Recent Reports of Fishery Authorities.

The Scottish Report for 1895.

Fourteenth Annual Report of the Fishery Board for Scotland, being for the year 1895. *Edinburgh,* 1896.

THE EFFECT OF THE CLOSURE OF INSHORE AREAS UPON THE SIZE AND ABUNDANCE OF THE FOOD-FISHES WHICH THEY CONTAIN.—In the Report under consideration Dr. T. Wemyss Fulton, the Scientific Superintendent of the Scottish Fishery Board, publishes an important Review of the Trawling Experiments of the *Garland* in the Firth of Forth and St. Andrews Bay in the years 1886–1895. As is well known, these areas have been closed to trawlers during the ten years under consideration. The Board's steamboat *Garland* has from time to time made experimental hauls with a 25 ft. beam-trawl along certain fixed lines within the areas, the fish captured being measured and recorded, and the results of the experiments published from year to year in the Reports. After ten years' work, Dr. Fulton now gives a general review of the whole investigation, and indicates the conclusions to which, in his opinion, the results of the experiments seem to point.

The views expressed are of so much importance that we prefer to give the account of the manner in which the observations were recorded, and the summary and general conclusions, in Dr. Fulton's own words:—

"In conducting the trawling experiments the aim has been, as far as possible, to trawl over each station at intervals of about a month, and to keep careful records of each haul, and of the conditions under which it was made. The regular trawling work has been done only in the day-time . . . . The observations at each station comprised (1) the date and hour of the haul and its duration; (2) the temperature of the air and of the water at surface and bottom; (3) the density of the water at surface and bottom; (4) the transparency of the water, as indicated by the depth at which an enamelled disc just ceased to be visible; (5) the direction and force of the wind, the state of the tide, the condition of the weather and of the sea in regard to surface disturbance, and the height of the barometer — the temperature, density, and other observations being taken at the beginning and at the end of the trawling; that is to say, at each end of the station; (6) the nature of the pelagic fauna, collections being made by means of tow-nets at surface and bottom, and occasionally at intermediate depths; (7) the number of each species of fish, and the length of each individual caught in the trawl; (8) the nature and relative abundance of the invertebrate organisms found in the trawl, which form a large portion of the food of the bottom-living fishes."

"Summary and Conclusions.

"While the trawling experiments of the *Garland* in the Firth of Forth and St. Andrews Bay have been productive of a great body of scientific knowledge respecting the reproduction, spawning areas, and the natural history generally of the food-fishes, the immediate practical object in view was to ascertain the influence which the cessation of beam-trawling would have upon the relative abundance of the food-fishes within the closed areas. The method adopted for this purpose has been already explained, namely, the periodic examination of certain selected stations in each of the areas, the enumeration and measurement of the fishes caught, and the comparison of the statistics thus obtained from month to month and year to year. A question which confronts one at the outset is whether the period during which the experiments have been carried on is sufficiently long to enable definite conclusions to be formulated with certainty. It is evident, on the one hand, that if trustworthy conclusions in regard to the influence of beam-trawling can be drawn from the ten years' experiments in the Firth of Forth and St. Andrews Bay, it is unnecessary that they should be continued there. On the other hand, it would be obviously unwise to terminate them until definite conclusions are obtained, since so much depends upon them.

"The problem is complex, inasmuch as the natural causes, which are of course by far the most important in producing fluctuations in the abundance of the food-fishes in any given area, are very variable and very obscure. There is in the first place the group of physical influences, such as the weather, storms, currents, and temperature, acting directly upon the fishes themselves at all stages of their life, from the floating egg onward to the adult condition, and upon the organisms upon which they feed; and in the second place, a group of biological causes, such as variations in reproductive activity, migrations from the closed area to the outer waters, and *vice versa*, and the presence, or absence, of other fishes upon which particular species feed, *e.g.*, the herring. For example, it was discovered by the fine-meshed nets of the *Garland* that in the autumn of 1889 a vast shoal of young whiting —computed after careful observations to number over 200,000,000— was present in the Firth of Forth. They were too small to be caught that year in the ordinary net used in the trawling experiments, and the average for that year was not large. But in 1890 the average number rose in the closed waters of the Forth from 13·6 to 56·9, and in the open waters from 19·9 to 121·6; and the fishermen in the district caught very nearly double the quantity of whitings that they did in 1889. This increase in the abundance of whitings was local, and may have been due to a combination of causes. Another example was the sudden and extraordinary abundance of small haddocks all along the east coast of Scotland in 1893. In the Firth of Forth the average sprang up from 22·1 to 118·8 in the closed waters (over 1000 being sometimes taken in a haul), and in the open waters from 42·4 to 176·3; and in the closed waters of St. Andrews Bay the average rose from 1·0 to 23·8, and in the open area from 8·8 to 43·8.

"These instances will suffice to show how sudden and marked the natural fluctuations may be, and how they tend to obscure the influence of a minor though constant factor, such as a mode of fishing. The answer to the question as to how long it is necessary to continue the observations in the Firth of Forth and St. Andrews Bay depends to a large extent upon the continuity of the results underlying the variations, as determined by a comparison of the averages in the first and second parts of the period during which they have been carried on. From the statistical analysis given in the foregoing pages, and summarised below, it appears to be fairly well proved that there has been a diminution of the more important flat-fishes in the closed waters, instead of an increase, as was anticipated; and that this may probably be traced to the influence of beam-trawling in the open waters where the fishes spawn; but with regard to round-fishes, which are more numerous and migratory, the same conclusion cannot at present be drawn. In my opinion, after full consideration of the question, the best course is in the meantime to suspend the trawling experiments in the Firth of Forth and St. Andrews Bay, and to carry them on systematically in the Firth of Clyde and the Moray Firth. Both of these areas contain within the closed limits extensive spawning grounds (which are absent from the Firth of Forth and St. Andrews Bay) that are frequented by successive shoals of the food-fishes at the spawning time; and it is of great importance to ascertain the effect of the protection of these spawning places.

"The statistics of the ten years' observations in the Firth of Forth and St. Andrews Bay point to the following conclusions:—

"1. No very marked change has taken place in the abundance of the food-fishes generally within the closed or open waters since the prohibition of trawling. The average number of the food-fishes (taken together) caught in each haul of the net in the years 1886–1890 was 242·6 in the closed waters of the Forth, and 160·9 in the open waters; in the closed waters of St. Andrews Bay the average was 290·2, and in the open waters 190·4. In the five years 1891–1895, the general averages were 252·8 for the closed area of the Forth, and 171·7 in the open area; for the closed area of St. Andrews Bay the average was 184·5, and for the open area 182·7. There was thus a decrease in both areas of St. Andrews Bay, and an increase in both areas of the Forth.

"2. Among round-fishes, cod increased in numbers in all the areas, closed and open. Haddocks increased in the closed and open areas of the Forth, and in the open waters of St. Andrews Bay, and decreased in the closed waters of St. Andrews Bay. Whitings decreased in abundance in all the areas, and gurnards increased in the closed waters of the Forth, and decreased in the other three areas.

"3. Flat-fishes, taking the different kinds together, increased in the open waters of St. Andrews Bay, and decreased in all the other areas. Plaice decreased in all the areas to the extent of 8·7 fishes per haul of the net in the closed waters of the Firth of Forth, and no less than 74·9 fishes per haul in the closed waters of St. Andrews Bay; in the open waters of St. Andrews Bay the decrease was 23·1 fishes per haul, and in the open waters of the Forth, where they are scarcer, 0·6 per haul. Lemon soles, in like manner, diminished in abundance in all the areas—to the extent of 8·4 fishes per haul of the net in the closed area of the Firth. In the other areas, where they are much scarcer, the decrease was less striking. These are the most important and valuable of the flat-fishes obtained: turbot and brill were not caught in sufficient numbers to enable an average to be usefully calculated. On the other hand, the common and abundant dabs, commercially of little importance, increased rather than diminished in numbers. The common dab increased in the closed area of the Forth by 8·9 fishes per haul, and in the open area of St. Andrews Bay by 29·3 fishes per haul; they decreased in the closed area of St. Andrews Bay by 20·3 fishes per haul, and in the open waters of the Forth by 2·1 per haul. The long rough dab increased in all the areas, except in the closed area of St. Andrews Bay, where they are very scarce, the decrease there being 0·5 per haul. In the closed waters of the Forth their increase amounted to 6·2 fishes per haul, and in the open waters to 4·9 per haul; in the open waters of St. Andrews Bay the increase was 3·3 per haul.

"These facts in connection with the relative abundance of flat-fishes are of importance. On the face of it, it appears strange that there should have been a fairly continuous decrease in the numbers of plaice and lemon soles in the closed waters throughout the period. Fluctuations have undoubtedly occurred from year to year, but, as has been frequently pointed out in previous reports, the statistics show a fairly steady falling off in the abundance of the species; and of such a character, when compared with the variations of other species, as to preclude the idea that it is due to the operation of natural causes. It was naturally expected that the prohibition of the use of the beam-trawl in the Firth of Forth and St. Andrews Bay would be followed by an increase and not by a decrease in the numbers of these species within the closed area, because the beam-trawl is the most effective fishing instrument by which they are captured, and its interdiction was equivalent to the removal probably of their greatest enemy.*

"But such has not been the case. Before dealing with the probable cause of the falling off among plaice and lemon soles attention may be directed to the increase in the numbers of common dabs and long rough dabs, which may be said to have taken the place to some extent in the closed waters of the more valuable flat-fishes. Taking the figures for the closed area of the Firth of Forth as the result of 574 hauls of the net during the ten years, the decrease in the number of plaice caught per haul of the net is found to have been 8·7, and of lemon soles 8·4, a decrease almost exactly counterbalanced by the increase in common dabs, which was 8·9, and in long rough dabs, which was 6·2. This clearly indicates a change in the relative proportion of the flat-fishes in the area, from whatever cause arising. Now there are some important differences in this connection between the dabs on the one hand, and the plaice and the lemon soles on the other. The dabs become mature while still comparatively small, and escape in great numbers through the meshes of an ordinary trawl net, and they spawn to a large extent in the closed waters. Plaice and lemon soles, on the contrary, do not spawn within the closed waters, and immature individuals are caught in great numbers by the ordinary trawl net. Thus the size at which common dabs and long rough dabs become mature is about 5 inches—the males frequently at a smaller size—while plaice do not become

* "The proportion of the fish present in a given area that may be captured by fishing apparatus is frequently under-estimated. Of several thousands of plaice, marked for future identification and returned living to the closed waters, about 12 per cent. were subsequently recaptured and returned to me within 18 months—and mostly within a few months—of their liberation. They were nearly all retaken in the closed waters by hook; and as there is no reason to suppose that the marked fish were more prone to seize the bait than the fish around them which had not previously been captured, it may be assumed that at least 1 in 9 or 1 in 10 of the plaice living on an area fall victims to the hook of the fisherman. With the beam-trawl the proportion would have been very much greater.—*Vide* 'An Experimental Investigation on the Migrations and Rate of Growth of the Food Fishes,' Part III., *Eleventh Annual Report*, p. 176."

mature until they are 13 or 14 inches long, and lemon soles not until they reach a length of 9 or 10 inches.*

"The consequence of this difference in the length when sexual maturity is first reached in the two groups is that all adult plaice and lemon soles, and large numbers which have not yet reached maturity, which enter an ordinary trawl net, cannot escape through the meshes, and are captured; while large numbers of adult dabs of both species, and by far the greater proportion of the immature, do escape through the meshes of the net, and are therefore not caught. In other words, the ordinary beam-trawl is not anything like so destructive to dabs as to plaice and lemon soles. The special experiments made on the *Garland* bring out this matter in a marked manner.†

"Thus in 43 hauls of the *Garland's* ordinary net, having meshes in the cod-end of 1½ inches from knot to knot, 2705 plaice of all sizes were retained in the net, and only 67 escaped through the meshes; among lemon soles 371 were retained, and 154 escaped; among common dabs 3367 were retained and 9892 escaped; and among long rough dabs 506 were retained, and 2562 passed through the meshes. Of the 67 plaice which escaped, 59 were 7 inches or less in length, and only 8 above that size (8 inches); of the 154 lemon soles none were above 7 inches; of the 9892 common dabs which found their way out of the net, 2086 were 6 inches or over—that is to say, of adult size—and 5426 were 5 inches in length, or about the size at which maturity is reached; of the 2562 long rough dabs which escaped, 1238 were 5 inches or over.

"The other point is also of importance, namely, the place where the fishes spawn; and the information on this subject obtained by the *Garland* is of great value.‡ The plaice and the lemon sole spawn outside the territorial waters, and therefore beyond the limits of the closed areas. All the plaice and almost all the lemon soles in the Firth of Forth and St. Andrews Bay come in from the outer waters, their floating pelagic eggs, or their equally helpless larvæ, being borne in by the currents; or some may have migrated thither at a later stage. The abundance of these forms in the closed areas is therefore strictly and directly dependent on the outer seas. It is not the same with the dabs. They seem to spawn indifferently in the closed and in the open waters, although spawning individuals are rather more numerous in the latter.

* "*Vide* 'Observations on the Reproduction, Maturity, and Sexual Relations of the Food-Fishes,' Part III., *Tenth Annual Report*, p. 232."

† "*Vide* 'The Capture and Destruction of Immature Sea Fishes,' Part III., 'The Relation between the Size of the Mesh of Trawl Nets and the Fish Captured,' Part III., *Twelfth Annual Report*, p. 302."

‡ "*Vide* 'The Spawning and Spawning-Places of Marine Food-Fishes,' Part III., *Eighth Annual Report*, p. 257; also Part III., *Tenth Annual Report*, p. 235."

An area like the Firth of Forth is therefore, to a very large extent, independent of the outer seas so far as concerns its supply of dabs, it being in large measure self-productive.

"The differences above described between the plaice and lemon soles and the dabs seem to furnish a reasonable explanation of their decrease and increase respectively. When beam-trawlers were prohibited from working in the Firth of Forth and St. Andrews Bay, they naturally concentrated their efforts in the free waters outside, and trawling operations there have very greatly increased since the Bye-laws were passed. The immediate consequence of the cessation of trawling in the Firth of Forth and St. Andrews Bay appears to have been an increase in the abundance of flat-fishes within the closed areas, as shown by the very high averages in the year 1887. The fact that this increase was not only not maintained, but that a progressive decrease in plaice and lemon soles occurred subsequently, indicates another influence, namely, excessive trawling on the offshore grounds where these fishes spawn. This would affect the abundance of the important flat-fishes, such as plaice and lemon soles, in two ways. By general overfishing, the numbers are decreased on the fishing-ground, as indicated by the averages for the open area; and in the second place, by the removal of too great a proportion of the mature spawning fishes, the supply of floating eggs and larvæ to the inshore closed areas, and upon which they are dependent, is diminished below the normal, with the result that the supply of adults is also subsequently diminished. This appears to me to be the only feasible explanation of the facts stated, and it would indicate protection of the spawning areas as the proper course to be pursued. The protection of the immature fishes, which has been so strongly advocated by many authorities, will not, it can be safely said, be sufficient in the areas under consideration. This is clearly proved by the fact that the fish which, above all others, has the nurseries of its young located in the inshore waters is the plaice. The distribution of immature plaice is special in this respect, by far the largest number being got near the shore, and fewer and fewer the further from the shore.* In the Firth of Forth and St. Andrews Bay immature plaice have therefore been particularly well protected since 1886, and yet this is the species whose diminution is most marked.

"The results of the trawling experiments hitherto conducted in the Firth of Forth and St. Andrews Bay point to two main conclusions of great importance for fishery regulations. One, which may be regarded as demonstrated, is that the mere closure of even large areas in the territorial waters, such as the Firth of Forth and St. Andrews

* "*Vide* 'The Distribution of Immature Sea Fish and their Capture by various Modes of Fishing,' Part III., *Eighth Annual Report*, p. 166."

Bay, which are destitute of spawning-grounds, will have little or no permanent effect in increasing the abundance of the important food-fishes, and especially the flat-fishes, within them. The other, which, although highly probable, has not yet been actually demonstrated by experiment, is that protection of the offshore spawning-grounds for certain periods is the most likely method of increasing the abundance of the fishes in the inshore waters. In completion of the experiments in the Firth of Forth and St. Andrews Bay, it would be desirable if a part at least of the offshore waters from which the supplies of floating eggs and larvæ to these areas are drawn were closed during the spawning season. It would then be possible to ascertain, by comparison of the results with those already obtained, to what extent protection of spawning areas will lead to an increase in the fish supply within the territorial waters. The extent and situation of the offshore areas which stand in this direct and close relationship to a given portion of the territorial waters have not yet been satisfactorily determined; but experiments are now being made to clear up this point."

THE DUNBAR HATCHERY.—Mr. Harald Dannevig gives an account of the working of the Marine Hatchery at Dunbar during 1895. Three species, the turbot, the lemon sole, and the plaice, were dealt with. As in previous years, the great difficulty has been in obtaining a sufficient supply of spawning fish in a healthy condition. In the case of the turbot, the supply consisted of thirty-four fish, which had to be brought to Dunbar from Girvan on the west coast, and no natural spawning took place. Eggs were, however, pressed from the ripe fish and successfully fertilised. About 3,800,000 larval turbot were hatched and distributed in the neighbourhood of Dunbar.

Less difficulty was experienced with the lemon soles, which, when they reached the hatchery uninjured, spawned naturally. About 4,480,000 fertilised eggs were obtained during the season from a stock of sixty-eight healthy fish, and from these 4,145,000 larvæ were successfully hatched out and distributed in the local waters and westwards as far as the Bass Rock, the loss of eggs during development being thus only 7·5 per cent.

In the case of the plaice again it was found necessary, in order to ensure a good supply of eggs, to press them from the ripe females and artificially fertilise. In this way 14,970,000 eggs were obtained, and from them 11,350,000 larvæ were hatched. About 7,000,000 of these larvæ were distributed in the North Sea in the neighbourhood of Dunbar. It was considered advisable, however, to test, if possible, the effect produced by thus placing large numbers of newly-hatched larvæ in the sea, and in order to do this it was determined to attempt to place them in a more or less confined area. For this purpose Loch

Fyne, on the west coast of Scotland, was selected, 4,000,000 larvæ being conveyed there by train in four separate consignments. The transport appears to have been fairly successful, though on two occasions the larvæ are reported as showing a certain amount of weakness when put out in the loch. This difficulty will no doubt be got over after further experience in the best methods of transport has been gained.

THE OYSTER BEDS OF THE FIRTH OF FORTH.—Dr. Fulton contributes a second valuable paper to the Report, in which he discusses the past and present condition of the oyster beds in the Firth of Forth. The causes of the exhaustion of the beds are considered, and various suggestions made as to the measures which should be adopted in order to make them again productive. Dr. Fulton considers that the present condition of the beds is entirely due to improper fishing and the neglect of efficient regulations; and further, that there is still a chance of restoring at least a part of them by judicious aid. The measures recommended are (1) the laying down of a stock of oysters to furnish spat; (2) the supply of suitable cultch for the reception of the spat; and (3) keeping the ground clean and as free as possible from enemies. As no oysters are so suitable for any locality as the oysters which naturally live there or in the neighbourhood, by far the best means of obtaining the breeding stock would be to collect the oysters at present scattered over the beds, and to lay them down in one or more selected places. This might be done by purchasing from the fishermen the oysters taken when dredging for mussels and clams. The oysters thus obtained for breeding purposes might be supplemented by others obtained elsewhere.

In order to obtain a supply of clean cultch for the spat to settle upon, mussel and clam shells might be collected from the various villages and exposed to the sun and air until the spatting time, when they should be strewn on the various grounds. Dr. Fulton calculates that an expenditure of £600 per annum for five or six years would be sufficient to carry out the scheme he recommends, including the protection of the areas where the breeding stock was deposited. On the other hand, the fishermen on the south side of the Firth of Forth have lost during the last twenty years fully £150,000 by the exhaustion of the beds, to say nothing of the loss to the citizens.

RATE OF GROWTH OF THE HERRING.—Mr. Masterman's paper, "On the Rate of Growth of the Food-Fishes," deals with the rate of growth of the Herring at St. Andrews, and the author gives the following summary of his conclusions:—"The young larva, hatched at from 5 to 7 mm. ($\frac{2}{10}$ inch) in length, lives near the bottom till some 10 mm. ($\frac{4}{10}$ inch) is attained by a rapid increase in length. The attenuated post-larval herring then migrates upwards through the mid-water to the surface, the mid-water stage lasting from about 10 mm. ($\frac{4}{10}$ inch) to

23–24 mm. ($\frac{9}{10}$ inch), and the surface stage from 24 mm. to 27–28 mm. (about 1 inch), when a movement shorewards takes place, and the littoral habit is acquired." The young herring of the spring-spawning remain near shore, chiefly at the mouths of rivers, until mid-winter, when the length of some 50 mm. (2 inches) has been reached. They are not found during the spring and summer, but recur in the same localities in the autumn with a length of about 80 mm. ($3\frac{1}{5}$ inches), which is increased to 100 mm. (4 inches) by the end of the year.

OTHER PAPERS.—Dr. J. H. Fullarton contributes a memoir on the European Lobster, in which he deals chiefly with the breeding and development of that animal. His results agree in the main with those obtained by Ehrenbaum in Heligoland, a full account of which was given in this Journal, vol. iv. pp. 60–69. A series of figures is given, showing the external appearance of the embryos and larvæ at various stages of development.

Amongst the other papers may be mentioned Professor M'Intosh's "Contributions to the Life-Histories and Development of the Food and other Fishes," and Mr. Thomas Scott's faunistic papers, dealing with the Firth of Forth, the inland waters of Scotland, and the inland waters of the Shetland Islands.

The Danish Report.

Report of the Danish Biological Station to the Home Department. V. 1894. *By C. G. John Petersen, Ph.D., Copenhagen,* 1896.

THE BRIDAL-DRESS OF THE COMMON EEL.*—Dr. C. G. J. Petersen's paper—"The Common Eel (*Anguilla vulgaris, Turton*) gets a particular breeding-dress before its emigration to the sea. The bearings of this fact on the classification and on the practical Eel-fisheries"—forms an important contribution to the solution of the mystery which has surrounded the life-history of the eel, and serves to complete the brilliant observations of Professor Grassi, an account of which was given in this Journal two years ago by Mr. Cunningham.

Three different kinds of eel have been recognised both by fishermen and naturalists. Thus Yarrel distinguishes three species, the sharp-nosed eel—silver eel of the fishermen—(*Anguilla acutirostris*), the broad-nosed eel—grig or frog-mouthed eel of fishermen—(*Anguilla*

* On this subject compare also Professor G. B. Grassi, "The Reproduction and Metamorphosis of the Common Eel (*Anguilla vulgaris*)." *Proceed. Roy. Soc. London*, No. 363, December, 1896. An account of Grassi's observations is given by Cunningham, "The Larva of the Eel," *Journ. Mar. Biol. Assoc.*, vol. iii. pp. 278-287.

latirostris), and the snig or yellow eel (*Anguilla mediorostris*). Later authors have, for the most part, regarded the three kinds as varieties of one species, *Anguilla vulgaris*. Günther, however, in his *Catalogue of the Fishes in the British Museum*, attempts to distinguish two species, *A. vulgaris* and *A. latirostris*, the latter being the frog-mouthed or broad-nosed eel of Yarrel.

In the Report now under review Petersen regards the three so-called varieties as representing three stages in the development of one and the same animal, and his conclusions, based upon a large number of carefully-considered observations, appear to be well founded. Briefly stated the result arrived at is, that the yellow eels comprise both males and females, but are all young fish, which have not yet commenced to assume the bridal-dress of the adult, and in which the generative organs are little developed. The frog-mouthed eels are larger females still in the same conditions, whilst the silver eels comprise both males and females which have taken on the bridal-dress. The generative organs of the latter class are more fully developed, and the animals just on the point of migrating to the sea to spawn.

The following more detailed account of the three kinds of eels is derived from that given by Petersen.

Yellow Eels.—The yellow eels are generally of rather light colour, the back, for instance, being grey or brownish, often with a greenish shade, the sides pale yellow, and the belly either like the sides or of a pure white. They are found in both salt and fresh water, and are taken during the winter as well as in summer. The digestive organs are well developed, and the eels feed voraciously. The snout in front of the eyes is much flattened; the eyes are small, the interorbital space being greater than the horizontal diameter of the eye—in larger specimens generally about double the size. Looked at vertically from above the eyes face upwards rather than sideways, and the corners of the mouth, with the lips, can be seen distinctly outside the eyes. The pectoral fins are light in colour and rounded posteriorly. The skin is thin, the scales are but slightly visible, and very little *guanine*, which gives the metallic, silvery look to the silver eels, is deposited. The lateral line and its branchings can be seen, but not very distinctly. The yellow eels comprise both males and females, but there are no good external characters to distinguish the sexes excepting size, the males being never longer than 48 cm. (19 inches), whilst the females can reach $\frac{1}{2}$ to 1 metre (20 to 40 inches). The generative organs are but little developed in either sex, although they are sufficiently so to make it quite possible to distinguish males from females, without microscopic examination, in specimens 10 inches long and upwards. With the aid of the microscope the sexes may be distinguished by an examination of the reproductive organs in specimens down to 8 inches. Below this size the distinction is impossible.

FROG-MOUTHED EELS.—These are really the same as the yellow eels, excepting that they are much larger and are all females. They are large females, with ovaries as yet but little developed, and which have not commenced to take on the breeding-dress. Their bodies are long and lean, and they feed voraciously. The pectoral fins are light coloured and rounded behind. The heads appear large in proportion to the bodies, and possess the same characters as the heads of the yellow eels in a more exaggerated form. These large, lean fish appear in numbers at the beginning of summer, having probably been starving during the winter. They are caught in large numbers on hooks baited with fish, and their stomachs are often much dilated with food. Later in the year they become less frequent, having become fat and taken on the breeding-dress.

SILVER EELS.—These are yellow eels, which have assumed the breeding-dress, and are about to migrate to the sea to breed. The author has observed all transition stages between yellow and silver eels, and yellow eels with commencing metallic lustre kept in caufs he has frequently observed transformed in a few weeks into silver eels.

Silver eels are all of large size, and comprise both males and females. No males have been found under 29 cm. (11½ inches) long, and they are rare at this size. The smallest female observed was 42 cm. (16½ inches) long, but these also are seldom seen so small. The bodies of the silver eels are plump and fat. The snout in front of the eyes, particularly in the males, is high and a little compressed, probably owing to the considerable development of the olfactory organs and an increase in the size of the eyes. When the head is looked at vertically from above, the eyes protrude beyond the lips, and face sideways or outwards rather than, as in the yellow eels, upwards. The eyes are also considerably larger than in yellow eels of the same length. This was proved both by measuring and weighing eyes from the two kinds. The colour of the back is dark, nearly black; there are bronze streaks at the sides, and the ventral side is silver-white with a metallic lustre. The pectoral fins are dark coloured, even black, pointed behind, and longer in proportion to the head than those of the yellow eels, which are bright coloured and rounded. The skin of the body is thick and firm, the outlines of the scales distinct, and the lateral line, with its ramifications, easily seen.

The silver eels do not feed much, and are seldom caught on hooks. The digestive organs are comparatively much smaller than those of yellow eels, as the author has proved by weighing them, whilst the reproductive organs of both males and females are in a much more advanced condition. The silver eels emigrate from the rivers to the sea in summer and autumn, and are caught in traps, the mouths of which are set to face up-stream. In winter all the eels caught are yellow eels.

Petersen points out that, in consequence of the above relations between the different kinds of eels in closed waters or rivers, where all the silver eels can be caught as they emigrate to the sea, the yellow eels should not be taken at other times, but allowed to remain until they become silver eels of larger size and greater value.

In confirmation of Petersen's views, and in order to complete the history, we may add the following quotation from Grassi's most recent paper in the *Proceedings of the Royal Society**:—

"In another point my researches have yielded a very interesting result. As a result of the observations of Petersen, we know now that the common eel develops a bridal coloration or 'mating habit,' which is chiefly characterised by the silver pigment without trace of yellow, and by the more or less black colour of the pectoral fin, and finally by the large eyes. Petersen inferred that this was the bridal coloration from the circumstance that the individuals exhibiting it had the genital organs largely developed, had ceased to take nourishment, and were migrating to the sea. Here Petersen's observations cease and mine begin. The same currents at Messina, which bring us the Leptocephali, bring us also many specimens of the common eel, all of which exhibit the silver coloration. Not a few of them present the characters described by Petersen in an exaggerated condition; that is to say, the eyes are larger and nearly round instead of elliptical, whilst the pectoral fins are of an intense black. It is worth noting that in a certain number of them the anterior margin of the gill-slit is intensely black, a character which I have never observed in eels which had not yet migrated to the sea, and which is wanting in the figures and in the originals sent to me by Petersen himself. Undoubtedly the most important of these changes is that of the increase of the diameter of the eye, because it finds its physiological explanation in the circumstance that the eel matures in the depths of the sea. That, as a matter of fact, eels dredged from the bottom of the sea have larger eyes than one ever finds in fresh-water eels, I have proved by many comparative measurements, made between eels dredged from the sea-bottom and others which had not yet passed into the deep waters of the sea. Thus, for instance, in a male eel taken from the Messina currents, and having a total length of $34\frac{1}{2}$ cm.,

* *Proceedings Roy. Soc.*, vol. lx. No. 363. See also *Quart. Journ. Micr. Sci.*, New Series, vol. xxxix. part 3.

the eye had a diameter, both vertical and transversal, of 9 mm.; and in another eel of 33½ cm. the same measurement was recorded. In a female eel, derived from the same source and purchased in the market, whose length was 48½ cm., the vertical diameter of the eye was 10 mm., and the transversal diameter rather more than 10 mm. These are not the greatest dimensions which I observed, and I conclude from these facts that the bridal-habit described by Petersen was not quite completed in his specimens, and that it becomes so only in the sea and at a great depth. In relation to these observations of mine stands the fact that the genital organs in the eel taken in the Messina currents are sometimes more developed than in eels which have not yet entered the deep water. Thus it has happened that male individuals have occurred, showing in the testes here and there knots of spermatozoa. These spermatozoa are similar to those of the *Conger vulgaris,* and must be considered as ripe. As is well known, so advanced a stage of sexual maturity has never before been observed in the common eel. This appears to be due to the fact that the males hitherto examined had not yet migrated into the deep water of the sea. . . . .

"To sum up, *Anguilla vulgaris,* the common eel, matures in the depths of the sea, where it acquires larger eyes than are ever observed in individuals which have not yet migrated to deep water, with the exception of the eels of the Roman cloacæ. The abysses of the sea are the spawning places of the common eel: its eggs float in the sea water. In developing from the egg, it undergoes a metamorphosis, that is to say, passes through a larval form denominated *Leptocephalus brevirostris.* What length of time this development requires is very difficult to establish. So far we have only the following data:—First, *Anguilla vulgaris* migrates to the sea from the month of October to the month of January; second, the currents, such as those of Messina, throw up from the abysses of the sea specimens which, from the commencement of November to the end of July, are observed to be more advanced in development than at other times, but not yet arrived at total maturity; third, eggs, which according to every probability belong to the common eel, are found in the sea from the month of August to that of January inclusive; fourth, the *Leptocephalus brevirostris* abounds from February to September. As to the other months, we are in some uncertainty, because during them our only natural fisherman, the *Orthagoriscus mola,* appears very rarely; fifth, I am inclined to believe that the elvers ascending our rivers are already one year old, and I have observed that in an aquarium specimens of *L. brevirostris* can transform themselves into young elvers in one month's time."

Report of the Heligoland Biological Station.

Wissenschaftliche Meeresuntersuchungen herausgegeben von der Kommission zur wissenschaftlichen Untersuchung der deutschen Meere in Kiel und der Biologischen Anstalt auf Helgoland. Neue Folge, Zweiter Band. Heft 1, Abt. 1. 1896.

THE EGGS AND LARVÆ OF FISHES.—In the present communication, which is to be followed by others on the same subject, the author deals with the eggs and various larval stages of the flat-fishes found in the neighbourhood of Heligoland, and with the eggs and larvæ of the sprat. Excellent figures are given of stages in the larval development of the plaice, dab, flounder, turbot, brill, scald-back, sole, solenette, and of the sprat. Similar larvæ of most of these species have already been figured by naturalists, but many intermediate stages are now shown for the first time, and it will be a great convenience to other workers to have such excellent figures of successive larvæ thus brought together.

The most important additions to our knowledge of the development of fishes which Dr. Ehrenbaum makes are the full accounts which he furnishes of the eggs and various larval stages of the scald-back (*Arnoglossus laterna*) and the solenette (*Solea lutea*), concerning which little was previously known. He has been able to show that in the case of the former species (*Arnoglossus laterna*) metamorphosis takes place in a similar way to that described by Steenstrup, Agassiz, and Pfeffer in the genus *Plagusia;* that is to say, the right eye, during metamorphosis, does not pass round the top of the head, as in the turbot, brill, etc., but appears to come through it. What really happens, however, in these cases is not that the eye actually comes through the skull of the fish, but that the dorsal fin extends forwards to the snout, whilst the eyes are still on each side, and with the rotation of the head during metamorphosis the eye is carried round and pierces the fleshy portion of the base of this fin.