .	4	28–29·5	4	30–31·6	4	52·8- 57	4	27·3 29·5	3	74·8–76
,, ,, . . .	North Sea ,, . . .	54	25·4–29·5	54	27·8–33	34	51·3–57·5	54	25·2–29·8	54	73–76·7
,, *dactylopterus* .	,, ,, . . .	10	29·1–30·9	10	32·1–33·8	10	50·5–53·6	10	24·6–26·9	10	72·5- 74·8

Species.	District.	Distance from Tip of Mandible. Anal Fin: End. Variants.	Anal Fin: End. Range.	Tail Fin. Base, Dorsal. Variants.	Tail Fin. Base, Dorsal. Range.	Tail Fin. Base, Ventral. Variants.	Tail Fin. Base, Ventral. Range.	Tail Fin. Tip of Dorsal Ramus. Variants.	Tail Fin. Tip of Dorsal Ramus. Range.	Tail Fin. Tip of Ventral Ramus. Variants.	Tail Fin. Tip of Ventral Ramus. Range.
Sebastes marinus . . .	Iceland — *continued* . . .	4	70·2–73	–	—	4	81·3–82·6	–	—	4	102·9-104
,, ,, . . .	North Sea ,, . . .	53	69·5–74·2	36	81·8–86·5	–	--	52	99·5–102·6	49	101-102·6
,, *dactylopterus* . .	,, ,, . . .	10	66–69·6	–	--	10	77·9–80·9	10	99·6–102·5	5	100·5-101·5

* All were pregnant females except two specimens, 17·6 and 19·3 cm. respectively, which were males having small testes; the two males may have been spents.

The details of the numbers of fin-rays and vertebræ for the fishes, small and large, in which the characters were noted are given in the next table.

ENUMERATION CHARACTERS.—Numbers of Fin-Rays and Vertebræ. All the fishes 17·7–24·4 cm. in length, except those marked thus (†), were female, and mature.

Length.*	Dorsal Fin.		Anal Fin.		Pectoral Fin.		Vertebræ
cm.	Spine Rays.	Soft Rays.	Spine Rays.	Soft Rays.	Thin Rays.	Thick Rays.	
17·7	15	15	3	8	8	10	30
†17·9	15	15	3	8	9	9	31
18	15	15	3	8	9	9	. .
18	15	14	3	7	9	9	30
18	15	15	3	8	9	8	30
18	15	14	3	7	9	9	30
18	15	15	3	8	9	9	. .
18	15	14	3	8	9	9	. .
18	15	15	3	8	8	10	. .
19	15	15	3	7	9	9	. .
19	15	14	3	8	8	10	. .
19	15	14	3	8	8	9	. .
19	15	13	3	7	9	8	. .
19	15	15	3	8	9	9	. .
19	15	15	3	8	9	9	30
19	15	15	3	8	9	9	30
19	15	14	3	7	8	9	30
19	15	14	3	8	9	9	30
19	15	15	3	8	9	9	. .
19	15	14	3	7	9	9	. .
19	15	14	3	8	9	9	30
‡19	15	14	3	7	8	9	30
19	15	15	3	8	9	8	. .
19	15	15	3	8	9	9	.
†19	15	14	3	8	9	9	30
19	15	15	3	8	9	8	30
19	15	15	3	8	10	9	. .
19	15	14	3	7	9	9	30
20	15	14	3	7	10	8	30
20	15	15	3	8	9	9	30
20	15	14	3	8	9	9	30
20	15	13	3	7	9	8	. .
20	15	15	3	8	9	9	30
20	15	14	3	8	9	9	31
20	15	14	3	8	9	9	30
20	15	15	3	8	9	9	30
20	15	15	3	8	8	10	30
20	15	15	3	8	9	9	. .
20	15	15	3	9	9	9	31

* The length is the distance from the tip of mandible, when the mouth is closed, to the end of the longest ray of the tail fin. † Male fish. ‡ Sex not noted.

Enumeration Characters—*continued.*

Length.* cm.	Dorsal Fin.		Anal Fin.		Pectoral Fin.		Vertebræ
	Spine Rays.	Soft Rays.	Spine Rays.	Soft Rays.	Thin Rays.	Thick Rays.	
20	15	14	3	8	9	8	..
20	15	14	3	7	8	10	..
20	15	15	3	8	9	9	..
21	15	15	3	8	9	9	..
21	15	15	3	8	9	9	..
21	15	15	3	8	8	10	30
21	15	15	3	8	8	10	30
21	15	14	3	7	9	9	30
21	15	15	3	8	9	9	30
21	15	15	3	8	10	8	30
21	15	15	3	7	9	9	..
21	15	15	3	8	8	10	30
22	15	15	3	7	9	9	30
22	15	15	3	8	9	9	30
23	14	14	3	8	9	8	30
24·4	15	17	3	8	9	9	30
†36	15	14	3	9	10	8	..
37	15	14	3	9	9	9	..
†38	15	17	3	9	10	9	31
‡39	15	15	3	8	..	..	31
‡39	15	15	3	8	..	..	31
‡39	15	14	3	8	..	..	31
‡42	15	15	3	8	..	..	31
§39	15	16	3	9	..	..	31
§40	15	17	3	10	..	..	31
§42	15	16	3	9	..	..	31
§43	15	15	3	9	..	..	31
§50	15	15	3	9	..	..	31

* The length is the distance from the tip of mandible, when the mouth is closed, to the end of the longest ray of the tail fin.

† Locality unknown. ‡ Iceland fishes. § Probably from Iceland.

Two kinds of fin-rays, viz., spine-rays and soft rays, are present in the dorsal, anal, and ventral fins.

The dorsal fin had from 28 to 32 rays. Of these, 15 were usually spines, the remainder soft rays. The spines occupy the larger part of the fin. The spinous portion of the fin is of a different breadth from the soft-rayed portion. The spine-ray has membrane attached right to the tip on its posterior edge. The bases of the two last soft rays are close together and attached to a single interspinous bone (Fig. 96a). The first two rays (spines) arise from a single interspinous bone also.

The anal fin had 10 to 13 rays, of which three were spines. The last two soft rays are close together and attached to a single interspinous bone (Fig. 96). The first two spines arise from the first interspinous bone.

The angle between the last ray of the dorsal and anal fins and the edge of the body is usually filled with a membrane (*mb.*, Fig. 98). This membrane varies in its size, and is more usually noticeable in the larger fishes. In the small fishes it is very slight.

The pectoral fin had 17 to 19 rays. The upper half of the fin is composed of rays which have thin tips; the lower half of the fin is composed of swollen rays, the tips of which are usually single and slightly separated from one another. The last ray is sometimes thin, and in one specimen it was branched. Most of the rays of the upper half of the fin have two points. In one fish, of the 9 thin rays the 4th to 9th had split tips.

The ventral fin consists of one spine-ray and five soft rays. The spine-ray is tightly bound to the first soft ray. A membrane fills the angle between the last soft ray and the surface of the abdomen.

The vertebræ numbered 30 and 31. Among the small fishes the most frequent number of vertebræ was 30. In 15 fishes, measuring from 38 to 50 cm. in length, the number was 31.

The vertebra bearing the first hæmal spine was in 9 fishes (19 to 21 cm. long) the 12th (total number, 30), while in the 15 larger fishes it was the 13th.

Differences have been noted between large fishes. Some fishes are not so deep nor so thick as others. Certain of these lighter fishes which were landed in December and January probably came from Icelandic waters. Six of them, measuring from 39 to 50 cm. in total length were compared with a North Sea specimen (May) measuring 37 cm. in length. The Iceland fishes were of a bright red; the dark bars were hardly to be detected at all. The North Sea fish had a larger eye, broader dorsal and anal fins, with, in each case, larger and stouter spines, a deeper and thicker body, than the other group. The latter had a bigger tail fin, and the hind margin of that fin was rather more deeply concave than in the North Sea fish. These characters were measured (in *cm.*) on the North Sea specimen and on an Iceland fish, and the results are shown in the following table:—

Length of Fish. *cm.*	Horizontal Diameter of Orbit.	Dorsal Fin.		Anal Fin.		Tail Fin.		Pectoral Fin Length.
		Height.	Largest Spine.	Height.	Largest Spine.	Least Spread.	Ventral Ramus.	
37 N. Sea	3·1	3·1	4·2	3·3	3·3	4·6	6·9	8·6
39 Iceland	2·8	2·1	2·6	2·3	3·1	6·9	7·9	8·7

The least spread of the tail was the breadth of the fin when it was smoothed out, with each fin-ray close to its neighbour. The ventral ramus of the tail was measured from the root of the tail, approximately at the beginning of the outer rays.

The North Sea specimen was compared with two other fishes measuring 48 and 50 cm. in length respectively, which had been landed fresh and ungutted at Aberdeen; they, no doubt, came from the North Sea. In the 48 cm. fish the dorsal fin was narrower and the spines were not so stout as in the specimen 37 cm. long. The fish 50 cm. long had the fin as broad and the spines about as stout as in the deep fish.

The differences were well marked; they may be racial. Both varieties seem to exist in the North Sea. It is possible that two species are included under the name *Sebastes marinus*, but, if that be so, it is probably the case that both grow comparatively large.

Lütken* regarded *Sebastes marinus* and *Sebastes viviparus* as distinct species. Smitt considered that the latter was merely a variety of the former. Vanhöffen† was of the opinion that a specimen of *Sebastes marinus* got at Greenland showed no important difference from examples of *Sebastes viviparus* captured in the North Sea. Cuvier and Valenciennes considered that forms of Sebastes from Norway and Newfoundland did not differ.

The Fishes Examined.

In order to study the development of the reproductive organs, specimens were examined during each month of the year.

In the following table an analysis of the fishes with respect to sex, length, and the stage of development of the ovary is given for each month. The length of the fish is the distance from the tip of the mandible (when the mouth is closed) to the end of the longest ray of the tail fin.

The investigation covered the period January, 1908, to November, 1910. Fishes examined in different years are included in the total for the month.

In most cases the locality of capture is not known. In some cases it is, no doubt, the North Sea.

* Smitt—"Scandinavian Fishes." Stockholm, 1893.

† "Gröndland Expedition der Gesellschaft für Erdkunde zu Berlin, 1891-1893." 3 Bd., 1 teil. Die Fische. Berlin, 1897.

TABLE

Month.	Locality.	Male.		Female.		Development of the Ovary.§
		No.	Range of Size.	No.	Range of Size.	
			cm.		*cm.*	
January, -	Iceland	18	34·5 to 47	25	34 to 48	Ova, ·4 to 1·0mm. in diameter.
February, -	Unknown	11	38 to 46	6	23·5 to 46	Ova, ·8 and ·9mm. in diameter.
March, -	Unknown	20	35 to 45	9	36 to 45	Ova, 1·0mm. in diameter.
March, -	Iceland	1	72	...	...	
April, -	Unknown	9	36 to 46	5	38 to 50	Ova, 1·12 to 1·4mm. in diam. Eggs free.
May, -	Unknown	†1	76	...	...	
May, .	*	90	34 to 47	34	24 to 50	Free eggs in ovary. Spent and immature ovaries.
June, -	North Sea	2	17·9, 19·3	47	17·7 to 24	Ova and larvæ free in ovary. Spent ovaries.
June, -	Unknown	‡10	36 to 44	5	38 to 42	Larvæ in ovary. Spent. Small ovary.
July, -	Unknown	10	38 to 43	7	38 to 50	Spent.
July, -	Unknown	...	...	1	74	Spent.
August, -	Unknown	8	35 to 45	18	37 to 48	Spent ovaries, developing.
September,	Unknown	7	39 to 47	5	41 to 49	Spent ovaries. Developing ovaries.
October, -	Unknown	2	42, 44	5	26, 42 to 49	Spent ovaries, developing. Developing ova ·37 to ·85mm.
November,	Unknown	...	...	2	42, 44	Yellow developing ovaries.
December,	Unknown	4	41 to 43	1	42	Yellow developing ovaries. Ova, ·7mm.

* The ripe fishes are supposed to have been got to the south of Aberdeen.
† Sex not known. ‡ Also a fish 47cm., recently spent; sex unnoted.
§ The data given in this column do not include the condition in every one of the fishes.

In this species, as Kröyer* showed, the larvæ develop in the ovary; internal fertilization is therefore necessary.

The *adult* fish is known by its having ripening reproductive organs, or by its being spent. Males measuring from 35 to 47 cm. in length were adult. Females measuring from 17·4 to 24, 26·5, 31 to 50, 74 cm., were adult. It is often easy to recognise a spent ovary from the fact that larvæ may have been retained in it, and these, although they have become shrivelled, betray their presence by the black pigment of the eyes. A second character which is also of value in the ovary is the presence of the old follicles, which can be recognised for some time after the ovary is spent.

The adult fishes may be sexually distinguished, previous to dissection, by the fact that in the male there is a large urogenital papilla (penis), (*pa.*, Fig. 62), while in the female this papilla is flattened out into an apron-like fringe (*ur. fr.*, Fig. 73). The urethra opens on the apex of the papilla, and on the distal border of the fringe (*urth.*,

*Collett, R.—"Norwegian North Atlantic Expedition, 1876-1878," Vol. III. Zoology: Fishes. Christiana, 1880.

Figs. 66 and 85). Sometimes a slender urinary papilla is present in the female, *e.g.*, in an immature fish 24 cm. long. In another fish the papilla was flattened and had a fringe along two sides (Fig. 75). The fringe in a female which had developing embryos in the ovary was large (*ur. fr.*, Fig. 73). In May the fringe was observed to be red, suffused with blood. In the case of one pregnant female (May), a red tube (?) projected from the oviduct. The filament which is shown projecting from the oviduct in Fig. 85 may have been accidentally torn from the wall of the oviduct. An enlarged drawing of a fringe is shown in Fig. 66. Its ventral surface was deeply ridged, especially so in the proximal half (*fo.*). It was less prominently ridged at *ri.* It ended distally in translucent processes between which the urethra opens. The upper surface of the fringe is practically plain. This organ probably acts as an aerating organ in connection with the developing embryos in the ovary.

A very marked difference exists between the two sexes in the size of the urinary bladder. This is seen in Figs. 62 and 63, which represent the abdomen of the male and female fishes in natural size. The urinary bladder of the male is enormous, (*urbl*, Fig. 62). The urinary bladder is a two-layered sac; the layers can be easily torn apart. The external coat of the bladder is usually grey or black, on part of its surface at least. The inside wall is deeply honeycombed and well supplied with blood-vessels. The bladder usually contains a cream-coloured or yellow fluid, in great quantity in the male, in small quantity in the female. The fluid, which is probably secreted by the bladder, is albuminous; it coagulates on the addition of water. Under the microscope it is seen to contain corpuscles and oil drops of various sizes. In the male the fluid issues by the apex of the papilla (*urth.*), while the sperm finds issue by a pore on the anterior side of the apex (*v.d.*, Figs. 89 and 90). The *vas deferens* is a wider channel than the urethra. The fluid is probably injected into the ovary along with the sperm, when impregnation takes place.

Development of the Testis.

In December, January, and February ripening testes are found. The urinary bladder is very large. In January and February ripe milt, which appeared to contain spermatophores, or groups of sperms, was observed. One male had in its urinary bladder during February a fluid that more nearly resembled water than the usual thick yellow fluid. Two of the testes were in this month apparently spent.

In March, April, May, and June the testes were all small. The urinary bladder varied in size, but usually contained yellow fluid. In two cases a collapsed bladder was found. Some of the small testes were no doubt spent. In July and August the small testes showed signs of beginning to ripen.

The testis was in September and October usually large and white in colour. The urinary bladder was large. Impregnation probably takes place in January and February.

Development of the Ovary.

The ovaries are separate (Fig. 85); the oviducts unite (*j*). The ovary is pigmented black, or a dark grey, externally. The pigmentation, which is more intense in the anterior half of the ovary, is mainly on the dorsal, outer, and ventral sides. The side of the ovary which is applied to the other ovary has little pigment. A row of small dots was observed along the course of the principal blood vessel. In some large ovaries which had been preserved, no black pigment was made out.

The ovary consists of a sac which encloses the lobed mass of ovarian tissue. The latter is attached to the wall along a narrow strip merely (Fig. 72). The greater part of the wall does not bear ova. In *Lophius** one half of the ovarian walls bears no ova. In Fig. 84 the wall (*w.*) of the ovary has been slit longitudinally to expose the ovarian mass (*ov.*). The groove (*ovd.*) is the opening of the oviduct of the other ovary. The wall which is opposite to the other ovary is supplied with large anastomosing blood-vessels (Fig. 85). The vessel *v.* is attached to the mesentery. A vessel runs down the oviduct; it may go to the urinary fringe.

The immature ovary is colourless. A fish measuring 32 cm. in length had in May a very small immature ovary. Great rolls of fat were present in the abdomen.

When the ovary is ripening it is yellow. The colour is due to the presence in the ova of yellow oil globules. In September a developing yolked ovum, preserved, measured ·37 × ·3 mm.; it had a large number of oil globules irregularly grouped (Fig. 74). The little eggs projected like bosses. Fulton* describes the eggs of *Lophius piscatorius* as projecting on stalks. The follicle is, like the stroma, composed of little cells (*sf.*). The follicle appeared to be two-layered, an outer smooth and an inner bossed layer. Some of the ovaries had, during this month, eggs measuring ·85 mm. in diameter, *e.g.*, *e*, Fig. 88. The old follicles, which denote a previous spawning, are shown (*fl.*). Another view of a portion of a ripening ovary is seen in Fig. 94. The larger eggs are now stalked.

In October very similar conditions are met with. Two ripening eggs, the largest of which measured ·5 mm. in diameter, are shown in Fig. 93. The processes (*pr.*) observed among the eggs are doubtless shrunken follicles. The eggs are developing along the side of a vessel that has thick walls. The eggs seem to lie inside the wall (*e*, Figs. 91 and 92); the inner layer (*vas.*) appears to be vascular.

Ripening eggs in January measured from ·4 to 1·0 mm. in diameter. The eggs were opaque yellow, and were still in the follicles, which are well supplied with blood vessels. The eggs, 1·0 mm. in diameter, broke away easily from the stalks. An opaque egg 1·0 mm. was filled with a yolk consisting of distinct corpuscles which separated readily when the egg was torn open. The corpuscles, which were round and oval, measured about ·05 mm. in greatest extent. The immature egg (·2 mm in diameter) is filled with minute oil globules, that give it an appearance recalling the egg of the eel.

In February and March the eggs measuring from ·8 to 1·2 mm., still in follicle, showed a central mass of oil globules, and a clear rind outside it. The latter in some instances appears to consist of round yolk corpuscles. Each egg had at least one big vessel attached to it.

*Fulton—"The Ovaries and Ovarian Eggs of *Lophius piscatorius* and of *Zeus faber*." 2 pl. 16th *Ann. Report of the Fishery Board for Scotland*, for 1897, Part III. 1898. P. 125, *et seq.*

When the preserved follicle was cut open, the egg was found to have a coarsely granular yellow core surrounded by a finely granular thick rind. A female had ripe eggs free in the ovary, but no segmentation of the ovum was made out. The stalks of the eggs are noteworthy: some are very long (*x.*, Fig. 83), others are short. The stroma exhibits a network of fine fibres, and of vessels large and small. One fish had a small ovary which was shrunken and mottled with brown.

April.—A fish had ripe eggs still in follicle. They measured 1·0 to 1·15 mm. in diameter and had a yellow oil globule measuring ·37 and ·4 mm. in diameter. The eggs were translucent. When free from the follicle they appear to imbibe fluid quickly and swell up.

Developing embryos were found in the ovaries during April, May, and June. The eggs had become free from the follicle, and they filled the ovary with a semi-fluid mass. The egg has a delicate investment; one coat only was made out. The embryos were found in various stages from the "disc" stage up to the embryo which was ready to hatch (Figs. 64, 65, 70, 71). Larvæ and post-larvæ were also found in the ovaries (Figs. 69, 77, 78). The posterior end of the ovary was well supplied with blood. Its wall was distended, and very thin, permitting the ova and larvæ to be seen from the outside.

The eggs varied in shape: some were oval, others round. Some oval eggs measured in the fresh condition, 1·4 × 1·1 (oil globule ·4); 1·4 × 1·1 (o.g. ·4); 1·3 × 1·05 (o.g. ·4) mm. A round egg containing an embryo was 1·12 (o.g. ·4) mm. in diameter. Preserved ovaries had eggs containing embryos measuring as follows:—1·5 × 1·12; 1·3; 1·15; 1·05 mm. Among the small pregnant fishes obtained in June two of the developing free ova measured while fresh 1·7 × 1·4 (o.g. ·4), and 1·7 × 1·15 mm. The oil globule was green. After preservation some ova obtained from the same lot of fishes measured 1·7 × 1·35 (o.g. ·4); 1·55 × 1·3 (o.g. ·4); 1·45 × 1·32 (o.g. ·4); 1·4 × 1·35 (o.g. ·42); 1·4 (o.g ·4); 1·4 × 1·3 (o.g. ·4) mm.

When the eggs have escaped from the follicles, the latter become very large (*fl.*, Figs. 80 and 86). They are well supplied with blood: a glomerulus can sometimes be made out in the swollen end. The ovarian lobes, *ovl.*, thickly covered with these follicles, stick out through the semi-fluid mass of ova (Fig. 59) The follicles are no doubt concerned in the aeration of the embryos and larvæ. In Fig. 80 two ripe eggs (*e*) are still in follicle. The young eggs are concentrated in groups on the large vessels of the ovarian tissue.

A fresh egg containing an embryo was put into formaline and it rapidly became opaque white. It was soon difficult to make out the oil globule and embryo. This was due to the fact that the perivitelline fluid coagulated.

In preserved ovaries two kinds of eggs (with embryos) were found; one an opaque egg, and the other a small translucent egg. When some of the opaque eggs, which were usually large, although some were small, were dissected, a thick outer finely granular opaque rind was found inside the zona. When the rind was removed the embryo was seen in several of the eggs, although not in all. When it was found it was semi-circular in shape, approximately at the stage represented in Fig. 65. In one large egg the embryo was visible from the outside. The small translucent egg may also show the embryo half-way round the yolk. Sometimes the zona is clearly crumpled, as if the small ovum had lost the contents of its perivitelline space. Some of the small yellow opaque eggs exhibit the white embryo on the outside.

Many of the eggs, then, found free in the ovary are larger than when they are in follicile. They have imbibed some fluid. In the ovary along with the free eggs there is a coagulable fluid, in which green oil globules are floating. This is, I consider, the fluid which is secreted in the urinary bladder of the male fish, and which is introduced into the ovary along with the sperm. The eggs when they escape from the follicile imbibe this fluid, and in this way a perivitelline space becomes formed. The remains of the fluid present among the eggs is found in the preserved ovary in the form of a granular solid, which is in the form of strings filling the interstices between the eggs, or is attached to the wall of the ovary in a honeycomb form (Figs. 57 and 58). It can be easily removed from the wall, but it has often attached to it a delicate skin which has probably been torn off the ovary or its wall. The material is translucent, and it encloses vesicles of various sizes; the latter resemble oil globules. In a preserved urinary bladder of a male fish the yellow fluid was coagulated to a granular powder.

The early embryos show no pigment. In one in which the tail nearly reached the head, no pigment was made out. The eyes were visible; the head was thick dorso-ventrally (Fig. 67).

When ready to hatch the embryos show pigment. In one (Fig. 71) the eyes contained black pigment, but no other pigment was observed. The yellow oil glubule was present and was still large. In others, however, a row of black spots was visible along the ventral edge of the post-anal body, but not extending as far as the end of the tail.

The black eyes of the embryos shining through the wall of the yellow ovary cause the latter to appear greenish.

The embryos in an ovary appeared to be all of about the same stage of development.

After the larvæ escape from the egg they remain in the ovary until the yolk is absorbed. Fig. 68 represents a larva which was found hatched in an ovary containing embryos still in the egg. The peculiar condition of the anterior end of the little fish is seemingly due to the fact that that region is still enveloped in the zona. In its bent condition the larva extended 3·25 mm.

A ventral view of the anterior end of a larva is shown in Fig. 69. The mouth is a small pore situated between the eyes. The eyes approach one another closely on the ventral surface. The round pectoral fin (*pf.*) is small. There are no jaws. In another specimen a semi-circle could be traced across the mouth region. This may indicate the line of separation between the jaws. A larva is exhibited in side view in Fig. 77. It had been preserved. The eyes were deeply pigmented. It had a characteristic blunt head. The marginal fin was composed of little round cells. The tail fin had a somewhat ragged edge. Pieces of cuticle were lying loose at *sk.*

Some larvæ measured from 3·7 to 4·3 mm. in length. The example 3·7 mm. long was bent. A little black pigment was present over the eyes and on the region of the rectum. A row of pigment spots was present on the dorsal and ventral edges of the hind half of the body. The ventral row commenced a short distance behind the anus and extended back to the beginning of the tail fin. Sometimes the pigment on the post-anal body is not made out. A couple of the largest larvæ had the jaws formed.

A few post-larvæ were found in an ovary in June. One which was drawn in the fresh condition is shown in Fig. 78. It measured 7 mm. in length. No yolk remained. The upper jaw was short, the lower jaw long. The eyes were large, black, and silvery. Fin-rays were present in the caudal and pectoral fins. The pigment, which was black, with perhaps some brown, was present on the top of the head, over the rectum, and along the dorsal and ventral edges of the long post-anal body. The latter pigment reaches to the beginning of the tail fin. The row on the ventral edge extends further forward and a little further posteriorly than the dorsal.

A preserved post-larva, which was one of eleven found in an ovary, is seen in Fig. 76. It measured 6·25 mm. in length. The marginal fin is drawn as it was, but it should no doubt be similar to that fin in Fig. 78. The pigmentation is similiar. In another larva, however, there were nine spots on the head. Two other post-larvæ measured 5·4 and 6·5 mm. in length ; neither was quite straight.

This is the condition to which the larva is reared before it is liberated from the ovary.

According to Collett* "the length of *Sebastes marinus* at birth is about 6 mm. ; they are, however, immediately able to swim and provide for themselves. On the Norwegian coasts the spawning season generally extends from the middle of April to the middle of May. *Sebastes viviparus*, on the contrary, does not as a rule produce its young earlier than July or August. Examples of *Sebastes marinus*, with fully-developed ova, are, however, occasionally met with late in summer." The same author states that the fry appears to rise towards the surface shortly, or perhaps immediately, after they are produced.

On June 9, 1910, a large number of small Sebastes, 17·7–24·4 cm. in total length, was obtained. Fifty-four were examined, and they were found, with two exceptions, to be pregnant females. This would indicate a tendency of the pregnant females to shoal together.

M'Intosh and Masterman† describe the larvæ found in the ovary of a specimen obtained in the Moray Firth. Comparing the old follicles in this form with the similar organs in the ovary of *Zoarces viviparus*, they suggest that the follicles supply amongst other things a nutritive pabulum for the larvæ.

Stuhlmann‡ has given a description of the histology of the ovary of Zoarces.

Wallace§ has more recently described the early development of the ovary, and also the histology of the villi of the pregnant ovary. He also discusses the egg-membranes, and the mode of absorption of ova that have been retained in the follicle.

Spent Ovaries.

A portion of a spent ovary in April is shown in Fig. 87. The old follicles (*fl.*) are dull granular in appearance ; they project from among the young eggs. The eggs are clear. The nucleus has not been shown

† "British Marine Food-Fishes." London, 1897.
* *Op. cit.*
‡ "Zur Kenntnis des Ovariums des Aalmutter (*Zoarces viviparus*, Cuv.)." 4 taf. *Abh. aus d. Gebiete des Naturwissenchaften.* Bd. x., Hamburg, 1887.
§ "Observations on Ovarian Ova and Follicles in certain Teleostean and Elosmobranch Fishes." *Quart. Jour. Micro. Science*, Vol. 47, Pt. 2, N.S., p. 160, 3 plates.

in each egg because, owing to the thick tissue, it was not always visible. The eggs were beginning to store up yolk; they were yellowish, and showed some oil globules.

In spent ovaries in May one or two larvæ similar to Fig. 78 were found. The follicles were shrivelled up, but were still large. The eggs were becoming yolked. The largest noticed measured ·22 mm. in one case and ·25 mm. in another in diameter. No rolls of fat were visible in the abdomen of the latter at least.

In June the ovarian tissue was in one spent reduced to the appearance of a thick rod. The wall of the ovary was a slack skin. The follicles were still big, and projected beyond the eggs, which were becoming yolked.

In July spents were recognised by the few larvæ left in the ovary, and also by the presence of old follicles. The eggs in a small ovary were becoming yolked; they stood out as round bosses. Smaller clear eggs were visible among the yolked eggs.

In September the old follicles are still to be traced in the ovary (Fig. 88).

Sebastes dactylopterus (Delaroche.)

This fish was described by Delaroche under the name of *Scorpæna dactyloptera.* Cuvier and Valenciennes, however, introduced it into their genus Sebastes, because, in their opinion, it pertained more to Perca than to Scorpæna. A number of authors, *e.g.*, Nilsson,* Roule,† Jaquet,‡ have made use of the name *Sebastes dactylopterus* (Delaroche). Recently Holt and Byrne§ gave a detailed description, with figure, of this form. They conserve the original name of *Scorpæna dactyloptera.* While admitting that this fish rather closely resembles *Sebastes marinus,* they do not agree with its exclusion from the Scorpænas.

The example described by Delaroche was obtained in the Mediterranean.

The fish is red-coloured. There is usually a black patch visible on the outside of the operculum. It is caused by the black inside surface of the operculum shining through the bone. This colouration is not, however, always evident.

There is some brown colour on the dorsum; sometimes there are greenish patches also. Two large specimens, about 40 cm. long, showed a good deal of brown pigment in this region. In one fish 33 cm. long, the brown was absent, or only traceable on close examination. One female had only pink colouration on the top-sides. There were white blotches scattered over the skin; they were prominent in most of the specimens, and could be traced in all.

When the fish lies damp for two or three days the red colour changes to amber. Fishes which had been preserved some time in formaline showed a thick spreckling with brown pigment on the dorsum, and on the sides above the lateral line chiefly.

* *Vide* Roule.

† Roule, L.—" Notes Ichthyologiques—Les Scorpénidés de la Mediterranée." *Arch. de Zool. Expérim. et Générale.* 1907 [4], Vol. vi. Notes et Revue, No. 1, p. xiv.-xxiv.

‡ Jaquet—" Considérations sur les Scorpénides Mer de Nice." *Bull. de l'Institut Oceânographique.* No. 109, Dec. 1907. Monaco.

§ Holt and Byrne—" Second Report on the Fishes of the Irish Atlantic Slope." *Fisheries Ireland Sci. Invest.*, 1906, V. [1908].

Bars may be sometimes traced on the sides, but often they are not at all clear. Three were noted in one fish. The first came down posterior to the operculum; the third was located below the soft part of the dorsal fin, while the second bar was located about mid-way between the two former. Several black or amber blotches were observed on the dorsal fin. The front part of the inside of the mouth is white; the pharynx is black or blue. The under edge of the gill-cover and branchiostegal apparatus was whitish.

The peritoneum is jet black.

Stellate black pigment corpuscles were observed on the wall of the stomach of one fish.

The urinary bladder is very small.

The swim-bladder, as Delaroche* pointed out, is absent,

Fig. 106 represents a specimen of this species. The correct number of fin-rays is not shown in every case. The scales are diagrammatically represented.

The eyes are very large. The orbit is oval.

The jaws are nearly equal when the mouth is closed; the mandible does, however, project a little in front of the premaxillæ. The horizontal membrane is present inside the lip of each jaw; it is narrow. Teeth are present on the vomer and palatines, in addition to the premaxillæ and dentaries. The teeth are all small.

The short ridge over the eye is often toothed, as many as six or seven teeth being made out. Sometimes it does not show teeth distinctly, but is simply a rough ridge. This condition may occur on one side of the fish, while three well-defined teeth may be present on the other side.

The head in side view is gently rounded.

The top of the head is depressed. The interorbital space is bounded on either side by the prominent ridge which forms the upper edge of the orbit. It is longitudinally hollowed out and bears, projecting from its sloping sides, two prominent ridges shown in *rd.*, Fig. 103. The interorbital space in Sebastes is flat, and the two secondary longitudinal ridges are absent.

The scales are ctenoid (Fig. 99). No scales were present on the outside of the lower jaw.

The number of pyloric cæca was in two cases seven, and in one case six.

Dorsal Fin.—The dorsal fin consists of two parts—a longer portion composed of spines, a shorter portion consisting of soft rays. In ten fishes only a slight variation was found in the number of fin-rays. In each of eight fishes the rays numbered 12 spines and 13 soft rays, while in two specimens the numbers were 12 spines and 14 soft rays. The 12th spine is longer than the spine preceding it. In one fish the longest spines were the 3rd to 6th.

The first two spines and the last two rays arise from a single interspinous bone in each case. The last two rays are close together at their bases. The angle between the last ray and the dorsal edge of the body is filled with a little membrane.

Anal Fin.—The anal fin consists of three spines and six soft rays. These numbers were found in all the fishes in which the character was noted, viz., eight. The first two spines and the last two rays arise

* *Vide* Cuvier et Valenciennes, *op. cit.*

from a single interspinous bone respectively. The last two rays are close together at their bases. Sometimes all the spines of this fin are covered with thick skin. The angle between the last ray and the ventral edge of the body is filled with a little membrane; it is usually not so large as the membrane at the end of the dorsal fin.

Pectoral Fin.—The pectoral fin furnishes an important specific character. Its lower rays are thick and fleshy, and separated from one another in a considerable proportion of their length. The upper part of the fin contains thin rays which have each from one to four points. This part of the fin is cut square across. The total number of rays was 19 (11 thin and 8 fleshy) in seven fishes, and 20 (11 thin and 9 fleshy) in three fishes. Of the thin rays the first and second had single tips; the third to tenth were split into more than two tips; the eleventh ray was either single or split into two at the tip. The fleshy rays are single. The fleshy rays are separated from each other in from one-third to one-half their length. They were often damaged. Sometimes certain of the rays were fixed bent at a sharp angle, as if they had been broken across and had healed in the bent condition. They may be damaged on one side of the fish and normal on the other side. In one fish several of the fleshy rays had been cut off on both sides.

The longest ray in the fin is sometimes one of the last thin rays, but in other cases it may be one of the first fleshy rays, *e.g.*, the 14th ray.

The axilla of the pectoral fin is deep, and there is much slack skin in it.

Ventral Fin.—The number of rays in this fin was counted in six fishes. No variation was found, the number being one spine-ray and five soft rays. There is a broad membrane binding the last ray to the ventral surface of the body (*mb.*, Fig. 100). The spine-ray is entirely covered with thick skin.

Caudal Fin.—Twenty-four rays were counted in the case of one fish. The dorsal and ventral edges of the base of the tail form somewhat sharp ridges. The top and bottom edges of the fin are often a little irregular, as if the rays had been shorn. The lowest three or four rays are sometimes of a thicker form than the other rays. The hind margin of the fin is either straight across or slightly concave.

Vertebræ.—In 12 fishes the number of vertebræ was not found to vary. Twenty-five were found in each case. The first hæmal arch was in twelve cases on the seventh vertebra; the first hæmal spine was in three cases on the eighth; the tip of the hæmal spine was forked in one case. The end of the first interspinous line of the anal fin met the hæmal spine of the eleventh vertebra in two instances.

Measurement Characters.

Certain measurements similar to those made on *Sebastes marinus* were recorded for this species. The results have been introduced into the Table on page 18.

Comparison between Sebastes dactylopterus and Sebastes marinus.

In colour they are very similar, both being red-coloured. The red colouration differs in the two fishes in its shade.

In side view the two species closely resemble one another. Important differences are also detected. Generally Dactylopterus is not so deep a fish as Marinus. The hump on the dorsal edge, in front of the fin, is a prominent character in Marinus, while it is absent in Dactylopterus. The orbit of the former is round; that of the latter is oval. The orbit of Marinus is the larger.

The pectoral fin forms an important distinguishing feature. The upper part is cut square across in Dactylopterus, while in Marinus the distal border is oval. The lower rays in the former fish are thick and much separated from one another; in the other species the lower rays, although they are thicker than the upper rays, are not so fleshy as those of Dactylopterus, and only their tips are free.

The lower jaw in Dactylopterus is not so prominent as in Marinus; the maxilla, although large in both species, is the bigger in the former.

The lateral line differs slightly in the two species. In Marinus it forms a more extended curve in its anterior half; in Dactylopterus it begins to descend immediately behind the operculum.

When the head is viewed from above an approach to the broad head of Cottus and Scorpæna is seen in Dactylopterus (*e.g.*, Fig. 114); in Marinus the head is narrower (Fig. 115). The interorbital region of the former is hollowed out, while it is flattened in the latter.

Well-marked differences occur in the numbers of the fin-rays (*vide* pp. 19 and 30). The membrane between the last ray of the dorsal and anal fins and the edge of the body is more extensive in Dactylopterus than in marinus. The colour of the inside of the mouth forms an important distinguishing feature. In Marinus it is white or pink; in Dactylopterus the pharynx is black or blue. The two species exhibit intermediate conditions between the forms Perca and Scorpæna. At one end of the series Perca is closely resembled by *Sebastes marinus*, while *Sebastes dactylopterus* shows in its general form and external features a near approach to Sebastes on one hand, and on the other indicates, in respect to its head, a tendency towards the form of Scorpæna (*e.g.*, *Porcus*). The classification of these fishes is not satisfactory. But any alteration demands a study of all the allied fishes.

The Reproductive Organs.

The male has a large muscular external urogenital papilla (*pa.*, Figs. 106 and 112). There are upon it two crater-like orifices, the anterior of which is the opening of the *vas deferens*, while the posterior one is the aperture of the urethra.

In the female there is sometimes a small urinary papilla (*ur. pap.*, Fig. 111). The external aperture of the oviduct is wide (*ovd.*). It lies between the anus and the urinary papilla. The hind edge of the anus is expanded into a crescent-shaped lip which lies over the vulva (*fr.*, Fig. 110). The flap varies in shape and size (Fig. 110, A and B). The hind lip of the vulva is sometimes prominent also. The urethra opens to the exterior a little below the apex of the papilla, and on its anterior side.

The Urinary Bladder.—Male—The urinary bladder was small and jet black on the outside. It was sometimes empty; but in one or two cases it contained a clear fluid like water. In lies on the right side of the black mesentery that supports the *vas deferens* and the ureter to the roof of the abdominal cavity. The ureter is median.

Female—The urinary bladder resembled that of the male. It is on the right side of the mesentery. In four females the bladder contained white granular fluid. The inside of the bladder was longitudinally ridged.

Testis.

In fishes measuring from 42 to 45 cm. in length in January the testis was large and white. A drawing of the testis in natural size is given in Fig. 112. The *vas deferens* is a thick-walled tube, apparently muscular.

In two fishes measuring 37 and 43 cm. in length the testis, although white, was small.

In February some of the testes were ripe in fishes measuring from 40 to 46 cm. in length. They contained milt of a white pasty nature. The *vas deferens* was distended with milt.

One fish in March measured 45 cm. in length. It had a white testis.

The Ovary.—January, February, March.

A general view of the ovary and its connections is given in natural size in Fig. 111. The ovary is remarkable: it is a long, narrow, flaccid organ. Its anterior end is bent on itself. It exhibits on its external surface a good deal of black pigment. If the outer wall be slit open (Fig. 108) the true ovary *(lov.)* is found lying loose within, except for the attachment to the skin formed by the blood vessel (*bv.*) at the anterior end. The ovary was dark red: it was well supplied with blood vessels. The line along which the mesentery is attached on the outer surface is indicated by the groove (*gro.*, Fig. 108). In the preserved condition the ovary was flattened: it was of one breadth in its whole length. The internal surface of the sac is ridged with longitudinal muscles. In some of the ovaries the outer wall was slack.

The united oviduct is opened to show the junction of the right and left oviducts (*r. ovd*, *l. ovd*, Fig. 111).

If the ovary be cut across, it is found to consist of a thick rind which encloses a space occupied by a loose network tissue (Fig. 107). In this central space two large blood vessels, an artery (*ar*) and a vein (*bv*) are to be seen. They break up into a network of vessels that fills up most but not all the space. Yellow gland-like bodies are present at *gl*.

The rind consists of a basement layer supporting columns or septa filled with eggs. Each column has two layers of eggs, between which is the principal blood vessel. At the ends of the columns a few eggs project on little stalks; they are becoming yolked.

An enlarged drawing of a portion of a column is shown in Fig. 102. The basement layer consists of round nucleated cells, accompanied by branching vessels, some of which have rigid walls, and therefore stand open. Some of the vessels had cæcum-like branches. Each ovum is contained in its own skin, and is supplied with blood vessels that go between the eggs. Some of the fibres on the inside of the column were wavy: they are probably muscular. Fig. 101 shows a theoretical section of a column. The column appears to be a sac enclosing two layers of eggs; it probably is the follicle of the ovum. In the centre are the blood vessels (*bv.*), and on either side are the ova. A loop (*bv'*) from the blood vessels is shown encircling each egg.

There appear to be differences among the blood vessels. The main blood vessels have walls composed of fibres, while the small blood vessels in the ovarian tissue have a wall of two layers at least, a fibrous layer and a cellular layer. The cellular wall consists of small round nucleated cells.

The skin that covers an unyolked egg (*imm.*) is thin; that which covers a yolked egg is thick (*yk.*, Fig. 102). In the follicle of the latter there is between the outer skin and the zona of the egg a thick layer of round cells (*pl.*, Fig. 104). This layer extends into the stalk of the egg. This placental layer is evidently attached to the vascular layer (*vas.*), but is independent of the follicle (*fl.*). It apparently comes away with the egg when the follicle is ruptured. The cells composing the layer are similar to the round nucleated cells of the basement layer. Such cells may be seen along the vessels and concentrated in gland-like bodies. The follicle, although cellular, is more dotted and not distinctly cellular on the stalk portion.

The *modus* seems to be as follows. The egg which is about to ripen has a layer of round cells developed round it. How they arise is not clear. Whether they are developed *in situ* or transferred there is an open question. This cellular layer, which is a sort of placenta, apparently secretes the yolk which the egg absorbs. The yolk consists of small corpuscles.

The egg-columns are thickly arranged over the surface of the ovary. They are not all of the same height. The yolked eggs are often terminal; some, however, come off the side, and even well down at the base of the column.

In January the ovaries in fishes 39 and 41 cm. long had not developed far towards ripeness. A few white yolked eggs measured ·27 mm. in diameter. The nucleus was visible. The clear eggs measuring ·25 mm. in diameter had some white pigment round the edge of the nucleus.

In February fishes measuring 28·5 and 35 to 41 cm. in length were examined. In the fish 28·5 cm. long a small (though long) immature ovary was found.

The ovaries in the others was very similar to those examined in January. The naked-eye appearance of the ovary was almost colourless, with only a pale pink colouration. Most of the eggs were clear. Some were beginning to store up yolk. The yolked eggs measured up to ·27 mm. in diameter. Here and there in the ovarian tissue there were patches of white granular matter (*gr.*, Fig. 109). It appears to be a coagulated albuminous matter. It was observed in more than one ovary, and in one case it was in greatest quantity in the oviduct. In parts it had assumed a cellular form.

In March a female 40 cm. long was obtained. The largest yolked eggs were ·35 mm. in diameter. An enlarged portion of the ovary, which had been cleared with a solution of sodium-hydrate, is shown in Fig. 105. Some of the terminal eggs have long stalks. The small eggs appear to be more numerous than in the ovaries examined previously.

Some of the white granular matter was seen in the ovary (*gr.*, Fig. 105). The general structure of the ovary in this fish would suggest the likelihood of the mode of development being viviparous. In none of the ovaries, however, were any old follicles, egg-capsules, or larvæ observed. Holt* says that this species appears to be oviparous.

A live nematode was found inside one ovary.

* "Recherches sur la Reproduction des Poissons Osseux." *Ann. du Musée d'Histoire Naturelle de Marseille.* Zoologie. T. 5. Marseille, 1899.

LETTERS USED.

a, an.—Anus, anal.
ab.—Abdomen.
ar.—Artery.
bv.—Blood-vessel.
c.—Concretion, cyst.
ci.—External ciliated edge of scale.
cl.—Clear process.
col.—Column.
d.—First portion of gut.
df.—Dorsal fin.
dm.—Dorsal mesentery.
e.—Egg.
f.—Fat.
fl.—Follicle.
fo.—Foliated surface.
fr.—Fringe.
g.—Gut.
gl.—Gland.
gr.—Granular matter.
gro.—Groove.
hæ.—Hæmal canal.
hd.—Head.
imm.—Unyolked eggs.
int.—Interspinous bone.
j.—Junction of oviducts.
k.—Kidney.
l.—Left.
la.—Lacunar tissue.
lar.—Larva.
l. ov.—Left ovary.
l. ovd.—Left oviduct.
m.—Mesentery.
mb.—Membrane.
mo.—Mouth.
neu.—Neural canal.
oc.—Eye.
og.—Oil globule.
ot.—Otocyst.
ov.—Ovary.
ovd.—Oviduct.
ovl.—Ovarian lobe.
pa.—Urogenital papilla.
pap.—Papilla.
per.—Peritoneum.
pf.—Pectoral fin.
pi.—Pigment.
pl.—Placental layer.
r.—Right.
rd.—Ridge.
rect.—Rectum.
ri.—Ridged surface.
r. ov.—Right ovary.
r. ovd.—Right oviduct.
sf.—Surface of follicle (Fig. 74).
sk.—Skin.
sm. e.—Small egg.
sp.—Spongy tissue.
spc.—Space.
sw.-bl.—Swim-bladder.
t.—Testis.
ul.—Upper lip.
uovd.—United oviduct.
ur.—Ureter.
urbl.—Urinary bladder.
urfr.—Urinary fringe.
urth.—Urethra.
v.—Vessel.
vas.—Vascular layer.
v. d.—Vas deferens.
vf.—Ventral fin.
vm.—Ventral mesentery.
w.—Wall.
yk.—Yolked.

PLATE I.

(*Sparus centrodontus*, Delaroche.)

FIG. 1. Abnormal reproductive organ of fish 47 cm. long.
,, 2. Side view of abdominal cavity of fish 44 cm. long.
,, 3. Fish 42 cm. long, with secondary anus.
,, 3a. Reproductive organ. January. Nat. size.
,, 4. *Sparus centrodontus.*
,, 5. Pelagic egg (? *Sparus centrodontus*). Enlarged.
,, 6. Side view of abdominal cavity of fish 46 cm. long.
,, 7. Drawing of gut at secondary anus (Fig. 3). Enlarged.
,, 8. Section across reproductive organ. January. Testis nearly ripe ; ovary immature.
,, 9. Reproductive organ ; testis large, ovary small. January. Nat. size.
,, 10. Portion of section of testis. Enlarged.
,, 11. Cross section of a developing testis. Enlarged.
,, 12. Embryo dissected out of the pelagic ovum (*cp.* Figs. 5 and 13). Enlarged.
,, 13. Pelagic egg (? *Sparus centrodontus*). Enlarged.
,, 14. External view of secondary anus (*cp.* Figs. 3, 7, 15).
,, 15. Sketch to show the portion of the gut passing through the abdominal wall to the secondary anus.
,, 16. Portion of ripe testis (Fig. 9) seen from outside. Enlarged.
,, 17. Reproductive organ ; testis and ovary equal in size. Nat. size.
,, 18. Section across the reproductive organ shown in Fig. 17.
,, 19. Abnormal reproductive organ. January.
,, 20. Drawing of opaque yolked eggs, in swollen follicle, in developing ovary January.
,, 21. Reproductive organ. January. Nat. size.
,, 22. ,, ,, ,, ,,

PLATE I.

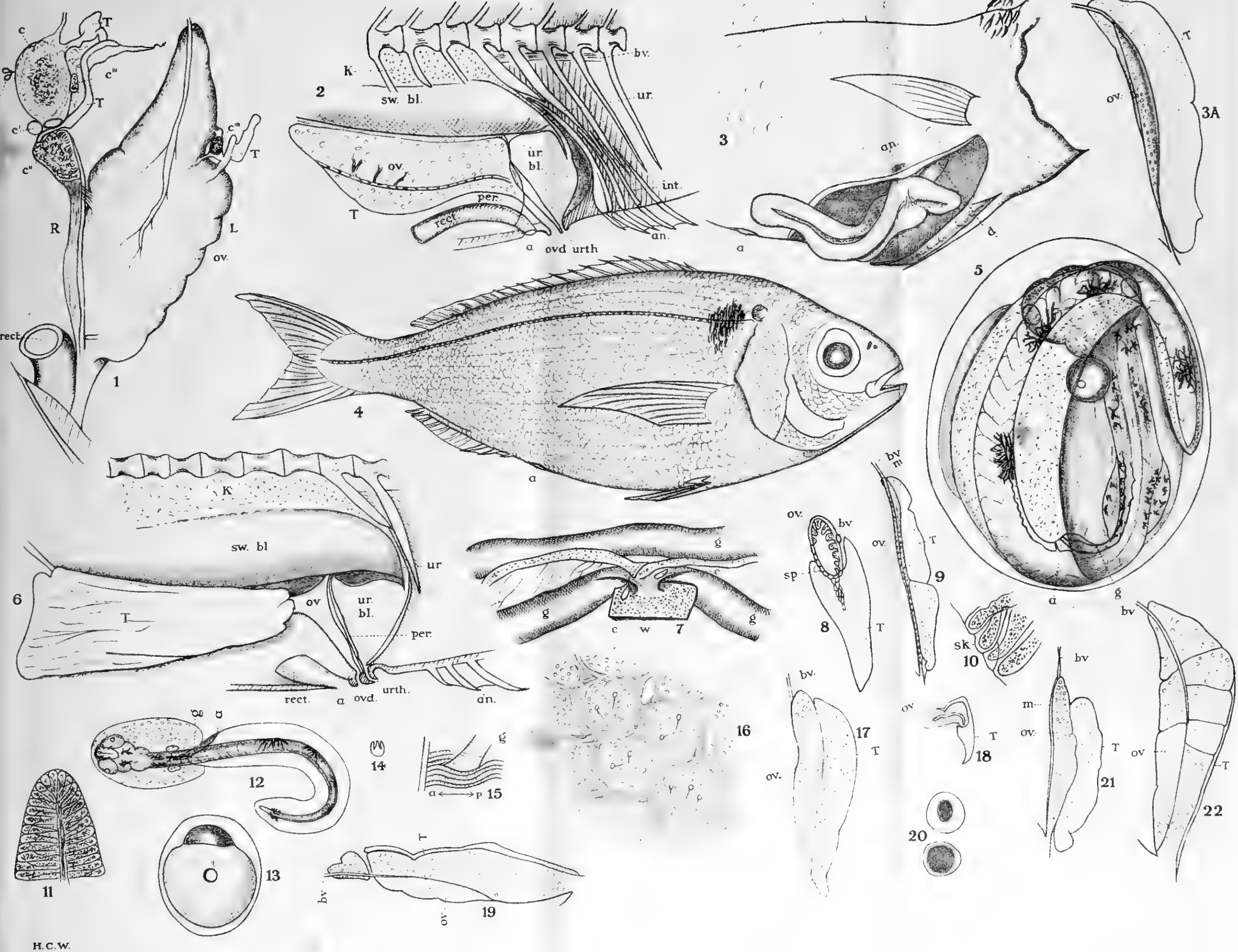

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PLATE II.

(The figures refer to *Sparus centrodontus*, except where otherwise stated.)

FIG. 23. Portion of oviduct-wall of ovary of a fish 46 cm. long. November. Enlarged.
,, 24. Section of testis of fish 43 cm. long. November. Enlarged.
,, 25. ,, ,, ,, ,, ,, ,,
,, 26. ,, ,, ,, ,, ,, ,,
,, 27. Section across the oviduct of fish 43 cm. long. November. Enlarged.
,, 28. Section across the union of the oviducts.
,, 29. The apertures in the cloacal slit of a predominating male 46 cm. long. Enlarged.
,, 30. *Sparus cantharus*, Linn. 40·5 cm. long.
,, 31. Longitudinal section through the cloacal slit of a predominating male. Enlarged.
,, 32. Section across the oviduct a little posterior to the position of Fig. 27. Enlarged.
,, 33. Section of oviduct of predominating male 36 cm. long. November. Enlarged.
,, 34. Section of the same oviduct as Fig. 33, but close to the abdominal wall. Enlarged.
,, 35. Oviduct of the same fish as Fig. 24, opened at its external aperture. View of internal surface. Enlarged.
,, 36. Drawing showing dentition in lower jaw of *Sparus cantharus*. Approximately natural size.
,, 37. Lower jaw, to show dentition. Approximately natural size.
,, 38. Reproductive organ, about natural size.
,, 39. Reproductive organ. January. Dorsal or posterior surface.
,, 40. Spent ovary developing, of fish 44 cm. long. November.
,, 41. Horizontal section of urogenital papilla of a predominating female, 42·5 cm. November.
,, 42. Section at A of reproductive organ shown in Fig. 38. Enlarged.
,, 43. ,, B ,, ,, ,, ,, ,,
,, 44. Diagram of developing egg: *pi.* indicates pigment in the nucleus. Enlarged.
,, 45. Section at A of the reproductive organ shown in Fig. 40. Enlarged.
,, 46. ,, B ,, ,, ,, ,,
,, 47. ,, C ,, ,, ,, ,,
,, 48. Section of the reproductive organ of *Sparus cantharus*, about the middle of its length. Enlarged.
,, 49. Section of the reproductive organ of a fish 46 cm. long across the junction of the ovaries. Enlarged.
,, 50. Section of the same reproductive organ as Fig. 49, but posterior to the junction of the ovaries. Enlarged.
,, 51. Diagrams of early developing eggs, showing different sizes of nuclei.
,, 52. Views of concave surface of the otolith of *Sparus cantharus*. Nat. size.
,, 53. Edge view of the otolith of *Sparus cantharus*.
,, 54. View of convex surface of the otolith of *Sparus cantharus*.
,, 56. *Sebastes marinus*, female, 37 cm. long. Reduced.
FIGS. 57 and 58. *Sebastes marinus*. Solidified albuminous matter from surface of the wall of the ovary. Enlarged.
FIG. 59. *Sebastes marinus*, section of pregnant ovary.
,, 60. Scale of fish 38 cm. long. About natural size.
,, 61. *Sebastes marinus*, 40 cm. long. Scale about natural size.

PLATE II.

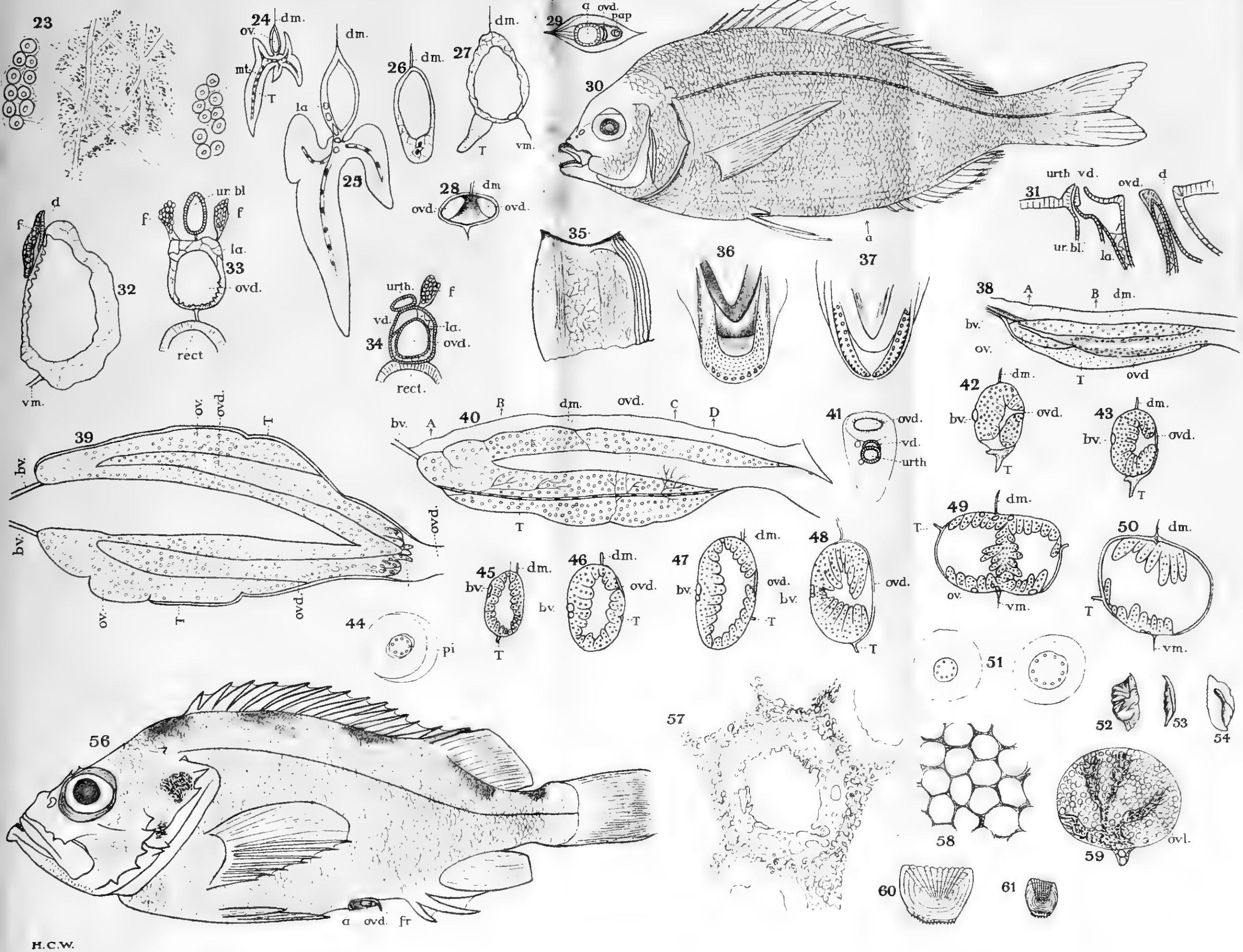

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PLATE III.

Fig. 62. *Sebastes marinus*, male, abdomen. Nat. size.
,, 63. ,, ,, female ,, ,, ,,
Figs. 64 and 65. *Sebastes marinus*, developing eggs. April.
Fig. 66. *Sebastes marinus*, female, urinary fringe. Enlarged.
,, 67. ,, ,, side view of head of embryo. May. The tail of the embryo nearly reached the head. Enlarged.
,, 68. ,, ,, larva, just hatched, abnormal. Enlarged.
,, 69. ,, ,, head of larva, recently hatched. Enlarged.
,, 70. ,, ,, developing embryo. The preserved egg measured 1·25mm. April. Enlarged.
,, 71. ,, ,, female, 34·5 cm. Developing embryo. May. Enlarged.
,, 72. ,, ,, section of ovary. September.
,, 73. ,, ,, pregnant ovary. Nat. size.
,, 74. ,, ,, developing yolked egg, ·37 × ·3 mm. September. Enlarged.
,, 75. ,, ,, female, spent. Urinary papilla. Enlarged.
,, 76. ,, ,, post-larva, 6·25 mm. long, from ovary. June. Enlarged.
,, 77. ,, ,, larva, length 4·9 cm. May. Enlarged.
,, 78. ,, ,, post-larva, 7 mm. long, from ovary. June.
,, 79. ,, ,, small egg, about ·4 mm. in diameter, becoming yolked. January.
,, 80. ,, ,, portion of ripe ovary. April. Enlarged.

PLATE III.

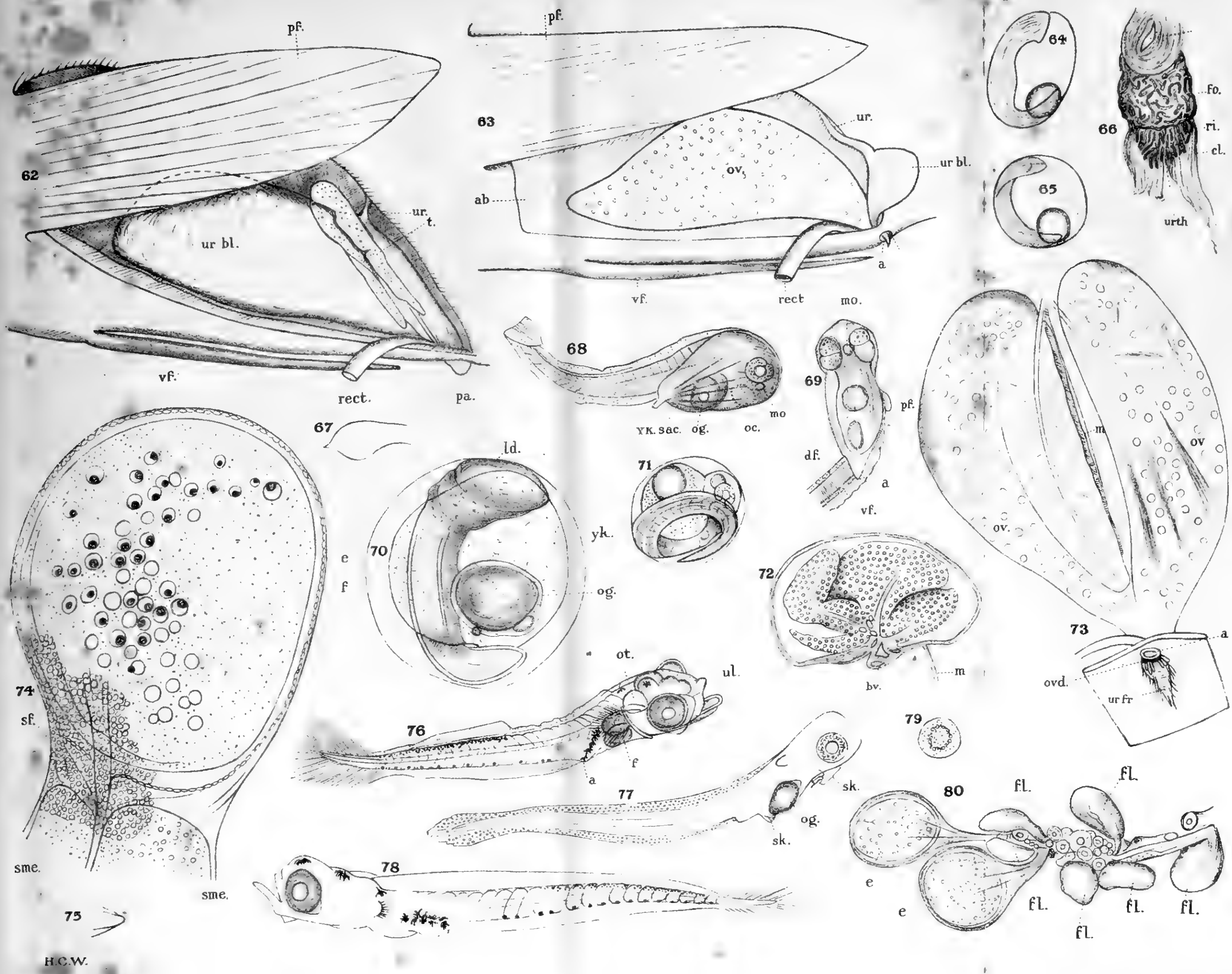

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PLATE IV.

Fig. 83.	*Sebastes marinus,*		portion of a large ovary. February-March. Enlarged.
,, 84.	,,	,,	spent ovary. September. Ovarian wall slit open.
,, 85.	,,	,,	spent ovaries and external apertures.
,, 86.	,,	,,	portion of ovary. April. Showing very large follicle. Enlarged.
,, 87.	,,	,,	spent ovary, developing. April. Enlarged.
,, 88.	,,	,,	,, ,, ,, September. Enlarged.
,, 89.	,,	,,	male, urogenital papilla. February.
,, 90.	,,	,,	section of urogenital papilla of male. February. Enlarged.
,, 91.	,,	,,	young egg in wall of vessel in ovary. October. Enlarged.
,, 92.	,,	,,	developing egg in ovary. October. Enlarged.
,, 93	,,	,,	,, eggs ,, ,, ,,
,, 94.	,,	,,	portion of spent ovary. September. Enlarged.
,, 95.	,,	,,	longitudinal section through the anal region of female. Enlarged.
,, 96a.	,,		dorsal fin, last interspinous bone and last two fin-rays. Enlarged. Semi-diagrammatic.
,, 96.	,,	,,	anal fin, last interspinous bone, and last two rays.
,, 97.	,,	,,	vertebra bearing the first hæmal spine.
,, 98.	,,	,,	dorsal fin, end of, showing membrane joining the last fin-ray to the dorsal edge of body.
,, 99.	*Sebastes dactylopterus,*		41 cm. long. Scale. Nat. size.
,, 100.	,,	,,	view of adnate ventral fin.
,, 101.	,,	,,	theoretical section of egg-column of ovary.
,, 102.	,,	,,	portion of ovary. January. Enlarged.
,, 103.	,,	,,	view of top of head, showing the interorbital and adjacent regions.
,, 104.	,,	,,	egg beginning to store yolk. Semi-diagrammatic. Enlarged.

PLATE IV.

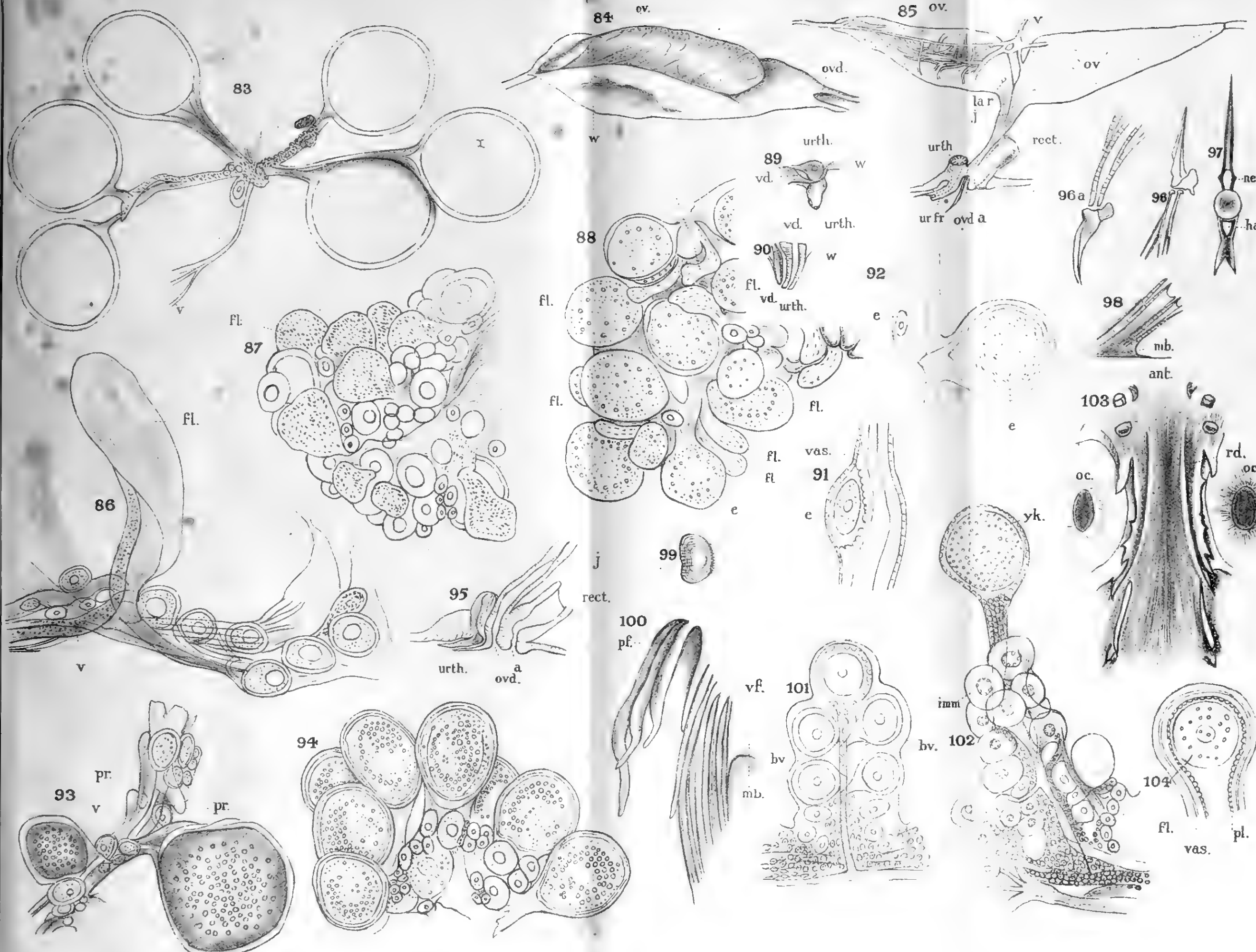

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PLATE V.

Fig. 105. *Sebastes dactylopterus*, portion of ovary, cleared with solution of NaOH. March. Enlarged.

,, 106. ,, ,, $\times \frac{1}{3}$. The scales are not shown in correct size.

,, 107. ,, ,, transverse section of ovary. January. Enlarged.

,, 108. ,, ,, ovary. January. Nat. size.

,, 109. ,, ,, transverse section of ovary, showing the granular matter attached. February. Enlarged.

,, 110 A and B. *Sebastes dactylopterus*, ventral views of the anal regions of two fishes.

,, 111. *Sebastes dactylopterus*, ovary. February. Nat. size.

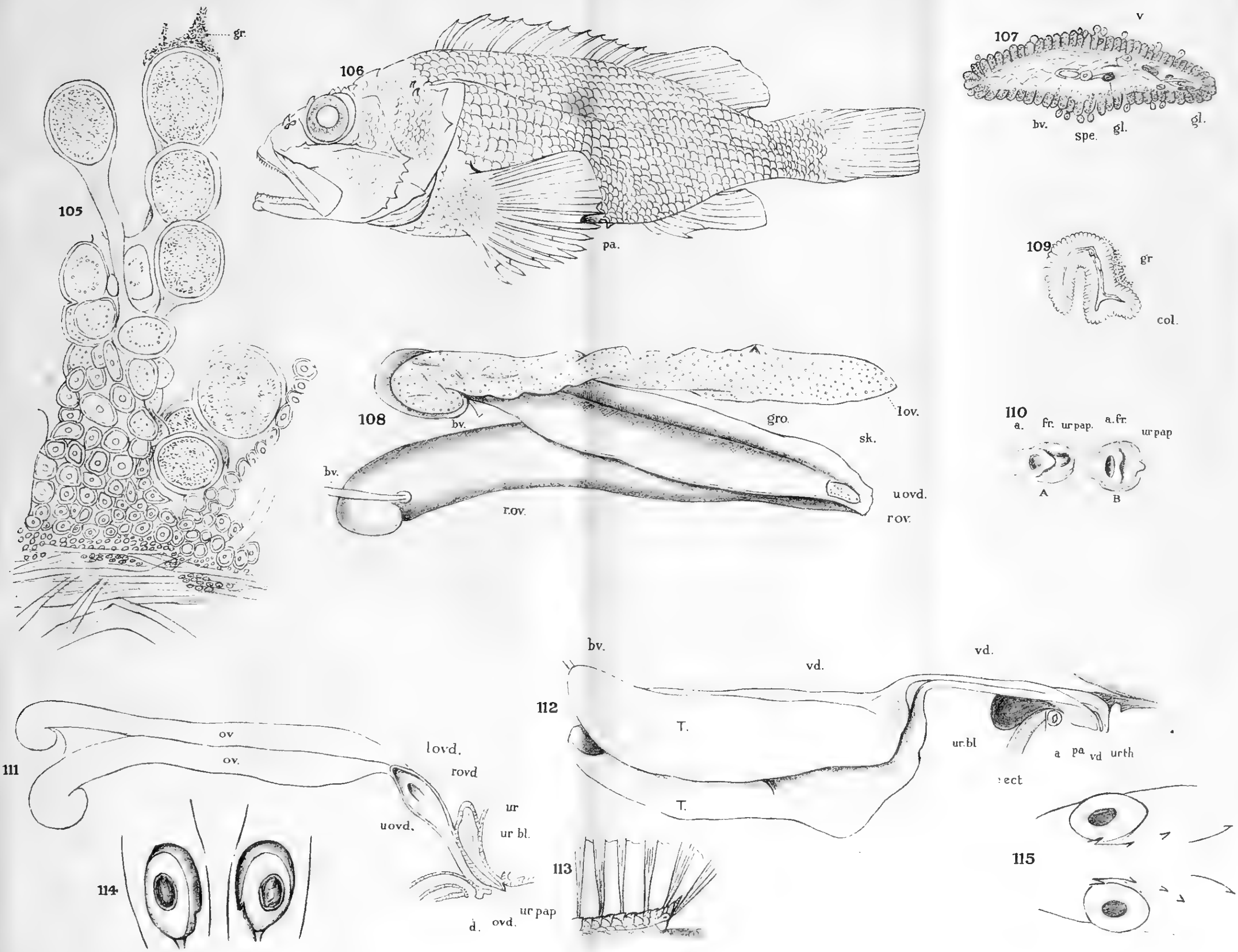
,, 112. ,, ,, testis. January. Nat. size.

,, 113. *Sparus cantharus*, end of dorsal fin, to show process formed by scales.

,, 114. *Sebastes dactylopterus*, head seen from above.

,, 115. *Sebastes marinus*, head seen from above.

PLATE V.



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SCIENTIFIC INVESTIGATIONS, 1910.

No. II.

THE RETARDATION OF THE DEVELOPMENT OF THE OVA OF THE HERRING

(WITH 1 PLATE).

BY

H. C. WILLIAMSON, M.A., D.Sc., F.R.S.E.

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FISHERY BOARD FOR SCOTLAND.

REPORT ON THE RETARDATION OF THE DEVELOPMENT OF THE OVA OF THE HERRING.

BY

H. CHAS. WILLIAMSON, M.A., D.Sc., F.R.S.E.,
MARINE LABORATORY, ABERDEEN.

(Plate I.)

CONTENTS.

The experiments on the retardation of the herring, which have been carried on at the request of the Government of New Zealand, were continued during the spring of 1911.

The eggs were fertilized on board a fishing boat on the evening of 27th February and the morning of the 29th February. The spawn was obtained from live herrings caught in a drift net. It was attached to glass plates and also to coarse gravel, as it was desired to see how the two methods compared in respect to the well-being of the ova. The method adopted in the case of the glass plates was similar to that described in my previous paper.* For the second method a layer of gravel was put on the bottom of a barrel partly filled with sea-water. Some milt was pressed out into the water, and then some spawn was pressed out and allowed to fall on to the gravel. The gravel was left undisturbed for some hours. Twelve hours or more later, the barrel, on arrival at Aberdeen, was tipped up and the gravel turned out into a tub. A considerable quantity of the ova

* "Experiments to show the Influence of Cold in retarding the Development of the Eggs of the Herring (*Clupea harengus*, L.), Plaice (*Pleuronectes platessa*, L.), and Haddock (*Gadus æglefinus*, L.)." *Twenty-seventh Annual Report of the Fishery Board for Scotland*, Part III., 1910, p. 100.

(4189.) Wt. 10769/231—500—9/1911.

was not attached to the gravel. Some eggs had been killed. A fair amount of ova was still adhering to the stones. They hatched out well, as did some of the eggs which were found loose among the gravel. The spawn was divided up. Part of both lots was cooled, while the remainder was kept in uncooled water. The glass plates, both cooled and uncooled, were made to revolve. The spawn on gravel, both cooled and uncooled, was put into trays, which were moved vertically. The revolution of the plates, and the raising and depressing of the trays, was intermittent, not continuous. The trays were made of wood, and they had bottoms sparred with glass tubes, and in one case covered with old galvanized wire netting.

The uncooled glass plates were put into the apparatus used in the 1910 experiment.* It consisted of a galvanized iron box, which revolved inside a galvanized iron tank.

The apparatus used for the cooled spawn was of wood, most of which was tarred. The box containing the plates was 21 inches square and 18 inches deep (A., fig. 2). A wooden frame, which carried a plate on each of its four external faces, revolved on iron axles. Each plate was in succession brought to meet the inflowing current of water.

In the case of the uncooled gravel spawn the trays were raised a little and then depressed. The cooled gravel spawn was arranged in trays that travelled round on a revolving frame (B., fig. 2). The trays were 9 inches by 7 inches by 2 inches deep.

The water was filtered through a barrel filled with sand, both for cooled and uncooled ova.

For cooling the water a series of galvanized iron pipes ($\frac{3}{4}$-inch wide diameter), covered with ice, was employed.

Sea-water had been running through the pipes and the apparatus for three months before the ova were introduced.

The spawn was put into running water by about 10 p.m. on the 28th February.

The temperature of the uncooled and cooled water, and the quantity of water supplied to several of the lots of eggs, are shown in the table, p. 5. The temperature in °C. was read almost hourly during the day and night. The maximum and minimum thermometers were read once, sometimes twice, a day. The temperatures given in the maximum and minimum columns refer to parts of two days. The quantity of water is indicated by the time required to fill a one-pint measure (= ·6 litre).

An estimate was made of the number of eggs on two plates, which were not too crowded with ova. They contained approximately 2600 and 2800 eggs respectively.

Rate of Movement of the Apparatus.

The cooled glass plates revolved once in from 1 to 2 minutes. The cooled gravel in trays made a revolution in from 5 to $10\frac{1}{2}$ minutes. The plates in the tin revolved once in from $1\frac{1}{2}$ to 2 minutes. The uncooled gravel spawn in trays was raised and depressed once in $5\frac{1}{2}$ to $7\frac{1}{2}$ minutes.

* "Experiment in retarding the Development of the Eggs of the Herring." *Twenty-eighth Annual Report of the Fishery Board for Scotland*, Part III., 1911.

INCUBATION OF HERRING OVA—TEMPERATURE OF THE WATER, ETC.

Number of Days.	Temperature of the Water. (1) Gravel. Range in °C.	(1) Gravel. Max. and Min. °F.	(2) Glass Plates. Max. and Min. °F.	(3) Tin. Max. and Min. °F.	Uncooled. Max. and Min. °F.	Flow of Water.* Nos. 1 and 2.	Tin.	Uncool'd Gravel.
						Secs.	Secs.	Secs.
1	3 – 2·6	42, 40	43, 40	42·5, 40	42·5, 40	13	..	..
2	3·4 – 2·6	42, 37	42, 37	42·5, 41	42·5, 41	14	22	95
3	3·2 – 2	38, 36	40, 36	44·5, 43	44·5, 43	18	..	..
4	4 – 1·6	38, 36	40, 36	42·5	42·5	13 – 24	22	20
5	2·5 – 1·6	38, 35	40, 35	44·5, 39	44·5, 39	17	..	..
6	2·6 – 1·6	36, 35	38, 35	41·5, 41	41·5, 41	21	..	..
7	2·2 – 1·4	36, 35	37, 36	41·5, 40	41·5, 40	9 – 21	..	..
8	2·1 – 1·4	35+, 35	36, 36	39·5	39·5	9 – 1	21, 30	14, 18
9	1·9 – 1·4	35+, 35	36, 35	42·5, 40	42·5, 40	18	22	17
10	1·9 – 1·6	37, 35	36, 35	42·5, 39	42·5, 39	16, 21	23	18
11	1·9 – 1·4	35, 35	35, 35	42·5, 39	42·5, 39	16, 22	27	20
12	1·9 – 1·4	35, 34·5	36, 35	41·5, 39	41·5, 39	14 – 26	22	..
13	1·8+ – 1·4	35, 34	35·5, 34·5	40·5, 39	40·5, 39	13 – 18	23	38
14	2·2 – 1·3	36, 34·5	36, 34·5	..	..	10 – 26	30	75
15	2 – 1·4	36, 34·5	36, 35	..	..	14 – 23	25	..
16	2·4 – 1·6	36, 35	36, 35·5	40·5, 38	40·5, 38	13 – 18	44	46
17	2·2 – 1·7	36, 35	36, 35·5	..	..	11 – 27	18 – 46	10
18	2 – 1·6	35·5, 35	36, 35·5	41·5, 40	41·5, 40	13, 17	19	10, 29
19	2 – 1·4	35·2, 34·5	35·5, 35	..	..	10 – 15	..	..
20	1·7 – 1·4	35·2, 34·5	35·5, 35	..	..	11 – 16	19	31
21	1·9 – 1·3	35, 35	35·5, 35	40·5, 37	41·5, 39	18	..	..
22	2 – 1·6	35·2, 35	35·5, 35	36, 35	..	13 – 18	..	..
23	1·8 – 1·6	35·2, 34·5	35·5, 35	37	41·5, 40	14 – 18	100	32
24	2 – 1·4	35·2, 34·5	35·5, 35	37, 35	39·5, 39	17	35	30
25	2 – 1·4	35·2, 34·5	35·2, 35	37, 35·2	42	19	34	32
26	1·8 – 1·4	35·5, 34·5	36, 35	37, 35	..	16	25	..
27	1·9 – 1·4	35·5, 34·5	36, 35	37, 35	42·5, 40	16	40	..
28	2 – 1·4	35, 34·5	35·5, 35	37, 36	42·5, 41	18, 20	..	..
29	1·9 – 1·6	35, 35	36, 35·5	37, 36	42·5, 41	20	65	..
30	1·9 – 1·6	35, 34·5	36, 35·5	37, 36	..	15 – 23	55	..
31	2 – 1·6	35·2, 34·5	36, 35·5	37·5, 36	..	15 – 32	75	..
32	2 – 1·4	35·2, 34·5	36, 35·5	37·5, 36	43·5, 41	16 – 28	65	..
33	2 – 1·4	35·2, 34·5	35·5, 35	37, 36	42·5, 41	17 – 26	..	..
34	1·9 – 1·2	35, 34	35·5, 34·5	38, 35	42·5, 40	15, 28	..	..
35	1·8 – 1·4	35, 34·2	35·5, 34·5	37, 35	41·5, 39	13 – 17	63	..
36	1·8 – 1·2	35, 34·2	35·5, 34·5	37, 35	40·5, 39	14 – 17	63	..
37	1·8 – 1·2	35, 34	35·5, 34·5	36, 35	39·5, 38	14 – 30	65	..
38	1·8 – 1·6	35, 35	36, 35·5	37·5, 35	42·5, 39	15 – 30	..	..
39	1·9 – 1·3	35·2, 34·2	36, 35	37, 37	42·5, 42	15 – 25	..	..
40	2 – 1·4	35, 35	36, 35	37, 37	..	20	..	..
41	1·8 – 1·2	35·2, 34·2	36, 34·5	38, 36	44·5, 42	15 – 25	..	..
42	2·1 – 1·4	35·5, 34·2	36, 35	..	42·5, 39	15, 17	..	..
43	1·9 – 1·4	35·5, 34·2	36, 35·2	..	..	17 – 26	63	..
44	2 – 1·4	35·5, 34·2	35·5, 35	..	44·5, 42	18 – 25	..	..

* The quantity of the flow of water is indicated by the time required to fill a vessel of a capacity of 1 pint (= ·6 litre).

INCUBATION OF HERRING OVA—*continued.*

Number of Days.	Temperature of the Water.					Flow of Water.		
	(1) Gravel.		(2) Glass Plates.	(3) Tin.	Un-cooled.			
	Range in °C.	Max. and Min. °F.	Max. and Min. °F.	Max. and Min. °F.	Max. and Min. °F.	Nos. 1 and 2.	Tin.	Uncool'd Gravel.
						Secs.	Secs.	Secs.
45	2·2 – 1·4	35, 35	36·5, 35·5	..	..	15 – 23	..	..
46	2 – 1·2	35·5, 34·2	36, 35·5	..	..	*17, 19	..	..
47	2 – 1	35·2, 34	36, 34·2	..	45·5, 42	14, 18	..	..
48	1·8 – 1	35, 34	35·5, 34·2	..	44·5, 38	18	..	..
49	2 – 1·2	35, 34	36, 35	..	43·5, 42	16 – 27	..	..
50	2·2 – 1·2	35·5, 34·2	36, 35·5	..	45·5, 44	17, 36	..	..
51	6·8	44, 36	44, 66	..	46, 44	9	..	..
52	..	..	..	..	44·5, 43·5	..	..	..
53	..	..	..	..	47, 43	..	..	..
54	..	..	..	..	49, 47	..	..	..
55	..	..	..	..	48·5, 48·5	..	..	..

* Water supply stopped for some time during the day.

RESULTS.

The Uncooled Spawn on Gravel.

This spawn was not very clean.

During incubation, the spawn was fully exposed to daylight, but not to direct sunlight. The eggs detached from the gravel varied in size from 1·32 to 1·5 mm. in diameter. Eggs which had been stuck to the gravel, and which had been forcibly detached, had lost a patch of the outer layer of the zona. This did not appear to exercise any ill effect. No crystals were observed in this lot of spawn.

The first larva appeared on the 19th day, and larvæ were obtained almost daily up to the 29th day. On the latter date a few of the eggs still contained embryos.

Spawn Incubated in the Galvanized Tin.

This lot of spawn was treated with water similar to that supplied to the uncooled gravel spawn up till the time when the larvæ began to appear, viz., on the 20th day. Thereafter the water was cooled, and the incubation-period was, in consequence, extended for an additional 21 days. The larvæ hatched out daily from the 20th to the 41st day. The results in this case were very satisfactory.

The retardation consisted in keeping the developed embryos in the egg after they were ready to hatch. The result was that many of the larvæ, when they hatched, had already consumed a large portion of the yolk. On the 40th day three had only a trace of yolk left (fig. 6), although a fourth had still a fairly large ball of yolk unabsorbed. A normally hatched larva may be 8 mm. in length: a post-larva measured 7·5 or 8 mm. The eggs did not seem to have suffered from the cooling.

Diatoms were noticed at different times on the eggs, some of which became somewhat dirty externally. They were, however, partly sheltered from the light by being enclosed within the partially-closed tin. They did not, therefore, become so dirty with diatomaceous growth as the other lots of eggs.

Crystals, in some cases in great quantity, were observed in certain eggs. The majority showed none. The crystals were attached to the zona, sometimes in rosette-form, or even inside the embryo. They were observed in one of the trunk canals, apparently the gut (fig. 3). In the embryo, a large corpuscle plugged the heart with each pulsation, and then receded again (fig. 9). Next day the corpuscle remained clear of the heart. Crystals were observed in the gut of another embryo, the heart of which had no plug. One lively embryo had a huge quantity of crystals attached to the inside of the zona.

Cooled Spawn.

The gravel spawn examined nine days after spawning seemed to be in a pretty good condition, but some dead eggs were to be seen. On the 11th day, the spawn on the glass plates looked well, except where the eggs were in a thick mass. In such places dead eggs were observed. Some of them had no doubt been killed by the pressure of adjacent eggs. Certain eggs were of especially large diameter. Three that contained embryos showed no crystals, but in certain of them a granular matter was sticking on the embryo—an unhealthy sign. An egg, 1·75 in diameter, had an unhealthy looking embryo. Two eggs measured 1·3 and 1·35 mm. in diameter. Both contained crystals. In one the crystals were large and few in number; in the other they were small and fairly numerous.

By the 22nd day a copious growth of diatoms was noticed on the eggs. The thickly-covered plates did not look so well as those that had a sparse coating of eggs. Larvæ began to appear on the 29th day. On the 42nd day a considerable quantity of dead eggs was observed. Many appeared to the naked eye of a milky tinge. That probably indicates that they had died recently. The milky appearance is due to the perivitelline fluid turning opaque. Some of the ova were yellow-coloured from the coating of diatoms.

On the 51st day, ripe eggs, containing live embryos, were quite yellowish. A good proportion of the eggs of one of the good plates seemed to have hatched.

I examined some eggs that had died recently. In one I could detect no movement of the embryo. I dissected it out of the egg capsule. The heart was found to be beating slowly. The embryo seemed to be perfect. It was, I think, dying from suffocation, due to the mat of diatoms that covered the zona. The larvæ which were obtained on each day from the 29th to the 38th day were prematurely hatched. They were very small, viz., 4·5–6 mm. long. The head was markedly bent downwards, *i.e.*, much more than in the older larvæ. The postlarval body is shorter than normal. Succeeding batches gradually improved in size. On the 38th day 94 were obtained. Compared with a larva which had consumed nearly all its yolk, they were shorter and had the head more flexed. They were pretty lively. Two measured 6 and 7·5 mm. in length respectively. Thereafter the following quantities of fry were obtained :—39th day, 120 (20 dead)*; 40th, 250 (20 dead); 41st, 191; 42nd, 335 (100 dead); 43rd, 160 (10 dead); 44th, 187 (10 dead); 45th, 98 (4 dead); 46th, 67 (8 dead); 47th, 24 (2 dead); 48th, 27 (1 dead); 49th, 16 (5 dead): 50th, 14 (4 dead): 51st, 8 (3 dead); 52nd, 1; 53rd, 1 larva.

After the 39th day the larvæ seemed normal. They were shorter on the whole than the average larva. and they had a comparatively large amount of yolk still remaining unabsorbed. The heads were flexed. They wriggled about quite actively with eel-like movement. On the 47th day two measured 7 and 8 mm. respectively. The head was only slightly flexed. On the 50th day 10 good fry showed still a good quantity of yolk. The heads were slightly flexed.

The hatching of the ova began prematurely in consequence, I consider, of the decay of the zona, caused by the diatoms attached to it. The same cause led, in my opinion, to the death, through suffocation, of many ova. There was also a large quantity of infusors and many nematodes among the eggs.

The larvæ do not appear to have developed much too rapidly. The cooling was doubtless not sufficiently low. I think a slightly lower temperature, 34° to 35° F., would not injure the ova and would probably be sufficient to retard the ova for the requisite period.

Gravel and Glass.

While the spawn attached to the gravel did very well, that on the glass could not be said to be distinctly inferior. Glass plates are much more easily handled and with their aid a larger quantity of ova can be dealt with. The spawn on the gravel was less in quantity, less crowded, and its situation on small pieces of stone permitted, possibly, a more effective aeration.

Exposure to Light: Growth of Diatoms.

A danger which was apparent during this experiment has, I believe, a greater bearing on the well-being of the ova than their location on glass or gravel. That is, exposure to light. Light has a great influence in stimulating the growth of diatoms as Allan† and Nelson show. If deprived of light the culture of diatoms dies off. The quality of the water also affects the growth of diatoms. The two authors point out that in the tank-water of the Plymouth Laboratory larger and healthier growths of diatoms were got than in water procured some distance off shore. This fact was ascribed to the greater quantity of organic matter in the tank-water.

The diatoms which grow on the ova tend to prevent the aeration of the embryo, and are also, I consider, the probable cause of the premature escape of the larvæ by hastening the decay of the zona. No doubt decay takes place normally during incubation. If that decay be hastened the embryo may be able to burst its way to freedom at a smaller size than the average.

* The larvæ were caught in a trap in which some were killed.

† "The Artificial Culture of Marine Plankton Organisms." *Quarterly Journal of Microscopical Science*, Vol. 55, Pl. 2. June, 1910.

Diatoms attached to the eggs of Lobster, exposed to bright light, caused the decay of the outer egg-membrane. (Anderton) *Report of Marine Department, New Zealand*, 1908-9. Wellington, 1909.

The Current of Water.

I think that the current of water should be strong. It is not necessary that it be continuous: it may be intermittent. A large quantity sent through the apparatus at intervals would probably be more effective than a small continuous current.

The Filter-Barrel.

During the experiment, the filter-barrel, in which was filtered the water that was cooled, was allowed to work for 40 days. This was probably an error. Whether it affected the success of the experiment is doubtful. It would be better to have the filters frequently cleaned.

Experiments with Spawn from Live and Dead Herrings.

On Galvanized Wire Gauze and Glass Plates.

A number of ripe herrings were put into a herring barrel and sent to Aberdeen. On arrival all but two were dead. The survivors were a male and a female. The herrings had been probably not more than 12 hours in the barrel. Four experiments were carried out on March 24th 1911.

(A) Some spawn was obtained from the two live fishes and it was put on a piece of galvanized wire gauze. The gauze was new, but it had been for a day or two in running sea-water. The eggs appeared to do well for a few days. They showed lots of crystals. The eggs gradually died off, and on the 25th day after fertilization all but three were dead. The embryo at that time showed black pigment in the eyes.

(B) Spawn and milt obtained from dead herrings were put on narrow-meshed galvanized wire gauze in hatchery water. The eggs developed for a time, but by the 20th day all but one or two were dead.

(C) Spawn was obtained from a dead fish and put on a glass plate. This spawn was put into the water in which the herring travelled to Aberdeen. No fresh milt was supplied to the water. I examined a drop of the water: tailed sperms were visible, but they showed little motion. Fertilization ensued, however. Although most of the eggs died off, two which had embryos ready to hatch were found alive on the 31st day. A good number of the eggs had died after pigment had began to show in the eyes of the embryo.

(D) Some spawn and milt were taken from dead herrings and put on a glass plate in new (hatchery) water. Fertilization took place in this case also. Many of the eggs had well developed embryos, but most died before hatching.

The four lots of spawn stood, after being prepared, for some hours in still water. They were then all put in a revolving tin box set in a galvanized iron tank. The water supplied to them was cooled. The temperature is given in the column marked "Tin" (p. 5) from the date March 26th onwards. One egg which had been in still water all night showed a large normally segmented disc and a huge quantity of crystals. Some fry were got from the spawn on the 26th to 31 days after fertilization.

Milt and Spawn.

Some milt from a dead herring was put into sea-water. I found the sperms (fig. 7) oscillating vigorously as if anchored by the tail. Many, however, oscillated very faintly.

No difference was observed between the spawn of the living and dead herrings.

Some unfertilized eggs, a quarter of an hour after they had been deposited on the glass plate, exhibited different shapes (fig. 8). Most of them show an inpushing where they had been pressed by another egg. No sign of perivitelline space was visible. The eggs were easily dislodged from the glass. They do not adhere strongly until the perivitelline space is formed. Three days later these unfertilized eggs had a fairly large perivitelline space, but they remained dull tinted on the outside, instead of showing a clear translucent zona.

The Crystals in the Eggs.

The crystals, which were very evident during the two previous experiments, were found also on this occasion. They are rectangular (fig. 5), sometimes ending in a tapering oblique point. They may be fine, needle-like, or fairly thick bars. They appeared in the batches of eggs which were exposed to the influence of galvanized iron. In one instance, they appeared within 36 hours after fertilization (fig. 10). This egg had been in still water in an enamelled bath for a night, and had probably with it some galvanized gauze.

No crystals were observed in the uncooled eggs on gravel. The water was delivered to these eggs through large galvanized iron pipes, which had been in use for several years. All the cooled spawn received water through a series of small galvanized iron pipes.

One remarkable fact is that the crystals were not present in all the eggs of a batch. They may be found (1) on the inside of the zona; (2) between the layers of the zona; (3) attached to the yolk or to the embryo; and (4) within the embryo.

These crystals are soluble in acetic acid, and in sodium hydrate solution. They are insoluble in water, alcohol, and methylic ether. Dr. J. K. Wood, Chemical Department, University College, Dundee, says that the crystals, being able to act both as a base and an acid, are probably formed from proteids by some process of decomposition.

I have came to regard the galvanized iron as, in some measure, the cause of the formation of these crystals. The galvanized iron becomes coated with a white incrustation in sea-water. Dr. Wood was not able to find zinc in solution in the sea-water in which a piece of this metal had been lying for several days. It seems possible that the cause of the formation of the crystals is to be found in electrolytic action. The electric current acting within the eggs on the fluids containing excretory products causes the crystallization. I formerly regarded the crystals as indicative of deficient aeration, and I still favour that view. The deficient aeration resulting in the accumulation of excretory products in the perivitelline fluid may afford the opportunity for the action of the current. All the eggs do not exhibit the crystals. It is possible that the zona may not be acting satisfactorily from the point of view of osmosis. It is possible that variation may occur in that capsule. As I pointed out above, the diameter of the zona varies much. In some eggs the two layers of the zona may be seen separated. In one egg here and there the vitelline membrane may be made out. Further, the eggs are differently served by the currents of water.

It is quite possible that the quality of the water at the Laboratory may be a contributory factor. It is probably charged with organic matter.

While active embryos are found in eggs containing the crystals, it is not likely that their presence is an advantage. When the crystals are formed in a canal in the embryo, they will almost surely prove a fatal encumbrance.

Recommendations.

If the experiment of transporting the ova of the herring to New Zealand be made, the following would, I think, be a suitable apparatus. It is shown in plan in fig. 1. It consists of six compartments, each of which contains a revolving frame. The frame will be able to carry on its external faces four glass plates, 9 inches by 7 inches. A section through two of the compartments is given in fig. 1a. A shaft running longitudinally above the middle of the apparatus would impart the revolving motion to the frames by means of little belts (rubber cord.)

The amount of water circulated through the apparatus should be as large as possible. If iron pipes are used to cool the water it will probably be better to have ordinary unprotected iron pipes.* In any case, the pipes and apparatus should be well seasoned, by being exposed to the action of sea-water, for some time previous to the experiment being made. The water when it leaves the cooling apparatus should pass into a reservoir, surrounded by ice. Thence it should flow through the apparatus. If the water be not used over again, the waste water can be utilized to cool the incoming water. Where the water is to be used over again, a pump will be required to bring it from the reservoir. A small quantity of freshly-cooled water should be steadily added.

This apparatus should be provided with lids, and should be kept in a dimly-lighted apartment.

It is most important to have clean water at all times for the spawn. This should be carefully arranged when the spawning is taking place, for mud, etc., adhere readily to the ova. Wherever necessary, the water should be filtered through sand. It is hardly possible that all the eggs pressed on to the plates will live.

Where only a small quantity of cooled water is available, it might be advisable to have it sterilized. I have not, however, made any experiments with sterilized water.

Some precautions should be observed when the spawn is being obtained. Only spawn that runs freely on gentle pressure should be employed. Milt and spawn should be preferably obtained from living fishes. The eggs should be arranged thinly on the plate. They should be protected from being touched after they are on the plate. The spawn should be brought into moving water as soon as possible.

* *Vide* Davis., "The Action of Water on Zinc and Galvanized Iron." *The Journal of Chemical Industry.* Vol. XVIII., Feb. 28, 1899.

An interval of four to six hours in quiescent water has, however, usually been given to allow of the ova becoming fastened to the glass.

The glass plates can be put into wooden boxes, each holding about six plates. The boxes may be put in a herring barrel into a frame, which can be revolved from time to time. The barrel would, if necessary, be surrounded with ice during the railway journey. The spawn should be protected from the light.

For the woodwork, I think coal-tar is a suitable preservative.

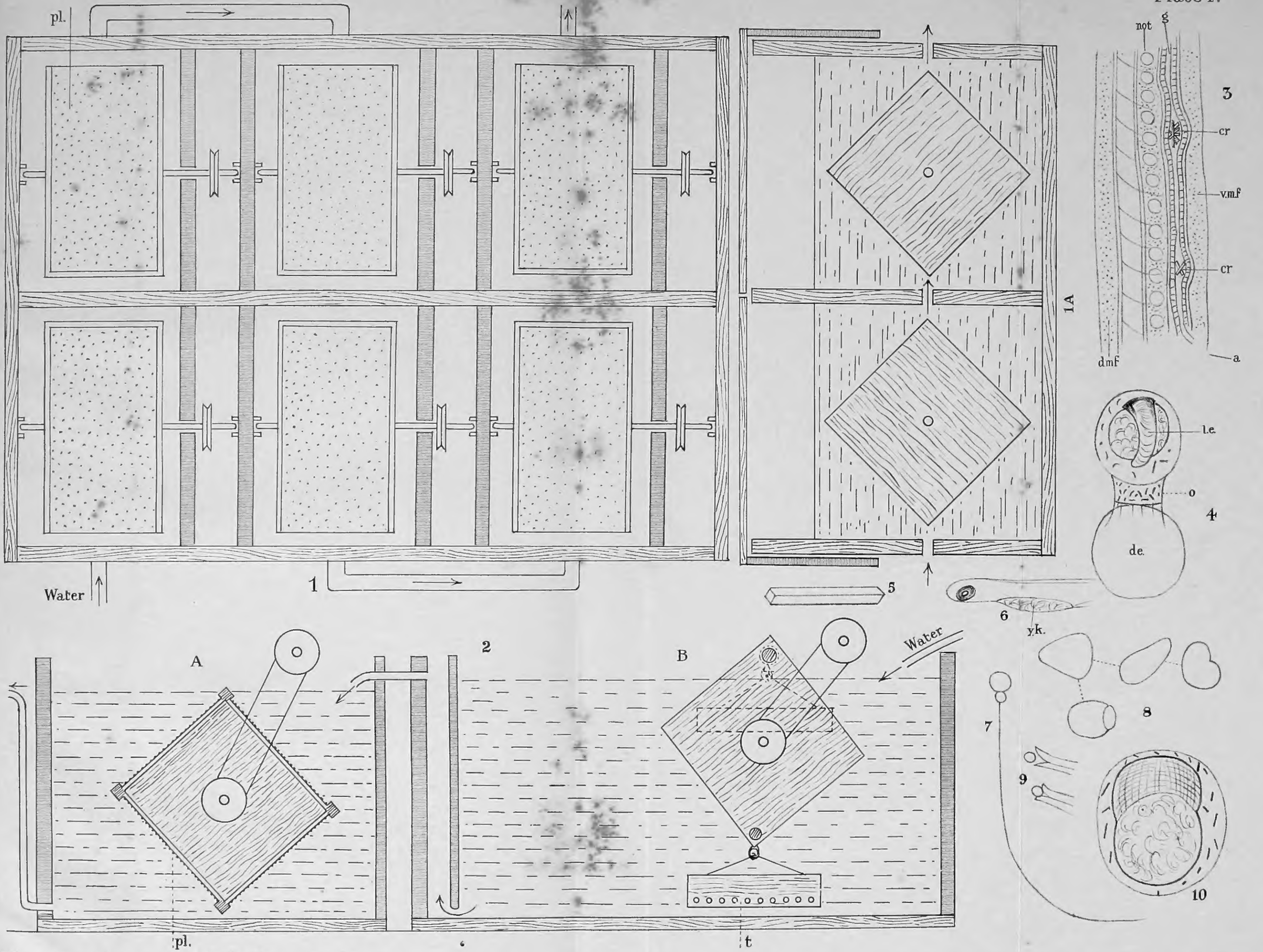
PLATE I.

Fig. 1. Drawing (plan) of apparatus for conveyance of herring spawn.
,, 1a. ,, (section) ,, ,, ,,
,, 2. Drawing of apparatus in which the cooled herring spawn was kept during the Spring of 1911.
,, 3. Enlarged drawing of part of embyro, to show crystals in gut.
,, 4. Live egg attached to dead egg, showing large number of crystals.
,, 5. Enlarged drawing of crystal.
,, 6. Enlarged drawing of anterior end of a larva, which had been retained in the egg until much of the yolk had been absorbed.
,, 7. Enlarged drawing of a sperm.
,, 8. Different shapes assumed by unfertilized eggs when they fell on the glass plate.
,, 9. Drawing to show the corpuscle which alternately blocked and receded from the heart of the embryo partially shown in fig. 3.
,, 10. Egg in which crystals had appeared within 36 hours of spawning.

LETTERS USED.

a.—Anus.
cr.—Crystal.
de.—Dead egg,
dmf.—Dorsal marginal fin.
gt.—Gut.
le.—Live egg.
nt.—Notochord.
o.—Outer skin of zona.
pl.—Glass plate.
t.—Tray.
vmf.—Ventral marginal fin.
yk.—Yolk.

Plate I.



H.C.W. Figs. I, 1A, 2 are drawn to the Scale – 1/8 inch = 1 inch.

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