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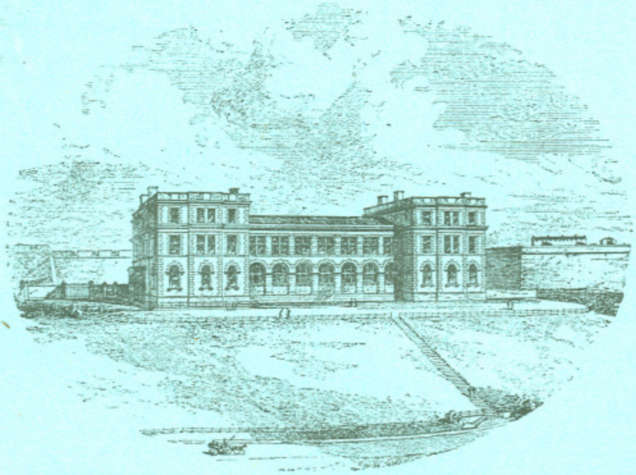

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The Impoverishment of the Sea.

A Critical Summary of the Experimental and Statistical Evidence bearing upon the Alleged Depletion of the Trawling Grounds.

By

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INTRODUCTION.

In the present essay I have endeavoured to bring together the most precise and reliable evidences available as to the recent and present condition of the great trawl and line fisheries of England and Wales. Both these fisheries depend for their success upon the same fundamental conditions, viz. the abundance of fish upon the bed of the sea. They may rightly, therefore, be grouped together under the single head of "bottom fisheries," in contrast to the fisheries for herrings, mackerel, and pilchards, which are "surface fisheries." From the nature of the case, even great fluctuations in the annual produce of the latter fisheries scarcely excite surprise, but a fairly constant yield is tacitly expected of the bottom fisheries, when the same apparatus is employed, owing to the greater uniformity in the conditions of life on the sea-floor.

It is probable, however, that the extent to which the stock of fish on the sea-bottom depends upon variable elements, largely influenced by the weather, is not fully appreciated even by the experienced fisherman. The reproduction even of bottom fishes is profoundly affected by the conditions of temperature, wind, and salinity prevailing at the surface and inshore during the breeding season,* since the majority of sea-fishes produce pelagic eggs, and many of them pass their early youth inshore. Temperature affects both the duration of the period of incubation and the rate of growth, directly by its action upon the metabolism of the fish, and indirectly by its influence on the growth and multiplication of lower organisms available as food. Changes in salinity may kill the larvæ, stunt their growth, or create an impassable barrier to fishes on migration. Unfavourable winds during the spawning seasons may drive millions of eggs and larvæ to a premature death. Even if the local weather, during any given term of years, be admitted to have shown no marked abnormality, it is always possible that weather changes of great magnitude beyond the region of the fishing grounds may so divert the great ocean drifts from their usual courses as to modify appreciably the normal distribution of temperature and other factors within the region. The recent hydrographic researches of Dickson, Pettersson, and others show that considerable importance must be attached to this factor in any determination of the physical influences at work in the North Sea basin. It is all the more regrettable that there exists no permanent organisation in this country which is adequately equipped for the task of investigating the state of the sea from year to year, and that such temperature data as are collected at coast stations and on board ships are not summarised and published as regularly (if not so frequently) as the observations made through the Meteorological Office upon the state of the atmosphere. Water-temperature, salinity, and the movements of great water-masses have relations to the fisheries which are at least as intimate as the relations to agriculture of air-temperature, rain, and the course of the air-currents.

These considerations show the necessity of caution in comparing the results of the fisheries in particular years, or for short terms of years; and considerable latitude must be allowed for temporary fluctuations attributable to the effects of the weather, even if, with our present

* The temperature of the deeper water offshore immediately prior to the breeding season must also affect the metabolism of fishes, and probably, therefore, their fecundity.

incomplete knowledge, we are unable to state confidently what the precise effect of any given type of weather has been upon the various species of fish, except, perhaps, in years of unusual severity or warmth.

The complaint of the fishermen, however, for many years past has been that the bottom fisheries have been annually and steadily diminishing in return for the same labour expended upon them; and, so far as the abundance of flat-fish alone is concerned, this view was adjudged correct by the Select Committee of the House of Commons which sat in 1893.

Professor McIntosh has recently expressed his dissent even from this conclusion, and in a remarkable book * boldly adopts the view that man's operations and the means of capture at his disposal are insufficient to affect the perennial abundance of sea-fishes. He says (pp. 239, 240): "A calm survey of the situation shows that the cry concerning the annual diminution of our fish-supply has been dispelled by the institution of statistics; that the alleged destruction of spawn has no basis in fact; that the destruction of immature fishes is common to all classes of fishermen, and nowhere is proved to have resulted in the ruin of any sea-fishery; that because the first five years of the decade 1886–95 had a higher average than the second in the Fishery Board's experiments, it therefore followed that diminution of the fishes had occurred, and called for further closures beyond the three-mile limit to remedy it, is shown to rest on insecure data; that the closure of the three-mile limit has failed to increase the number or the size of the food-fishes, is ineffective in regard to the supply of the public, and is a continual source of friction and expense, while falling short of the expectations of those who clamoured for it; that the evidence given before the Trawling Commission of 'trawling out' certain grounds in three years with a small vessel carrying a small trawl, the working period being about three days a week for three months in autumn, is at variance with experience; that the statements to the effect that fishes captured by the trawl are inferior as articles of food to the general public cannot be maintained either by science or by a knowledge of the markets; that the *Garland's* work shows the comparatively small destruction of immature fishes of value, even though she often trawled where no commercial ships would; that the perusal of masses of fishery statistics shows the constant series of changes that take place on every area, yet the fisheries are not destroyed; that such a fishery as that for sparlings in the estuary of the Tay has from time immemorial been very much as it is; that though salmon and sea-trout abound in the sea, men derive little knowledge of their presence by either trawl or hook, and yet many of both must come in their way."

* *The Resources of the Sea.* London, 1899.

Again, "The returns from the various centres all over the country have for the most part steadily increased since 1884, and though it is true that large quantities are captured on the Great Fisher Bank, Iceland, and other regions at a distance from British waters proper, yet this is due to the more remunerative nature of the work, and not to the dearth of fishes in the seas at home" (p. 241).

The foregoing quotations indicate sufficiently the general tenor of Professor McIntosh's conclusions. Some of these may be readily granted, but the most important ones, which deny the alleged impoverishment of the older fishing grounds, and even the possibility of depleting them by human interference, are, as the Professor admits, "so different from the oft-repeated views and wide-spread opinions of the fishing community and the public," that I have felt the necessity of making an independent examination of the evidence upon which the Professor relies, as well as of the evidences bearing on the English fisheries, which do not appear to have so seriously engaged his attention. These evidences have not hitherto been brought together in any form convenient for reference, so that even if my conclusions should contain any elements of uncertainty, the collation of the scattered data should at any rate serve a useful end.

One claim, however, is made by Professor McIntosh, which, though it would not affect the decisions of scientific men, is likely to unduly bias the opinions of the public in the direction of the Professor's views, viz. his claim of a similarity between his own conclusions and those reached by the late Professor Huxley "from a totally different standpoint" (preface, p. x.; text, pp. 234, 235).

Had Professor McIntosh claimed a resemblance between his views on the inexhaustibility of the bottom fisheries and Professor Huxley's on the inexhaustibility of the surface fisheries, no objection could be raised to the comparison; but the implication (however unintentional) in the preceding paragraph is clearly that Professor McIntosh's views on the trawl fisheries are more or less identical with those entertained by Professor Huxley concerning the same fisheries, although arrived at by different modes of reasoning. Professor Huxley's opinions on matters connected with the sea fisheries are deservedly held in high esteem—whether from the thorough character of his inquiries, or from the liberality and independence of his judgment; but the views which Professor Huxley expressed on the inexhaustibility of the fisheries are characterised by his usual precision of language, and cannot be construed as referring to the bottom fisheries in general.

After admitting that a salmon fishery (and all river fisheries) can be exhausted by man, because man is, under ordinary circumstances, one of the chief agents of destruction, Professor Huxley asks, Does the same reasoning apply to the sea fisheries? Are there any sea fisheries which are exhaustible? He replies, "I believe that it may be affirmed with confidence that, **in relation to our present modes of fishing*, a number of the most important sea fisheries, such as the cod fishery, the herring fishery, and the mackerel fishery, are inexhaustible. And I base this conviction on two grounds—first, that the multitude of these fishes is so inconceivably great that the number we catch is relatively insignificant; and, secondly, that the magnitude of the destructive agencies at work upon them is so prodigious that the destruction effected by the fisherman cannot sensibly increase the death-rate" (International Fishery Exhibition, London, 1883, Inaugural Meeting of the Congress, Report, p. 14).

It is clear from this passage and the context that Professor Huxley limits his conviction as to the inexhaustibility of sea fisheries to the drift-net fisheries of all kinds, and to the cod fishery as it was then pursued by means of lines and hooks. He expressly excludes the remaining sea fisheries from the category to which his conviction refers, for, after giving illustrations in support of the conviction just quoted, he continues: "There are other sea fisheries, however, of which this cannot be said. . . . Theoretically, at any rate, an oyster-bed can be dredged clean. In practice, of course it ceases to be worth while to dredge long before this limit is reached. . . . Thus I arrive at the conclusion that oyster fisheries may be exhaustible. . . . *I have no doubt that those who take up the subjects of trawling and of the shell fisheries will discuss the question in relation to those fisheries*" (*l.c.*, pp. 16, 18).

Professor Huxley's views on this important question have been so widely misunderstood that I am glad to have the present opportunity of reiterating his actual statements, and the limits within which he expressly intended them to apply. If I may go a step further than Professor Huxley's words authorise as forming part of his personal opinions, it will be to point out that far the most valuable, and formerly the most abundant item in the produce of the trawl fisheries, is the catch of flat fishes; and that, from their relatively sedentary habits of life, their permanent location on the sea-bottom in more or less shallow water, and the methods adopted for their capture, these fishes more nearly approximate to the oyster, as regards the conditions of their exhaustibility, than to the mackerel, herring, or even the cod-fish tribes.†

I have, moreover, no hesitation in affirming that, as regards the relative influence of the various destructive agencies upon the death-rate of flat fishes, the destruction directly effected by man far exceeds the destruction wrought by other enemies. These are practically limited to gulls and the more rapacious members of their own tribe

* The italics are mine. † Cf. *Report of Trawling Commission*, 1885, pp. xxxv., xliii.

(turbot, brill); but the latter may be neglected, since they themselves form an important item in the produce of the same fishery, and their numbers naturally bear a fairly constant proportion to the numbers of the less predatory fishes (by no means limited to flat fishes) upon which they prey. Professor McIntosh concludes that the destruction of immature flat-fish by trawls and other drag-nets may be disregarded, since immature fish of all kinds are destroyed in every mode of fishery without injuriously affecting the supplies. Probably the most considerable destruction of immature fish, other than flat-fish, occurs in the whitebait fisheries on our own coasts, and in the sardine fisheries of France. But there are three excellent reasons why this destruction should have less effect upon the abundance of herrings, sprats, and pilchards than upon the stock of flat-fish—firstly, because the destruction of the former fishes in any given locality is necessarily limited to a small portion of the year, owing to the periodicity in their surface migrations, while the common types of flat-fish, whether young or old, are never removed from the influence of the fisherman's implements of capture; secondly, because first-year herrings and sprats are sought so eagerly by shoals of mackerel, etc., that the destruction wrought by man at this stage can scarcely exceed a small fraction of the total mortality; and thirdly, because the larvæ of plaice, and probably soles, in consequence of their specialised habits, must undergo a heavy preliminary mortality * at the time of metamorphosis, from which herrings, at any rate, are probably exempt. Nature may thus be said to have made provision for a heavy death-toll of young herrings, but not of young flat fish.

The important question, in fact, is not whether some immature fishes may be destroyed with impunity by all classes of fishermen, but whether in any fishery the destruction of immature fish of any particular species is sufficiently great to sensibly increase the death-rate due to natural (*i.e.* non-human) causes. For evidence upon this point I may refer especially to the investigations of my colleague, Mr. Holt, and of Mr. Cunningham, upon the destruction of immature plaice in the North Sea (this Journal, vol. iii. pp. 339–448, vol. iv. pp. 410–4; and vol. iv. pp. 97–143).

In the present paper, however, I do not pretend to do more than analyse the evidence as to whether the bottom fisheries are, or are not, in a stable condition; and, if they are undergoing the process of exhaustion which Professor Huxley regarded as within the bounds of possibility, to attempt to determine at what rate the process of depletion is going on.

Professor McIntosh bases his conclusions upon the alleged failure of the Scottish Fishery Board to demonstrate by their trawling experiments

* Cf. PETERSEN, *Rep. Danish Biol. Station*, IV., 1894, p. 15.

any appreciable change either of decrease or increase in the inshore fisheries, and appeals to the general statistics of the sea fisheries to show that the enormous fecundity of sea fishes and similar causes "enable Nature to cope, in regard to the food-fishes, with all the wonderful advances in apparatus of capture, and with the steady increase of population."

Summary.

I have therefore, in the first place, made an independent examination of the results of the Fishery Board's experiments. It will be seen, in the sequel, that I agree with Professor McIntosh that the methods by which it was sought to demonstrate the observed changes in the fish population of the closed waters were inadequate, and caused the Fishery Board's conclusions to rest upon an insecure basis; but after eliminating all sources of uncertainty in the methods, I find that the changes in the fish fauna, which were especially emphasised by Dr. Fulton, are capable of abundant verification. There appears to me to be no further room for doubt that during the ten years' closure of St. Andrews Bay and the Firth of Forth against trawlers, there was a decrease of plaice in the closed waters of both areas, and a marked increase of common dabs; and that in the Forth lemon soles markedly decreased, and long rough dabs increased. These latter species are too scarce in St. Andrews Bay to be worth considering in respect to that area. I concur with Dr. Fulton that the decrease of plaice and lemon soles, in spite of the protection inshore, is most probably to be attributed to the effects of over-fishing by trawlers on the offshore grounds, which causes, as one of its results, a great reduction in the quantity of eggs by which alone the stock of these fish can be maintained, whether on the inshore or offshore grounds. I also agree in part with Dr. Fulton that the increase in dabs and long rough dabs may be attributed to some extent to the protection of the inshore spawners of these species; but am inclined to attribute a certain and probably a large portion of the increase to the advantage conferred on the dabs by the reduced numbers of their competitors, the plaice and lemon soles. The reported increase of dabs and long rough dabs outside, as well as inside, the closed waters tends to support this view.

In the second place, I have endeavoured to make a fairly exhaustive analysis of all the available statistics, official and unofficial, which deal with the English fisheries. They consist of the following separate items:

1. The actual annual catches of Grimsby sailing trawlers for a nearly continuous period of thirty-three years, from 1860 to 1892 (supplied by Grimsby smack-owners).

2. The weight of fish annually sent inland by rail from the port of Grimsby, compared with the numbers of fishing vessels, both sailing

and steam, registered at the port, from 1886 to 1899 (from returns provided by the Great Central Railway Company).

3. The weight of fish annually landed by trawlers at the Lowestoft fish-docks, from 1883 to 1898, compared with the gross number of trawling vessels landing at the port (from returns provided by the Great Eastern Railway Company).

4. The total weight of bottom fish annually landed on the various coasts of England and Wales during the decade 1889 to 1898, compared with detailed estimates of the number and catching power of the deep-sea trawlers and liners during the period (from the Board of Trade returns and numerous other sources specified below).

The results obtained from all these various independent sources of information display a melancholy unanimity. Whatever the period—whether ten years or thirty years—and whatever the extent of the fishery—whether the smack fisheries of Grimsby and Lowestoft, the general fisheries of Grimsby, or the entire bottom fisheries of England and Wales, either as an entirety or according to the seas frequented—the average return for each vessel engaged in the fishery, or for each equivalent unit of fishing power, is shown to fall from year to year with none but insignificant fluctuations in the rate of fall.

We have, accordingly, so far as I can see, to face the established fact that the bottom fisheries are not only exhaustible, but in rapid and continuous process of exhaustion; that the rate at which sea fishes multiply and grow, even in favourable seasons, is exceeded by the rate of capture. The rate of exhaustion is shown to be different for different species of fish. The more valuable flat fishes, plaice and prime fish, show the most marked signs of diminished and diminishing abundance. These differences should obviously be noted, and if possible still further elucidated, in order that the difficulties in the way of remedial measures may be intelligently anticipated and met.

In conclusion, it is with much pleasure that I acknowledge the assistance which I have received in the preparation of this paper from numerous individuals and official representatives, without whose co-operation it would have been impossible to undertake certain parts of this revision of the fishery statistics on anything like so extensive a scale. To Mr. G. L. Alward, of Grimsby, I am under a particular debt of gratitude, not only for the information placed by him at my disposal, but for the frequency with which he has sacrificed time and labour, probably at great personal inconvenience, to respond to my inquiries. I have also been aided by Mr. W. E. Archer, H. M. Inspector of Sea Fisheries, and his colleagues at the Board of Trade; by Mr. J. W. Towse, Clerk to the Fishmongers' Company; by the General Managers of the Great Central and Great Eastern Railway

Companies; the Manager of the Milford Docks Company; Commander Scobell Clapp, R.N., Queen's Harbourmaster of Holyhead; the Harbourmasters of Neyland, Newlyn, Ramsgate, and Lowestoft; Mr. Sanders, of Brixham; Mr. Shepherd, of Plymouth; Mr. B. J. Ridge, of Newlyn; Mr. J. W. Turner, of Lowestoft; Mr. R. L. Ascroft, of Lytham; Mr. W. H. Ashford, Fishery Officer of the North-Eastern Sea Fisheries Committee, Scarborough; as well as by other gentlemen, the results of whose assistance do not directly appear in the present communication. I desire to express my cordial thanks to all who have co-operated with me in the work.

If errors, either great or small, should be detected in my methods or calculations, I am alone responsible for them; but I trust that they will be found to be neither numerous nor serious. So far as the methods are concerned, I have endeavoured throughout to base the conclusions as far as possible upon grounds which are capable of verification, and in matters where absolute precision was unattainable, to steer a moderate course in the estimates adopted.

The Experimental Evidence.

The scientific evidence which bears upon the alleged depletion of the trawling grounds is necessarily limited, since neither the Fishery Board for Scotland nor the Marine Biological Association has been enabled to carry out prolonged researches upon the deep-sea fishing grounds. Nevertheless, the experiments made by the Scottish Fishery Board in closing certain areas off the Scottish coasts against trawling operations have a distinct bearing upon the question. It was alleged that these areas, as well as other inshore waters, had been depleted of fish as a consequence either of general over-fishing or of the excessive destruction of immature fish by trawlers. It was consequently expected that the protection of these large areas for a term of years against the ravages of trawlers would result in their gradual recovery and in an increase in the quantities of fish upon the grounds.

The areas were closed against trawlers in 1886, and during the following ten years experimental trawlings within the closed and open areas were conducted by the Fishery Board at frequent intervals, in order to obtain a record of the changes induced by the prohibition of trawling. It is clear that any general increase in the stock of fish that could be definitely attributed to the prohibition of trawling would also furnish a practical proof of the extent to which over-trawling had previously reduced the productiveness of the same grounds.

Moreover, the experiments bear indirectly upon the subject of the present inquiry from the fact that they constitute the first extensive experiment on a scientific basis for determining whether it is possible or not by human interference to materially influence the productiveness of a considerable arm of the sea.

It is well known from Dr. Fulton's review of the experiments (*Fourteenth Annual Report of the Scottish Fishery Board*) that, contrary to expectations, "no very marked change took place in the abundance of the food-fishes generally, either in the closed or open waters of the Firth of Forth or St. Andrews Bay," as a consequence of the prohibition of trawling. Nevertheless, among flat fishes a distinct change was reported to have ensued in the relative abundance of certain kinds. Plaice and lemon soles were reported to have decreased in abundance in all the areas investigated, whether closed or open, while dabs and long rough dabs were reported to have shown a preponderating, if not quite universal increase.

This change in the relative proportions of plaice and dabs was explained by Dr. Fulton as principally due to the fact that the protected waters enclosed a considerable area of spawning ground for dabs and long rough dabs, but not for plaice and lemon soles, which spawn exclusively offshore. Moreover, while all four species were subjected to capture by trawlers outside the closed waters, the smaller size of dabs and long rough dabs at maturity would enable many adult and all immature dabs of both kinds to escape through the meshes of the trawl; whereas all mature and a considerable number of immature plaice and lemon soles entering the trawl would be captured. Thus the alleged increase of dabs and long rough dabs was attributed by Dr. Fulton principally to the beneficial effects of the protection of their spawning grounds, while the continued decrease of plaice and lemon soles was attributed to excessive destruction of adults and young of both species in the open sea.

Dr. Fulton accordingly draws the following main conclusions from his examination of the results of the trawling experiments: (1) that the mere closure of even large areas in the territorial waters which are destitute of spawning grounds is of little practical benefit to the inshore fisheries, and (2) that the most likely method of benefiting the inshore fisheries would be to protect the offshore spawning grounds for certain periods in the year.

Professor McIntosh, however, entirely rejects the conclusions drawn in this report, together with the figures upon which the conclusions were based, principally on the ground that the statistical methods by which the results were attained are vitiated by an important error. Dr. Fulton divided the ten years into two quinquennial periods, and contrasted the average catches per haul of the trawl during the first period with those made during the second. Professor McIntosh points out that during the first period there was a preponderance of hauls during the summer or productive months, whereas during the second period the preponderance of hauls fell in the winter or comparatively unproductive months. The validity of the criticism is borne out by the official figures; but whether the error caused by these differences alone is sufficient to invalidate the whole of Dr. Fulton's conclusions is rendered very doubtful by the contrast which Dr. Fulton emphasised between the decrease of one group of flat fishes and the increase of the other. The error might account for the decrease in plaice, but how can it also account for the increase in dabs?

Professor McIntosh does not, however, directly controvert the statement that plaice and lemon soles did, as a matter of fact, decrease in numbers, and that dabs increased; unless we construe in this sense his remarks that the average catch of plaice in the Forth was higher in 1895 than in 1886, both for the colder and warmer months (*Resources*, p. 167). But in the last Report of the Fishery Board (for 1898) Dr. Fulton gives a new summary of the results, based upon a comparison of corresponding cold and warm periods, and concludes that "the same result (*i.e.* decrease of plaice and increase of dabs) is found, whether the whole year is contrasted in the two quinquennial periods, or the warm months against the warm months or the cold months against the cold months." He provides, also, a table of averages for the two quinquennial periods, to show that "the change in the relative abundance of the offshore-spawning plaice and lemon soles, and of the inshore-spawning dabs, was common to almost every month of the year." A decrease of plaice and lemon soles is observed for every month except January, July, and December; and an increase of dabs and long rough dabs for every month except August. It is also shown that during the first period plaice and lemon soles together were more numerous than dabs in every month except December; whereas in the second period dabs assumed the preponderance in six months out of the twelve, *i.e.* from June to December with the exception of July. Dr. Fulton reiterates his conclusion that the "inshore-spawning dabs, therefore, to a very large extent supplanted the offshore-spawning plaice and lemon soles in the closed waters."

The sequence of figures submitted in further support of this conclusion is undoubtedly impressive, and would have set the question at rest if the monthly averages for each quinquennial period had all been equally reliable. But the admitted irregularity of the *Garland's* experiments, especially in the earlier years of the decade, prevented anything like a monthly survey of the experimental areas in successive years. Accordingly, the monthly averages submitted by Dr. Fulton are not based upon a uniform set of data, and there is nothing in the new summary to show which of the averages may be taken as reliable, and which are based on an insufficient series of observations. As the figures ostensibly represent the average conditions prevailing during periods of five years' duration, it is manifestly impossible to regard any of them as satisfactory which are based on the surveys of one or two years only in each period, especially if the years fall exclusively near the middle of the decade. The averages for the second period may be accepted as thoroughly satisfactory, so far as the number of years is concerned; but in the case of the first period the averages for January, February, March, and possibly December, may justly be discredited, either on account of the insufficiency of the number of years represented by the averages (January—one year only), or by the fact that the two years included are limited to the latter portion of the period (February and March, 1889 and 1890; December, 1888 and 1890).

Four of the monthly averages out of the twelve are thus eliminated upon merely preliminary examination of the data upon which they are based. Further scrutiny shows that an equally serious objection may be urged against several of the remaining averages, owing to the unequal representation of the two areas in the combined averages. The great differences between the Firth of Forth and St. Andrews Bay in regard to the seasonal abundance of the different kinds of flat-fish render it imperative that in any combination of the averages for comparative purposes the two areas should be represented in equal proportions during the two periods. Yet during the second period, while the Forth was investigated with almost perfect regularity month by month during the successive years, there are four months (January, May, August, and September) in which no examinations whatever were made in the Bay for four years out of the five. For these months, therefore, during the second period, the influence of the Forth largely predominates in the "averages"; whereas during the first period the Bay and the Forth were equally represented, so far as the number of surveys is concerned, in three out of the four months (viz. January, May, and August). On this count, therefore, the January averages are still further discredited, and we are also forced to add May and August to the list of unreliable averages, which brings the total up to six out of the twelve.

That the fallacy caused by disproportionate representation of the two areas in the two quinquennial periods has led to errors of an appreciable and serious character may be judged from the following figures. They represent approximately the average number of fish of the different kinds distinguished taken in one haul of the trawl in each month of the year in the closed waters, the numbers for St. Andrews Bay being kept distinct from the numbers for the Firth of Forth. They are based on the "monthly averages per shot" published in the annual reports of the trawling experiments, and are the mean of those averages for the entire decade, except that fractions of the resultant figures are here omitted, and that the averages for the first two years in the case of dabs have been independently worked out, since for those years the official averages for dabs and long rough dabs were not distinguished.

TABLE I., *showing Average Number of Fish per Haul of the Trawl for each month of the year in the closed waters of St. Andrews Bay and the Firth of Forth respectively (from the ten years' experiments of the "Garland")*.

	St. Andrews Bay.				Firth of Forth.			
	Plaice.	Lemon Soles.	Dabs.	Long Roughs.	Plaice.	Lemon Soles.	Dabs.	Long Roughs.
January .	6	0	1	1	26	3	6	16
February .	13	0	5	1	38	3	8	16
March . .	56	0	9	0	35	5	17	20
April . .	81	0	21	0	42	16	25	17
May . .	89	0	70	1	42	18	29	20
June . .	149	0	121	2	56	25	42	17
July . .	*122	0	55	1	56	25	69	24
August .	303	0	209	1	79	33	69	28
September .	140	0	177	4	60†	28	77	25
October .	120	0	69	1	55†	15	46	23
November .	65	0	57	0	31	8	19	22
December .	3	0	11	1	21	4	13	23

It will be seen from these figures that the average catch regularly increases or diminishes in numbers with the sequence of the months. The only serious discrepancy is in the St. Andrews averages for July, the low value of which is entirely due to the insufficient number of observations made in this month (only three surveys in the ten years), and to the accident that the surveys which actually were made fell in relatively unproductive years. Had surveys been also made in this month in the year 1887, and in either 1890 or 1895 (as was

* The figures for July, 1886, have been altogether omitted for St. Andrews Bay, owing to the incomplete examinations made of the stations in that month.

† September and October, Firth of Forth.—In 1886 five of the seven Forth stations were surveyed in September, the remaining two stations in October. The data have therefore been merged together in my table under September, and altogether excluded from October. In the official report on the first year's work, the September and October averages are based on the partial data of the stations examined in each month respectively; but as the figures for the most productive station (No. II.) are thereby omitted from the October data this separation can scarcely be approved.

the case with the June and August surveys), it is perfectly clear upon examination that the averages for the month would have been intermediate in value between those of June and August.

Nothing could illustrate more forcibly than this table the great differences between the two areas as regards the influence of the seasons upon their productivity. The changes in the abundance of each species are relatively slight in the case of the Forth, but are exceedingly great in St. Andrews Bay. In the Forth the maximum summer average is not four times the minimum winter average in the case of plaice, nor elevenfold in the case of dabs; but in the Bay the maximum abundance in August exceeds the minimum abundance in December a hundredfold in the case of plaice, and even two hundredfold in the case of dabs. The monthly catch of plaice in St. Andrews Bay exceeds that in the Forth for each month of the year except December, January, and February, the degree of excess rising to fourfold in the height of the summer (August), and falling away to three- and two-fold towards the earlier and later months of the year. In the three winter months, on the other hand, the catch in the Forth exceeds the catch in the Bay by as much as three, four, or seven fold. The figures for dabs present the same general features, but the excess of the summer catches in the Bay over those in the Forth is not quite so great, and the winter excess of the Forth catches over those in the Bay is shown in five instead of three months only.

With these facts before one, which refer, it must be remembered, exclusively to the closed waters under discussion, it is easy to forecast the general effect of combining the statistics of the two areas. With a perfectly equivalent number of hauls the monthly average of the combined areas will assume a mean character intermediate between the average for the two areas taken separately; but any deviation from strict equivalence will raise or lower the combined average to an extent depending on the nature of the seasonal differences between the two areas for the month in question. Thus for April the combined average for plaice would be 61 upon an equivalent number of hauls from the two areas; but if two hauls in the Forth were combined with one in the Bay the average would be reduced to 55; and if the hauls in the Bay preponderated over those in the Forth to the same extent the combined average would be raised to 68. For August the changes introduced would be still greater; with equivalent hauls the combined average would be 191; with two hauls in the Forth to one in the Bay it would be reduced to 154; with two in the Bay to one in the Forth it would be raised as much as to 262. Consequently, monthly averages based on quite irregular combinations of hauls in the two areas are fallacious and misleading, and it is quite impossible to judge of the effect of the closure of the Scottish bays from figures calculated upon this basis.

Yet, if a table be drawn up setting forth the yearly frequency of the monthly surveys actually carried out in the two areas, it will be seen at once that, with the single exception of June, the proportion which the number of surveys in either area bears to that in the other area for the first quinquennial period is never exactly repeated for the second quinquennial period—a lack of co-ordination which necessarily biases the combined averages and precludes any exact comparison between the two periods by the methods which Dr. Fulton has pursued. Thus for January the average from one year's survey in St. Andrews Bay and one in the Forth in the first period is contrasted with the average derived from one survey in the Bay and five surveys in the Forth during the second period. For February the average for the first period is based exclusively on surveys in the Forth, and this is contrasted with an average for the second period derived from four surveys in the Bay and five in the Forth. For March the average is derived from two surveys from each area in the first period, but from a combination of three St. Andrews surveys with four Forth surveys in the second, and so on, the general tendency being to give the Forth a preponderating influence on the combined averages, which is considerably greater during the second period than the first. The only exceptions are June, in which the proportion of surveys in the two areas is the same in the two periods, and February, July, and November, for which months the Bay exercises a greater influence on the averages for the second period than for the first.

Leaving these exceptional cases out of consideration for a moment, we may trace the general tendency of this excessive influence of the Forth on the averages for the second period by reference again to the data contained in Table I.

In the case of plaice, owing to the productivity of the Forth in this species being much lower than that of St. Andrews Bay for all except the three winter months, there can be no doubt that a preponderating influence of the Forth on the combined averages for the second quinquennial period must tend, *ceteris paribus*, to depress the average for plaice below its value for the first period, thus fallaciously producing an appearance of a diminution in the numbers of plaice in the combined areas, even when no such diminution may be apparent from the figures for the two areas taken separately.

If lemon soles are added to plaice, as in Dr. Fulton's last figures, such inclusion will not materially affect the figures for St. Andrews Bay, but will increase those for the Forth to an appreciable extent in the summer months; but even under these circumstances the Bay maintains its greater productivity for the same number of months as for plaice alone.

Of the months* in which the influence of St. Andrews Bay on the averages is greater for the second period than for the first, it will be noticed that February is one of the three exceptional months in which plaice and lemon soles are less abundant in the Bay than in the Forth. Consequently, the fall in the combined average catch of these fishes, when the two periods are compared, is again explicable merely from the fallacy latent in the disproportionate combination of the statistics of the two areas. The July averages are exceptional in showing an increased catch in the second period compared with the first. This feature also may be directly attributed to the increased influence of the Bay in the second period. In November alone is the verdict of the averages at variance with the tendency caused by the increased influence of the Bay during the second period—an exception which can be conclusively traced to an altogether exceptional catch of plaice in St. Andrews Bay in 1889. The average haul of plaice in November, 1889, in the Bay, amounted to 213 fishes. The average for the four other years during which surveys were made in the same month were 38, 47, 16, and 10 respectively, and only one of these fell in the first quinquennial period. Had observations been also made in the five remaining years, no doubt the abnormal difference in the averages for the two periods caused by the exceptional catch just mentioned would have been reduced to juster proportions.

There is, therefore, no escape from the conclusion that *the combination of the figures for the Forth and the Bay is sufficient in itself to account for decreased averages for plaice and lemon soles in the second period as compared with the first.*

As regards the reported increase of dabs and long rough dabs, the same argument holds to a considerable extent. It has already been pointed out that the disproportion between the Bay and the Forth is less in the case of dabs than in the case of plaice. This is particularly so if dabs and long rough dabs are grouped together, since the scarcity of the latter in the Bay, and their relatively large numbers in the Forth, greatly reduce the difference which exists between the two areas in regard to the relative abundance of common dabs alone. It can be seen from Table I. that in the closed waters dabs and long rough dabs together are more numerous in the Forth than in the Bay in January, February, March, April, July, and December. There can be no doubt, as previously remarked, that the July figures for St. Andrews Bay cannot be regarded as strictly accurate, owing to the inadequate number of observations; but the fact remains that, under the conditions of the

* February, July, and November.

experiments, the average number of dabs taken from the Forth considerably exceeded the corresponding number from the Bay in six months out of the twelve. It is consequently not surprising, if, owing to the increased influence of the Forth on the averages for the second quinquennial period, there should be displayed a considerable number of months in which the combined averages show an apparent increase in the abundance of dabs.

I conclude that the figures recently submitted by Dr. Fulton in his new summary of the results of the *Garland's* experiments by no means re-establish the conclusions set forth in his original review. It appears to me that, in consequence of the irregularity of the *Garland's* operations, it is quite impracticable to set up well-founded conclusions upon a basis formed by combining the figures for the Forth and Bay. One or other of these areas, under the conditions of the experiments, must unduly bias the averages, and unless an equivalent proportion is maintained between the monthly surveys in the two areas in each period, the resultant differences between the quinquennial averages must necessarily be fallacious.

Nevertheless, while going even a step further than Professor McIntosh in his criticism of the methods by which the results of the *Garland's* experiments have been set forth, I am quite unable to follow the Professor in his condemnation of the experiments themselves, which would appear from internal evidence to have been well designed and executed. The irregularity of the surveys in the earlier years is much to be regretted, and demands more than ordinary care to be bestowed upon the analysis of the results. But from the impartial and critical examination which I may claim to have made of the published records of the experiments, I am satisfied that the experiments have been largely successful in throwing light on the problem which they were designed to elucidate, in spite of the unfortunate errors of method with which the conclusions have been associated.

It appears to me, under the circumstances of the case, that Dr. Fulton's method of averaging the figures for two quinquennial periods and for the different months of the year is perhaps the best method to adopt in order to obtain a general view of the changes wrought during the ten years of prohibited trawling; although, in view of the small number of surveys made during the first two years and their greater frequency during the last five years, there would be certain advantages in dividing the decade into a first period of six years and a second period of four years. This alternative method would have the effect of increasing the number of monthly surveys in the first period, and thus of rendering valid certain of the monthly averages which, in the quinquennial period adopted, are based upon too small a number of surveys. On the other hand, by adopting such an extension of the first period the averages could be less confidently claimed to represent the condition of the areas immediately subsequent to the prohibition of trawling. But it appears to me to be in any case indispensable that the figures for the Forth and for St. Andrews Bay should be kept distinct, as well as the figures for the different species of fish.

I have therefore prepared a table (II.) of quinquennial averages based upon these principles. The averages are not, it is true, based upon the original numbers of fish taken in each haul of the trawl, but upon the monthly averages per haul of the trawl published in each year's report of the trawling experiments. In the case of St. Andrews Bay the closed area embraced four trawling stations, so that each of the monthly averages published for this area represented usually the mean of four hauls of the trawl. The closed area of the Firth of Forth embraced seven such stations, the monthly average therefore representing the mean of seven hauls. The figures in my table represent the

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TABLE II., *showing the Average Monthly Numbers of Flat-Fish per Haul of the Trawl taken by the "Garland" in the closed waters during each quinquennial period, distinguishing the different areas and the different kinds of Fish.*

ST. ANDREWS BAY.

	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Plaice.												
1st Period .	[9]	—	[63]	[134]	[101]	155	[148]	368	[120]	137	[126]	[4]
2nd „ .	[3]	13	51	46	[64]	145	[108]	[42]	[179]	98	36	5
Dab.												
1st Period .	[1]	—	[5]	[13]	[72]	135	[81]	249	[149]	39	[24]	[7]
2nd „ .	[1]	5	12	26	[65]	135	[42]	[48]	[254]	108	[80]	13

FIRTH OF FORTH.

	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Plaice.												
1st Period .	[14]	[46]	[33]	44	[28]	60	64	95	71	61	28	[7]
2nd „ .	28	35	36	40	49	53	66	62	54	51	35	27
Lemon Sole.												
1st Period .	[1]	[1]	[4]	18	[17]	32	31	37	35	17	11	[3]
2nd „ .	4	4	6	14	18	19	28	30	23	14	5	5
Dab.												
1st Period .	[3]	[3]	[11]	20	[15]	37	65	49	54	42	14	[13]
2nd „ .	7	10	20	29	35	47	73	94	90	49	25	14
Long Rough Dab.												
1st Period .	[10]	[6]	[13]	12	[22]	16	21	23	18	21	20	[12]
2nd „ .	17	20	23	19	19	18	25	32	32	24	24	28

means of these averages for the respective periods. They are, therefore, not strictly correct as averages of the entire number of fish taken in the respective months; but the deviations due to the method are of a minute character and do not affect the general results, especially if a margin of several units in the resultant averages is allowed to cover the errors of method and experiment. As the monthly averages for dabs and long rough dabs were not officially separated during the first two years, I have calculated them anew from the details of the monthly surveys for those years; and the same alterations have been made in regard to the monthly averages for 1886 as were described in the footnotes to Table I., p. 13.

I have, moreover, placed in brackets all such averages as are based on less than three surveys in each quinquennial period. This precaution shows at a glance which of the averages may be depended upon as accurately representing the general condition of the fauna during the corresponding period. The method falls rather severely upon the averages for St. Andrews Bay, but the natural fluctuations in that area, due to its shallowness and exposed situation, are so great that no less rigorous method could be safely relied upon to eliminate the irregularities due to these circumstances.

For **St. Andrews Bay** the two quinquennial averages are seen from the table to be reliable in only two months out of the twelve, viz. June and October. They show in each case a fall in the abundance of plaice, correlated with an equality or a marked rise in the number of dabs. The change for June is seen to have been slight; but for October a great predominance of plaice over dabs in the first period is replaced by a superiority of dabs over plaice in the second period.

I have not included any statement of the averages for lemon soles and long rough dabs in connection with this area, owing to the great scarcity of these forms in the Bay as shown by Table I.

For the **Firth of Forth** seven months out of the twelve are seen to afford reliable averages for each period, viz. April to November inclusive, with the exception of May. The differences between the quinquennial averages are not great, except for August; but it is certainly noteworthy that the general tendency of the change is in the same direction as in the case of St. Andrews Bay.

The averages for plaice decrease in five months out of the seven, by amounts which vary between 9 per cent. and 33 per cent. The two increased averages show a rise of 3 per cent. and 25 per cent. respectively.

The averages for lemon soles show a decrease in every one of the seven months; whereas the averages for dabs and long rough dabs respectively show an increase in every month.

In spite of all that has been said as to the inadequacy of the *Garland's* experiments for yielding a scientific verdict on the effects of the prohibition of trawling, there appears to me to be only one possible conclusion from the foregoing figures; viz. that there was a general diminution both of plaice and lemon soles in the closed waters after the prohibition of trawling, and a still more marked increase in the abundance of dabs and long rough dabs.

It must be remembered that whatever irregularities occurred in the *Garland's* work as to the duration of the hauls of the trawl and such matters, these necessarily affect the figures for all species of flat-fish alike. The contrast remains that, under precisely the same experimental and climatic conditions, plaice and lemon soles are seen to have decreased, and dabs and long rough dabs to have increased during the decade.

Dr. Fulton's conclusions are, therefore, in all respects correct, so far as I am able to determine, and are independent of the errors which were associated with his methods of demonstration.

Under these circumstances I see no reason for disputing Dr. Fulton's principal explanation of the changes which were induced in the relative abundance of flat fishes in the closed waters during the period of prohibited trawling. It appears to me to be reasonably established that *pari passu* with the increased destruction of plaice and lemon soles in the open waters, there has been a progressive diminution of these fishes even in inshore waters which have been continuously protected from the effects of trawling operations. It also appears to be satisfactorily demonstrated that under the conditions just mentioned a conspicuous increase in the abundance of dabs and long rough dabs has taken place in the inshore waters.

Nevertheless, it is certainly open to reasonable doubt whether this increase in dabs has been exclusively, or even mainly, due to the protection of the spawning grounds of these fishes; for the observed increase of long rough dabs is as great as that of common dabs, yet, from their preference for the deeper waters, the long rough dabs cannot have received the same measure of protection as the common dabs from the prohibition of inshore trawling. The possibility should be borne in mind that the increase of dabs may have taken place quite independently of the prohibition of trawling, in consequence of the decrease of plaice and lemon soles with which they may be supposed to be natural competitors—a suggestion previously made by my colleague Mr. Holt, in connection with similar problems on the Devonshire coast (*Jour. M. B. A.*, vol. v., 1898, p. 320). It is obvious that any diminution of the species which normally maintain a rivalry with dabs for the available food supply must confer an advantage upon the dabs, enabling a greater stock of these fish to live on the same extent of ground. Moreover, from their smaller size, there is reason to believe that the numerical increase in dabs would be greater than the numerical decrease of the plaice and lemon soles which they may be held to have supplanted. This explanation derives support from the reported increase of dabs in the open, as well as the closed waters of the regions investigated.

It is, however, sufficient for my present purpose if I have demonstrated that changes have taken place in the abundance of fish in Scottish waters, which are attributable in all probability to the effect of man's operations; the decrease of plaice and lemon soles to the reduced supply of fry caused by the excessive destruction of these species by over-fishing in the offshore waters, the increase of dabs and long rough dabs either directly to the protection of their spawning grounds, or indirectly to the natural consequences, in the struggle for existence, of the reduction in the numbers of their competitors.

THE STATISTICAL EVIDENCE.

I. Annual Catches of Grimsby Sailing Trawlers, 1860–92.

Two Grimsby smack-owners have submitted statements concerning the annual catches of their vessels during the last forty years.

At the request of the Sea Fisheries Commission of 1863, Mr. Henry Knott provided a statement of the weight and value of fish caught by an average Grimsby trawler during the years 1860 to 1864, which is printed as an appendix to the report of the Commissioners (p. 46), and is quoted in Holdsworth's *Deep-Sea Fishing*, 1874, p. 88. The original statement gives the weight in tons, hundredweights, and quarters, and the value in pounds, shillings, and pence. I give below a copy of this statement, omitting unnecessary details, and adding an average of the five years' records.

TABLE III., *showing the Weight and Value of Fish caught by one Grimsby Trawler during the years* 1860 *to* 1864.

(From a Return submitted by Mr. Knott to the Sea Fisheries Commission in 1865).

	Prime. cwts.	Offal. cwts.	Total. cwts.	Prime. £	Offal. £	Total. £
1860	379	1325	1704	320	114	434
1861	262	1396	1658	393	177	570
1862	259	1054	1313	360	106	466
1863	364	1489	1853	455	145	600
1864	458	1888	2346	443	189	633
Average	345	1430	1775	394	146	540

It was stated by Mr. Knott that the figures do not refer to the same trawler throughout, but "the selection made in the vessel for each year may be taken as a fair average."

For so short a term of years the annual catches of a single trawler cannot be held to afford much evidence as to the increase or decrease of fish on the fishing grounds within the period. The obvious feature of the table is the abundance and cheapness of fish. Nothing like an average capture of 345 cwts. of prime fish and of 1,450 cwts. of "offal" is realised by trawling smacks at the present time, in spite of the inducements offered by the far higher prices to be obtained to-day for fish of all kinds. The average prices yielded by the figures in the table are 22*s.* 10*d.* per cwt. for prime, and 2*s.* 1*d.* for offal fish. In 1898 the average values, as given in the Board of Trade returns, were £4 17*s.* 11¾*d.* per cwt. for prime fish, £1 4*s.* 5*d.* per cwt. for plaice, and 11*s.* 8¼*d.* per cwt. for haddock. It must be remembered that plaice and haddock in 1860 formed the bulk of the "offal" in a trawler's catch.

The second series of returns of the annual catches of trawling smacks was submitted, in condensed form, to the Select Committee on Sea Fisheries in 1893 by Mr. G. L. Alward, of Grimsby, but the returns themselves were not handed in to be printed in the report. Mr. Alward has, however, kindly allowed me to examine his returns, and as they bear internal evidence of general reliability, and provide most valuable information on the past condition of the Grimsby fishery, I have obtained Mr. Alward's consent to publish a copy of them in the present paper (Tables A–D, pp. 65–6). The only deviations from the original manuscripts consist in the omission of shillings and pence in the values and of fractions of hundredweights in the weights assigned, and in the correction of a few unimportant arithmetical errors in the totals.

The figures represent the actual annual catches of four Grimsby trawling smacks (the names of which are given at the head of each table) for a term of eighteen years, from 1875 to 1892, together with the values realised at the port of landing. The catch of each vessel is divided into Plaice, Haddock, Prime, and Rough. Mr. Alward informs me that "prime" here includes soles, turbot, and brill, and excludes lemon soles; while "rough" includes lemon soles, dabs, cod, catfish, rokers (rays), and other sundry items not specially distinguished.

The vessels were engaged on the various fishing grounds of the North Sea, from the Fisher Bank as the northern limit, to the Lemon and Ore Shoals as the southern limit, and from the grounds off the Yorkshire and Lincolnshire grounds on the west to the Dutch and German coasts on the east.

The vessels formed part of the Grimsby fleets during the summer of each year, but fished independently during the winter. Previous to 1882 they generally commenced fleeting in April or May, and left off in August or September. In 1882 and 1883 there was a general extension of the fleeting period on a more complete system, which lasted from March to the end of October. But in 1883 a general strike occurred at Grimsby against the new system, and the period of fleeting was in dispute. After 1883 fleeting commenced, as before, in April or May, and lasted till August or September. Thus the duration of the fleeting period varied between four and six months in all years except 1882 and 1883, when it was prolonged to about eight months.

It will be seen from the returns in the detailed tables that, however variable the catches of the vessels were from year to year, there was a remarkable uniformity, with few exceptions, in the individual catches for the same year. This circumstance enables us to attach considerable importance to the evidence which they furnish for the whole term of years as to the abundance of fish on the grounds frequented, although undue weight should not be attached to the figures in comparing individual years with one another, owing to the inevitable fluctuations in the catches of sailing vessels dependent so largely upon wind and weather, which would affect the duration of the fleeting period as well as other elements in their catching power.

The figures representing the quantities of fish landed by all four vessels have been combined and averaged in the following table. Figures showing the maximum catch for the entire period, as well as increases in the annual catch, have been thrown up in blacker type in order to distinguish the years of greatest abundance and of increasing returns. I have also, for comparison, prefixed to the series the figures which Mr. Alward had also prepared to show the average catch of his vessels in 1867.

There does not appear to be any need to dwell at great length upon the meaning of these figures, which, except for the sudden rise in 1882, caused by the reorganisation of the fleeting system already described, show a practically continuous fall in the average annual catches. The amount of the total fall, after all possible allowances for variations due to wind and duration of the fleeting period, cannot be placed at less than one-half of the catch obtained at the beginning of the period; while the catch of plaice at the end of the period is scarcely more than one-third of that obtained at the beginning. Rough fish, on the other hand, show a distinct increase up to the last five or six years of the period, when they also begin to show signs of diminishing abundance. The explanation of this contrast is doubtless to be sought in the increasing scarcity of better fish and the advancing prices of all kinds of fish owing to the increased demand. There is abundant evidence in the reports of the various Sea Fishery Commissions that in the palmier days of the trawling industry large quantities of the less valuable fish were thrown away at every haul to leave room for a greater quantity of the better kinds. Conditions have changed in more recent times, and the fisherman, under ordinary circumstances, brings home all he can catch. The increase under "rough" fish is, therefore, evidence rather of an increased attention to the less valuable kinds than of an increased abundance. The catches of haddock fluctuate considerably, as is natural with so migratory a fish; but there can be no doubt, even in this case, as in that of prime fish, that a greater abundance was maintained in the earlier part of the period than in the later years.

TABLE IV., *showing the Average Annual Catch (in cwts.) of four Grimsby trawling smacks*, 1875 *to* 1892.

	Plaice.	Haddock.	Prime.	Rough.	Total.
1867	**998**	831	**137**	46	**2012**
1875	549	**937**	63	30	1565
1876	**601**	891	50	**33**	**1576**
1877	421	668	**88**	21	1198
1878	254	481	76	**31**	843
1879	**298**	**488**	**98**	**44**	**928**
1880	291	359	65	39	754
1881	242	280	**84**	**70**	675
1882	**385**	**717**	**84**	**86**	**1273**
1883	340	665	**97**	74	1177
1884	325	526	96	**79**	1025
1885	280	477	90	**89**	936
1886	250	**510**	77	87	925
1887	221	475	62	87	846
1888	195	372	42	57	667
1889	177	342	**64**	**69**	652
1890	**205**	**465**	47	65	**783**
1891	203	**590**	47	**79**	**920**
1892	168	436	29	49	683

The following summary shows the average annual catch during successive periods of five years' duration.

TABLE V., *showing a Quinquennial Summary of the preceding table.*

	Plaice.	Haddock.	Prime.	Rough.	Total.
1875–9	**425**	**693**	75	32	**1222**
1880–4	317	509	**85**	**70**	981
1885–9	225	435	67	**78**	805
1890–2	192	497	41	64	795

If these figures be compared with those advanced by Mr. Knott for the years 1860 to 1864, the fall in the annual catches becomes still more striking, whether prime fish alone or the total catch be considered. The return provided by Mr. Alward for 1867 forms a connecting link between the two series, and shows that there is no ground for discrediting the results of a comparison between them.

The explanation, however, of the very extraordinary catches of prime fish by the trawlers from 1860 to 1867 requires consideration, since it is not so obvious as that of the abundance of plaice. It is known that an extension of the trawling grounds on the Dogger Bank took place in 1860 and 1861, according to Mr. Alward's chart* of the fishing grounds; and also that the new grounds, when first exploited, were found to be very rich, especially in plaice and haddock (Sea Fisheries Commission, 1865, §§ 4,777–81, 6,908–10, 7,562, 7,672–8, 11,117–24).

The abundance of the two latter species appears to have been maintained down to the year 1876, since the offal catches of Mr. Knott's trawlers may safely be taken to have consisted principally of these fishes, and the corresponding items in Mr. Alward's returns did not fall below the same high average until the year 1877. This is a long period (seventeen years), and although there is a gap of seven years—from 1868 to 1874—in the returns, the evidence undoubtedly points to the conclusion that the large catches of plaice and haddock were not exceptional phenomena limited to one or two isolated years, but were indicative of the general abundance of these fish on relatively virgin grounds.

Nevertheless it is far from improbable that the abundance of fish fluctuated at that, as in more recent times, under the influence of climatic causes; and there is some evidence that the difference between the minimum and maximum catches within the period 1860–7, should be in part attributed to causes of this nature. The evidence tendered to the Sea Fishery Commissioners in 1863 by Grimsby, Yarmouth, and other fishermen tends to show that a general improvement of the fisheries took place in that year, which was not altogether to be accounted for by the exploitation of new grounds. Thus a Grimsby line fisherman stated in November, 1863, that the catches of liners had considerably increased that season, which was the best in his long experience (§§ 15,942–3); and similar statements were also made concerning soles and turbot (§§ 7,555–8, 16,085). Accordingly the increased catches of Grimsby trawlers in 1863 and 1864, both of prime and offal fish, should probably be treated as exceptional features due to the occurrence about this time of exceptionally favourable physical conditions, just as there is good reason

* Deposited with the Fishmongers' Company; printed in Captain Dannevig's recent pamphlet, *Fiskeri og Videnskab*, Arendal, 1899.

to believe (see below, p. 55) that the weather in 1893 also caused an increased abundance of the same kinds of fish (prime, plaice, and haddock). I have not access at present to the detailed temperature returns prior to 1866, and must leave the verification of this suggestion to a later stage; but the years 1863 and 1864 occur in lists of exceptionally hot and dry summers (the spring also was hot in 1863), so that there is some preliminary evidence in support of this view. (Ramsay's *Bibliography, Guide and Index to Climate*, 1884, p. 348.) It is unfortunate that Mr. Alward's returns do not cover the period from 1868 to 1871, since the temperature conditions which prevailed in 1868 were remarkably similar to those of 1893, both in regard to the mildness of the first (winter) quarter, and the exceptional warmth of the spring and summer.

The possibility of this interpretation should, in any case, be borne in mind, especially as it would, if confirmed, render intelligible the extraordinary drop in the average catches of prime fish after the year 1864, as shown by the returns of these Grimsby trawlers. The fall from 458 cwts., in 1864, to 137 cwts., in 1867, is far too rapid to be attributable to the effects of over-fishing under the conditions which then prevailed, but a fall to the same level from 259 cwts., in 1862, would be less incredible as a consequence of such a cause. From the difference in the distribution of plaice and soles it is not improbable that the effects of over-fishing would be earlier shown by the latter species than by the former.

On the other hand, it is exceedingly improbable that the difference between the abundance of prime fish at the beginning of this period (1860–2) and the scarcity at the end of the period (1888–92), as indicated by the average catches, is attributable to weather conditions, since this would involve the assumption that a type of weather prevailed in the former period capable of multiplying fourfold the normal abundance of these fishes. I do not dispute the possibility of such an increase, but it is so improbable that it would require a very elaborate investigation to establish it as a reasonable hypothesis.

The returns of both series of Grimsby smacks seem, therefore, to provide unequivocal evidence of a great depletion of the North Sea trawling grounds. Between 1860 and 1892 the average annual catch of prime fish dwindled from at least 300 cwts. to less than 60 cwts. per vessel; the catch of plaice and haddock from about 1,300 cwts. to 700 cwts.; and the total catch (in spite of increased attention to the less valuable kinds of fish) from *at least* 1,300 cwts. to *at most* 900 cwts.

From Mr. Alward's returns, which distinguish plaice from other offal fish, it is clear that the fall in plaice over the whole term of years must have been nearly as great as the fall in prime fish, since the catches at the end of the period averaged not more than about 200 cwts. per vessel, whereas they were nearly 1,000 cwts. in 1867, and were obviously not less than 600 or 700 cwts. in any of the years from 1860 to 1864, unless the high averages of offal in Mr. Knott's returns are to be attributed exclusively to the exceptional abundance of haddock.

These conclusions show that the depletion which has actually occurred in the North Sea is principally due to an enormous reduction in the abundance of flat-fish, both prime and plaice, the catches under each head about 1890 being less than one-fifth and one-third respectively of the quantities taken from twenty-five to thirty years previously. The catches of haddock have also diminished, but to a less extent, viz. from an average of over 800 cwts. per vessel to less than 500 cwts.

II. Official Statistics of the Grimsby Fisheries, 1886–99.

The smack-owners' returns, from which the foregoing conclusions have been drawn, bear internal evidences of their substantial accuracy, but to make assurance doubly sure upon this important point I subjoin a statement as to the condition of the Grimsby fisheries since 1885, based upon returns which have been kindly placed at my disposal by the Great Central Railway Company, and upon the Grimsby Registers of Fishing Vessels published in the Annual Statements of Navigation and Shipping.

TABLE VI., *illustrating the state of the Grimsby Fisheries (of all kinds) from* 1886 *to* 1899, *and showing for each year the Number of first class Fishing Vessels on the Register, the Total Weight of Fish sent inland by Rail, and the Average Weight (tons) of Fish per Unit of Fishing Power, each Steamer being regarded as equivalent to four Smacks.*

Year.	Fishing Vessels (First Class). Total Registered.	Smacks.	Steamers.	Fishing Units (4:1).	Fish sent inland by Rail (tons). Total.	Average per Unit.
1886	823	803	20	883	69,609	79
1887	839	818	21	902	66,698	74
1888	811	785	26	889	68,883	77
1889	789	752	37	900	66,280	74
1890	777	727	50	927	67,974	73
1891	811	713	98	1105	69,593	63
1892	793	683	110	1123	74,117	66
1893	787	649	138	1201	75,527	63
1894	771	604	167	1272	83,001	65
1895	720	532	188	1284	85,430	66
1896	630	400	230	1320	92,638	70
1897	630	350	280	1470	89,006	60
1898	611	247	364	1703	94,643	55
1899	524	99	425	1799	103,783	58

The figures representing the weight of fish sent inland by rail from the port of Grimsby have been provided by the General Manager of the Great Central Railway Company. They are exclusive of exported fish, and correspond with the figures annually published by the Board of Trade in their *Statistical Tables and Memorandum*, except for the years 1886–90 inclusive, for which years the Board of Trade's figures yield slightly lower "averages per unit" than mine, viz. 77, 73, 76, 72, and 72 respectively. The difference is insignificant, since both series of figures show practically the same progressive reduction in the annual averages.

The Railway Company's returns, however, exaggerate the true product of the Grimsby fisheries in two respects. They include a considerable quantity of herrings and mackerel landed at the port by Lowestoft, Scottish, and other vessels from the drift-net fisheries which are not pursued by Grimsby boats; and they also include the weight of boxes and ice, etc., in which the fish are packed for transport—items which it is well known are by no means inconsiderable.* From calculations which I have made, I estimate that about two-fifths of the total weight sent inland by rail should be deducted in order to cover these two sources of exaggeration. The inclusion of these extraneous items does not, however, affect the validity of the returns for my present purpose, which is merely to determine whether the official returns exhibit a constant or a declining catch per fishing boat per annum.

In order to establish this point I have taken each fishing steamer registered at the port to be equivalent in catching power to four sailing vessels; and in order to avoid any suspicion of having exaggerated the catching power in the later years of the period, I have purposely neglected all advances in the efficiency of the steamers due to increased tonnage or the adoption of new gear, such as otter trawls (cf. pp. 46–52).

In spite of these omissions, it is seen in the table that the averages per fishing unit have steadily diminished from 1886 to the present time. Owing to the increase of steam vessels and the decline of sailing vessels during the period, the amount of this diminution would be shown to have been very much greater if account had been taken of the relative increase in the catching power of steamers during the period. The results provide a conclusive confirmation of the general accuracy of the conclusions drawn from the smack-owners' returns in the preceding section of my paper.

A table of a somewhat similar character to the above, for the years 1878 to 1892, was submitted by Mr. Alward to the Select Committee in 1893, and is printed in their report (p. 9, § 216). The general character of our respective figures is the same, but Mr. Alward's figures yield

* The fish occasionally landed by foreign trawlers also tend to swell the returns (cf. HOLT, this Journal, iii. p. 411).

rather higher averages than mine when worked out in the same way, the averages from 1886 to 1892 being 86, 84, 89, 75, 70, 65, and 66 respectively. From information received from the Railway Company, however, it would appear that Mr. Alward's figures representing the tonnage of the Grimsby fish traffic have not in all cases been subjected to the full deductions of fish exported to the Continent.

The quantity of fish exported to the Continent from Grimsby was uniformly about 4,000 tons annually from 1886 to 1892, after which year it regularly increased, being 5,000 tons in 1894, 8,000 tons in 1896, and over 10,000 tons in 1899. Nevertheless, even if this class of fish should also be attributed to the Grimsby fisheries, the fall in the average catch is equally apparent, being 83 tons for 1886, 70 tons for 1892, and 65 tons for 1899.

Moreover, the fall in the average catches cannot be attributed to any marked diversion to London during the later years of fish from Grimsby vessels which landed their catches at the home port in the earlier years of the period; for the proportion of sea-borne to rail-borne fish in the London markets has decreased appreciably since 1888, whether the calculation be based on the returns of the Fishmongers' Company (37 per cent. to 32 per cent.) or on those of the Board of Trade (33 per cent. to 29 per cent.). (Cf. *Statistical Tables and Memorandum for 1891*, p. 7: "The inference would be that there is a tendency to bring fish to London from distant parts by rail, instead of bringing them direct from the fishing grounds by sea. It seems highly probable that this is not merely a temporary change, but is one of a permanent character.")

III. The Lowestoft Trawl Fishery, 1883–98.

By the kindness of the Great Eastern Railway Company I am able to bring up to a more recent date the statistics of the Lowestoft trawl fishery which were submitted to the Select Committee in 1893 by Mr. Hame (*Minutes*, pp. 67–75). As stated by Mr. Hame in his evidence before the Committee, the Railway Company owns the fish docks, and receives a small toll for every package of fish landed. Consequently the returns of fish landed at the docks, as supplied by the Railway Company, possess an unusual degree of accuracy. A record is also kept by the Company of the number of trawling vessels which land their fish at Lowestoft; and although there is an inaccuracy here caused by the want of discrimination between vessels which regularly land their fish at Lowestoft and those (mostly hailing from Ramsgate and French ports) which only do so from time to time, it nevertheless seems possible to obtain a rough idea of the progress of the fishery by comparing the totals of fish landed by the trawlers with the gross number of trawling vessels from year to year.

The trawled fish landed at the port are classified by the Railway Company under Cod, Prime, and Offal. The returns of cod are given in "scores," those of prime and offal in "packages." Mr. Hame, in his evidence, treated the average weight of each package as about one hundredweight, and I am informed by the Dock Superintendent that this estimate is approximately correct; but there is no need to enter into this question for my present purpose, as the number of packages affords a sufficient index for comparing the condition of the fishery in successive years.

In the following table the returns of fish landed and of the fishing vessels prior to 1893 are copied from Mr. Hame's figures as published in the Minutes of the Select Committee. Those from 1893 onwards have been supplied to me directly by the Railway Company.

On recalculating the averages per vessel for the first period my results in three cases do not quite coincide with Mr. Hame's, probably as a result of printer's errors. For 1892 the error in Mr. Hame's table is undoubtedly in the averages, since the accuracy of the figures representing the total returns of fish landed in that year has been confirmed for me by the Railway Company. Consequently I have provided a new series of averages, marking with an asterisk those figures which differ by more than two units from the figures published by the Select Committee, which are placed in brackets alongside. The smaller quantities of cod-fish have not been averaged, for obvious reasons.

TABLE VII., *showing the Condition of the Lowestoft Trawl Fishery from 1883 to 1898 (from Returns provided by the Great Eastern Railway Company.)*

		Total Packages Landed.			Average No. per Vessel.	
Year.	Vessels.	Cod (scores).	Prime.	Offal.	Prime.	Offal.
1883	157	227	18,056	59,393	*115 (128)	378
1884	167	2,010 (*sic!*)	18,613	59,640	111	357
1885	173	225	24,228	77,948	140	450
1886	168	372	28,208	90,482	*168 (160)	539
1887	190	101	24,341	87,710	128	462
1888	230	53	23,022	117,552	100	511
1889	235	169	24,844	128,156	106	545
1890	260	151	25,647	136,810	99	507
1891	265	32	34,701	189,770	131	716
1892	360	338	32,013	210,504	*89 (100)	*585 (684)
1893	394	258	37,523	219,830	95	558
1894	365	189	34,340	184,099	94	504
1895	369	57	31,088	187,564	84	508
1896	350	84	28,018	177,437	80	507
1897	326	13	28,455	168,678	87	517
1898	318	5	29,283	170,543	92	536

The averages per vessel indicate a distinct falling off in the quantities of prime fish landed by each vessel and a rise in the quantities of offal, though the fall in prime fish occurs throughout the period, while the rise in offal is limited to the earlier years. These features can best be seen by averaging the returns per vessel for longer (quinquennial) periods, a method which eliminates the minor fluctuations, thus:—

	Prime.	Offal.
1883–88	127	449
1889–93	104	582
1894–98	87	514

So far as the official figures go, therefore, the Lowestoft trawl fishery is declining as well as the fisheries further north. It should be remembered that the trawling grounds of the Lowestoft smacks are mostly in shallower water than those of the Hull and Grimsby vessels, and are bounded approximately by the parallels 51°·30 and 53°·30, being altogether south of the Dogger and south and west of Heligoland (Select Committee, 1893, §§ 1,538, 1,539, 1,634, 1,639; also first Report of the Inspectors of Sea Fisheries, p. 14).

On the other hand, the inclusion of temporary visitors in the list of vessels working from the port has the effect of depressing the estimated averages below the true values, and in particular years this source of error may attain exceptional dimensions, *e.g.* 1892 (cf. the actual average of an exclusively local fleet of that year, cited below, p. 45). Consequently the evidence afforded by these returns should be treated cautiously, and no undue importance should be attached to the averages deduced from them for isolated years.

IV. The Entire Bottom Fisheries of England and Wales during the decade 1889–98.

In this section I propose to compare the total quantities of "bottom fish" landed annually on the English coasts with the total number and catching power of the deep-sea trawlers and liners for each year of the decade, separating the fisheries prosecuted by the East Coast vessels in the North Sea from the fisheries carried on in the English and Bristol Channels and other Western waters.

1. Statistics of Bottom Fish.

The method adopted for determining the quantity of bottom fish annually landed is the same as that used by my predecessor, Mr. Cunningham, as described in his paper on "The Immature Fish Question" in this Journal (vol. iii. p. 54). The Board of Trade's returns in their annual *Statistical Tables and Memorandum* have been taken as the basis, the annual totals of mackerel, herrings, pilchards, and sprats being deducted from the totals of "all fish, except shellfish." The elimination of the drift-net fish yields a remainder which may safely be regarded as the product of the trawl and line fisheries together.

In distinguishing the products of the North Sea fishery, however, it has been necessary to deviate to some extent from the line of separation adopted by the Board of Trade (the North Foreland), whereby Ramsgate is excluded from the East Coast ports (Mr. Berrington's Evidence, Select Committee, 1893, § 2,426). The principal fishing grounds of the Ramsgate trawlers largely coincide with those of the Lowestoft vessels in the southern part of the North Sea, and I am informed by the Harbour-master of Ramsgate through the Board of Trade, that "most of the Ramsgate trawlers work in and out of Lowestoft as much as they do here [*i.e.* Ramsgate]; it depends greatly upon the wind which port they can more easily make." Under these circumstances it was clearly necessary to transfer the figures for Ramsgate catches and vessels from the South to the East Coast. Accordingly, the line which I have adopted for separating the East from the South Coast lies between Ramsgate and Deal, thus coinciding with the classification of the fishing ports originally given by the Inspectors of Sea Fisheries in their first Annual Report, p. 25. It is, perhaps, worthy of consideration whether it would not be advisable to revert to this original scheme in any future rearrangement of the fishery statistics.

The Board of Trade has kindly provided me with a detailed return of the fish landed annually at Ramsgate since 1888, from which the following figures, representing the total quantities of "bottom fish" landed at the port, have been derived.

Year.	cwts.	Year.	cwts.
1889	30,319	1894	31,425
1890	29,285	1895	37,162
1891	30,837	1896	36,129
1892	33,351	1897	36,417
1893	35,406	1898	31,606

These figures have been deducted from the totals of bottom fish for the South Coast derived from the *Statistical Tables*, and added to the corresponding figures for the East Coast. The resultant figures,*

* The figures in Cunningham's table on p. 55 (*l.c.*) contain two errors of some importance. His total for drift-net fish in 1889 should be 2,428,118, instead of 1,428,118; and his total for bottom fish in the same year should be reduced by the same amount (one million). For 1890 his figures for the same two items should be 2,000,644 and 4,099,986 respectively. The latter errors clearly arose from an alteration in the order of the various items in the *Statistical Tables* for that year, the figures for plaice having been taken by Cunningham to represent herrings. These errors materially affect his conclusions at the top of p. 57, which need correction.

prepared in the manner described and reduced to tons, are given for the various coasts in Table VIII. (p. 34).

The only source of uncertainty (apart from the question as to the general reliability of the official returns) which I can discover in this method of determining the annual quantities of bottom fish landed arises from the unspecified nature of the item which appears in the *Statistical Tables* as "Fish not separately distinguished, except shell-fish." As this item, however, clearly includes such fish as whitings, gurnards, dabs, skates, and rays, and as all the important drift-net fish are separately distinguished, no appreciable error can be introduced by treating this item of sundries as forming part of the total of bottom fish. It forms one-fifth of the total catch in 1889, and one-seventh in 1898; but the proportion is considerably greater for the South and West Coasts than for the East Coast—a feature of which one would like to know the explanation.

2. Statistics of Fishing Boats.

By Clause 17 of an Order in Council of the 18th of June, 1869, which has reference to the Registration of British Sea Fishing Boats under Part II. of the Sea Fisheries Act of 1868, it is provided that the register of sea fishing boats shall contain, among other details, "the name of the vessel and of the port to which she belongs, description of her rig and of her ordinary mode of fishing, her registered number, class, tonnage, and length of keel, and number of crew usually employed."

In view of this provision I expected, in the course of the present investigation, to be able to obtain an authentic statement of the number of trawling vessels on the register for each of the past ten years; but, after correspondence with the Customs Establishment and the Board of Trade, it has been found necessary to depend upon indirect sources of information, in consequence of information received from the Board of Trade to the effect that "the Returns rendered by Collectors of Customs prior to 1893 no longer exist" (March, 1900). This circumstance is much to be regretted, for I am confident that for the purposes of fishery statistics the unpublished portions of the fishing-boat registers contain data which are sufficient to provide an authentic list of the numbers of deep-sea fishing boats engaged in trawling, even if they are of less value for determining the numbers of deep-sea line vessels and drifters. It is rare, however, for the same port to possess fleets of all three classes of vessel, so that even the numbers of first class liners and drifters could usually be obtained by deducting the number of registered trawlers from the total of all kinds registered at the respective ports.

Nevertheless, in spite of the absence of any official lists of the total

TABLE VIII., *showing the Total Weight of Bottom Fish landed (tons), the Total Catching Power of First Class Trawlers and Liners expressed in "Smack-units," and the Average Catch per Smack-unit for all Coasts of England and Wales and the Isle of Man, and for each Year from* 1889 *to* 1898 *(tons).*

Year.	East Coast.			South and West Coasts.*			Total of all Coasts.		
	Total Catch.	Smack-units.	Catch per Unit.	Total Catch.	Smack-units.	Catch per Unit.	Total Catch.	Smack-units.	Catch per Unit.
1889	173,180	2,859	60·6	28,642	946	30·3	201,822	3,675	54·9
1890	172,055	3,086	55·7	32,944	1,071	30·8	204,999	3,942	52·0
1891	180,054	3,711	48·5	28,772	1,067	27·0	208,826	4,558	45·8
1892	187,512	4,057	46·2	33,820	1,254	27·0	221,332	4,876	45·4
1893	200,281	4,307	46·5	33,737	1,157	29·1	234,019	5,133	45·6
1894	215,408	4,599	46·7	33,819	1,070	31·6	249,227	5,400	46·1
1895	228,180	4,918	46·4	36,626	1,243	29·5	264,805	5,781	45·8
1896	232,034	5,620	41·3	40,732	1,514	26·9	272,766	6,544	41·7
1897	225,864	6,099	37·0	45,775	1,788	25·6	271,640	7,363	36·9
1898	230,656	7,143	32·3	55,010	1,896	29·0	285,667	8,503	33·6

* See remarks on pp. 62 to 64.

number of boats engaged in each of the different kinds of fishery, it has been possible to prepare a list of first class vessels which is probably sufficiently accurate for my present purpose from the information published in the Annual Reports of the Inspectors of Sea Fisheries and in the Annual Statements of Navigation and Shipping, supplemented, where desirable, by correspondence with local authorities.

The Annual Reports of the Inspectors contain returns rendered by the collectors of fishery statistics at each port, giving the approximate number of boats of each class engaged in each fishery, whether belonging to the station or not. These returns commenced in 1889. In 1892 a column was added to the returns showing the total number of boats of each class belonging to each station, and, although there are slight differences between the figures in this column and those in the Fishing Boat Registers, the numbers assigned to the first class boats are practically the same.

It is not difficult from a perusal of these returns to form a fairly correct idea of the numbers of local boats engaged in the different modes of fishery. The irregular numbers and migrant habits of the drift fleets, and the periodic movements of such vessels as the Brixham and Ramsgate trawlers, undoubtedly affect the collectors' returns for various ports to a considerable extent, and preclude the possibility of using their figures, without further analysis, for statistical purposes, owing to the inclusion of large numbers of vessels in the returns for more than one port. But, so far as the first class vessels are concerned, it is always possible to trace the number of non-local boats by comparing the collector's total for each port with the register of fishing vessels, and in the great majority of cases it is possible also to discover the kind, or kinds, of fishery in which the visitors are engaged. In this way the number of local boats engaged in each fishery can be determined with a considerable degree of exactitude, thus permitting the addition of the numbers so obtained in order to form an approximate total of the boats engaged in any one form of fishery, either for the country as a whole, or for particular sections of the coast line.

The method pursued was in the first place to tabulate the collectors' annual returns of the vessels engaged in trawling for the entire term of years since 1889, and for all ports, distinguishing steam trawlers from smacks, first class from second and third class boats, and deep-sea from inshore trawling vessels. The table showed at a glance that the numbers of trawlers of the second and third class might be neglected entirely, partly on account of their small size (under fifteen tons), and partly from their relatively small numbers throughout the period. The inclusion of these boats, with their feeble catching power, would obviously not materially affect the results.

§ i. *Number of Trawling Smacks.*

Leaving the question of steam trawlers for later consideration, it appeared, upon detailed examination, that first class sailing trawlers are practically limited to the ports mentioned in Table E. The returns also assign a number of these boats to the fisheries from London (Shadwell), Hastings,* Eastbourne, Shoreham, Newlyn, Ilfracombe, Milford, Holyhead, and Bangor. But the figures for Shadwell in reality indicate the numbers of trawlers supplying the Shadwell carriers, the few boats at Eastbourne trawl for a very short portion of the year, and none of the remaining ports possess sailing trawlers of their own. The Hastings trawlers hail from Rye; the Shoreham boats partly from Lowestoft and partly from Brixham; the Newlyn, Ilfracombe, Milford, and, to some extent, Tenby boats from Brixham and Plymouth; the Holyhead, and, probably, Bangor boats from Douglas, Liverpool, Fleetwood, and Carnarvon.

As regards the determination of the actual numbers of trawlers owned at the various ports, no difficulty was experienced in regard to the ports of the South and West Coasts, since, with the exceptions just mentioned, the number of trawlers estimated by the collectors to be working from the various ports was found to correspond to all intents and purposes with the total of first class vessels, less steam fishing vessels, registered at the ports. The same remark applies to Ramsgate, which, so far as trawling is concerned, should be included among the East Coast ports, owing to the position of the fishing grounds usually frequented by the Ramsgate trawlers.

But there were considerable difficulties in determining exactly the number of trawlers at the remaining ports on the East Coast, principally due to the uncertainties as to the number of local vessels engaged in the drift fisheries from each port. It is, of course, well known that these fisheries are pursued by a nomad fleet composed of Lowestoft, Yarmouth, Scottish, Manx, and Cornish vessels; and as the collector's estimate of the number of vessels engaged in these fisheries from Yarmouth or Lowestoft does not discriminate between the local and the non-local boats, it was impossible to use the method of comparing the total of the collector's returns with the registered total in order to decide whether his estimates of the trawlers included any proportion of boats from other ports.

Fortunately, in the most difficult case (Lowestoft), it was possible

* The trawlers for Hastings in 1891 are returned as follows: "Steam, 20; second class, 50." As the collector remarks that "the twenty first class *smacks* are from Rye," and as neither Rye nor Hastings ever possessed more than three steam trawlers, it is obvious that the figures should be "Steam, 2; first class, 20; second class, 50," the numbers approximating to the returns for Rye as in other years.

to obtain reliable information as to the number of trawlers using the port for a long term of years from the Great Eastern Railway Company, the owners of the fish-docks (Table VII). Evidence from the same source, together with independent evidence as to the numbers of the local trawlers, was furnished to the Select Committee on Sea Fisheries in 1893 by Mr. Hame, who places the local trawlers for 1892 at about 300, and for 1893 at 325 (Minutes of Evidence, §§ 1,532 and 1,642). The latter number practically coincides with the collector's return for the same year in the Report of the Inspectors, whereas the gross number of trawlers using the port is given by the Railway Company as 394 for 1893, and for each year from 1889 to 1896 uniformly exceeds the collector's figure, the excess usually amounting to from 30 to 70. The dock superintendent informs me that the number of Ramsgate trawlers landing their fish in Lowestoft may be placed at about 50 or 60.

From all this evidence it is clear that the collector's returns of the trawlers engaged in the Lowestoft fishery are not the gross returns of trawlers using the port, but more nearly represent the numbers of local trawlers. On the other hand, the collector's returns for the four years 1890 to 1893 (viz. 203, 186, 350, 320) fluctuate in a manner which is inconsistent with the view that they represent the local trawlers exactly, and as the Railway Company's gross (but exact) returns show a continuous increase from 1886 to 1896, I have "smoothed" the collector's figures for 1891 and 1892 in conformity with this fact. The correction may not be perfectly exact, but it probably reduces the error to insignificant dimensions. Mr. Alfred Turner, of Lowestoft, informs me that the local boats have increased since 1893, but rather than exaggerate the catching power in these later years, I have preferred to retain the collector's estimate, in the absence of definite information.

In the case of Grimsby an exact classification of the fishing boats registered in 1899 is given by the Great Central Railway Company in an official pamphlet* dealing with that port, the whole of the vessels being included as trawlers or liners, without mention of drift boats. As the number of trawlers and liners in the collector's returns for Grimsby in any year does not exceed the total registered, it may be safely assumed that at this port also the collector's returns of these classes of boat approximately represent the numbers of local boats in

* *Leading Events and Statistics in connection with the Formation and Development of the Port of Great Grimsby.* Manchester, 1900. "Steam line vessels, 52; sailing line vessels, 29; steam trawlers, 373; sailing trawlers, 70; total (registered), 524." In a previous edition, dated 1894, the Grimsby fishing boats for 1893 are classified as, "Trawlers, 670; cod vessels, 127; total, 797." These figures show that my figures for the whole period are sufficiently near the mark.

active work. It is possible that a number of Grimsby trawlers, which supply the Shadwell market by means of steam carriers, should be added to these figures, but in the absence of conclusive information I have preferred to omit them.

The collector's returns for Yarmouth have been accepted without change. The same is true for Hull, except that the collector's number for 1892 has been reduced from 300 to 280, since the Register, as well as other evidence, precludes the possibility of admitting any increase in the number of Hull smacks during the decade.

In the case of Scarborough Mr. Ashford, the Fishery Officer of the North-Eastern Committee, informs me that the local smacks have now (February, 1900) entirely given up trawling. "There are a few (7) which have been altered in rig, and are at present engaged in line fishing. These, with twenty yawls, also liners, belong to the port. There are about twenty yawls laid up, which have not left the harbour for years, it being considered not worth while to keep them fit for sea. We have also belonging to Scarborough fifteen paddle trawlers and three screw trawlers, and one screw trawler working from Scarborough but owned at Hull." Mr. Cunningham reported only eighteen sailing trawlers and nine or ten steamers as belonging to Scarborough in 1895 (*Jour. M. B. A.*, iv. p. 113). The collector's returns of the sailing trawlers working from the port are adopted in my table up to 1893, but his subsequent returns (40, 40, 19, 28, 8) so clearly include a variable non-local element that, in view of the evidence cited above, I have reduced the excessive figures for three of these years, so that the entire array of figures for the ten years exhibits a continuous decrease within verifiable limits.

The results of my analysis, as set forth in Table E, p. 67, show that the estimated number of first class trawling smacks belonging to the East Coast has fallen considerably during the decade, from 1,737 in 1889 to 1,015 in 1898. The fall is not, however, quite regular. The Scarborough, Hull, and Grimsby smacks show a general decrease, but the Yarmouth fleet (though subsequently broken up) was greatly increased in 1890 and the Lowestoft fleet about 1892 (cf. the collector's returns for 1892 and 1893 and the Great Eastern Railway Company's returns, Table VII.), while the Ramsgate vessels, as shown by the collector's returns and the Fishing-boat Register, have also steadily, though slightly, increased in numbers.

On the South and West Coasts the total number of smacks has remained practically constant throughout the decade, varying from 546 at the beginning to 525 at the end. Here, also, the same phenomenon is exhibited as on the East Coast, viz. a decrease at certain centres (Liverpool, Fleetwood) where the smacks are being replaced by steamers, and an increase, though slight, at others (Rye, Brixham) where steam trawlers show no signs of increase.

§ ii. *The Number of Steam Trawlers.*

The number of steam trawlers has been determined upon a different plan from that followed in the case of the smacks, owing to the circumstance that they form the great majority of the steam fishing boats in general. Consequently the Register has provided the basis for my estimates, and the collectors' returns have been used merely for determining the number of deductions which should be made to cover the number of steam liners, carriers, and drifters. According to the Reports of the Scottish Fishery Board a certain number of English steam trawlers land their fish regularly at Scottish ports. These, therefore, have been also deducted. The total deductions made for the different years of the decade (Table H, p. 69) are as follows:—

	1889	1890	1891	1892	1893	1894	1895	1896	1897	1898
Steam liners . . .	40	50	50	60	70	80	90	100	100	80
" drifters . . .	—	—	—	—	—	—	5	15	20	35
" carriers . . .	33	32	34	37	41	39	45	45	50	50
" trawlers, in Scotland	30	31	37	(38)	39	38	35	32	31	37
Total deductions .	103	113	121	135	150	157	175	192	201	202

The figures representing the liners in the above table are discussed below. The numbers of steamers engaged in the drift fisheries are estimated from the figures returned by the collectors of statistics for Grimsby and Yarmouth. They are undoubtedly excessive, since Grimsby possesses no drift boats at all, and it seems probable that the majority of the steamers engaged were only temporarily occupied as carriers during the summer season: but as the deductions to be made under this head are limited to the later years of the decade, I have purposely taken the highest estimates possible in order to avoid the possibility of exaggerating the catching power in these years. The "carriers" of mackerel mentioned in the collectors' returns under Neyland are not registered as fishing vessels. The Harbourmaster informs me that these vessels are merely chartered for the season, and are employed in the coasting trade or in towing at other times. Consequently no deductions have been made for them.

The principal uncertainty in the series of deductions concerns the numbers which should be written off to cover the carriers for the trawling fleets. The collectors of statistics only enumerate such vessels for the ports of Yarmouth, Shadwell, and Billingsgate, and my figures represent the totals for those stations. They no doubt include the majority of the carriers, so that the error introduced under this head is probably insignificant. Indeed, the steam carrier, although merely engaged in transporting fish caught by other boats, is undoubtedly an element in the catching power as a time-saving contrivance; and the deficiencies in my estimates of these vessels may serve, by their inclusion among the trawlers proper, as a rough measure of the catching power due to the carriers in general.

The figures representing East Coast trawlers which regularly land their fish at Scottish ports have been taken from the Annual Reports and other official publications of the Scottish Fishery Board, except for the year 1892, the figure for which has been interpolated, owing to my failure to find an official record for that year.

The total deductions enumerated in the table have been made both for the entire coast of England and Wales and for the East Coast, but not for the Western Coasts, since they are based on data which apply to the East Coast only. The steamers registered for the South and West Coasts have been taken as being trawlers without exception.

§ iii. *East Coast Trawlers in Western Waters.*

As already remarked, for the purpose of these statistics of Bottom Fish and Fishing Vessels, Ramsgate has been included among the East Coast ports and as the southern boundary of the East Coast district. But in determining the number of boats engaged off the East Coast and off the remaining coasts respectively, it seemed necessary to take account of the East Coast trawlers (both steamers and smacks) which have more or less regularly visited the South and West Coasts during recent years. The methods adopted in order to estimate the numbers of these "East Coast visitors" of each kind were as follows.

In the case of steamers the collectors' estimates of the number of steam trawlers working from the ports of Plymouth, Newlyn, Milford, and Fleetwood were added together for each year, and the numbers of steam fishing boats actually registered at these ports were deducted from the total so obtained. The differences have been taken to represent the visitors from the East Coast. Thus:—

Steamers reported to be Working.

	1889	1890	1891	1892	1893	1894	1895	1896	1897	1898
Plymouth	2	—	—	—	—	—	13	27	30	35
Newlyn	6	8	8	4	3	3	1	1	2	2
Milford	20	35	36	67	60	47	45	55	60	60
Fleetwood	—	—	—	11	11	10	21	19	36	40
Total . . .	28	43	44	82	74	60	80	102	128	137

Steamers registered.

	1889	1890	1891	1892	1893	1894	1895	1896	1897	1898
Plymouth	—	—	—	—	—	—	—	—	—	2
Milford	2	2	4	12	12	12	12	24	24	30
Fleetwood	—	—	—	—	—	—	6	8	36	38
Total	2	2	4	12	12	12	18	32	60	70
Difference.										
East Coast visitors	26	41	40	70	62	48	62	70	68	67

It is probable that by this method the number of visitors has been exaggerated, as a certain number of the steamers were no doubt included by the collectors in their returns for more than one port. Moreover, the East Coast steamers do not invariably spend more than a portion of the year in the Western waters, so that for strict accuracy a suitable deduction should be made under this head. In the absence at present of satisfactory information on those points, however, I have provisionally retained the gross numbers given above as the basis of my calculations, reserving to the sequel the consideration of the extent of the error thereby introduced.

The allowance thus made to cover the North Sea immigrants has only been added to the numbers of registered steamers on the South and West Coasts. Strictly speaking, a corresponding deduction should be made from the registered total for the East Coast steamers, but this has not been done. The difference in treatment is due to the fact that, whatever the exact number of these East Coast immigrants in successive years, they clearly formed a large percentage of the total number of steamers fishing off the Western Coasts (see Table H, p. 69), whereas their deduction from the totals for the East Coast would make no difference in the general result beyond causing a slight and practically uniform increase in the average catches throughout the period.

The numbers of the East Coast sailing trawlers working from the ports mentioned above and from Holyhead have been determined after careful study of the information given in the Annual Reports of the Inspectors of Sea Fisheries and the collectors' returns, and after correspondence with the harbourmasters of Milford and Holyhead. "When these [the Milford] Docks were first opened (in 1889) a large number of Hull vessels, both steam and sail, landed their fish here in addition to many Brixham smacks. The Hull smacks, proving somewhat large and expensive for the short voyages made on this coast, were gradually withdrawn, but most of the steamers continued fishing here until the end of 1893. The nucleus of a local fleet of steamers formed in the interval, and this fleet has gradually been increased to its present size. The steamers here at present are all owned by firms whose headquarters are here, and very few of them fished out of other ports previous to their arrival here" (J. C. Ward, Manager of the Milford Docks Company, February, 1900). In 1899, during the principal season (February 1st to June 30th), the fleet of smacks working from Milford consisted of 206 vessels, composed as follows: Brixham vessels, 142; Lowestoft, 25; Ramsgate, 12; various, 27.

As regards Holyhead, the trawlers landing fish at the present time appear to hail principally from Douglas and Liverpool, a small number, however, belonging to Fleetwood, Carnarvon, and Grimsby. During the year from March, 1899, to February, 1900, fourteen trawlers, on twenty-three voyages, were boarded by the boats of the Queen's Harbour-master. Two only were East Coast (Grimsby) vessels, five hailing from Douglas, five from Liverpool, and one each from Fleetwood and Carnarvon. These figures, however, merely serve to convey an idea of the proportion of boats from various ports, as the majority of fishing-vessels are never boarded by the Harbourmaster's officers. The Grimsby vessels were each boarded on one occasion only; the Douglas, Liverpool, and Fleetwood boats usually twice. This tends to show that the Grimsby vessels were not using the port so frequently as the Lancashire and Manx trawlers, and were possibly there for only a portion of the year. Their "voyages" both occurred in February, 1900.

For Plymouth the number of East Coast trawlers fishing from the port in 1898 is stated by the collector of fishery statistics (Report of Inspectors, p. 165) to have been sixteen, *i.e.* twelve from Lowestoft and four from Ramsgate. These boats, however, do not use the port for more than a short period in the spring (February and March), so that it is probable that a majority of the same boats reappear later on at Milford, and are included in the estimates for that port. I have therefore taken the number of Lowestoft and Ramsgate trawlers known to have frequented the harbour of Milford in 1899 as representing approximately the total number of East Coast smacks fishing in the Western waters generally during the preceding year. The figures for the previous years are rough estimates, culminating in this number and determined in correspondence with the principal features known to have characterised these immigrations of East Coast trawlers, viz. the original invasion of Hull trawlers in 1889 and 1890, the subsequent falling off, and the ultimate increase of the smaller class of vessel from Lowestoft and Ramsgate (Table E). In selecting the figures, I have been also influenced to some extent by the fluctuations in the numbers of vessels estimated by the collector of fishery statistics at Milford, the general features of which have been corroborated by the harbourmaster at that port.* Owing, however, to the fact that these vessels usually

* I am informed by the Harbourmaster of Ramsgate that about twenty Ramsgate trawlers were fishing in the Bristol Channel during the spring of 1900, and were already returning home in the middle of May. A certain number, however, always work off the Sussex Coast in the summer, landing their fish daily at Brighton or Hastings.

return to their own ports for the winter season, it is probable that the figures exaggerate the additional catching power due to the East Coast immigrations, although they probably convey a correct idea of the relative number of the immigrants in successive years. This point, as in the case of the steamers, will be reconsidered in the sequel.

§ iv. *Number of Liners.*

In determining the number of first class vessels engaged in line fishing, it seemed preferable, after examination of the figures given by the collectors of fishery statistics for successive years, to restrict the computation to the East Coast ports, since the number of boats principally engaged in this mode of fishing from the ports of the South and West Coasts is exceedingly small and uncertain. In the case of steam liners, the ports of North Shields, Hull, and Grimsby have been alone selected, since the figures assigned by the collectors to such ports as Sunderland, Hartlepool, and Whitby are both insignificant and variable. In the case of sailing liners, the ports selected were Staithes, Scarborough, Filey, Bridlington, Grimsby, and Harwich. The figures assigned to each of these ports in each year in Table F are those given by the collectors of statistics, subject to deductions, where necessary, of vessels clearly belonging to other ports.

The totals, as set forth in Table F, show that while the steam liners have doubled during the decade, the sailing liners of the first class have fallen from about 240 to 80.

3. Relative Catching Power of Trawlers and Liners.

However accurate the returns of the quantity of fish landed may be, and however exact the estimation of the numbers of vessels engaged in the different kinds of fishery, it is impossible to obtain a satisfactory view of the condition of the fisheries in general without also taking into consideration the relative catching power of the different classes of fishing vessels and the changes wrought in their efficiency at different times by the introduction of new fishing appliances, and by increased speed and storage capacity. The gross returns of fish landed from year to year are meaningless for purposes of accurate comparison unless they are taken in relation with the total catching power of the fishing vessels for the same periods, and it is impossible to form even an approximate idea of the growth of catching power from the mere numbers and registered tonnage of the vessels as a whole. It is indispensable that the vessels should be sorted out according to their mode of fishery and their means of propulsion, and their respective catching powers reduced to some uniform standard of efficiency.

§ i. *The Trawling Smack as a Unit of Catching Power.*

I have therefore adopted the deep-sea sailing trawler as a standard unit of catching power, and have sought to express the average catching powers of other vessels in terms of this "smack-unit." It will be seen from Tables A–D, which give the actual annual catches of four Grimsby sailing trawlers for a long term of years, that, however variable the catches are from year to year, there is an appreciable uniformity (with few exceptions) in the individual catches for the same year; and, although the sizes of deep-sea sailing trawlers vary to some extent at different ports, it appears to be admitted that these differences are mainly adaptations to the local conditions of the fishery, and do not seriously affect the gross catches made by the respective types of vessel on the grounds to which they are suited and on which they usually work.

On the other hand, the gross catches of individual trawlers are undoubtedly affected by the "fleeting" system. The large increase in 1882 in the catches of the Grimsby trawlers (compare Table IV.) is principally due, as Mr. Alward informs me, to a general extension of the fleeting period which took place at Grimsby in that year—from an average of about five or six months in previous years to eight months in 1882. The system could not, however, be maintained owing to the opposition it aroused, which culminated in a general strike of the hands in 1883. The subsequent restriction of the fleeting period in 1884 to its former limits was followed, as may be seen in Table IV., by a reduction of the annual catches to their former proportions. The illustration suffices to give an idea of the increased catches which may directly ensue from the adoption of means of propulsion, or methods of work, which save the time spent in voyaging to and from the more distant fishing grounds. Nevertheless it must be borne in mind that the distances to be traversed by the Humber smacks are necessarily greater than those usually covered by the "single boaters" of more southern and of western ports, whose fishing grounds, though more limited, are situated in closer proximity to the ports of landing. Consequently there is no ground for believing that the annual catches of the Ramsgate and Brixham trawlers are very much less than they would be if these vessels were to adopt the fleeting system as carried out at Grimsby and Yarmouth. So far as the Lowestoft trawlers are concerned—and they fish to a large extent on the same grounds and under the same conditions as the Ramsgate vessels, and do not fleet for more than a couple of months in the year—this conclusion can be verified; for in his evidence submitted to the Select Committee in 1893, Mr. Hame stated that the average catch for 1892 yielded by thirty-eight vessels worked by one firm at Lowestoft amounted to 139 cwts. of prime fish and 710 cwts. of offal (Minutes of Evidence, §§ 1,540, 1,626). It will be seen by comparison with Table IV. that the total catch (849 cwts.) even exceeded the average catch of Mr. Alward's four smacks for the same year, though practically identical if we take the previous year's average also into consideration. The data, however, upon which I principally depend for my estimate of the catching power of the sailing-trawler unit consist of Mr. Alward's returns of the actual catches of four of his Grimsby trawlers, already discussed (see Tables A–D and IV.).

§ ii. *Relative Efficiency of Steam Beam Trawlers.*

The catching power of steam beam trawlers compared with smacks has been variously placed at from three to six fold (Select Committee, 1893, Minutes, §§ 351, 1,165, 4,119). Mr. Alward, in 1893, estimated it at between four and five times the efficiency of the sailer, and I am able to submit actual figures in substantiation of this opinion. Mr. Alward has kindly lent me extracts from his books, which show the actual annual catches of one of his steam trawlers for each of the years 1883, 1884, and 1885, and the catch of another steamer for 1885.

TABLE IX., *comparing the Average Annual Catches of Steam and Sailing Beam Trawlers, Grimsby,* 1883–85, *and showing the Relative Efficiency of the Steamer at that date.*

	Boats.	Period.	Average Annual Catch (cwts.). Plaice.	Haddock.	Prime.*	Rough.†	Total.
A	1 steamer	3 years, '83–'85.	818	2325	125	668	3936
	4 smacks	do.	315	556	94	81	1043
B	2 steamers	1885 . . .	717	2352	120	654	3844
	4 smacks	do. . . .	280	477	90	89	961
Relative Efficiency of Steamer.		A	2·60	4·18	1·33	8·25	3·77
		B	2·56	4·93	1·33	7·35	4·00

In Table IX. I have averaged these figures in two ways, and it will be seen that, as in the case of the sailing trawlers, the average quantity landed

* "Prime" includes Turbot, Sole, and Brill. In these figures, however, Lemon Soles also are probably included in the case of the steamers, but excluded in the case of the smacks. Consequently the figures representing the relative efficiency of the steamer in catching prime fish are probably excessive. The steamer's average annual catch of "soles" in 1883-5 was 62 cwts. If we assume one-third of the catch to have consisted of lemon soles, the efficiency of the steamer for prime fish is reduced to 1·11.

† "Rough" includes Cod, Gurnet, Dabs, Catfish, Skates, and Rays (Roker), etc. In the case of the smacks it also probably includes Lemon Soles, so that the index of the steamer's relative efficiency in catching "rough fish" is probably rather below the true value. The figures for "prime" and "rough" fish are invalidated by Mr. Alward's uncertainty at this date as to his treatment of lemon soles in the case of the steamers.

by the steamers in adjacent years is remarkably uniform. Side by side with these averages I have placed in the same table the average catches of the four sailing trawlers for the same term of years, and it can thus be seen that during the period 1883–5 the steam trawler caught close upon four times as much fish in a year as the sailing trawler. The relative efficiency of the steamer is seen to vary as regards the different items brought up in the trawl—a variation which is apparently determined, to a large extent, by the natural distribution of fish in the North Sea. Thus the steamer caught two and a half times as much plaice as the smack, from four to five times as much haddock, about the same quantity of prime fish, and from seven to eight times as much rough fish. Leaving out the latter item, the steamer's great efficiency as regards haddock would appear to be due to the greater abundance of this fish in the more distant grounds to the northward; its moderate efficiency as regards plaice to the more uniform distribution of this fish over the whole basin of the North Sea; and its small efficiency as regards turbot, sole, and brill to the southern and shallow water proclivities of these latter types of fish. That is to say, the steamer's efficiency increases in proportion to the distance from the port of landing of the grounds on which the different species live in greatest abundance.

But it is well known that since 1885 the relative catching powers of steam and sailing trawlers have diverged to a still greater extent, for, whereas the rig and fishing gear of the smacks have remained practically stationary, the steamers have been subject to continuous improvements as regards speed, storage capacity, tonnage, and size of trawl. The improvements under the latter head culminated in 1895 in the adaptation and general use of the otter trawl in place of the beam trawl. Consequently if the relative efficiency of steamers to smacks was fourfold in 1885 it must have become distinctly greater than that by 1893, and has undoubtedly increased since then. The increased efficiency due to the adoption of the otter trawl can be determined with precision (see Tables XI., XII.), and exceeds 30 per cent. on the gross catches, but the data on which I depend for measuring the improvement due to other causes are necessarily somewhat indirect. To directly compare the average catches of steamers in 1885 with the catches in 1894, and to conclude that the difference is a measure of the changes wrought in efficiency during the interim, would be to beg the question at issue, and to assume that the abundance of fish on the grounds has not changed. In view of the evidence afforded by the catches of Mr. Knott's and Mr. Alward's smacks, this position cannot be assumed as a basis for calculations. The question could be decided most conclusively by comparing the catches of Grimsby steamers in 1893 and 1894 with the average catches of the smacks in the same years; for, assuming that the efficiency of the smacks has remained the same, any difference in the relative efficiency of the steamers since 1885 would be attributable to improvements in the type of vessel and fishing gear. Unfortunately exact returns of individual catches for these later years are not yet available either for steamers or smacks, though Mr. Alward tells me that he has long intended, and still hopes, at some future time to bring his figures up to date both for sailing and steam fishing vessels. I have tried in various other directions to obtain such information from smack-owners, but hitherto without success.

Nevertheless Mr. Alward's opinion is entitled to consideration. When sending me his returns already quoted, he wrote: "The figures for the two steam trawlers which I am submitting will convey a very poor idea of the quantity of fish caught in the interval between 1885 and the present time. They will serve only as a comparison of the early class of steam trawlers and the sailing trawlers of that day. In the interval between 1885 and the present time several new fishing grounds have been worked, and the modern steam trawler would catch about *double the quantity* caught by either of the two steam trawlers whose figures I give, *if they had been fishing on the same ground at the same time*."

In a further communication Mr. Alward writes, "With regard to the tonnage of the steam trawlers in 1883, as well as at the present time, the returns of the Board of Trade give only the nett tonnage, which is very misleading as to the size of the vessel, owing to the deductions from gross to nett of the space occupied by engine space and coals. These deductions have increased from 1883 up to the present time on account of the increased power demanding larger space. In many instances a gross tonnage 180 is now reduced to 50 nett, whereas in 1883 a gross tonnage of 100 would not be reduced to less than 50. These figures apply to Grimsby and no doubt to most ports. The average gross tonnage here at the present time will be 150 tons, whereas in 1883 it did not exceed 100." (cf. McIntosh, *Resources of the Sea*, p. 59.)

From these quotations it is clear that, in Mr. Alward's opinion, the relative efficiency of the modern steam trawler compared with the smack is about eightfold (*i.e.* twice the relative efficiency in 1883). Other correspondents, all of them being smack-owners or men equally familiar with the practical side of the trawling industry, have assigned a catching power to the modern steam otter trawler of from at least sevenfold to at least tenfold the power of the sailing trawler. The grounds for their opinions are various, and need not be detailed. The limits which they assign show that Mr. Alward's opinion is by no means an exaggerated one, and that it forms indeed a kind of average of the views generally held by practical men.

Now a considerable portion of the increase in the catching power of the steam trawler is due to the exchange of beam for otter trawls in 1895, and it is shown below that this change of fishing gear has increased the catches of steam trawlers by 37 per cent., or, approximately, one-third of the total, *i.e.* has multiplied the catching power by one and a third.

If this deduction be made from the gross catching power of the otter trawler (estimating the latter at eight times the catching power of the sailing trawler), we obtain a figure which approximately represents the relative efficiency of the vessel less the advantages recently conferred on it by the adoption of the otter trawl. Assuming for a moment the accuracy of the foregoing estimates (which will be dealt with in greater detail below), we thus find that the modern steam trawler, if fitted with beam trawls, would catch approximately six times as much fish as the average sailing trawler, an increase in efficiency of 50 per cent. since 1883–5, viz. from fourfold to sixfold.

Now, according to Mr. Alward's figures, the gross tonnage of Grimsby steam trawlers has increased by exactly the same amount in the interval; and, on working out the average of the registered tonnage of English steam fishing vessels from the data given in the Annual Statements of Navigation, I find that precisely the same increase has taken place in the average registered—or nett—tonnage, viz. from 34 tons in 1884 to 52 tons in 1898.

We may therefore conclude that the efficiency of steam trawlers, apart from the question of the otter trawl, has increased *pari passu* with the increase in their average registered tonnage, or rather with the increase in the registered tonnage of English steam fishing vessels in general, the great majority of which, however, are steam trawlers. If therefore for each year since 1884 the average registered tonnage be plotted out, and the relative efficiency of the steam trawler be placed at four for 1884 and six for 1898, the rate of increase in the efficiency during the period may be obtained in proportion to the rise in tonnage. This has been done in Table X. The result is, briefly, that in 1889 the efficiency was fivefold that of the smack, and in 1893 five and a half times.

TABLE X., *showing the increase in Average Registered Tonnage of English Steam Fishing Vessels, and the increase in Relative Efficiency of Steam Trawlers, from* 1884 *to* 1898.

	1884	1889	1890	1891	1892	1893	1894	1895	1896	1897	1898
Average tonnage .	34	42	45	48	48	48	48·5	49·5	50	51	52
Efficiency (beam trawls)	4	5	5·25	5·5	5·5	5·5	5·6	5·7	5·8	5·9	6
Otter trawls (factor).	—	—	—	—	—	—	—	1·1	1·2	1·3	1·3
Total efficiency .	4	5	5·25	5·5	5·5	5·5	5·6	6·3	7	7·7	8

The only means at my disposal for verifying the accuracy of these conclusions is to compare the average catch of Scottish steam trawlers during 1893 and 1894 with the probable catch of Grimsby sailing trawlers for the same years. The admirable statistics of the Scottish Fishery Board show, when worked out for this purpose, that the average annual catch of Scottish steam trawlers landing fish on the East Coast in the years 1893 and 1894 amounted to 3,802 cwts. per vessel (see Table XI.). From the average catch of Mr. Alward's sailing trawlers for 1890–2, as well as from the figures for Lowestoft trawlers already cited for 1892 (p. 45), we may infer that their catch in the two following years would probably average not more than from 700 to 900 cwts. per vessel. Comparison of the two sets of figures yields a relative efficiency for the Scottish steam trawlers between 4·2 and 5·4. The efficiency of English steam trawlers for the same years is calculated to have been from 5·5 to 5·6 (Table X.). Seeing that the average registered tonnage of the Scottish vessels only amounts to 32·5 tons for the years in question, whereas the average tonnage of English steam vessels was from 48 to 48·5 tons, we may justly conclude that the average English steam trawler at that time was a more powerful vessel than the type prevalent in Scottish waters, although exact comparison is impossible, owing to the inclusion in the English figures of a certain number of steam carriers and liners, which no doubt affect the figures to some slight extent. Under these circumstances the close correspondence between the estimated efficiency of the Scottish East Coast steam trawlers and of the English vessels for the years 1893 and 1894 may be regarded, if not as an actual verification of the accuracy of Mr. Alward's estimates, at any rate as a substantial proof of their freedom from serious exaggeration.

I conclude, therefore, that in order to convert the number of English steam trawlers into their smack-equivalents for each of the years from 1889 to 1894, the figures in Table X., which represent the relative efficiency of the steam trawlers for those years, may be treated as factors by means of which the conversion can be effected on an approximately accurate basis.

§ iii. *Otter Trawls on Steam Trawlers.*

In 1894, however, the otter trawl was introduced, and the extent of the change in catching power which its rapid adoption in 1895 wrought among steam trawlers must now be examined.

Mr. Cunningham has stated that in the opinion of Hull fishermen the otter trawl increased the catches of steam trawlers in 1895 by as much as 50 per cent., and various correspondents engaged in the fishing industry, to whom I have put the question, have agreed in estimating the increase in the total catches as from 33 per cent. to 50 per cent., the catch of round fishes alone having been even doubled.

The relative efficiency of the otter and beam trawls as worked by steamers can be measured, however, in a reliable manner without recourse to personal opinions. It happens that the trawlers landing fish on the East Coast of Scotland have been exclusively steamers for some years past, and the aggregate catches of these boats, together with the number of vessels at work, are given in the Annual Reports of the Scottish Fishery Board. There are usually about a hundred steam trawlers working annually from Aberdeen and other East Coast ports. The otter trawl having been introduced at Granton in 1894, and rapidly adopted by steam trawlers in general during the course of 1895, the changes wrought by its adoption can be clearly determined by comparing the average catch per trawler for a year or two prior to 1895 with the average catch per trawler for the years immediately following 1895, the year of transition being of course omitted.

TABLE XI., *showing the Total Catches of Scottish Steam Trawlers for two years before and after the introduction of the Otter Trawl in* 1895.

	Trawlers.			Aggregate Catch (cwts.).				
	Number.	Tonnage.		Cod.	Haddock.	Lemon Sole.	Flounder, Plaice, and Brill.	Total.
1893.	111	3,584	...	52,965	241,762	17,018	45,744	421,410
94.	115	3,770	...	72,778	259,168	17,656	46,711	437,815
1896.	104	3,524	...	107,139	319,013	18,357	54,132	545,652
97.	112	3,795	...	124,576	349,742	13,010	41,531	583,212

TABLE XII., *showing the Average Annual Catches per Boat (cwts.) of Scottish Steam Trawlers,* 1893 *to* 1897, *and the Relative Efficiency of the Otter and Beam Trawls deduced therefrom.*

	Average Tonnage.	Cod.	Haddock.	Lemon Sole.	Plaice, etc.	Total (cwts.).	
1893 . .	32·3	477	2,178	153	412	3,796	Beam trawls.
94 . .	32·8	533	2,254	153	406	3,807	
1896 . .	33·9	1,030	3,067	176	525	5,247	Otter trawls.
97 . .	33·9	1,112	3,123	116	371	5,207	
1893–4 . .	32·5	505	2,216	153	409	3,802	
1896–7 . .	33·9	1071	3,095	146	448	5,227	
Relative efficiency of Otter		2·12	1·35	0·95	1·10	1·37	

The results of a comparison on these lines are set forth in Tables XI. and XII. It will be seen that the aggregate total catches in 1893 and

1894 were much less than the corresponding catches in 1896 and 1897, although the number of vessels at work during the latter years was slightly less. For the first two years the average total catch per trawler amounted to 3,796 and 3,807 cwts. respectively; for the last two years to 5,247 and 5,207 cwts. respectively—a difference which can only be attributed to the change from beam to otter trawl. If the average catches for each pair of years are combined, we find that the average annual catch of the beam trawlers was 3,802 cwts. and of the otter trawlers 5,227 cwts.—a difference which yields a relative efficiency in favour of the otter trawl amounting to 1·37 times that of the beam trawl, or, in other words, an increase of 37 per cent. on the total catches.

In regard to the different kinds of fish, the table shows that the otter trawl caught more than twice the quantity of cod, 35 per cent. more haddock, and about the same quantity of flat-fish as was obtained by the beam trawl in each case. These figures certainly do not overstate the efficiency of the otter trawl, since the years 1893 and 1894 were notorious for the exceptional abundance of haddock on the East Coast of Scotland, while the remarkable fall in the catch of flat fishes, both lemon soles and plaice, in 1897 suggests that the quantity of these fishes caught in the second period was below the average in consequence of exceptional scarcity. This reduced catch can scarcely be attributed to the change of fishing gear, otherwise the catch in 1896 would have shown the same depression.

It makes, however, no material difference in the resultant averages whether we take 30 per cent. or 40 per cent., or any intermediate figure, to represent the increase in catching power due to the adoption of otter gear. The figure already chosen for deducing the tonnage efficiency was, for convenience, 33 per cent.; and in order to make full allowance for the time required for the supersession of the beam trawls on English steam trawlers, I have assumed that only one-third of the increased efficiency (10 per cent.) came into operation during the year of transition (1895), and only two-thirds (20 per cent.) during the following year. For 1897 practically the full efficiency (30 per cent.) has been allowed, and for 1898 of course the power of the otter trawl has been included in Mr. Alward's estimate of the gross catching power of the modern steamer, which there is every reason to believe is approximately correct (cf. Table X., p. 48).

For evidence as to the introduction of the otter trawl reference may be made to the full account given by Mr. Cunningham* in this Journal

* Cf. also McIntosh, *Resources*, pp. 65 and 91; Tenth Report of the Inspectors of Sea Fisheries, England and Wales, for 1895, pp. 11, 121 (Hull), and 121 (Milford); Reports of the Scottish Fishery Board, xiv. p. vii.; xv. p. ix.

in 1896 (vol. iv. pp. 114–21). Mr. Scott's patent modification of the otter gear was fitted to some of the Granton Steam Fishing Company's vessels in June, 1894, but it was not until the summer of 1895 that the new gear began to be generally adopted by English steamers. During his visit to Hull in August, 1895, Mr. Cunningham was informed by Mr. Scott that the patent gear was then in use on sixteen or seventeen steamers in that port, on eight in Granton, on one at Boston, two at Grimsby, and two at Milford Haven, and Mr. Cunningham saw it on one in Scarborough earlier in the same month. In addition to these vessels, a large number of steamers were also fitted with otter trawls of a somewhat different construction; but there is no available means at present of determining the total number of steamers which had adopted the new gear by any particular date in the year. There is, however, abundant evidence that as soon as the advantages of the beamless trawl became generally understood the exchange was effected with great rapidity. Mr. Ascroft, of Lytham, informs me that he was with the Red Cross fleet (Hull) on the Dogger when the otter trawl was first tried there, on the steam trawler *Madras,* and that the difference between the catches of this vessel and the steam beam trawlers was so great that, as the boats went back to Hull for coal, they were not sent out again until they had the otter gear fitted, even if it took a week or ten days.

§ iv. *Relative Efficiency of Liners.*

For estimating the catching power of the line fishing-boats (first class) I am compelled in the present essay to depend upon evidence which probably yields nothing but a rough approximation to the true values, since precise information upon the point has been unavailable. One difficulty arises from the fact that the sailing liners frequently devote themselves to the herring fishery during the summer months; and, although this custom of combining two methods of fishery is more especially found among the smaller boats, there is little to show to what extent the custom prevails among vessels of the first class, to which my statistics are limited.

In the Report of the Sea Fishery Commissioners of 1879 (Buckland and Walpole, p. 133) it is stated that the total annual catch of sixteen large liners at Staithes might be estimated at 1,400 (2,000 – 600) tons—an average of 87 tons per vessel. This figure, however, includes the produce of the summer herring fishery from June to October. If a deduction of from one-half to two-thirds of the total catch be made to cover this item, the catch of bottom fish per vessel is reduced to an average of from 29 to 43 tons. At this period the Grimsby trawlers were catching from 45 to 60 tons per vessel.

Even the catch of the Grimsby codmen must be below that of the trawling smacks, for it was stated at Grimsby in evidence before the Royal Commission of 1863 that "a trawl smack as a rule will catch a greater weight of fish than a liner, but it is of less value" (§ 15,932).

At Billingsgate, before the same Commission, it was stated, even at that time, that the "liners did not bring more than 10 per cent. (5 per cent. to 10 per cent.) of the fish coming to this market" (§ 12,862); and again, "A trawler catches ten times the weight of fish obtained by a line boat, day for day, or year for year, taking the twelve months round" (§§ 12,867–8).

This latter estimate no doubt refers to the average catch of all line boats, large and small.

A similar contrast exists between the catches of the modern steam trawlers and liners. Thus in March of the present year, ten Aberdeen steam liners were reported to have landed 28 tons of fish at one time, *i.e.* an average of 56 cwts. per boat per voyage. Simultaneously thirty-six steam trawlers at the same port landed 250 tons—an average of 138 cwts. per boat per voyage (*Fish Trades Gazette*, March 31st, 1900, p. 17). Thus the average catch of the steam liner was only two-fifths as great as that of the steam (otter) trawler, if we assume that the voyages made by the two classes of boat were of equal duration. In view, however, of the liner's dependence upon bait, this assumption is not likely to be strictly correct, even in these days of ice and preserved bait. Moreover, as the number of steam liners during the decade has not increased at the same rate as the number of trawlers (twofold instead of fourfold), it is necessary to ensure that their catching power shall not be under-estimated, since any serious deficit would reduce the estimated total catching power to a greater extent in the earlier than the later years, and so conduce towards a spurious fall in the estimated average catches.

If, therefore, we allow to the steam liner a catching power of three-fourths that of the otter trawler, any error in the estimate is likely to be rather in the nature of an exaggeration of the true efficiency than otherwise. This would be equivalent in 1898 to the catching power of six sailing trawlers—that is to say, it would be practically identical with the estimated catching power of a steam trawler fitted with beam, instead of otter, trawls (see Table X., p. 48). Assuming that the efficiency of the steam liners has increased during the decade in proportion to the increase in average registered tonnage, the same factors may therefore be applied to the numbers of steam liners as to the steam beam trawlers, in order to convert their catching power into the proper number of "smack-equivalents." The results of this conversion are set forth in Table F (p. 68). The aggregate catching power of the steam liners is there seen to have nearly trebled in 1897 as compared with 1889, but fell considerably in the following year, owing to the reduction of the number of steamers engaged in line fishing.

For a similar reason the average catching power of the sailing liner (first class) is assumed to have been four-fifths that of the sailing trawler throughout the decade, although the evidence cited above points rather to a lower coefficient as more strictly correct.

4. Total Catching Power of Bottom Fishing Boats.

The total catching power of the first class vessels engaged in catching "bottom fish," as derived from the various sources already discussed, is set forth in Table H (p. 69). Each year of the decade 1889 to 1898 is separately distinguished, and the catching power devoted to the North Sea fisheries is separated from that engaged in the South and West Coast industry.

The catching power of all vessels, whether trawlers or liners, and whether steamboats or smacks, is there expressed in terms of "smack-units," the various computations for which have already been described.

For the East Coast the catching power is seen to have increased continuously during the decade, from a power represented by 2,859 trawling smacks in 1889 to the power of 7,143 smacks in 1898, the catching power having nearly trebled during the period.

For the South and West Coasts the power is seen to have doubled during the decade, from the equivalence of 946 smacks in 1889 to that of 1,896 smacks in 1898. But the increase is seen to have been far from uniform, as the rise up to 1892 was followed by a fall during the next two years, to be succeeded by a steady and conspicuous rise to the end of the period. These irregularities are principally due to the invasion of the Western waters by East Coast vessels, both steamers and smacks, about the time of the opening of Milford Docks in 1889. These yearly immigrations fell off to a large extent after a few years, the smacks first of all, on account of their excessive size, and the steamers after 1892. The remarks made in an earlier section (p. 41) as to the figures representing the East Coast steam trawlers in this table should be borne in mind (see also pp. 62–4).

For the Entire Coasts of England and Wales the catching power is shown to have steadily increased from 3,675 smack-units in 1889 to 8,503 units in 1898, the power at the end of the decade being two and a third times that at the beginning.

5. Average Annual Catch per Unit of Catching Power.

The results obtained by distributing the total weight of fish landed on the different coasts among the corresponding number of smack-units estimated for each year of the decade are set forth in Table VIII. (p. 34).

For the **East Coast** fisheries there was a steady increase, both in the weight of fish annually landed and in the catching power devoted to the industry. **But whereas the increase in fish amounted to only about 30 per cent. during the decade, the catching power nearly trebled in the same period.** The result is that for each unit of catching power the average annual catch has fallen from 60·6 tons in 1889 to 32·3 tons in 1898. The fall was rapid both in the three first and three last years of the decade, but the three middle years of the decade (1893, 1894, and 1895) maintained practically the same average as the year 1892, showing even a minute increase in 1893 and 1894.

The year 1893, it will be remembered, was characterised by two features, each of which probably exerted a special influence on the East Coast fisheries, viz. the exploitation of the Iceland trawling grounds and an exceptionally long warm summer—the warmest spring,* according to the Reports of the Meteorological Office, for a period of thirty-three years at least. To these may perhaps be added an increased activity (after a period of self-imposed abstinence) of the trawlers on the Eastern grounds, whence large quantities of small fish were landed in that year (Eighth Report of the Inspectors of Sea Fisheries, p. 11). Each of these circumstances must have contributed to swell the catches in 1893, the first and third directly, and the second by its effect on the inshore migrations of flat-fish, and on the rate of growth of these as well as of other bottom fishes.

These suggestions are confirmed by a study of the Board of Trade's returns of the quantities of the different kinds of fish annually landed on the East Coast. Since 1888, the year when the statistics for plaice were first distinguished, there have been only two years in which the returns of sole, turbot, plaice, and brill have all increased beyond the returns for the previous year, viz. 1891 and 1893. But the increase of plaice in 1893 was unequalled within the period, and greatly exceeded the increase in 1891, the total catch rising suddenly from 621,000 cwts. in 1892 to nearly 759,000 cwts. in 1893, the previous maximum having been 648,000 cwts. in 1891. This exceptional increase was not due to any unusual increase in the catching power. Indeed, as the weather in 1893 was unfavourable to the voyages of sailing vessels (from lack of wind in the summer, and winter gales), the relative increase in catching power, so far as the shallower waters are concerned, should probably be less rather than more than the increase shown in my tables, a fact which renders the general increase in the quantities of flat fishes landed all the more remarkable. The Iceland catches no doubt contributed largely to increase the captures of plaice, but could have no effect upon the supply of soles, turbot, and brill; so that the general increase of all kinds of flat fishes in 1893

* See Table G (temperatures), p. 68.

must be attributed largely to the favourable effects of the hot spring and summer in the manner suggested above. The reports of the collectors of fishery statistics at Lowestoft and Ramsgate, and the returns made to the Board of Trade by the Sea Fisheries Committees, strongly corroborate this view (see Report of the Inspectors).

In any case, the abnormal increase of flat fishes in 1893 is sufficient in itself to show that exceptional influences were at work in 1893 tending towards an increase in the trawlers' captures. Consequently the temporary cessation in the fall of the average catches shown by my table for this year is in accord with the independent evidence from other sources, and to that extent confirms the accuracy of my results.

An explanation of a similar kind, though differing in details, appears to me to account for the maintenance of the average catches at about the same figure during the next two years. The catches of plaice and brill were about the same in 1894 as in 1893, and the catches of soles and turbot still further increased. The weather was favourable for smacks; more vessels visited the Iceland grounds; and the good effects of the warmth of the previous year on the reproduction, food-supply, and rate of growth of fishes were not yet exhausted. Haddocks, the young stages of which had been exceptionally abundant* during the previous year, were taken this year of larger size and in abnormal quantities. The *increase* of haddocks in 1894 amounted to 200,000 cwts.; in 1893 it was only 50,000 cwts.; in 1892, 150,000 cwts.; in 1891, the same. This is but an illustration of a phenomenon well known to fishermen, that an exceptional abundance of young fish in one season is usually followed by larger catches of the same species in the following year; but the importance of the fact in this case is in the evidence it affords of the far-reaching effects of the exceptionally favourable season of 1893.

In 1895 the abundance of haddocks was still maintained, the increase over 1894 amounting to 250,000 cwts., a result which, though partly attributable to the introduction of the otter trawl, was principally a consequence of the same climatic cause as the increase in 1894. Since 1895 the annual increments in the catch of haddocks have markedly diminished in spite of the otter trawl and its great catching power, the annual changes having been an increase of 110,000 cwts. in 1896, a decrease of 20,000 cwts. in 1897, and an increase of 60,000 cwts. in 1898.

Turning now to the estimated average catches for the bottom fisheries of the **South and West Coasts,** two remarkable differences are presented between the results of these fisheries and those of the East Coast. The catches are much less in amount, and are remarkably constant throughout the period. Nevertheless it is noteworthy that a slight fall in the

* *Fourteenth Report of the Scottish Fishery Board*, p. 145; McIntosh, *Resources*, p. 194.

first few years is followed by an increase in 1893 and 1894, which is again succeeded by a continuous fall until the last year of the decade, which is marked by a moderate increase. The figures, therefore, appear to show, on the whole, that the abundance of fish on the grounds is slightly decreasing, though subject to temporary increases under the influence of particularly favourable seasons.* (N.B.—See below, pp. 62–4.)

The average catches for all coasts together naturally display the same predominant features as the East Coast fisheries, though the catches are lower than those for the East Coast alone for all except the last years of the decade in consequence of the depressing effect of the inclusion of the figures for the South and West Coasts.

6. Reconsideration of the Methods and Results.

As this is the first detailed attempt which has been made to present a statistical review of the condition of the English trawl fisheries, and as the basis upon which it depends has necessarily been of a limited character, there can be no doubt that in various details my computations need correction and modification. If more authentic lists of the different kinds of fishing boat were available, if the products of the trawl and line fisheries were distinguished in the fishery statistics, and if smack-owners from a larger number of centres would co-operate by providing information as to the actual annual catches of their vessels on different grounds, I believe the method which has been followed in the present essay could be relied upon to provide unquestionable evidence concerning the condition of the fishing grounds. The whole question of fishery statistics is now, I understand, under consideration by the Board of Trade. We may therefore reasonably expect that more exact information will in due course be provided as to the numbers and size of the vessels engaged in the different fisheries, and that the reiterated demand for a separation of the products of the different fisheries in the Board's annual statements will receive the attention it deserves. Of the willingness of the smack-owners to co-operate when the importance of their assistance becomes apparent I have no doubt.

In the present essay, however, it is by no means certain that the results arrived at in the case of the different coasts are of equal value. The fundamental assumption in my calculations is the catching power of the sailing trawler and the relative catching power of the steam trawler in comparison with it. From the absence of positive informa-

* For evidence of the remarkable effect of the weather in 1893 upon the fauna of Plymouth Sound, see this Journal, vol. iii., 1894, pp. 210–11. For its effects on the reproduction of the oyster, see Herdman in *Nature*, July, 1893, p. 269. For the exceptional abundance of haddock in the Irish Sea in 1894, see *Ninth Report of the Inspectors of Sea Fisheries*, pp. 16, 155, 157, etc. The summer in 1898 was exceptionally hot, as in 1893; and, although the spring was normal, the autumn was the hottest for thirty-three years (see Table G).

tion as to the average weight of fish landed by smacks on the South and West Coasts, I have been compelled to use the same coefficients for these coasts as for the East Coast. The evidence submitted in the earlier portions of this paper seems to me to show that for the East Coast those coefficients are approximately and sufficiently correct; but the low averages which result from the application of the same factors to the boats of Western ports appear to demonstrate that the relative catching power of steamers and smacks in these waters is not the same as for those of the East Coast (cf. p. 62).

It is, however, first of all necessary to determine the degree of error which is introduced into the results by dividing the whole catch of bottom fish among the first class boats alone. Part of this catch is, of course, derived from small trawlers and liners, and it is conceivable that changes in the quantity of fish landed by the smaller boats might seriously affect the averages which have here been assigned to the larger boats alone.

In the middle of the period (viz. 1893) the gross number of second class liners fishing from the East Coast ports as determined from the returns of the collectors of fishery statistics was, approximately, 650. The number of second class trawlers engaged in inshore fishing was about 300, or 500 if we include the shrimpers of Yarmouth, Gravesend, etc. Many of these boats are engaged in the line and trawl fisheries for a limited portion of the year, and, of course, the weight of fishes actually landed by the shrimpers is infinitesimal. Taking, however, the total of these small boats at about 1,000, and allowing them an average catch amounting to one-tenth that of a deep-sea trawler (see above, p. 53), we may estimate the total catch of bottom fish derived from these sources as 80,000 cwts., or 4,000 tons. If this amount be deducted from the total quantity of bottom fish landed on the East Coast in 1889 and 1898 respectively, the remainder, when distributed among the estimated number of smack-units for those years, yields an average catch per unit of 58·9 tons in 1889 and 31·7 tons in 1898. The differences between these averages and those given in Table VIII. (p. 34) are so minute that no serious error in my results can be attributed to this source.

The next point to examine is the discrepancy between my estimated averages per smack-unit for the **East Coast** and the actual catches of the Grimsby and Lowestoft smacks for the same years. The only figures available are for the first four years of the decade, and are as follows:—

	Catch per Unit.	Grimsby Smacks.	Lowestoft Smacks.
1889	60·6	32·6	—
90	55·7	36·1	—
91	48·5	46·0	—
92	46·2	34·1	42·4

For the last two years in this table my estimated averages are in substantial agreement with the actual catches of the smacks. How is it that my earlier averages are so much higher than those of the Grimsby smacks?

In the first place it should be noticed that all my averages for the above four years are in excess of the actual catches of the smacks. This appears to indicate either that the total catch of bottom fish has been exaggerated by the collectors of statistics, or that my estimates of the catching power are inadequate. If the exaggeration of the catch, or the under-estimation of the catching power, were uniform throughout the period, this would not materially affect the value which my averages possess in showing the rate at which the depletion of the North Sea grounds has been proceeding. Consequently we may limit the inquiry to the question whether there is any reason to regard the Board of Trade's statistics of fish landed, or my estimates of the catching power, as of unequal value during the years in question.

Concerning the first point, there is no doubt that in the earlier years of the fishery statistics the catch of fish was unduly exaggerated. In the *Statistical Tables and Memorandum for 1889* it is stated (p. 4) that the great falling off in the Board's Returns of Prime Fish landed was largely nominal only, and arose from increased accuracy in the methods of collecting the returns. The returns of Prime Fish for the first few years in thousands of hundredweights, were as follows: 1886, 503; 1887, 235; 1888, 206; 1889, 118; 1890, 133. The fall during those early years was certainly enormous, and the degree of error correspondingly large, after all allowances for depletion of the grounds. But my calculations do not include those years, and from 1889 onwards for a considerable number of years the Board's returns for Prime Fish steadily increase, which appears to imply, as has indeed been officially stated,* that at any rate from 1889 onwards the greater experience of the collectors, and the more accurate methods introduced, render the Board's returns sufficiently reliable for comparative purposes. Consequently, so far as an opinion can be formed from the internal evidence of the returns, and the official statements of the Board, it is very improbable that the fall in my estimated averages can be considered as exclusively, or even largely, due to inaccuracies in the Fishery Statistics for 1889 and 1890, especially as my averages again fall by equal amounts in the latter years of the decade when the fishery statistics may be regarded as free from extensive errors of the kind contained in the earlier years of their publication.

As regards the possible errors in my estimates of the total catching

* Cf. Mr. Berrington, Minutes of Evidence, Select Committee, 1893, §§ 2,435, 3,083.

power, this can best be examined by considering the whole series of years together; for if the decline in the estimated averages during the decade is to be attributed to errors in the estimated catching power, these errors must include an over-estimation of the catching power in the later years as well as an under-estimation in the earlier years.

The fall in the averages is so great that any errors responsible for the fall must be of equally great magnitude. The average of the estimated catches per unit amounts to 46·5 tons for the decade. To reduce the average catch for 1889 to this amount would need the addition of 865 smack-units (=173 steamers) to my estimated total for the year. It is certain, however, that, so far as the steamers are concerned, the error in my estimates is rather an exaggeration than an under-estimation, for no deductions have been made for steamers working on the South and West Coasts, and further deductions should probably have been made for additional Hull and Grimsby carriers. Moreover, whatever minor errors occur in my list of the trawling smacks, they certainly do not amount to anything like an omission of the number above mentioned, which is exactly one-half of my estimated total of trawling smacks for 1889 (Table E, p. 67).

The same argument applies to the figures for 1898. To increase the estimated average catch to the average for the decade would need the withdrawal of 2,183 smack-units (=273 steam trawlers) from my estimated total. The former number actually exceeds the number of smacks estimated for the East Coast in that year, while we have already seen (p. 41) that an estimate of sixty-seven steamers working on the West Coast in that year is probably excessive. The gross number of fishing steamers is, of course, accurately known from the Register of British Ships, and my figures are based upon those in the Register.

It is impossible, therefore, to ascribe the fall in the average catches to sufficiently serious errors in the number of fishing boats.

The remaining estimates which contain sources of error in my figures are the factors indicating the relative catching power of the steam trawlers and of the liners. The sailing liners may be omitted from consideration: their small numbers and the high catching power already assigned them render it certain that no error in connection with them can contribute seriously to the discrepancy in the annual averages. The steam trawlers and liners may be considered together, since for the first six years their efficiency has been considered as identical. The coefficients for the conversion of steam trawlers to their equivalents in smacks are based on a comparison of the catches of both classes of vessels in 1883–5, but especially the latter year. There can be no doubt, from an examination of the yearly averages of Mr. Alward's smacks, that the catches assigned to the smacks at the period in question were above the average. The increase in 1882 and 1883 has been explained as due to an exceptional extension of the fleeting period; but even after the latter year, when the fleeting period was reduced to its normal duration, the catches were higher in 1884 and 1885 than during all the subsequent years included in the table, and were even higher than for a number of years prior to 1882. Consequently there is some ground for believing that my coefficients for steam trawlers may be below rather than above the true index of their catching power as compared with that of smacks.

It must be admitted, therefore, that part of the excess in the average catches per unit for 1889–92 over the average catches of the Grimsby smacks for the same years may be attributed to a slight under-estimation of the relative efficiency of the steam trawler. The error, however, thus caused in the amount of the factor is merely a fractional one, and, owing to the great preponderance of sailing vessels at this period, is insufficient to produce more than an insignificant reduction in the average catch per unit during the earlier years of the decade; whereas the least addition to this fundamental factor produces a far more considerable effect in the later years of the decade, when smacks had decreased in numbers and steam trawlers had greatly increased both in numbers and catching power. If, therefore, my coefficient for steam trawlers at the beginning of the period is regarded as seriously inadequate (which, I confess, does not appear to be the case), and is raised accordingly, the averages at the beginning of the decade will be undoubtedly reduced, *but the averages for each successive year will also be reduced to a still greater extent*, and the decline in the average catches of North Sea vessels per unit of catching power will be shown to be greater than is actually revealed by my figures.

On the other hand, if my estimates of the increase in the average catching power of steam trawlers (Table X., p. 48) are based on insufficient data (and I admit the desirability of ampler confirmation), the error arising from this source is also inconsiderable, as may be seen by taking the efficiency of the steamers as a constant quantity throughout the period, subject only to the verifiable increase due to otter gear. Assuming this efficiency to have been fourfold that of the smack (see Table IX.) up to 1895, rising to 5·2-fold in 1898, we still get a considerable difference in total catching power of East Coast vessels between 1889 and 1898, viz. from 2,673 units in 1889 to 5,029 units in 1898. These figures yield an average return of 64·8 tons of fish per unit in the former year as contrasted with 45·8 tons in the latter year. The rate of fall is reduced by this alteration, but the decrease is by no means eliminated, since it exceeds an average of one ton of fish per unit per annum.

Accordingly, from the data available, I can discover no error of sufficient magnitude to account for the yearly decline in the average catches which my table reveals. The discrepancy between my estimated averages for 1889 and 1890 and the actual averages of Mr. Alward's smacks for the same years should probably be attributed to the incidental differences which cannot fail to manifest themselves between the averages of a few sailing vessels working upon a small portion of the field and the averages derived from all boats over the entire North Sea area. The difference between the averages of the Grimsby and Lowestoft smacks in 1892 is sufficient to indicate the extent of the variations which must be expected in any year in the catches of sailing vessels working upon different and limited grounds. The catches of sailing vessels cannot, of course, do more than indicate the fluctuations in the fishery on the grounds frequented by the vessels. My estimated averages, however, profess to indicate the relative fluctuations in the fishery over the entire region of the North Sea visited by steamers and smacks alike.

Owing to the fact that the catch per unit was assumed to have been 961 cwts. (=48 tons) in 1885, my figures would appear to indicate that between that year and 1889 a rise took place in the general averages, possibly in consequence of the exploitation of new grounds by the steamers. It is of course perfectly possible that the amount of this rise has been exaggerated by the mode of determination adopted in this essay and by the multiplication of small errors in the assumptions which have been made. To this I can only reply that it is improbable that irregularities of this kind should affect the figures in the same direction throughout the decade, especially when every precaution has been taken under each item in the calculations to prefer such alternatives (where any choice was presented) as would prevent underestimation of the catching power in the earlier years and exaggeration of the same in the later years of the decade.

But in regard to the averages for the **South and West Coasts**, the figures which represent them are so far below the actual catches of the Grimsby smacks at the beginning of the period, and yet are so uniform throughout the whole period, that I cannot place the same confidence in the results. It has already been pointed out that an exceptional difficulty occurs in regard to this area in consequence of the number of North Sea vessels which have visited these waters during the period under consideration, and the probability that the numbers which I have assigned to them are excessive both in consequence of the method of determination and of the uncertainty as to the length of their sojourn. The extent of the error introduced from this source may best be determined by comparing the averages in Table VIII. (p. 34) with the corresponding averages derived from a distribution of the total catch of fish among the local vessels alone. For 1889 my estimate of the local trawlers belonging to ports on the South and West Coasts (see Table H, p. 69) yields 46 steamers and 546 smacks—a total of 776 smack-units. For 1898 I estimate 100 steamers and 525 smacks, *i.e.* 1,325 smack-units. The average catch per unit yielded by these figures is 36·9 tons in 1889 and 41·5 tons in 1898. As there is no doubt, however, that the actual catching power should include a considerable number of North Sea vessels, it is quite clear from these figures that the error introduced by my estimates of their numbers does not account for the low average catches as compared with those of the Grimsby smacks; for not only are the averages for the early years increased to a small extent only, but the slight evidence of a fall in the averages which is yielded by the figures in Table VIII. is altogether swept away by the exclusion of the North Sea vessels from the total catching power. It is therefore certain that the relative catching power of steamers and smacks on the South and West Coasts is not the same as on the East Coast, *i.e.* the actual catches of smacks on the former coasts are not so great as those of the East Coast vessels, and the factors which are applicable to the East Coast statistics are inapplicable to those of the South and West Coasts.

I have indeed been assured by smack-owners of Western ports that the relative catching power of steamers on these coasts is now at least ten to one as compared with smacks, but from absence of positive data as to the actual weight of fish landed I am unable to give the precise ratio. Nevertheless the establishment of this point is of great importance, for it will be seen from a study of Table H that any increase in the relative efficiency of steamers over smacks in this region must have the effect of depressing the average catches to a greater extent in the later than in the earlier years of the decade, owing to the great increase in the proportion of steamers to smacks during the decade. This increase holds whether we consider the local vessels alone or the totals of the local vessels and the estimated numbers of North Sea visitors. The consequence is that the slight fall in the average catches shown in Table VIII. for the South and West Coasts is less than the fall which has actually occurred,* so that for these coasts there is no escape from the conclusion that during the past ten years there has been an indubitable fall in the average catches of the trawling vessels per unit of catching power, though of less extent than for the East Coast. This proof, which is largely independent of personal opinions, of the progressive impoverishment of the fishing grounds has all the more force when it is remembered that the period has been characterised by increasingly

* See figures on next page.

warm weather, and includes one year at least in the middle of the period (1893) which was exceptionally favourable for the reproduction and growth of fishes on almost all our coasts. The influence of this year should have increased the catches in the second half of the decade as compared with the first, and there is some evidence that a favourable effect was temporarily manifested. But the fact that, according to my figures, even the occurrence of so exceptionally favourable a year in the middle of the decade did not arrest the decline in the average catches for more than two or three years tends to show that the rate at which sea fishes reproduce and grow is no longer sufficient to enable them to keep pace with the increasing rate of capture. In other words, the bottom fisheries are undergoing a process of exhaustion.

The following figures have been prepared to show the annual growth of catching power and the average catch per smack-unit for the South and West Coasts, if we assume the relative efficiency of steamers in 1898 to have been tenfold (instead of eightfold) that of smacks, and if the efficiency factors for the previous years be multiplied to the same extent (*i.e.* by 1·25). The other items, as given in Table H., II., have not been changed.

Year.	Smack-units.	Catch per unit.	Year.	Smack-units.	Catch per unit.
1889	1,036	27·6	1894	1,204	28·1
1890	1,186	27·8	1895	1,420	25·8
1891	1,190	24·2	1896	1,755	23·2
1892	1,424	23·7	1897	2,092	21·9
1893	1,308	25·8	1898	2,230	24·7

These figures are alternative to those given in Table VIII., p. 34, and probably represent more accurately the amount of the fluctuations in the trawl fishery during the decade, although the general features are the same in both cases (see pp. 56, 57).

In conclusion, I may state that if smack-owners and steamer-owners will kindly assist me with detailed returns of the annual catches of their vessels for individual years, or for any series of years, I will gladly prepare a revised edition of the tables in this paper, based upon such new information. Needless to say, the value of conclusions drawn from calculations of this kind depends entirely on the basis of fact underlying them.

TABLES A–D, *showing the Weight of Fish annually landed, and the Value realised, by four Grimsby Trawling Smacks for each year from* 1875 *to* 1892.

TABLE A. SAILING TRAWLER "ANGELUS."

YEAR.	PLAICE.		HADDOCK.		"PRIME."		"ROUGH."		TOTAL.	
	cwts.	£	cwts.	£	cwts.	£	cwts.	£	cwts.	£
1875	585	300	727	419	80	223	26	24	1418	967
1876	531	254	781	387	53	149	21	20	1386	810
1877	434	228	589	286	146	408	18	17	1187	929
1878	250	152	394	207	106	298	33	31	783	787
1879	264	146	258	110	45	128	11	10	578	394
1880	279	153	343	138	87	242	36	34	745	568
1881	242	172	244	102	84	314	60	57	630	645
1882	308	212	488	147	104	393	70	68	970	819
1883	282	220	604	207	93	346	77	71	1056	844
1884	310	215	520	171	90	331	80	72	1000	789
1885	290	195	480	156	90	340	100	89	960	781
1886	282	209	520	206	80	280	110	91	992	787
1887	240	180	480	162	60	240	100	90	880	672
1888	200	192	400	120	35	175	60	54	695	541
1889	180	173	350	97	60	240	70	56	660	567
1890	210	184	400	125	50	233	60	58	720	601
1891	205	178	595	235	40	215	75	72	915	701
1892	164	184	479	192	27	148	50	47	720	571

TABLE B. SAILING TRAWLER "THOMAS STRATTON."

YEAR.	PLAICE.		HADDOCK.		"PRIME."		"ROUGH."		TOTAL.	
	cwts.	£	cwts.	£	cwts.	£	cwts.	£	cwts.	£
1875	549	319	937	543	63	178	30	28	1579	1069
1876	601	318	894	471	50	133	31	32	1576	954
1877	422	224	573	310	80	232	17	16	1092	782
1878	239	141	403	188	62	182	27	26	731	538
1879	298	195	252	107	111	324	72	68	733	693
1880	249	151	228	64	79	221	46	44	602	480
1881	138	88	105	46	81	228	47	43	371	405
1882	411	283	741	277	87	250	95	89	1334	899
1883	274	234	648	320	123	345	90	85	1135	984
1884	260	155	530	180	100	360	95	93	985	789
1885	240	142	400	162	80	310	100	86	820	701
1886	220	182	500	200	65	211	90	83	875	677
1887	200	164	480	160	60	242	90	89	830	626
1888	180	172	360	108	45	225	65	59	650	565
1889	160	153	330	94	60	240	75	59	625	546
1890	200	172	450	150	50	231	70	69	770	623
1891	200	175	590	230	49	240	90	80	929	726
1892	126	134	374	140	28	160	29	27	557	460

TABLE C. SAILING TRAWLER "CLIMAX."

YEAR.	PLAICE.		HADDOCK.		"PRIME."		"ROUGH."		TOTAL.	
	cwts.	£	cwts.	£	cwts.	£	cwts.	£	cwts.	£
1875	506 ...	317	1145 ...	698	54 ...	151	37 ...	34	1742 ...	1200
1876	565 ...	361	993 ...	513	53 ...	150	36 ...	34	1647 ...	1058
1877	317 ...	206	792 ...	409	61 ...	172	37 ...	35	1207 ...	822
1878	230 ...	102	381 ...	159	39 ...	107	24 ...	23	674 ...	391
1879	292 ...	156	859 ...	327	71 ...	199	37 ...	33	1259 ...	714
1880	344 ...	219	373 ...	177	49 ...	137	41 ...	39	807 ...	573
1881	292 ...	188	341 ...	146	144 ...	404	137 ...	128	914 ...	867
1882	420 ...	300	870 ...	314	100 ...	280	92 ...	86	1482 ...	981
1883	347 ...	243	675 ...	249	131 ...	368	68 ...	54	1221 ...	924
1884	320 ...	225	620 ...	201	130 ...	366	70 ...	54	1140 ...	846
1885	290 ...	198	510 ...	172	110 ...	390	80 ...	58	990 ...	818
1886	250 ...	202	530 ...	216	100 ...	350	90 ...	82	970 ...	850
1887	225 ...	168	480 ...	160	80 ...	320	80 ...	75	865 ...	723
1888	190 ...	183	380 ...	114	50 ...	250	45 ...	41	665 ...	589
1889	190 ...	176	350 ...	98	70 ...	249	60 ...	54	670 ...	577
1890	200 ...	181	420 ...	129	40 ...	212	50 ...	46	710 ...	569
1891	200 ...	174	590 ...	233	55 ...	252	70 ...	64	915 ...	723
1892	194 ...	231	325 ...	124	27 ...	208	55 ...	51	601 ...	614

TABLE D. SAILING TRAWLER "NYANZA."

YEAR.	PLAICE.		HADDOCK.		"PRIME."		"ROUGH."		TOTAL.	
	cwts.	£	cwts.	£	cwts.	£	cwts.	£	cwts.	£
1875	557 ...	341	941 ...	514	56 ...	160	27 ...	26	1581 ...	1041
1876	709 ...	339	896 ...	512	46 ...	131	46 ...	43	1697 ...	1025
1877	511 ...	222	717 ...	422	66 ...	186	12 ...	11	1306 ...	840
1878	299 ...	156	747 ...	327	98 ...	275	41 ...	39	1185 ...	797
1879	340 ...	185	583 ...	214	164 ...	436	57 ...	54	1144 ...	890
1880	291 ...	157	493 ...	212	47 ...	177	33 ...	31	864 ...	577
1881	295 ...	155	430 ...	202	27 ...	102	35 ...	33	787 ...	492
1882	403 ...	212	770 ...	298	46 ...	172	87 ...	83	1306 ...	764
1883	456 ...	256	734 ...	312	43 ...	163	63 ...	59	1296 ...	790
1884	410 ...	220	430 ...	182	65 ...	182	70 ...	55	975 ...	639
1885	300 ...	160	520 ...	168	80 ...	308	75 ...	62	975 ...	698
1886	250 ...	200	490 ...	193	65 ...	209	60 ...	57	865 ...	659
1887	220 ...	168	460 ...	152	50 ...	195	80 ...	73	810 ...	588
1888	210 ...	196	350 ...	102	40 ...	201	60 ...	55	660 ...	555
1889	180 ...	161	340 ...	89	65 ...	249	70 ...	71	655 ...	571
1890	210 ...	185	592 ...	231	50 ...	231	80 ...	77	932 ...	725
1891	208 ...	183	586 ...	228	46 ...	235	80 ...	76	920 ...	722
1892	189 ...	202	568 ...	235	33 ...	208	64 ...	60	854 ...	706

TABLE E, *showing approximately the number of First Class* TRAWLING SMACKS *belonging to* (1) *the East Coast,* (2) *the South and West Coasts, and* (3) *the Entire Coasts of England and Wales and the Isle of Man.*

	Source of Data.	1889	1890	1891	1892	1893	1894	1895	1896	1897	1898
Scarborough.	‡	60	40	33	30	30	20	20	19	12	(?) 8
Hull . .	*	360	300	280	280	280	250	215	160	140	44
Grimsby	. I.R.	602	521	513	531	546	502	452	336	227	168
Yarmouth	. I.R.	380	500	501	465	422	446	360	378	314	289
Lowestoft .	*	180	203	206(?)	320	320	320	320	320	320	320
Ramsgate .	§	155	158	160	161	158	176	183	183	188	186
(1) **E. Coast:** total		1737	1722	1693	1787	1756	1714	1550	1396	1201	1015
Dover	. I.R.	16	16	16	16	16	16	15	15	15	18
Folkestone	. I.R.	—	—	—	—	—	1	2	3	2	2
Rye .	. Reg.	29	28	28	30	28	28	28	33	38	39
Newhaven	. Reg.	8	8	7	8	9	7	9	8	8	4
Brixham (Dartmouth)	. Reg.	244	244	245	252	248	243	244	252	260	264
Plymouth .	†	74	70	68	63	63	62	61	60	62	60
Tenby	. I.R.	21	19	19	24	23	23	23	23	23	23
Aberystwyth	I.R.	1	2	3	3	4	4	5	3	3	5
Carnarvon (Pwllheli)	. Reg.	11	12	12	10	11	11	10	10	11	10
Liverpool (Hoylake)	. Reg.	44	50	34	34	34	24	27	29	28	26
Fleetwood	. Reg.	65	67	66	59	58	53	51	51	46	44
Whitehaven	Reg.	13	13	14	13	13	15	11	11	10	10
Isle of Man	. Est.	20	20	20	20	20	20	20	20	20	20
(2) **S. & W. Coasts:** total owned .		546	549	532	532	527	507	506	518	526	525
East Coast visitors		40	60	40	40	25	25	25	30	30	35
S. & W. Coasts: total working		586	609	572	572	552	532	531	548	556	560
(3) **Entire Coasts:** total . .		2323	2331	2265	2309	2318	2246	2091	1944	1757	1575

I.R. = Inspectors' Reports. Reg. = Register of first class fishing vessels *less* steam fishing vessels registered. Est. = Estimated from Register and Inspectors' Reports.

* Inspectors' Reports, except 1891 and 1892 (see pp. 37, 38).

† Inspectors' Reports, slightly modified for years 1889, 1890, 1894, 1895 (cf. *Jour. M.B.A.*, vol. i., O.S., p. 66).

‡ Inspectors' Reports, modified in the years 1894, 1895, and 1897.

§ Inspectors' Reports, except that the figure assigned for 1894 has been reduced by 10, in order to keep it within the limit of vessels registered at the port. The remaining figures approximately correspond with the Register.

TABLE F, *showing approximately the number of* (1) *Steam Vessels and* (2) *First Class Sailing Vessels engaged in* LINE FISHING *from the principal ports on the East Coast (estimated from the Inspectors' Reports); together with a reduction of the above to a uniform unit of catching power ("trawler equivalent").*

(1) **Steamers:**	1889	1890	1891	1892	1893	1894	1895	1896	1897	1898
N. Shields .	30	34	22	26	32	36	44	46	39	31
Hull . .	2	8	8	10	12	12	12	12	12	8
Grimsby . .	6	15	17	25	25	30	33	42	50	41
Total . .	38	57	47	61	69	78	89	100	101	80
"Smoothed".	**40**	**50**	**50**	**60**	**70**	**80**	**90**	**100**	**100**	**80**
Factors .	5	5·25	5·5	5·5	5·5	5·6	5·7	5·8	5·9	6
Trawler-equivs.	200	262	270	330	385	448	513	580	590	480
(2) **Sailers:**										
Staithes . .	12	5	9	9	9	9	7	5	5	4
Scarborough .	60	50	36	35	35	35	40	40 (?)	40 (?)	30 (?)
Filey . .	15	9	9	8	9	9	9	9	9	9
Bridlington .	7	18	14	14	14	13	13	13	11	11
Grimsby . .	138	104	101	124	135	114	99	89	50	20
Harwich . .	15 (?)	15 (?)	15 (?)	15	15	13	7	7	6	7
Total . .	247	201	184	205	217	193	175	163	121	81
"Smoothed"	**240**	**210**	**205**	**205**	**205**	**190**	**175**	**160**	**120**	**80**
Trawl.-equivs. ($\frac{4}{5}$)	192	168	164	164	164	152	140	128	96	64
Add do. of Steam.	200	262	270	330	385	448	513	580	590	480
Total equivalents of all liners .	392	430	434	494	549	600	653	708	686	544

TABLE G, *showing the Mean Quarterly* TEMPERATURES *for the British Islands for the years* 1889 *to* 1898, *together with the Means for the period of thirty-three years,* 1866 *to* 1898 (*from the Summaries of the Weekly Weather Reports*).

	Jan.–March.	April–June.	July–Sept.	Oct.–Dec.
Mean, 1866–98	40·3	51·5	58·2	43·9
1889	39·7	52·5	57·0	44·2
1890	41·3	51·0	57·6	42·7
1891	39·2	50·6	57·3	43·6
1892	37·9	50·9	56·3	42·1
1893	**41·1**	**54·6**	**59·2**	**44·4**
1894	41·2	51·0	56·9	45·9
1895	35·2	52·2	59·1	43·8
1896	42·4	53·2	58·0	42·2
1897	40·4	51·2	58·1	45·9
1898	**41·9**	**51·5**	**59·4**	**47·5**

TABLE H, *showing approximately the total number of First Class Trawling Smacks, and of Steam Trawlers and Steam and Sailing Liners reduced to* SMACK-EQUIVALENTS, *for each year from* 1889 *to* 1898, *distinguishing the East Coast, the South and West Coasts combined, and the Entire Coasts of England and Wales and the Isle of Man.*

I. EAST COAST (BERWICK TO RAMSGATE).

YEAR	1889	1890	1891	1892	1893	1894	1895	1896	1897	1898
Steamers regd. .	249	291	409	458	514	565	606	680	748	900
Deduct liners, etc.	103	113	121	135	150	157	175	192	201	202
Steam trawlers	146	178	288	323	364	408	431	488	547	698
Factors .	5	5·25	5·5	5·5	5·5	5·6	6·3	7	7·7	8
Smack-equivs.	730	934	1584	1776	2002	2285	2715	3416	4212	5584
Smacks . .	1737	1722	1693	1787	1756	1714	1550	1396	1201	1015
Equivs. of liners	392	430	434	494	549	600	653	708	686	544
Total smack-units	2859	3086	3711	4057	4307	4599	4918	5620	6099	7143

II. SOUTH AND WEST COASTS (DEAL TO SOLWAY FIRTH).

YEAR	1889	1890	1891	1892	1893	1894	1895	1896	1897	1898
Steamers regd. .	46	47	50	54	48	48	51	68	92	100
East Coast visitors	26	41	40	70	62	48	62	70	68	67
Total st. trawlers	72	88	90	124	110	96	113	138	160	167
Factors .	5	5·25	5·5	5·5	5·5	5·6	6·3	7	7·7	8
Smack-equivs.	360	462	495	682	605	538	712	966	1232	1336
Smacks (local)	546	549	532	532	527	507	506	518	526	525
Smacks (visitors)	40	60	40	40	25	25	25	30	30	35
Total smack-units	946	1071	1067	1254	1157	1070	1243	1514	1788	1896

III. ENTIRE COASTS (ENGLAND, WALES, AND I. OF MAN).

YEAR	1889	1890	1891	1892	1893	1894	1895	1896	1897	1898
Steamers regd. .	295	338	459	512	562	613	657	748	840	1000
Deduct liners, etc.	103	113	121	135	150	157	175	192	201	202
Steam trawlers	192	225	338	377	412	456	482	556	639	798
Factors .	5	5·25	5·5	5·5	5·5	5·6	6·3	7	7·7	8
Smack-equivs.	960	1181	1859	2073	2266	2554	3037	3892	4920	6384
Smacks . .	2323	2331	2265	2309	2318	2246	2091	1944	1757	1575
Equivs. of liners	392	430	434	494	549	600	653	708	686	544
Total smack-units	3675	3942	4558	4876	5133	5400	5781	6544	7363	8503

Preliminary Experiments on the Rearing of Sea-Fish Larvæ.

By

Walter Garstang.

THE present paper contains an account of experiments made at the Plymouth Laboratory in the summer of 1899 with the object of determining the conditions necessary for the artificial rearing of sea-fish larvæ through the critical stages of their development. As is well known, the majority of the attempts which have hitherto been made in this direction have proved abortive, and such success as has been obtained has been limited to the survival of a very small proportion of the original stock of fry. There was therefore ample scope for new work upon the subject, especially for experiments based on comparative methods which should aim more particularly to elucidate the habits of fish larvæ under clearly contrasted conditions. In this way only did it appear possible to make further progress in our knowledge of the physiological peculiarities of the delicate fry and of the conditions which are essential to their healthy development in confinement. The successful issue of the present experiments is entirely attributable, I think, to the fact that they were not undertaken until practically undivided attention could be given to them, which enabled me to watch long and closely the habits of individual larvæ under different conditions, and under the guidance of these observations to modify and perfect the simple apparatus employed until the mortality became reduced to reasonable proportions.

The only records of successful experiments in the rearing of sea-fish larvæ are those of Dr. H. A. Meyer in 1878 with the Baltic herring, of Captain Dannevig in 1886 with the cod in Norway, and of Mr. Harald Dannevig in 1896 with the plaice at Dunbar.

Dr. Meyer* reared a number of larvæ of the Baltic winter herring from eggs which had been artificially fertilised on the Schlei River. The larvæ were confined in a large tub containing water from the Bay

* *Biologische Beobachtungen bei künstlicher Aufzucht des Herings der Westlichen Ostsee.* Berlin, 1878. (Translated in *Report U.S. Fish Commission for* 1878, pp. 629–38.)

of Kiel. Half the water was changed daily, and was filtered before its introduction into the tub in order to remove all but the most minute organisms from the water. A considerable mortality among the larvæ took place after the tenth day, apparently from an insufficient supply of food of the right kind; but the beneficial effects which followed the subsequent introduction of unfiltered water (containing a richer supply of larger organisms) were so conspicuous that a number of the larvæ completed their metamorphosis and were reared to a length of 72 millimetres (nearly 3 inches), their age at this length being about five months. Unfortunately neither the number nor percentage of the survivors is mentioned.

Captain Dannevig's* experiment was carried out on a greater scale. He placed about 500,000 young fry of the cod, which had been artificially hatched, into a large basin of sea-water attached to the Flödevigen hatchery on the south coast of Norway. The capacity of the basin was about 2,500 cubic metres (88,000 cubic feet), the greatest dimensions being:—length, 43 metres; breadth, 20 metres; depth, 5 metres (*i.e.* about 140 by 66 by 16 feet). During the first month the larvæ refused artificial food, and no plankton (minute floating life) was provided for them except such as was already present in the sea-water. They were observed to attack, kill, and eat each other in considerable numbers, but were still too small to attack the numerous crab larvæ which were also present in the water. From the second month onwards, however, they ate considerable quantities of finely-powdered mackerel, which was given them twice a day, and their rate of growth greatly increased. At the end of the fifth month they had attained an average length of 115 mm. ($4\frac{1}{2}$ inches), the largest caught being 157 mm. (6 inches) long. At the eighth month the number of survivors was estimated to amount to "several thousands." This famous and most important experiment served Captain Dannevig's purpose in demonstrating that fry artificially hatched have the power to live, grow, and develop when set more or less at liberty; but it is clear that, strictly speaking, the demonstration is limited to a small percentage† (not more than one or two per cent.) of the original stock of larvæ. By the following April, *i.e.* when about a year old, some of the survivors were about a foot in length.‡

* *Report of the Codfish Hatchery at Flödevig, Norway, for* 1886. (Translated in *Bull. U.S. Fish Commission*, VII., 1887, pp. 113–19.)

† Mr. Harald Dannevig, in a reference to his father's experiments, states that "*most* of the young fishes survived the following winter" (*Fifteenth Report Scottish Fishery Board*, part iii. p. 176). Although I have not seen the original report, this would appear from the American translation to be a mistake.

‡ Ewart, *Fifth Report Scottish Fishery Board*, pp. 235, 244; McIntosh, *British Food Fishes*, p. 244; Cunningham, *British Marketable Fishes*, p. 287.

According to Professor Ewart,* Dannevig also set free a number of young herring in the same pond. Some completed their metamorphosis, but the greater number fell victims to the hungry cod.

Lastly, in 1896, Mr. Harald Dannevig,† at the Dunbar hatchery, succeeded in rearing a number of plaice through their complete metamorphosis, in a glass carboy holding ten gallons of sea-water. Twelve hundred larvæ were introduced, but the proportion of the survivors is not stated, except that the healthy larvæ, from which alone the survivors were derived, formed the minority from the beginning. The water was changed once or twice a day, and plankton from the harbour was added twice a day. The water in the carboy was subject to convection currents, caused by inequalities in the temperature of the water and that of the surrounding air. To the gentle movements of the water, due to this cause, Mr. Dannevig attaches much importance. The oldest stage described by Dannevig is that of an average specimen of the forty-fifth day, which had been on the bottom of the jar for several days, and measured 13·76 mm. ($\frac{7}{16}$ inch) in length, and 6·4 mm. ($\frac{1}{4}$ inch) in breadth.

On the other hand, the difficulties of the problem are clearly brought out in the numerous unsuccessful experiments described by Cunningham,‡ and by MM. Fabre-Domergue and Biètrix,§ as well as by the experiments known to have been made without result by other naturalists. Cunningham's experiments dealt chiefly with pelagic eggs; those of the French naturalists were based upon the demersal eggs of *Cottus,* but also included experiments with various kinds of pelagic eggs.

When the metamorphosis of a Teleostean larva has been accomplished, however, no further difficulty in rearing the young fish is experienced in most cases. This remark is particularly true of bottom fishes, such as flat fishes and gadoids, which have been repeatedly reared from the earliest adolescent stages even up to maturity, both in the Plymouth Laboratory and elsewhere; and it has been shown that the rate of growth is principally dependent upon the temperature and the food-supply to which the young fishes are subjected—conditions which can easily be controlled. There can, indeed, be no doubt that the possibilities of marine fish culture would be great and various, if we

* "On the Artificial Hatching and Rearing of Sea Fish." *Fifth Report Scottish Fishery Board,* 1886, p. 235.

† "On the Rearing of the Larval and Post-larval Stages of the Plaice and other Flat Fishes," *loc. cit.*, pp. 175–192; also *Sixteenth Report*, pp. 223–4.

‡ "Experiments on the Rearing of Fish Larvæ in 1894." *Journal of the Marine Biol. Assoc.*, iii., 1894, p. 206.

§ "Recherches biologiques applicables à la Pisciculture Maritime." *Ann. Sci. Nat.* (viii.), t. 4, 1897, pp. 151–220.

could bridge the gap in our knowledge as to the proper methods of treating the fry during the transformation from the larval to the adolescent stages. Promising as are the results of the experiments described above, it is clear that our knowledge of the conditions of larval life and development is quite inadequate so long as we can only ensure the survival of a minute percentage of the fry in our rearing experiments.

The species employed in my experiments was the "Butterfly Blenny" (*Blennius ocellaris*), which, at Plymouth, usually lays its eggs in the empty shells of whelks (*Buccinum*), in moderately deep water offshore (15 to 20 fathoms), whence relays of its eggs were easily obtainable with the dredge during the past summer (1899).

Although many offshore types of fish doubtless differ from it as to the special conditions requisite for their development, yet the observations made upon the development of this species cannot be without value in regard to the rearing of other offshore larvæ in captivity.

The eggs of the Butterfly Blenny have been described by Cunningham,* and the structure of the larva soon after hatching by Holt.† The larva at this stage is already well organised: the mouth is formed, the eyes pigmented, the yolk relatively small in quantity and moderately protuberant, and the pectoral fins well developed. On the other hand, the vertical fin membrane is still in the primitive undivided condition, the lower jaw is immovable, and the permanent skeleton has not yet made its appearance. The larva thus approximates in type to the early larva of *Cottus* and other demersal forms, and is more highly organised than the early larvæ derived from pelagic eggs such as those of flat fishes and gadoids, which indeed do not, strictly speaking, merit the term "larvæ," since they are merely embryos released from their shells, and incapable of capturing food for themselves. These so-called "pelagic larvæ" (which are not more peculiarly pelagic than the larvæ arising from demersal eggs) might well be distinguished from true larvæ, as "embryonic larvæ" or "embryo larvæ." The larva of the Butterfly Blenny, at the time of hatching, corresponds in its grade of organisation with a plaice larva five or six days old.

Holt assigns a length of 6·30 mm. to the larva of the Butterfly Blenny when twelve to twenty-four hours old. This dimension considerably exceeds that of all the specimens which I have measured at a corresponding age, as will be seen from the following records of the size of four specimens, in millimetres :—

* *Journ. M. B. A.*, i. 1891, p. 36, fig. 35.

† *Ann. du Musée d'Hist. Nat. de Marseille, Zool.*, v., 1899, p. 45, pl. 6, fig. 63; *Journ. M. B. A.*, v. p. 122.

	3 to 4 hours old.				20 to 24 hours.
Total length	4·6	4·5	4·6	...	4·6
Length from anterior extremity to posterior surface of yolk . .	1·18	1·15	1·17	...	1·15
Ditto to posterior surface of rectum .	1·62	1·55	1·58	...	1·60

These larvæ were hatched on August 4th from a batch of eggs dredged the same day. They were killed and preserved in weak formalin, and measured on August 5th. In view of the slight nature of the differences in my measurements of separate individuals, it is difficult to account for the discrepancy * between our observations, especially as I find the same length in early larvæ of another batch hatched on June 16th. The difference can scarcely be attributed to contraction of my specimens in formalin, since in the oldest of the above-mentioned larvæ the longest rays of the pectoral fin were seen to fall short of the anus by 0·15 mm., whereas in Holt's specimen they extended 0·12 mm. behind the anus. Moreover, in larvæ which had died a natural death and become opaque, the pectoral fin-rays were often noticed to stretch beyond the anus, as in Holt's specimen, but this was never the case with fresh or living larvæ derived from the August batch referred to above. Several larvæ measured fresh on the third and fourth days had a length of exactly 5 mm.

Holt remarks upon the delicacy of the larvæ and their susceptibilities to slight injuries, an observation which in the early stages of these experiments I had frequent opportunities of confirming. The water in the jars was at first renewed by siphoning off half the water and pouring slowly from a broad-lipped jug, at first directly and subsequently through a funnel; but the currents produced by the first method, and the impact of the bubbles of air driven down the funnel, were excessive and caused considerable injury. This method was subsequently replaced by allowing the water to enter the jars in a slow stream from a siphon provided with a stopcock. Even the capture of a larva by means of a dipping tube was sufficient to stun and kill it.

If the larvæ are kept in a "plunger-jar," the diameter of the plunger-plate in relation to the diameter of the jar is an important item, and any excess which produces eddies of any violence during the movements of the plunger is certain to prove fatal. At first my larvæ were placed in tall bell-shaped hatching jars having a height of 16 inches and an internal diameter of 8 inches. The plunger-plate was circular and had a diameter of 4½ inches. The plunger made three complete strokes in exactly two minutes, *i.e.* one plunge, including both down and up stroke, in 40 seconds. The downward stroke was gentle and

* Mr. Holt informs me by letter that the total length assigned to the larva in his papers is a mistake due to an error of transcription, and should have been 5·30 mm. After a re-examination of his specimens, however, I find the total length to be the same as in mine, viz. 4·6 mm. (varying between 4·55 and 4·65). I have verified the accuracy of my micrometer, so that no difference between our larvæ need be assumed.

occupied 15 or 16 seconds, followed by a pause of 5 seconds, but the upward stroke was smarter and lasted only 8 seconds. The apparatus was then quiescent for about 12 seconds before the next stroke began. The eddies in the water caused by the rapid movements of the plunger were so extensive that the larvæ were frequently caught in the streams and whirled around, and, although these involuntary gyrations did not appear at the time to have any greater effect than to temporarily arrest the activity of the larvæ, I was soon convinced that the mortality which the larvæ exhibited in these first experiments was largely attributable to the incessant harrying to which the movements of the plunger subjected them. When the original plunger-plate was replaced by a much smaller one of 2½ inches diameter, not only were the water-movements greatly moderated, but the condition of the larvæ generally improved.

The powers of the larvæ in stemming a constant current, however, were considerable. When the water in a jar was being changed, the waste water was at first siphoned off through a glass tube provided with a thistle-funnel (covered with fine gauze) at one end and a stop-cock at the other. It was remarkable to notice the success with which both Copepods and young Blenny larvæ could for some time compete with the current setting through the funnel, even when the tap was fully open. As soon as they felt themselves within the influence of the current they would give vigorous darts in the opposite direction, the fishes generally escaping, the Copepods often. But the weaker larvæ which did not dart away smartly enough were drawn up against the gauze. The weakest would remain there, scarcely offering resistance; but the majority, as soon as they touched the tight gauze surface, would give a most powerful leap, and dart clear away from funnel and current alike into relatively still water. Many showed no serious objection to the current itself, and allowed themselves to be drifted up against the gauze; but the moment they felt this obstacle they leaped away as just described. The Copepods, as a rule, were unable to jerk themselves beyond the influence of the current except momentarily, and thus maintained a prolonged contest in the form of incessant darts or leaps from the neighbourhood of the sieve, to be repeated as fast as the current beat them back upon it.

Experiments A, B, and C.

The experiments which I made last year fall into four groups (see table p. 76). The first set (A, B, and C) was designed to test the effect of confining the young larvæ in jars of water fitted with Browne's stirring* apparatus known as the "plunger." Three jars of the same size and shape were employed, and were fitted with plungers of equal

* See *Journ. M. B. A.*, v., 1898, p. 176.

size worked from the same motor. All the jars were filled with water from the offing beyond the Breakwater, but in one (A) the water had been standing in the Laboratory for some weeks and had previously contained Echinoderm larvæ, while in the other two the water was fresh from the sea. One of the latter jars (C) was immersed in a tank of circulating water downstairs in order to maintain a fairly constant temperature; the other (B), together with the jar of stale water, was placed in front of a window facing west, and was fully exposed to the changes of temperature in the air of the building. The same number of larvæ (twenty-five) was placed in each two-gallon jar (August 4th). The larvæ in the stale water were all dead or moribund in three days. Half of the larvæ in each of the remaining jars had died within a week, and all were dead on the tenth day, except one which survived until the fourteenth. The rapid mortality in experiment A was obviously attributable to some impurity in the stale water; that in B and C was traceable partly to the excessive movements of the plunger, as described above, partly to insufficient food in the first week, and partly to the over-accumulation of dead plankton in the limited quantity of water.

Table showing, for each experiment, the initial number of larvæ, and the number surviving on every fourth day.

Experiment begun (=date of hatching).	Aug. 4th. A	B	C	Aug. 10th. D	Aug. 17th. F	G	H	Aug. 23rd. J	K	L
Age: Newly hatched	25	25	25	19	10	10	?	10	10	10
4 days old	0	17	18	11	9	7§	6	6	4	7
8 ,,	—	3	3	11	9	4§	6	all moribund.		
12 ,,	—	1	0	9*	9	4	4			
16 ,,	—	0	—	9	8	4	4			
20 ,,	—	—	—	2‡	6†	...	3†			
24 ,,	—	—	—	2	5	...	3			
28 ,,	—	—	—	2	5	...	3			
32 ,,	—	—	—	2	4	...	3			
36 ,,	—	—	—	2	4	...	3			
40 ,,	—	—	—	2	3	...	3			
44 ,,	—	—	—	2	2	...	3			
48 ,,	—	—	—	2	—	...	—			
52 ,,	—	—	—	1	—	...	—			

(D, F, H) Merged together in jar H on Oct. 1st.

* Deaths caused by the water becoming impure and turbid.

† Deaths caused by mechanical accidents.

‡ Deaths caused chiefly by transference of larvæ to a tank of circulating water in which, by an accident, they were exposed to the attacks of rapacious Copepods.

§ Deaths probably caused by mechanical accidents due to a defect in the jar subsequently discovered (August 26th), and rectified same day.

These factors so completely dominated the conditions of the experiments that no conclusions could be drawn from the slight differences between the jars at constant and variable temperature, although the heat at the time was so great and the fluctuations in the temperature of the exposed jars were so considerable that further experiments were all carried on in immersed vessels.

The water in the three jars was left unchanged for the first three days of the experiments, but half of the water in each jar was changed daily after this date. To avoid any ill effects from subjecting the larvæ to rapid changes of temperature, the new supplies of "outside water" in these and all other experiments were always raised to the same temperature as the water in the jars before being added. The temperature of the water in these and the remaining experiments described below was daily observed and recorded at about the same hour in the forenoon, 10 to 11.30 a.m., and oftener in certain experiments.

The food supplied was always plankton, which was obtained with fine silk nets beyond the Breakwater as a rule. But no food was given in A, B, and C until the fifth day of the experiments, when the larvæ were already four days old. This was a radical error. The larvæ must, to some extent, have been starved, since on this day I found from an examination of the corpses that the yolk had already been absorbed in some, and on the following day was entirely absorbed in eight out of the ten corpses examined. After this date plankton was added daily, and in the remaining experiments was provided from the beginning of each experiment.

The size of the plungers was reduced on the seventh day in B, and on the eighth day in C.

Faeces and plankton débris were removed by a dipping tube at first, and subsequently by a siphon. This was an essential item in each day's operations. If neglected, the larvæ at once began to suffer.

Experiment D.

A second experiment (D) was begun a week after the preceding (August 10th), in order to subject a slightly smaller initial number of larvæ (nineteen) to similar conditions, modified, however, by the adoption of a smaller plunger from the second day of the experiment, and by closer attention from the beginning of the experiment to the feeding of the larvæ, and the cleansing and change of the water in the jar. These modifications resulted in a marked reduction of the mortality, especially after the third day, and in a healthier appearance of the larvæ. More than one-third of the larvæ died in the first three days, leaving eleven alive and active on the fourth day of the experiment. These numbers remained unchanged until the eighth day, when one or two larvæ were observed to be somewhat feeble, in consequence of the turbidity of the water, and on the ninth day only nine larvæ survived. These, however, after careful cleansing of the jar, were all flourishing. They were growing in bulk, and displayed the greatest activity in their search for food. Their numbers remained unchanged for another week, at the end of which time (the sixteenth day) it was clear that the conditions of the experiment were perfectly suitable for their development, so long as the water could be kept clean and abundance of food could be provided. During the course of the experiment, from one-half to two-thirds of the water had been changed every day, and fresh plankton added daily with rare exceptions. But irregularities in the quantity and condition of the available plankton were unavoidable, causing occasionally a slight deficiency in the amount provided, and at other times an over-accumulation of dead Copepods, etc., in the jar, and consequent soiling of the water. The larvæ at this time had grown considerably, being about 7·5 mm. in length, and nearly 2·0 mm. in maximum depth, as taken through the hinder part of the eye. The larval fin membrane was still continuous, but the notochord was turned up posteriorly, the tail fin properly formed, the hypural plates and caudal fin-rays established, the fin-rays in the dorsal and ventral fins in process of formation, and the rudiments of the pelvic fins present. There was thus no doubt that the larvæ were growing and developing properly, and were already undergoing the critical stages of their metamorphosis.

On the other hand, the increasing difficulty of keeping their jar clean in consequence of the large amount of food they required, and the death of a larva on the seventeenth day, induced me to remove some of the larvæ from this jar, and see the effect of placing them in a circulation of the ordinary tank water, which would at any rate solve the difficulty of keeping the water clean.

Three of the larvæ were therefore transferred on the eighteenth day to a portable slate tank, with a glass front, holding four gallons of water, and placed in the main laboratory on the south side of the central tanks. The bottom was covered with gravel, and a circulation was set up with every precaution to avoid loss or injury of the larvæ from the current established. On the following day all three were alive and active, whereas another death had occurred in the original plunger-jar. The four survivors were thereupon cautiously transferred to the portable tank, and a liberal supply of fine plankton was provided. Late in the afternoon only three or four out of the seven were swimming about, the others being on the gravel at the bottom. They appeared to be incommoded by the brighter light of their new situation, so a sheet of green glass was placed in front of the tank. No obvious effect on the fishes was noticeable, but the tank was appreciably darkened. Next day five of the larvæ had completely disappeared, and no trace of their remains could be discovered in the gravel or elsewhere. The circulation was all right, and escape by the siphon overflow (a broad funnel imbedded deeply in the gravel) was quite impossible. On further examination it became practically certain that the larvæ had been devoured by Harpacticid Copepods (almost exclusively *Idya furcata*) which had entered their tank through the siphon from the supply tank above. These Copepods were present in the fishes' tank in myriads—on the slate sides, on the glass, in the gravel, and freely swimming; and I subsequently found, from an examination of the supply tanks, that they abounded in many of these tanks, especially on the glass fronts, from which, in this case, they had clearly been drawn through the siphon supplying the portable tank. The siphon had inadvertently been displaced, so that its mouth rested against the glass front of the supply tank.

The rapacity of these Copepods was easily tested upon dead or moribund larvæ derived from other experiments. The *Idya* appears to fix itself to its prey by the second antennæ in front, and the second maxillipeds behind. The mandibles, or neighbouring appendages (the precise organs were not determined), then make a rapid series of bites from before backwards, accompanied by an incessant scratching movement carried on by the setæ of the mouth parts. The fin membrane of a larva was quickly gnawed away in semicircular patches, like the holes on the edge of a leaf by caterpillars. To test the rate of dismemberment, three entire corpses of Blenny larvæ were placed at 4 p.m. in a small dish containing sixty-eight Copepods, all of which, as determined after the experiment, were *Idya furcata.* Next morning the corpses had entirely disappeared except a fragment of one larva, and the faintest possible traces on the sites of the other two.

In order to see whether the Copepods would also attack living prey, I placed four healthy young *Gobius minutus,* each about one inch long, in the tank. On examining one, which was near the glass front, some time afterwards with a lens, I could see two of the Copepods on the base of the tail fin, busily engaged eating the fin membrane. The Goby appeared to feel no serious discomfort from their proceedings, though it occasionally made restless movements as though slightly irritated. Its movements, which were repeated three or four times while I watched, did not dislodge the Copepods. Next morning one of the Gobies was dead, and had been browsed upon by one at least of its companions, as well as by the Copepods. Its death, however, seemed attributable to the latter.

On the other hand, the Copepods appeared to prefer dead to living prey. A moribund Blenny larva was placed in a watch-glass of sea-water with a number of the Copepods, and kept under observation under the microscope for twenty minutes. The larva was still capable of spasmodic darts. The Copepods occasionally settled on the larva, but usually left it at once, even when the latter made no signs of objection to their presence. If they remained, and began to feed, the larva would shake them off by wriggling away, though sometimes with difficulty if the Copepod was tenacious. Twelve Copepods visited the larva during the time. Of these, seven left at once, three very soon, and two after being shaken off by the larva. At the end of twenty minutes the moribund larva was removed, and a corpse offered to the same Copepods. In the same time nine Copepods visited the corpse. Of these only three left at once, while the other six remained to feed, some for five minutes, but the majority for the remainder of the experiment. The moribund larva was now weaker; the heart was beating, but the respiratory movements had ceased. It could no longer shake off the Copepods, and these remained to feed precisely as on the corpse.

The above experiments indicate that these carnivorous Copepods, especially *Idya furcata*, prefer dead prey, but do not hesitate to attack living fishes or larvæ on occasions. Although even Blenny larvæ could probably free themselves of these pests under ordinary circumstances, the extraordinary accumulation of the Copepods in my rearing tank appears to have subjected the larvæ to such incessant attacks from them that they were unable to cope with them, and finally gave way, especially as the second lot of larvæ appears to have been rendered temporarily torpid from the beginning by the change from the plunger-jar to the tank—a condition which would reduce their ability to drive off the pests.

I made one further experiment which may provide a useful means of preventing the accumulation of these Copepods in aquaria. A small Wrasse (*Ctenolabrus rupestris*), 2 inches long, was introduced into the tank when the Copepods were literally teeming within it. Next morning the Wrasse was very lively, and the Copepods were exceedingly scarce. On watching further, I saw the Wrasse busily engaged picking them off the slate walls one by one with unvarying exactitude. Its stomach on dissection was found to be filled with the Copepods.

The result of this instructive accident in my second rearing experiment was that the two larvæ which still survived in the slate tank were again transferred to a plunger-jar as before; and in this they continued to thrive for another month without further incidents calling for notice. They completed their metamorphosis, and one survived to become a sturdy little fish an inch in length, with the entire organisation and habits of the adult, even to the extent of making a house for itself out of a small *Trochus* shell. It was preserved with the survivors from other experiments in the second week of November, at an age of three months (thirteen weeks). Its companion had died a month earlier (October 1st) of a complaint which frequently recurred among the larger fry, and which at this time I did not properly understand. As will be described below, I eventually satisfied myself that this ailment (the principal symptoms of which were a kind of flatulence and an inability to remain below the surface of the water) was a result of the excessive feeding in which the fry frequently indulged after the daily supply of plankton.

Experiments F, G, and H.

These experiments were begun with a new batch of larvæ a week later than the preceding experiment (August 17th) with the object of determining whether the initial death-rate in the earlier experiments might not be prevented by placing a still smaller number of larvæ in the rearing jars—a plan which would render the larvæ less liable to suffer from the occasional impurity caused by an excess of dead plankton in the limited quantity of water, which could not conveniently be changed more than once a day as a rule. All these experiments, it should be remembered, were begun in the height of a hot summer (August, 1899) when the temperature of the aquarium water stood constantly in the forenoon at about 19°·0 C. (=more than 65° Fahr.), and varied only between 18°·8 and 19°·2 at that time on different days.

Two jars (F and G) were at first taken, of the same kind as before, and were immersed side by side, under precisely similar conditions, in the same tank of water. The same plunger-plates (diameter 2½ inches) were also employed, and were worked by the same motor and therefore at the same rate. The only difference between the two experiments that was intentionally introduced was in the character of the water supplied, as I was anxious to compare the mortality of the larvæ when kept in offshore and harbour water respectively. One jar, therefore (F), was kept constantly supplied with inshore water pumped up from immediately below the Laboratory. It was taken from one of the large Laboratory settling reservoirs before being circulated through the aquaria, and was therefore pure unused harbour water. The other jar (G) was supplied with offshore water brought in carboys rom beyond the Breakwater as before. The remaining conditions of the experiment would have been practically identical had it not been for a defect in the latter jar, which was not discovered until nine days after the experiment commenced. The rearing jars are each perforated at the apex for the insertion of a supply pipe (for hatching purposes), but for my purposes these holes were closed by the insertion of corks, the inner surfaces of which were covered with a layer of hard paraffin wax to prevent the entrance of impurities from the corks in the inverted position in which they were employed. On the fourth day of the experiment (August 20th) three larvæ in G had completely disappeared, and one had again disappeared three days later (August 23rd) without leaving any trace—a most unusual occurrence. On the 26th, when siphoning off the sediment from the bottom of this jar, I saw a larva sucked into a gap beneath the layer of paraffin covering the cork at the bottom, and was only able to release it with difficulty. The cork had clearly not been driven in quite flush with the outer neck of the jar before the experiment, and had thus been forced inwards to a slight extent after being placed upright in the inverted position, thus detaching the paraffin layer from the inner face of the glass. The crevice so formed was just large enough to allow a larva to enter. This jar was the only one in which such a detachment of the paraffin had taken place, and the defect accounts in all probability for the frequent deaths in G as compared with F in the early stages, the larvæ having got in, and either injured themselves or failed to emerge. After the defect was remedied no further deaths occurred in the jar except one on the following day, which probably resulted from the accident which I had observed.

Thus exact comparison between the two experiments is scarcely possible, though the healthy development of the larvæ in F fortunately renders such comparison unnecessary.

Ten newly hatched larvæ from the same batch of eggs were placed in each of the two jars. They were fed with plankton from the beginning, and half of the water, or even more, according to circumstances, was changed daily in each jar. A summary of the results is shown in the table (p. 76).

The advantage of giving the larvæ a more plentiful supply of water and food from the beginning was clearly shown by the trifling death-rate at the beginning of the experiment, and by the healthy and vigorous condition of the larvæ. In F one corpse was removed on the second day of the experiment, a death which was almost certainly of an accidental character, but from this day no deaths occurred until the end of a fortnight. The larvæ were active and healthy during the whole of this period until the last few days, when two, which were not growing so rapidly as the others, showed signs of inactivity and died during the following week. Another was lost on the seventeenth day (September 3rd) by being drawn up the siphon during the cleaning of the jar. From this date I was unable to watch the experiments from day to day, owing to absences caused by work at sea and my attendance at the Dover meeting of the British Association. As far as possible, however, the same routine was continued in the treatment of the fry in my absence, and two survived the forty-fourth day (September 30th) when they, with the survivors from D and H, were merged together into the jar devoted to this last-mentioned experiment, the conditions of which appeared to be more suitable than plunger-jars for the later stages of development.

During the course of this experiment the larvæ throve splendidly during the first few weeks, up to a length of about 10 mm., and completed all the essential structural changes in their metamorphosis, the permanent fins having been formed and the skeleton established. They were always very lively, and darted about after Copepods with great agility, displaying much pertinacity and considerable acrobatic powers in their efforts to secure their prey.

Their methods of hunting were always alike, and were so eminently characteristic as to merit a brief description. Upon noticing some fancied morsel, the larva would immediately become transformed with excitement, and, keeping its face constantly towards the object, would commence a series of evolutions, the first purpose of which was to investigate the nature of the prey, and the second to circumvent the latter's escape. Wheeling round through the quadrant of a circle by a series of strokes of the tail, aided by synchronous movements of the pectoral fins, the larva, if satisfied with the result of this preliminary survey, would leap smartly round from side to side of the chosen morsel until by a well-directed forward dart the quarry was seized or frightened away. If the attack were successful, the larva would swim quietly about again; but if unsuccessful, it would swiftly pursue and repeat the same process until success rewarded its efforts or the Copepod finally escaped. The pectoral fins were ceaselessly employed in these movements, whether from side to side, up and down, or even backwards. Under these circumstances Mr. Holt's suggestion* that the large size of the pectorals in these larvæ may be of merely ancestral significance appears unnecessary. It is true, as my colleague remarks, that these fins are not very effective organs of locomotion, so far as pace alone is concerned; but it is impossible to spend any time in watching these larvæ hunting for food without forming the conviction that the fins are particularly adapted to enable their possessors to cope with the peculiar dodging movements of the Copepods they pursue, which resemble to some extent the well-known tricks of the so-called hovering flies of our gardens and hedge-rows (fam. *Syrphidæ*).

Resuming my narrative, however, the fry, in later stages, after the third week, did not as a rule appear to do so well in this jar as those in jar H, to be described below. They continued to grow rapidly, but

* *Journ. M. B. A.*, v., 1898, p. 123.

individuals from time to time had strange fits of torpidity, and at a stage when the larvæ in H were already settling on the bottom, those in F showed a marked preference for the surface, which they refused to leave. They were obviously not quite healthy; and, although I adopted a different interpretation later on (see p. 86) in connection with similar phenomena in jar H, I attributed the unhealthiness of the larvæ at the time to the unsuitability of the conditions in the plunger-jar, since after the larvæ were transferred to the stagnant water in H they assumed habits similar to those of their companions almost immediately (next day).

It is possible, though unlikely, that the ill health of the later larvæ in F was due to a deterioration in the reservoir water, which was changed a few weeks after the commencement of the experiment. In August the harbour water was doubtless of an exceptionally pure character, in consequence of the long dry summer, but the rains of September must have subsequently affected its salinity and quality in the neighbourhood of the Laboratory, as they undoubtedly drove away the Red Mullet which had previously been lurking about the mouth of the Cattewater in exceptional abundance.

Thus in spite of the low mortality in this experiment during the first few weeks, which points to the suitability of the harbour water at that time, I should hesitate to conclude that the harbour water would be usually suitable for the development of this fish in other years or at other seasons of the year, when the salinity is lowered by the greater quantity of fresh water coming down the Tamar, Tavy, and Plym.

Experiment G requires little to be said of it in consequence of the initial defects in the jar already alluded to. On the nineteenth day (September 4th), prior to my Channel cruise, I preserved the four survivors in this experiment in order to have some material for studying the anatomical details of the progress made in development. The larvæ varied in length at this stage between 6·8 mm. and 8·0 mm. The maximum depth through the hinder part of the eye was 2·0 mm. in the largest specimen. The notochord was turned up posteriorly in the largest, but scarcely bent at all in the smaller specimens. Two hypural bony plates were developed in the largest, but were quite insignificant in the smallest larva. Delicate caudal fin-rays in fan-like tufts were conspicuous in all, and formed a protruding ventral lobe to the fin in the smaller specimens.

A noteworthy, though not conspicuous feature of the larva up to this stage, and even for another week beyond it, is the permanently gaping mouth. The larvæ do not close their jaws until they are a full month old, when the teeth begin to appear.

Experiment H was started on August 22nd, in order to see the effect of transferring larvæ four or five days old from a plunger-jar to a jar of stagnant water, devoid of a plunger, and aërated by means of green algæ exposed to direct sunlight immediately in front of a south window. The jar was broader than the rearing jars, and of different shape, having a flat bottom and cylindrical sides, and terminating above in a shoulder and a neck about 3 inches in diameter. It contained about 3 gallons when full, but was not filled during the first few weeks beyond about two-thirds or three-quarters of its total height. It was immersed to a little below the same height in a tank of circulating water in the full blaze of the midday and afternoon sun. The current in the outer tank was not strong enough to keep the temperature in the jar constant, but served to moderate it. The following series of temperatures give an idea of the range of temperature to which the larvæ were exposed:—

	Aug. 25.		Aug. 26.	Aug. 27.	Sep. 2.	Sep. 7.
	10 a.m.	4 p.m.	3 p.m.	Noon.	2 p.m.	? hour.
Temp. of water in tank . .	19°·9	21°·0	21°·6	19°·7	18°·7	19°·2
" " jar (top) .	20°·3	23°·0	24°·1	19°·8	19°·2	20°·0
" " " (bottom)	19°·8	21°·3	21°·6	19°·7	18°·8	19°·2

As shown by the figures, the uppermost layer of water in the jar was generally warmer than the rest during the daytime, since the outer jacket of circulating water was not high enough to surround it; and the amount of the excess depended on the sunshine, amounting to $2\frac{1}{2}°$ C. on hot afternoons (*e.g.* August 26th) or of a mere fraction of a degree on cloudy days (August 27th, September 2nd). The bottom temperature amounted to 22°·0 at 4 p.m. on August 23rd, but rarely exceeded 21°·0 after the first few days.

A small tuft of *Ectocarpus* was placed at the bottom of the jar under a small glass funnel as a means of aërating and purifying the water. During sunshine the small bubbles of oxygen emitted by the plant escaped into the surrounding water in a continuous stream through the narrow aperture of the funnel; and in a very short time the bottom and sides of the jar became covered with a perfect jungle of the same alga from the fixation and development of the spores liberated by the original tuft, which, with the funnel, was then removed.

Into this jar, on August 22nd, were placed six larvæ derived from the same batch of eggs as those in experiments F and G, but they were already from four to five days old at the time of their introduction. Previous to this they had been kept in a plunger-jar (E) under the same external conditions as F and G. They had not, however, received much attention. The six larvæ were the survivors of ten or eleven which had been isolated on the 18th (from twelve to twenty-four hours after hatching), and had received no change of water and only one supply of plankton in the interval. The feebler larvæ may therefore be supposed to have been already weeded out.

In the new jar (H) the larvæ were subjected to the same attention as those in F and G; that is, the water was partially changed every day, a daily supply of plankton was provided, and débris and faeces were removed every morning by means of a siphon.

Although no deaths occurred during the first four days, the larvæ did not thrive so well at the beginning as in the plunger-jars. Several of them from the beginning showed signs of torpidity and lay about on the bottom in a listless condition, possibly in consequence of the greater heat to which they were subjected, possibly also from the lack of motion in the water. Two deaths soon resulted. The remainder, however, became increasingly active, and two in particular began to grow at an unusually rapid rate, soon outstripping their companions. The improvement coincided with a cessation of the excessive heat towards the end of August. On the 30th of August they were all lively, and one was particularly large, being to all appearances as far advanced as the two survivors in D at the same date, although a full week younger. The tail fin was formed, as well as the early skeleton. My diary for the 30th states: "All these larvæ are very healthy and are incessantly swimming. They seem to be in no need of a plunger at this stage." Except the two cases recorded above, no deaths whatever occurred in this jar up to the end of October, when the larvæ were seventy-four days old. The reduction in the number between the sixteenth and twentieth days shown in the table (p 76) was caused by one being accidentally lost during the changing of the water on September 5th. Occasionally one or other of the largest fry exhibited temporary fits of ill health. The fish would lie at the top of the water, immediately beneath the surface film, spasmodically wriggling and often curling up as if in pain. The abdomen in such cases was always distended with food and gas, and the whole body was lighter than the water, so that the fish could not do otherwise than float at the top. I could diagnose the complaint in no other way than as a kind of flatulence or dyspepsia resulting from over-feeding. I fear this explanation may seem to others to savour of anthropomorphism, but I can only point to the fact that before I arrived at this explanation several deaths occurred in jars D and F from similar causes, from inability to treat the cases properly, whereas, after I became convinced of it, I repeatedly brought these ailing fishes back to health again by reducing their supplies of food. It should be borne in mind that fish larvæ in the sea are never surrounded by such quantities of food in small compass as these fry confined to the space of a two or three gallon jar in my experiments, especially as no attempt was made to spread the supplies of food over a long portion of the day. When the tow-nettings arrived, the bottles were always allowed to stand for a few minutes in a convenient position near the jars, so that the Copepods might concentrate themselves near the source of light. They were then poured directly into the jars, or siphoned in, according to the degree of their concentration. Thus the fishes were surrounded by a superabundance of food during a portion of the day, and as their instincts were obviously to catch a Copepod whenever the chance presented itself, it is scarcely surprising that they should have occasionally suffered from an excessive diet. For rearing work on a larger scale I therefore believe that one of the many principles that will need attention will be to avoid the possibility of the larvæ enjoying these periodic surfeits by securing a more uniform supply of food for the fry than was attempted in these preliminary experiments.

On October 1st, when the larvæ in H were forty-five days old, my diary states that the fry were all healthy and that they were already giving up their pelagic habits so as to rest for considerable intervals on the bottom of the jar, from which they would rise, however, from time to time in search of food or from mere love of movement.

On this day, as already related, I transferred the three survivors from experiments D and F to the same jar, in which they lived together without loss for another period of five weeks, *i.e.* to the end of the first week in November, although the smallest was removed on the 1st of this month for preservation and anatomical examination.

It measured 15 mm. in length, and the length of the pectoral fin was 4·9 mm. The dorsal fin possessed twenty-six rays (12 + 14); the anal, eighteen; and the caudal eighteen rays. The mandible, which protruded in front of the upper jaw, possessed four teeth on each side of a median gap. Teeth were also present in the upper jaw, but were not counted. The supraorbital tentacles were invisible to the naked eye, but could be detected with a lens as a pair of short unpigmented papillæ situated vertically above the most anterior margin of the pupil of the eye. The eyes were set far forward, their anterior margins coinciding with the frontal margin of the head. The pupil alone was blue or black, the iris being golden. The black chromatophores on the head formed a continuous sheet and were not arranged in radii. The colour of the body (both living and preserved in formalin) was dark brown, almost black, over the whole head region (top and sides), over the anterior half of the abdomen, and over the pectoral and pelvic fins. The entire caudal region was colourless and transparent excepting a single line of chromatophores along the base of the anal fin. A line of internal pigment ran along the spinal column as far back as the fifth ray of the posterior dorsal fin.

The other Blennies, five in number, appeared to vary at this time from about 16 mm. to 22 mm. in length. The actual dimensions a fortnight later are given below.

Up to this time (the end of October) the fry had been regularly fed with plankton, but at the end of this period the available supplies of large Copepods became much reduced, partly from the impoverishment of the plankton which normally takes place in autumn, and partly from bad weather in November, which interfered with the work of collection. The fry would no longer attack the smaller Copepods (*Oithona, Paracalanus, Acartia*, etc.), and *Calanus* was not obtainable. No Crabs, Prawns, or Shrimps could be found in berry, except isolated specimens carrying new-laid eggs, which the fish refused to touch. I therefore tried feeding them with bits of chopped Prawn. They would occasionally seize morsels as they fell through the water, but not after the fragments had settled on the bottom. On the 6th of November one of the largest Blennies died, almost certainly of starvation, owing to the difficulty of providing suitable food. On the 9th I introduced a number of small Crustacea (Mysidæ, Cumacea, and Amphipods) obtained by working a tow-net immediately above the sandy bottom in Cawsand Bay. A more successful diet was provided on the following day by working a cheese-cloth net over the Zostera bed in the same locality, which brought in a number of small Terebellid and Nereid worms with a few Crustacea. The results were excellent, for the wriggling movements of the worms after they were thrown into the jar at once attracted the attention of the fishes, which snapped them up with avidity. The Nereids appeared to prick the fishes and to be relatively unpalatable, but the Terebellids were eaten with great satisfaction. The largest of the surviving Blennies, which had been ailing during the past week, and had refused all food, now began to recover, and shared the new food with the others. I saw it capture quite a large Amphipod, which, after a little difficulty, it succeeded in swallowing. Only one further incident demands notice. On the 8th of November, having observed that for several days past a piece of Ulva frequently had one of the fishes underneath it, I introduced a number of small empty Gastropod shells, chiefly *Trochus*, into the jar. One of the little Blennies at once tucked himself inside one, resting on his pelvic fins, with his head outwards near the orifice, in all respects like the adult fish. A little later there were two fish inhabiting shells. The adoption of this habit at so early a period was not only a sign that the fry had completely departed from the pelagic habits of the larval stages, but is interesting from a general point of view. It shows that the conchicolous habit of the adult fish is not a mere nesting device for the protection of the eggs, but is adopted at probably all stages of growth for concealment and protection.

The object of the experiments being now achieved, I decided to preserve the little fishes at this stage (three months old) in order to have material for a detailed account of their development.

The young fishes, even in the preserved condition, are attractive little objects. Compared with young salmon or trout fry of the same length, they are seen to be much more robust, partly owing to the shortness and distension of the abdominal region. In the young trout the ventral surface of the body from mouth to tail forms a practically straight line, while the dorsal surface is evenly arched; in the young Blenny the dorsal surface is straight, and the ventral is arched. The greatest depth of the body in the young trout lies nearly midway between the mouth and the base of the tail; in the Blenny it occurs immediately behind the head.

The skin is darkly pigmented with black chromatophores over the front half of the body, but is still colourless and transparent in the posterior part of the caudal postanal region. Behind the head the dark brown pigment is distinctly arranged in a series of vertical bars. A broad bar covers the front half of the abdominal region, and extends over the anterior part of the first dorsal fin. After a narrow interval, a narrower and more clearly defined bar extends across the hindmost region of the abdomen at the boundary between it and the caudal region. Corresponding with this bar, though slightly anterior to it, is the black ocellus of the first dorsal fin, which extends between the sixth and eighth fin-rays, and is well defined in the larger specimens, though still undeveloped in the two smallest. From the ocellus to the ventral margin of the body the bar follows a backwardly directed curve, which becomes almost vertical below the region of the lateral line. The alternating pigmented and unpigmented stripes are of about equal width, equivalent to about the width of two adjacent interspaces between the dorsal fin-rays. In the caudal (postanal) region, only one of these bars is completely formed, but an additional one is distinctly indicated in the largest specimens. The brown pigmentation of the trunk thus extends backwards as growth proceeds, not as a continuous sheet, but in the form of vertical stripes.

Yellow and red chromatophores are also present, but are not easily located.

The pupil of the eye is black, without any suggestion of blue. The iris has a golden basis, obscured to a large extent by black chromatophores.

The pectoral and pelvic fins are covered with black chromatophores. An interesting series of changes in the colour of the pectoral fins took place during growth. In the newly hatched larva these organs were black, as figured by Holt; but about a week or ten days afterwards, if development had proceeded normally (as in my experiments D, F, G, and H), the black chromatophores were kept constantly contracted, the resulting colour being a bright greenish yellow. This condition was retained until the end of the third week, when the black chromatophores began to be partially relaxed, producing a distinct green-finned stage, which gradually passed into the ultimate dark-finned condition, the change being more or less synchronous with the abandonment of pelagic habits.

The supraorbital tentacles are larger than in the specimen 15 mm. long described above, and are pigmented. They can be seen in the larger specimens without the aid of a lens.

The lower jaw does not protrude beyond the upper in any of these specimens. In other structural details the fry do not materially differ from the smaller specimen already described. The eyes in all specimens are set equally far forward.

The dimensions of the body and number of fin-rays in all five fishes are given in the subjoined table. To complete the series I have added the figures already given for the specimen killed on November 1st:—

	Maximum			Number of Fin-rays.		
Age.	Length.	Depth.		Dorsal.	Anal.	Caudal.
13 to 14 weeks	25·5 mm.	6·6 mm.	...	11 + 14	17	20
	24·5 ,,	6·6 ,,	...	11 + 14	17	20
	24·5 ,,	6·4 ,,	...	11 + 14	17	19
	21·5 ,,	6·3 ,,	...	11 + 14	17	17
	19 ,,	5·0 ,,	...	11 + 14	17	20
11 weeks	15 ,,	4·0 ,,	...	12 + 14	18	18

In explanation of the figures I should add that the length of body includes the caudal fin; but the depth has been determined from the base of the dorsal fin to the ventral surface, the exact line being drawn across the base of the pectoral fins. The number of fin-rays was in each case determined with the microscope.

It will be noticed that the number of dorsal and anal fin-rays is remarkably constant, since it is identical in five out of six specimens. The abnormality which occurs in the smallest fish is apparently not a variation due to difference of size, but a true individual variation affecting the upper and lower fin alike. The caudal fin is subject to greater variation, partly due to growth.

On comparing these numbers with those assigned by Holt to the later larva figured in his paper,* a considerable difference is noticeable, since Holt's larva, having a body length of 18 mm., possessed twenty-seven dorsal (12 + 15) and nineteen anal rays, thus exceeding by one dorsal and one anal ray the numbers exhibited by the abnormal specimen in

* *Ann. Mus. Hist. Nat. Marseille*, 1899, p. 46, pl. 6, fig 64.

my series. The identification of Holt's larva* with *Blennius ocellaris* was admittedly tentative; but in view of the data now available, I am inclined to think that this identification should be abandoned, and that the larva should be provisionally referred to *B. trigloïdes*.

In support of this suggestion I would point principally to the difference between my specimens and Holt's description and figure in regard to the position and colouration of the eye, the pigmentation of the head, and the possession of preorbital and supraorbital tentacles.

The eye in Holt's figure is set much further back than in any of my larvæ; there is no trace in the latter of the radial arrangement of facial pigment which is so prominent a feature in my colleague's specimen; and the preorbital tentacle figured by Holt has no counterpart in my larvæ. This tentacle is not referred to in the text of Holt's description, but can only represent the tentacle which in several species of Blenny is situated at the anterior orifice of the nares. According to Moreau the nasal tentacle is found both in *B. inæqualis* and *B. trigloïdes*, but is sometimes wanting in *B. ocellaris*. On the other hand, a supraorbital tentacle is found in *B. inæqualis* and *B. ocellaris*, but not in *B. trigloïdes*. In Holt's larva the supraorbital tentacle appears to have been wanting, but is distinctly developed in my larvæ, even at a smaller size. Consequently it is probable that Holt's larva should be referred to *B. trigloïdes*.

In general features, however, Holt's figure gives a fairly good idea of the proportions of the body in larvæ of *B. ocellaris* at the same stage.†

Experiments J, K, and L.

These experiments were begun with a new batch of larvæ on August 23rd, after I had already gained considerable experience as to their habits, in order to determine whether agitation of the water was necessary or not for their successful development during the period immediately after hatching, care being taken that the water should be thoroughly oxygenated, and that ample supplies of food should be present in the water from the beginning.

Shallow rectangular glass aquaria were chosen for the experiment, since they presented a large surface for aëration of the water. They were immersed in the circulating water of the aquarium tanks, in order to preserve a fairly constant temperature; and were filled with the same water as was proving so successful with experiment F. No plunging apparatus was set up, and no convection currents were possible under the conditions of the experiment, the water being absolutely stagnant. Ten active larvæ hatched the same day were placed in each jar.

* I have since had an opportunity of examining this specimen, which is far more slender and of less robust appearance than my larvæ at the same stage. It should certainly be assigned to a different species.

† My friend and pupil, Mr. Arthur Darbishire, of Oxford, is kindly preparing some figures illustrating the development of *B. ocellaris* with a view to publication.

Jar J was larger than the other two, and measured 18 inches long by 12 inches wide and 6 inches deep. This was immersed side by side with jars D and F in one of the table tanks of the aquarium.

Jars K and L were identical in shape and size, and measured 12 by 8 by 4 inches. They were immersed in the same tank as jar H in front of a south window.

One-quarter of the water was changed each day and fine plankton was added each morning, as in the early days of experiments F and G.

The early results of the experiments are shown in the table (p. 76). Two of the losses recorded (one in J, and one in L) resulted from accidents in changing the water, but from the second day of the experiment it was obvious that the larvæ were doing badly. A few swam about a little in the early days, more particularly in J, but the vast majority were very listless and inactive, making no efforts to feed, and lying passively on the bottom of the jars or at the very surface of the water immediately below the surface film. Their movements were limited to occasional spasmodic jerks, contrasting markedly not only with the movements of the larvæ in the plunger-jars D, F, and G, at a corresponding stage, but also with their own movements in the plunger-jar in which they were hatched, previously to their transference to the stagnant water. On the fifth day, when they were four days old, their numbers were reduced to six, four, and seven respectively; and all, except one or two in J, were exceedingly torpid and several in L were on the point of death. The experiments were continued a few days longer with no favourable change in the condition of the larvæ and an increasing number of deaths; but, as the results were already conclusive, I soon afterwards abandoned the experiments as not worthy of further attention.

The behaviour of the larvæ was precisely similar to that described with such careful detail by Fabre-Domergue and Biétrix in their admirable experiments upon *Cottus* and other forms, the principal symptom of which was the progressive anæmia and "etiolation" to which the larvæ in all their experiments fell victims. These naturalists at first* attributed these results to the noxious influence of the water in confinement, the precise nature of which was undetermined; but in a later note† they account for the result as more probably due to the failure to provide the larvæ with the food most suitable to them at the particular stage of growth.

I quite agree with the French naturalists, as well as with Mr. Harald Dannevig (*loc. cit.*), as to the necessity of supplying the larvæ with suit-

* *Ann. Sci. Nat.*, viii., 1897, pp. 212–17.

† *Role de la Vésicule Vitelline dans la Nutrition larvaire des Poissons marins.* Comptes Rendus dés Séances de la Société de Biologie, 30th Avril, 1898.

able food before the complete absorption of the yolk; but, in view of the precautions taken in my experiments, I can adopt no other explanation of the debility of the larvæ in experiments J, K, and L than that it was directly attributable to the absolute stagnancy of the water. Gentle movements of the water appear to be indispensable to the healthy development of fish-larvæ in the earliest stages after hatching; and I believe the physiological explanation of this necessity is to be sought in the stimulus to exercise and movement which the larvæ derive from the play of the currents. I am strengthened in this opinion by the successful results attained by Mr. Harald Dannevig in his experiments on the rearing of plaice larvæ, since he attached considerable importance in his experiments to the movements of the water brought about by convection currents. I am, however, strongly inclined to believe that a far greater percentage of larvæ would have survived in Dannevig's experiments if he had placed a much smaller number of larvæ in the ten-gallon jar he employed, and if he had amplified the currents by some mechanical contrivance in the first week or fortnight of development.

Conclusions.

From the experiments detailed in the preceding pages it appears reasonable to conclude that the conditions which are most important for the healthy development of sea-fish larvæ, and to the survival of a high percentage of fry through the critical stages of the metamorphosis, are the following:—

(1) A liberal supply of pure water;

(2) Mechanical, but moderate, agitation of the water until the larvæ have become thoroughly active and accustomed to catch the food provided them;

(3) Provision of suitable food prior to the absorption of the yolk; and

(4) A fairly constant, but not excessive, supply of food each day, which should be introduced in frequent small doses, rather than in single concentrated supplies.

Reviewing the evidence, I am inclined to think that the water problem can best be solved in large experiments by maintaining a constant slow current through the rearing tanks, with plungers or other stirring apparatus in addition, so long as necessary. The former would tend to keep the water pure, the latter would give the larvæ a healthy start in the important matters of exercise and general activity. The precise method by which the food should be administered would depend largely on the species to be reared, since different larvæ are now known to have well-marked preferences for different articles of food.

Notes on the Rearing of Echinoid Larvæ.

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The problem of successfully rearing the larvæ of Echinoidea until they had completed their metamorphosis, has been solved by several naturalists. Agassiz* was able, for three weeks, to keep plutei alive which he had fished from the sea, at the end of which time they sank to the bottom and became young echini. Bury† was able also to rear a few of the plutei of one of the Neapolitan species through the whole of their larval life, and finally Théel‡ has published an account of how he obtained all stages in the development of *Echinocyamus pusillus* from the result of artificial fertilisation.

During the months of May and June in both 1898 and 1899, I was occupied with a similar, though not identical problem. I wished to obtain sufficient material of all the stages of development of *Echinus esculentus* to enable me to make an exhaustive investigation of the formation of all the organs of the adult *Echinus*. For this purpose it was not sufficient to be able to rear one or two specimens through the metamorphosis; the question was to be able to obtain a considerable number of late and metamorphosing stages. This end was finally attained in July, 1899, twenty-four young echini and a large number of plutei, with an advanced rudiment of the echinus within them, were obtained.

Reviewing the history of two seasons' experiments, it seems possible to arrive at some idea of the conditions for the healthy life of these larvæ, and for the sake of future investigators these are outlined here.

The greatest number of experiments were made with *Echinus*

* *Revision of the Echini*, L. Agassiz.

† According to a statement made to the author in 1894.

‡ "The Development of *Echinocyamus pusillus*," by H. Théel. *Proceedings of the Royal Society of Sweden*, Upsala, 1892.

esculentus, but for the sake of comparison, cultures of the larvæ of *Echinus miliaris* were also prepared.

The first condition for a healthy experiment is that only *full-sized* and *perfectly ripe* individuals of both sexes should be used for fertilisation. It is generally possible to get a few eggs capable of fertilisation from unripe individuals, but the resulting plutei are feeble, and soon die.

The fertilisation is best performed in a large square glass dish; a *small quantity* only of spermatozoa must be added to the clean sea-water with which the dish is filled. The ova are added in sufficient quantity to make a *single layer* over the bottom. A piece of bolting-silk of medium mesh will permit the ova to pass, but will keep back pieces of ovary, and to a large extent *unripe ova*.

The laboratory at Plymouth is provided with bolting-cloth of mesh exactly suitable to the eggs of *E. esculentus*. The unripe eggs appear to be surrounded by a thick, glassy membrane (entirely distinct from the membrane formed after fertilisation), which prevents their passing through the meshes of the silk.

After fertilisation, the water full of spermatozoa must not be allowed to stand more than twenty minutes before it is decanted off, and during the first twenty-four hours the water covering the eggs should be frequently changed.

Next in importance to the proper choice of individuals for the experiment is the selection of a proper source whence the sea-water is to be obtained. Water obtained close inshore is perfectly useless. The plutei will live for at most a week in it. In Plymouth, water must be brought from outside the Breakwater, and only this water must be employed for both fertilisation and the subsequent culture.

At the end of twenty-four to thirty hours, all the eggs which are developing normally will have reached the blastula stage, and have risen to the surface. They must then be decanted off into culture jars. The jars which I used at this stage in the experiments were of a deep bell-shape, and of a capacity of two gallons. Each was fitted with a Browne plunger. This invaluable apparatus has already been described elsewhere. It is sufficient here to notice that by means of it the water in the jars is kept in constant though gentle agitation, and the formation of a surface film of dust, bacteria, etc., effectually prevented.

The jars must be carefully guarded from direct sunlight, which soon proves fatal to the larvæ. They must be covered in as much as is consistent with the free motion of the plunger, and the water ought to be changed to the extent of one-third of its bulk every day. This is effected by temporarily stopping the action of the plunger, when the healthy larvæ will come to the top. The bottom water can then be siphoned off. It is advisable to have a small amount of a filamentous alga, such as *Ectocarpus*, floating in the water. Ulva, and other leaf-like forms, are more apt to decay, and then foul the water.

After the lapse of about eight to ten days, it will usually be seen that in one or two of the jars, development is proceeding normally, whereas in the others, symptoms of unhealthiness have appeared. The healthy larvæ are then transferred to larger culture jars, in which they complete the remainder of their development. The jars used for this purpose by me had a capacity of ten gallons, and each was fitted with a large plunger. Not more than 250 larvæ should be placed in each jar, and as before, the water should be changed to the extent of one-third of its bulk daily.

It may seem to many that the course of proceedings which I have sketched out is a very roundabout one. Why, it may be asked, should not 250 blastulæ be transferred directly from the dish in which fertilisation is effected to the larger jar? The answer is, that this course has been tried and it failed. In a word, it is not possible for the experimenter to discriminate between larvæ which have vigour enough to complete their development and those which will soon die, until the second week of their existence. We must, in the first instance, allow natural selection to weed out the weaker. In this connection a curious fact may be mentioned. A very successful result was obtained from a culture of larvæ proceeding from a fertilisation carried out very badly. The eggs were piled on one another, several layers deep, and the water remained full of spermatozoa all night. As a result, only about 10 per cent. or less of the eggs became blastulæ. But those which survived showed remarkable hardiness, and from them young echini were obtained.

Echinus esculentus and *Echinus miliaris* are decidedly different in colour, size, and general appearance, and it is not therefore surprising to learn that their larvæ are different in every period of existence, as has been detailed in a paper in the *Quarterly Journal of Microscopical Science* (vol. xlii., 1899, p. 335). Here it need only be mentioned that the larva of *E. miliaris* has only four ciliated epaulettes, and that the young echinus at metamorphosis has one pair of tube feet in each interradius, in addition to the azygous tentacle. The pluteus of *E. esculentus* on the other hand has six ciliated epaulettes, which eventually coalesce in order to form two circular bands of cilia, and the young echinus has at first only the azygous tentacle in each interradius.

The necessity for such frequent changes of sea-water seems to arise rather from lack of food than from lack of oxygen, and it is more urgent in some years than in others, according to variations in the amount of vegetable plankton. In 1898 it did not seem so necessary, and in that year there were great quantities of *Halosphaera* in the water. I did not realise until late in 1899 that such a quantity of water should be added each day; had I done so earlier, my success might have been even greater than it was. The fact was brought to my attention by observing that plutei went on living in an apparently healthy manner, but that the rudiment of the echinus within them either failed to increase in size, or was actually resorbed.

It appears to me likely that the difficulty experienced in rearing many marine larvæ is largely that of finding food; for there appears to be no reason why they should require more oxygen per day than do the yolky eggs of other species in which development is direct, and goes on with great rapidity.

In conclusion, I have to express my gratitude to my friends Mr. E. J. Allen, the Director of the Station, and Mr. E. T. Browne, of University College, London, for much assistance and advice.

Zoological Laboratory, McGill University,
Montreal, *October* 9, 1899.

On *Maclovia iricolor* (Montagu).

By

Arthur Willey,

D.Sc., London, Hon. M.A., Cantab.

It is a pity that there should be any doubt as to the legitimacy of the generic and specific names of one of the longest Chaetopoda inhabiting Plymouth Sound, and it seems worth while to devote a special note to its synonymy and identification.

[*Names marked with an asterisk are synonyms.*]

*1. *Nereis iricolor*, Montagu, 1802. Description of several marine animals found on the South Coast of Devonshire. Tr. Linn. Soc., London, VII., Dec., 1802, p. 82.

Montagu found his specimen coiled under a stone among the rocks at Milton. It was the largest specimen of the genus [s.l.] hitherto recorded in British seas, measuring, when extended, about 3 feet in length, with the thickness of a raven's quill. When placed in fresh water it contracted to 1 foot in length, with the thickness of a goose-quill.

*2. *Lumbrineris gigantea*, Quatrefages, 1865. Hist. des Annelés, vol. i. p. 360. Hab. Bréhat; individuals in life measuring upwards of 60 cm.

*3. *Lumbrineris tricolor*, Johnston, 1865. A Catalogue of the British non-parasitical worms, London, p. 142. Hab. South Devon. "One specimen in the Museum Collection is 11 inches in length, and as thick as a large quill."

The parapodia are figured upside down. Johnson mentions "two dark spots obscurely marked, which may be eyes," at the posterior border of the cephalic lobe.

*4. *Arabella tricolor* (Johnst.). Ehlers, 1868. Die Borstenwürmer, pp. 399 and 405.

5. *Notocirrus scoticus,* M'Intosh, 1869 [see also under par. 7]. On the Structure of the British Nemerteans, and some new British Annelids. Tr. R. Soc., Edinb., XXV., p. 417. Points out that at least three species of Lumbrinereidae had been previously recorded in British seas, viz. *Lysidice ninetta* (Aud. Edw.), *Lumbriconereis tricolor* (Mont.), and *Lumbriconereis latreillii* (Aud. Edw.). "The two latter have probably been confounded with the *L. fragilis* of Müller, a species abounding on our northern and southern coasts." *N. scoticus* was taken in 6–9 fathoms in Lochmaddy, and subsequently in several parts of the Hebridean Seas. Body moniliform, much slenderer than *L. fragilis*; head acutely conical, with two eyes; parapodia ligulate; setae uniform.

*6. *Maclovia gigantea* (Qfg.), Grube, 1871. Vorlage einer *Lumbriconereis gigantea* (Qfg.), Jahresber. Schlesisch. Ges. 1871, Breslau, 1872, p. 58. Also Mittheilungen über St. Malo und Roscoff. Abh. Schlesisch. Ges. 1869–1872, Breslau, 1872, p. 86.

Specimen taken at St. Malo 1½ feet long; Grube saw only two eyes.

7. *Notocirrus tricolor* (Johnst.), Ehlers, 1874. Beiträge zur Kenntniss der Verticalverbreitung der Borstenwürmer im Meere. Zeitschr. wiss. Zool. XXV., 1875, p. 55, Taf. III. f. 33. Hab. off Galway, in 15–20 fathoms.

This is said to be the *N. scoticus* of M'Intosh [see under par. 5], which Ehlers erroneously identified with Johnston's *Lumbrineris tricolor*. It is described as having an ovate prostomium with two eye-spots; body submoniliform; maxillae I. unequal and without a large terminal claw. The character of the jaws resembles that described and figured by MARION and BOBRETZKY [Étude des Annélides du Golfe de Marseille. Ann. Sci. nat. (6) II., 1875, p. 15, Pl. I. f. 2] for *Notocirrus geniculatus,* Clpd., and proves conclusively that *N. scoticus* is quite distinct from our species.

*8. *Lumbriconereis iricolor* (Mont.), Grube, 1878. Fortsetzung der Mittheilungen über die Familie Eunicea. II[te] Abth. Lumbriconereidea Schmarda. Jahresber. Schlesisch. Ges. 1878, Breslau, 1879, p. 87.

Grube here expresses his well-founded suspicion that the specific name "tricolor," given by Johnston, was due to a clerical error in copying a label in Leach's collection. He adds that both Montagu's and Johnston's descriptions indicate that the worm belongs to the genus *Arabella,* and is probably *A. quadristriata,* Gr.

*9. *Notocirrus tricolor* (Johnst.), M'Intosh, 1885. Annelida Polychaeta. Chall. Rep. XII., p. 236. M'Intosh here refers repeatedly to Johnston's species under the above name in continuation of Ehlers's mistaken identification [see above, par. 7].

*10. *Maclovia gigantea* (Qfg.), Saint-Joseph, 1888. Les Annélides Polychètes des côtes de Dinard. Ann. Sci. nat. (7), V., p. 30, Pl. IX. f. 92–95.

Maclovia is here regarded as a sub-genus of *Arabella*, characterised by the presence of five pairs of superior jaw-pieces and tripartite sustentacular apparatus. There are four eyes in the head in a transverse row.

The following will serve as a brief diagnosis of our worm :—

Corpus lumbriconereiforme, long. usque ad 600 mm.; lat. c. 5 mm.

Prostomium sub-ovate, oculis 4 transversa serie.

Segmenta buccalia bina, fere similia.

Pharetrae setarum in lingulas postero-inferiores carneas productae.

Cirrus dorsalis rudimentaris, fasciculo acicularum (5-7) haud emergentium praeditus.

Setae flavae, fere similes, acuminatae, plus minusve limbatae, geniculatae, saepe crenatae, paucae (c. 12).

Aciculae flavae, plures (6–7).

Segmentum anale lobis brevibus 4.

Maxillae I. inaequales (sinistra paullo major) unciformes, basi serrata dentibus c. 10; II. inaequales, dextra fere duplo longior dentibus 12–14, sinistra dentibus 6–7; V. hamuli singuli.

Radices maxillarum (sustentacular apparatus) 3.

Laminae ventrales nigrae edentatae.

The importance of the identification of the above species lies in the fact that it cohabits with a true *Lumbriconereis*, which bears a striking superficial resemblance to the *Maclovia*, but does not attain to the length of the latter. The two forms have often masqueraded under a common denomination.

The *Lumbriconereis* is probably co-specific with *L. latreilli* (Aud. Edw.) and may possess a length of about 6 inches.

It must be left to the future to decide upon the respective merits of *L. latreilli* and *L. fragilis*.

LONDON, *May* 19*th*, 1900.

International Conference for the Exploration of the Sea, Stockholm, 1899.

ON the invitation of the Swedish Government an International Conference met at Stockholm, in June, 1899, for the purpose of formulating a scheme for a combined investigation of the Northern Atlantic, the North Sea, and the Baltic in the interests of the sea-fisheries.

The delegates appointed to represent the different countries who took part in the Conference were as follows:—

GERMANY.—Prof. F. Heincke, Prof. V. Hensen, Dr. H. Herwig, Prof. O. Krümmel.

DENMARK.—Captain C. F. Drechsel, Dr. M. Knudsen, Prof. C. G. J. Petersen.

GREAT BRITAIN AND IRELAND.—Mr. W. Archer, Prof. D'Arcy W. Thompson, Sir John Murray.

NORWAY.—Dr. J. Hjort, M. K. Lehmkuhl, Prof. F. Nansen.

HOLLAND.—Prof. P. P. C. Hoek.

RUSSIA.—Prof. O. von Grimm.

SWEDEN.—Prof. P. T. Cleve, M. G. Ekman, Dr. N. R. Lundberg, Prof. O. Pettersson, Dr. F. Trybom, Prof. A. R. Åkerman.

The scheme recommended by the Conference was embodied in a series of formal resolutions, which were passed unanimously by all the delegates.

The following are these resolutions:—

Considering that a rational exploitation of the sea should rest as far as possible on scientific inquiry, and considering that international co-operation is the best way of arriving at satisfactory results in this direction, especially if in the execution of the investigations it be kept constantly in view that their primary object is to promote and improve the fisheries through international agreements, this International Conference resolves to recommend to the states concerned the following scheme of investigations which should be carried out for a period of at least five years.

Programme for the Hydrographical and Biological work in the Northern parts of the Atlantic Ocean, the North Sea, the Baltic and adjoining Seas.

A.
THE HYDROGRAPHICAL WORK.

I.

The hydrographical researches shall have for their object: the distinction of the different water-strata, according to their geographical distribution, their depths, their temperature, salinity, gas-contents, plankton, and currents, in order to find the fundamental principles not only for the determination of the external conditions of the useful marine animals, but also for weather-forecasts for extended periods in the interests of agriculture.

II.

As the hydrographical conditions are subject to seasonal changes, and as these strongly influence the distribution and life-conditions of useful marine animals and the state of the weather and other general meteorological conditions, it is desirable that the observations should be made so far as possible simultaneously in the four typical months, February, May, August, and November, at definite points along the same determined lines.

III.

The observations referred to in II. would consist of :—

(*a*) Observations of temperature, humidity and pressure of the air every two hours; self-registering instruments for interpolation, and Assmann's aspirator should be used.

Opportunities should be afforded to the meteorological offices to make on board the ships physical observations on the higher levels of the atmosphere by means of kites.

The other meteorological observations are to be carried out according to the methods adopted by the meteorological offices of the nations represented.

The observations, meteorological as well as hydrographical, made on board the special steamers at the time of the survey in the typical months, are to be immediately worked out under the supervision of the central bureau (see C) for publication in a bulletin, wherein the conditions of the sea and the atmosphere are to be represented by tables and synoptical charts in co-operation with the meteorological institutes of the nations represented.

(*b*) The temperature of the surface water shall be taken every two hours, or, when necessary, more frequently. It is desirable that self-registering apparatus should be used for interpolation.

Observations on the vertical distribution of the temperature are to be taken at the points mentioned in II., and should be taken regularly at intervals of 0, 5, 10, 15, 20, 30, 40, 50, 75, 100, 150, 200, 250, 300, 400 metres and so on; but all *critical* parts of the curve must be determined by extra-readings.

The bottom-temperature is to be investigated with all possible care.

(*c*) At every point and from every depth where the temperature is observed, a sample of water shall be collected for the determination of its salinity and density.

By *salinity* is to be understood the total weight in grammes of the solid matter dissolved in 1,000 grammes of water.

By *density* is to be understood the weight in grammes* of one cubic centimetre of water of the temperature *in situ* t°, *i.e.* the specific gravity *in situ* referred to pure water of $+4^\circ C$ $\left(=S\frac{t^\circ}{4^\circ}\right)$.

For orientation, preliminary determination of the salinity should be made on board ship with expedient instruments, but the exact determination of the salinity and density of all samples shall take place in a laboratory for scientific work.

(*d*) At certain depths of the points mentioned in II., and elsewhere on the surface, water samples should be collected for analysis of the gas-constituents (oxygen, nitrogen, and carbonic acid).

IV.

For measurement of depth the *unit* to be adopted is the metre, together with which the depth may be also recorded in English fathoms.

Geographical points are to be referred to the longitude of Greenwich, and horizontal distances are to be expressed in sea-miles (=1,852 metres).

Thermometers to be used for the determination of the surface-temperature may be either centigrade or Fahrenheit, but for publication all numbers are to be reduced to centigrade.

In the centigrade thermometers the distance between two degree-marks should be at least 5 mm. and the degree divided at least in two parts, the Fahrenheit thermometer to be divided in a corresponding manner.

The use of Pettersson's insulated water-bottle is recommended for moderate depths, and the thermometers used for this apparatus should

* Units of weight are here used instead of mass-units.

have a space at least 10 mm. between the marks of one degree, and the degree should be divided in ten parts.

For greater depths of the ocean Negretti-Zambra's or other thermometers of a similar type should be used.

The glass to be used for the thermometers as well as the thermometers should be tested and approved by the central bureau (see C, *a*).

For the determination of salinity and density, either chemical or physical methods may be adopted, provided that the salinity can be determined with an accuracy of $0{,}05$ in a thousand parts (and the density up to $0{,}00004$).

The determination of these constants can be founded either upon chemical analysis of the halogen by weighing or titration, or upon physical determination of the specific gravity by means of hydrostatical balance pycnometers and hydrometers, provided that measures be taken to exclude disturbances arising from thermal effects, capillarity, viscosity, etc.

The chemical analysis shall be controlled by physical methods, and the physical determinations by chemical analysis in the following manner:—

From every collection of samples examined at least three shall be selected and sent to the central bureau. *Standard samples* shall be sent in return.*

The *specific gravity* is to be represented in the tables by the formula $S\left(\frac{0^\circ}{4^\circ}\right)$.

V.

Samples for gas analysis are to be collected each time in a pair of sterilised vacuum tubes.

It is desirable that the existing tables of absorption of nitrogen and oxygen should be revised.

VI.

Qualitative plankton-observations should be made every six hours by pumping through a silk net (Nr. 18) for the space of fifteen minutes, and at the same time a sample of water (III. *c*) should be taken.

At the points mentioned in II. samples for quantitative analysis are to be collected according to the method of Prof. Hensen at different depths depending on the hydrographical circumstances.

Petersen's modification of Hensen's net is recommended.

* By *standard* water shall be understood samples of filtered sea-water, the physical and chemical properties of which are known with all possible accuracy by analysis, and statements of which are sent to the different laboratories, together with samples.

In respect to halogen the ordinary water-samples have to be compared with the standard water by analytical methods.

Observations on transparency and colour of the water should be made at the points mentioned in II.

Opportunities should be afforded to bacteriological institutions to carry out investigations in the ocean.

VII.

Observations on currents and tides should be carried out as frequently as the circumstances allow.

The currents should be examined, when possible, by direct current-meters and by surface and intermediate floats and by bottom-rollers.

The ship should be anchored occasionally in order to make frequent observations during a complete period of tide.

VIII.

It is desirable that a chart should be prepared of the bottom of the seas examined, showing the nature of the sea-bottom.

The description of the deposits is to be carried out on a definite plan, to be afterwards settled. (See Appendix III.)

IX.

The normal observations are to be carried out along the lines provisionally drawn on the annexed chart, where *R* denotes the Russian, *F* the Finnish, *S* the Swedish, *G* the German, *Da* the Danish, *Du* the Dutch, *N* the Norwegian, and *B* the British lines.

The special points are to be decided by the respective nations, and when once chosen the subsequent observations are to be repeated at the same points.

The particular instructions for the stations will be given by the respective nations, and the communications as to the extent and the nature of the observations shall take place through the central bureau. (See C, *a* and *e*.)

X.

It is desirable, in carrying out these investigations, to make use of regular liners, light-ships, etc., and coast stations for the purpose of taking temperature-observations and collecting samples of sea-water and plankton.

These observations are to be taken not only in the typical months but also during the intervening periods.

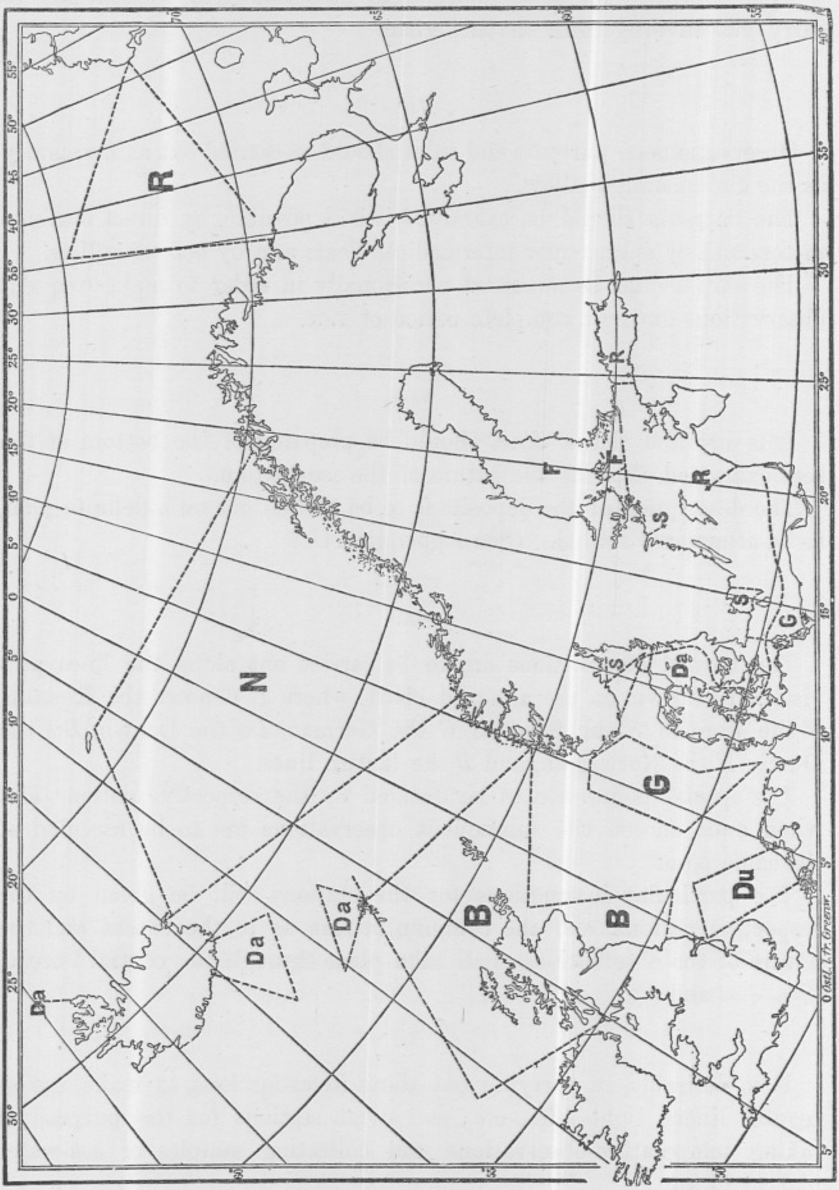

CHART SHOWING THE LINES OF OBSERVATION RECOMMENDED BY THE STOCKHOLM FISHERIES CONFERENCE.

B.

THE BIOLOGICAL WORK.

I.

(*a*) Determination of the topographical and bathymetrical distribution of eggs and larvæ of marine economic fishes; for example, by quantitative methods, such as those of Hensen, and with special reference to the most important species, such as plaice, cod and haddock, herring, etc. (See Appendix I.)

(*b*) Continued investigation of the life-history and conditions of life of young fishes of economic species in their post-larval stages and till they reach maturity, with special reference to their local distribution.

(*c*) Systematic observation of mature marketable fishes with reference to their local varieties and migrations, their conditions of life, nourishment (as, for instance, by investigation of the contents of the stomach), and natural enemies: also observations on the occurrence and nature of fish food at the bottom, the surface and intermediate waters down to depths of at least 600 metres. (See Appendix I.)

(*d*) Determination of periodic variations in the occurrence, abundance, and average size of economic fishes, and the causes of the same.

II.

(*a*) Experimental fishings *on* the known fishing grounds during the time of the fishery, as well as *outside* these areas and seasons.

(*b*) Preparation of uniform statistics of the experimental catches, with particulars of the number, species, size, weight, and condition of the fish; for example, as done on board the *Garland* by the Scottish Fishery Board.

(*c*) The uniform use of appropriate apparatus for the experimental capture of the different species and sizes of fish.

(*d*) The experimental marking and liberation of fish, for instance of plaice, on as large a scale as possible and over extensive areas; for example, as carried out by Dr. C. G. Joh. Petersen and Dr. T. W. Fulton (Reports of the Danish Biological Station and the Fishery Board for Scotland), and others. (See Appendix IV.)

III.

(*a*) It is desirable to collect uniform statistics of the number, weight, and value of the fish landed, of the means of capture, and of the persons engaged in the industry; for example, as in the General Reports of the Scottish Fishery Board.

(*b*) It is desirable to collect material for the preparation of maps, showing the fishing grounds and the kinds of fishing there practised. (Cf. A. VIII.)

C.

ORGANISATION OF A CENTRAL BUREAU.

I.

The Conference recommends that there should be for the international hydrographical and biological researches of the seas an international council with a central bureau, furnished with a laboratory. (See Appendix II.) The central bureau will be:—

(*a*) To give uniform directions for the hydrographical and biological researches in accordance with the resolutions drawn up in the programme of the present Conference, or in accordance with such modifications as may be introduced later with the consent of the States represented.

(*b*) To control the apparatus and to ensure uniformity of methods.

(*c*) To undertake such particular work as may be entrusted to it by the participating Governments.

(*d*) To publish periodical reports and papers which may prove useful in carrying out the co-operative work.

(*e*) To decide the graphic representations, scales, signs, and colours to be used in the charts for the purpose of obtaining uniformity in the publications.

(*f*) To make, in connection with the investigations, application to the telegraph administrations for the purpose of obtaining determinations from time to time of the changes in the resistance of the cables which cross the areas in any direction.

II.

(*a*) The permanent International Council should consist of commissioners elected by the Governments interested. Each Government may appoint two commissioners, who may be represented at meetings by substitutes.

(*b*) The Council elects its president and vice-president, and appoints all officials connected with the central bureau. Should the general secretary represent hydrographical sciences, his principal assistant should represent the biological sciences, or *vice versâ*.

(*c*) The Council shall draw up its own order of proceedings.

(*b*) It is desirable to collect material for the preparation of maps, showing the fishing grounds and the kinds of fishing there practised. (Cf. A. VIII.)

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(*c*) The Council shall draw up its own order of proceedings.

(*d*) The expenses of the central office are approximately estimated £4,800 (96,000 marks) yearly.

(*e*) The place of the central bureau, to be decided by the Governments concerned, shall at the same time be the residence of the general secretary, and should be conveniently situated for hydrographical and biological researches.

(*f*) It will be for the Governments concerned to decide among themselves the share to be borne by each.

Scheme for the expenditure of the Central Bureau.

	£
1. General Secretary	750
2. Principal Assistant	500
3. President, for incidental expenses other than travelling expenses	200
4. Vice-President, for incidental expenses other than travelling expenses	100
5. Office, laboratory, scientific and technical assistants, draughtsmen, clerks, servants, postage, telegrams, and similar expenses	2,250
6. Travelling expenses	300
Note : Travelling expenses of commissioners attending meetings of the Council shall be borne by their respective Governments.	
7. Printing	500
8. Incidental expenses	200
	£4,800

D.

It is desirable that these investigations should begin May 1st, 1901.

E.

The Conference declares that it is of the greatest importance, both for high-sea fisheries and for the weather forecasts for long periods, that the Faröe Islands and Iceland should be included in the European telegraph system as soon as possible.

F.

The relation between the quantity of halogen contained in the water and the density of the water shall be carefully investigated by an experimental revision of the tables compiled by Knudsen (Ingolf Exp. II. 37). The tables compiled by Makaroff, Krümmel, and others for the relation of specific gravity to density and salinity are likewise in urgent need of experimental revision.

It is proposed to undertake these investigations in the technical institute at Copenhagen under the direction of a committee, consisting of Messrs. Sir John Murray, Knudsen, Pettersson, Nansen, Krümmel, H. N. Dickson, and Makaroff. The means for carrying out these works are to be requested from such learned societies as have funds for such purposes.

G.

The Conference recommends that these resolutions be brought by the nations concerned to the knowledge of the Governments of France and Belgium.

H.

In case the resolutions of the Conference should be accepted by the States, it is anticipated that some length of time will elapse before the organisation of the central bureau is completed. In the meantime the Governments may wish to possess an organisation in connection with this Conference which may be useful in constituting the Council and the central bureau.

The members of the third Committee, Åkerman, Drechsel, Von Grimm, Herwig, Hoek, J. Murray, Nansen, Pettersson, hereby offer their services for this purpose.

STOCKHOLM, *June 23rd*, 1899.

APPENDIX I.

In the quantitative estimation of pelagic fish eggs, and of the free-swimming larval stages that proceed from eggs, whether pelagic or demersal, the following considerations have to be kept in view:—

1. According to our present knowledge these floating objects are distributed over somewhat extensive areas, by the agency of winds, waves, and currents, in such a manner that a reasonable approximation of the total number of eggs present within the whole area may be arrived at by means of samples taken at certain points.

2. Since the stages of development are not confined to the surface-water, but partly, in the case of the riper eggs and larvæ, float deeper down, the net must be drawn, for purpose of quantitative estimation, in a *vertical* direction.

3. The several series of observations must be carried out in a uniform manner in order that the results may be comparable. An example of the method of procedure lies to hand in the "Bericht der Kommission zur Untersuchung der deutschen Meere" on the experimental cruises

undertaken by the German Seefischereiverein in the North Sea in the beginning of 1895, and minutely described by Hensen and Apstein.

The method employed is as follows: A funnel-shaped net with a ring $1\frac{1}{2}$ metre in diameter, and capable of folding or closing up, and with a bag, to the end of which a beaker is attached, is let down perpendicularly to the bottom and then drawn up, until it hangs at the side of the ship. The net is then rinsed with a jet of water, so that its entire contents are washed down into the beaker at its extremity; the beaker is then detached and its contents removed.

It is usually impossible to examine this material at once, and it must consequently be suitably preserved for study ashore. The method of preservation should likewise be identical throughout the whole series of researches, as also should be the size and mesh of the net. The net is constructed of miller's gauze (or "bolting-cloth"), No. 3, as already used in the German deep-sea expeditions.

4. The ship has to be laid on a determined course, and an observation taken at least every twenty knots. If at the first glance eggs are present in considerable numbers in the catch (in which case over 200 eggs will be present), it will be necessary to take samples at shorter intervals, according to the judgment of the person in charge.

5. The eggs so obtained must be examined on shore for the purpose of estimating their number, and, so far as possible, of determining their species.

Specific determination of the larvæ, and even of the embryos in the eggs, is admittedly possible, and for such determination the works of M'Intosh, of Apstein, and the forthcoming publications of the Heligoland station, will afford material. The young eggs of the plaice, sole, etc., can be identified and therefore enumerated, while the eggs of the cod and haddock in the early stages of their development cannot, with our present knowledge, be distinguished from each other.

6. It is to be supposed that the hydrographic cruises in February, May, August, and November will also furnish material for determining the occurrence of eggs and larvæ, and will indicate when the time is come, or is approaching, for the commencement of systematic observation of the eggs. Since the spawning period differs somewhat in different years and in different parts of the sea, an agreement as to new courses of investigation in special areas of the various seas must be arranged through the central bureau or otherwise, on the basis of the results obtained during the hydrographic and other cruises.

7. Other methods for the numerical estimation of eggs and larvæ are by no means to be excluded, but should not interfere with or supplant the methods of research determined by international agreement.

HENSEN.

APPENDIX II.

In connection with the central bureau there should be a central laboratory, where, amongst other things, the following work might be carried out:—

1. The various methods for determining salinity, temperature, gases, plankton, etc., of the sea should be carefully tested, in order that standard methods may be fixed.

2. The various apparatus and instruments now used for hydrographical and biological research should be examined in order to settle which are the most trustworthy. Experiments may also be made to improve the apparatus and instruments, or to construct new and better ones.

3. Instruments and apparatus used in the investigations should be approved and tested at certain intervals at the central laboratory.

4. The water-samples sent by the workers of the participating states should be analysed and examined at the central laboratory, from which also samples of standard water should be provided. (See A. IV.).

5. If desired the water-, plankton-, or bottom-samples collected by the expeditions of the participating states could be examined at the laboratory on payment of a sum to be fixed by the international council.

6. In the central laboratory various important investigations of general interest for the hydrographical and biological researches may be carried out; *e.g.* analyses of the relation between the various saline constituents of the sea-water in the different parts of the ocean, analyses of the nature and quantity of plankton, as proposed by Prof. Cleve.

7. Facilities should be afforded to the participating states for sending students to the central laboratory to be trained for hydrographical and biological work.

8. The investigators of the participating states, or special expeditions, might, if desired, be supplied from the central laboratory with instruments, apparatus, and typical specimens of organisms and deposits for hydrographical and biological research at cost price.

FRIDTJOF NANSEN.

APPENDIX III.

About Plankton Investigations.

I. For estimating the amount of plankton I propose that a method be adopted founded on the following principles :—

1. Separation of the organic matter in a certain quantity of water, by means of centrifuge or by filtration.

2. Determination of the amount of carbon and nitrogen by combustion of the residuum in a vacuum tube by means of cupric oxide, and determination of the nitrogen and the dioxide of carbon.

P. T. Cleve.

II. As it is desirable to know the amount of fat in the plankton, we propose that a sample from each station be dried and extracted with ether. A small quantity of the non-extracted material may be tested on carbon or nitrogen, so that the total amount of fat in a certain quantity of water can be calculated, the amount of organic carbon or nitrogen (proposal I.) being known.

O. Pettersson.
P. T. Cleve.

III. It seems desirable that a systematic examination of the plankton close above the bottom be carried out, especially on the fishing-banks.

P. T. Cleve.

IV. It seems desirable to examine the bottom-fauna (benthos) of the fishing-banks of the North Sea *at different seasons;* for instance, by counting the animals present in a certain volume of the mud, or on a certain area of the bottom.

P. T. Cleve.

V. It seems to be of a certain importance to determine the amount of carbon (organic), nitrogen, sulphur, and phosphorus in the bottom-mud of the fishing-banks.

P. T. Cleve.

APPENDIX IV.

Marking of Fishes in the Waters of the Region of the Baltic and the North Sea.

The marking of fishes in order to facilitate a systematic control and investigation as to their migrations and growth, and also to the periodicity and frequency of their spawning seasons, is, in most cases, to be regarded as the most certain and direct means of arriving at reliable and satisfactory conclusions. The method of marking salmon, already known and practised in Great Britain a number of years ago, has of late, for some ten years, been taken up and carried on in Norway, as may also have been the case in some of the other countries here represented. In Denmark the marking of plaice has been practised of late years. As to Sweden, it has been proposed and agreed upon more than once that such a proceeding ought to be more generally and methodically made use of, as, for instance, at the general conferences on questions regarding the fisheries of Sweden, held at Gothenburg and Stockholm in 1891 and 1897, when, at both those occasions, there were also present several distinguished specialists as representatives of the other Scandinavian countries; but this plan, although unanimously assented to and approved of, has nevertheless not as yet been carried into execution, owing perhaps to a certain extent to the circumstance of there not being any common plan and method of marking adopted for the whole Baltic region, a condition which was especially made an essential point of by the Stockholm Conference.

Being of opinion that the question of marking fishes, more especially of the different species of sea-salmon and flat-fish, and also, if possible, other kinds of fishes of all the coasts and waters of the different countries represented at this meeting, no doubt belongs to the competence of this Conference, and still more, when considering that there are some most distinguished gentlemen here present, being of unquestionable renown as specialists on this subject, I beg to propose that this question be admitted on the programme of the meeting in order to be duly discussed and decided upon according to circumstances.

Filip Trybom.

Stockholm, *June* 14*th*, 1899.

List of Publications Recording the Results of Researches carried out under the Auspices of the Marine Biological Association of the United Kingdom in their Laboratory at Plymouth or on the North Sea Coast from 1886–1900.

The following list has been classified, so far as practicable, according to subjects, in order that it may be useful for purposes of reference. The list does not include publications recording the results of observations made on material supplied by the Association to workers in different parts of the country, of which a considerable amount is sent out each year.

In attempting to distinguish between economic and more purely scientific publications considerable difficulty has been experienced; indeed such a distinction is in reality impossible, since all researches bearing on the distribution and habits of marine life of any kind have a more or less direct bearing on fishery problems. All papers dealing with the distribution, habits, and young stages of fishes have been included in the economic division, whether the fishes are themselves marketable or not.

Economic Publications.

FISHES.

1. *General.*

The Natural History of the Marketable Marine Fishes of the British Islands. Prepared by order of the Council of the Marine Biological Association especially for the use of those interested in the Sea-Fishing Industries. By J. T. Cunningham, M.A. With a preface by E. Ray Lankester, M.A., LL.D., F.R.S. London: Macmillan and Co., Ltd., 1896.

The Ovaries of Fishes. By J. T. Cunningham, M.A. Journ. M.B.A. N.S. iii. 1893–95, p. 154.

On the Histology of the Ovary and of the Ovarian Ova in certain Marine Fishes. By J. T. Cunningham, M.A. Quart. Journ. Micr. Sci. XL. 1897, p. 101.

A Contribution to the Knowledge of the Ovary and Intra-ovarian Egg in Teleosteans (with Plates XI. and XII.). By W. L. Calderwood. Journ. M.B.A. N.S. ii. 1891–92, p. 298.

A Record of the Teleostean Eggs and Larvæ observed at Plymouth in 1897. By E. W. L. Holt and S. D. Scott, B.A. Journ. M.B.A. N.S. v. 1897–99, p. 156.

Studies on the Reproduction and Development of Teleostean Fishes occurring in the neighbourhood of Plymouth (with Plates I.–VI.) By J. T. Cunningham, M.A. Journ. M.B.A. N.S. i. 1889–90, p. 10.

On some Larval Stages of Fishes (with Plates III. and IV.) By J. T. Cunningham, M.A. Journ. M.B.A. N.S. ii. 1891–92, p. 68.

On Some Disputed Points in Teleostean Embryology. By J. T. Cunningham, M.A. Ann. and Mag. Nat. Hist. 1891.

Recherches sur la Reproduction des Poissons osseux. Par E. W. L. Holt. Ann. Mus. Hist. Nat. Marseille, v., 1899.

Preliminary notes on the Reproduction of Teleostean Fishes in the South-Western District. By E. W. L. Holt. Journ. M.B.A. N.S. v. 1897–99, p. 41.

Notes on the Reproduction of Teleostean Fishes in the South-Western District. By E. W. L. Holt and L. W. Byrne, B.A. Journ. M.B.A. N.S. v. 1897–99, p. 333.

Notes on the Reproduction of Teleostean Fishes in the South-Western District. By E. W. L. Holt. Journ. M.B.A. N.S. v. 1897–99, p. 107.

Report on a Collection of Very Young Fishes obtained by Dr. G. H. Fowler in the Faeroë Channel. By E. W. L. Holt. Proceed. Zool. Soc., London. 1898, p. 550.

The Rate of Growth of some Sea Fishes and their Distribution at Different Ages. By J. T. Cunningham, M.A. Journ. M.B.A. N.S. ii. 1891–92, p. 95.

On the rate of Growth of some Sea Fishes and the Age and Size at which they begin to breed. By J. T. Cunningham, M.A. Journ. M.B.A. N.S. ii. 1891–92, p. 222.

Report on the Probable Ages of Young Fish collected by Mr. Holt in the North Sea. By J. T. Cunningham, M.A. Journ. M.B.A. N.S. ii. 1891–92, p. 344.

On the Relation of Size to Sexual Maturity in Pleuronectids. (North Sea Investigations.) By E. W. L. Holt. Journ. M.B.A. N.S. ii. 1891–92, p. 363.

On the Relation of Size to Sexual Maturity in Round-fish. (North Sea Investigations.) By E. W. L. Holt. Journ. M.B.A. N.S. iii. 1893–95, p. 78.

On the Relations of the Generative Organs and of the Sexes in some Fishes. (North Sea Investigations.) By J. T. Cunningham, M.A. Journ. M.B.A. N.S. iv. 1895–97, p. 28.

An Examination of the Present State of the Grimsby Trawl Fishery, with especial reference to the Destruction of Immature Fish. By E. W. L. Holt. Journ. M.B.A. N.S. iii. 1893–95, p. 339. (Cf. N.S. iv. 1895–97, p. 410.) Also issued as a separate publication.

Destruction of Immature Fish. By G. C. Bourne, M.A. Journ. M.B.A. N.S. i. 1889–90, p. 153.

On the Destruction of Immature Fish in the North Sea. Remedial Measures. (North Sea Investigations.) By E. W. L. Holt. Journ. M.B.A. N.S. ii. 1891–92, pp. 380, 388.

The Immature Fish Question. By J. T. Cunningham, M.A. Journ. M.B.A. N.S. iii. 1893–95, p. 54.

Growth and Distribution of Young Food-fishes. By J. T. Cunningham, M.A. Journ. M.B.A. N.S. iii. 1893–95, p. 272.

On the Destruction of Immature Fish in the North Sea. (North Sea Investigations.) By E. W. L. Holt. Journ. M.B.A. N.S. iii. 1893–95, pp. 81, 123, 169, 288.

Statistics of Small Fish landed at Grimsby. (North Sea Investigations.) By J. T. Cunningham, M.A. Journ. M.B.A. N.S. iv. 1895–97, p. 10.

The Impoverishment of the Sea. By W. Garstang, M.A. Journ. M.B.A. N.S. vi. 1900, p. 1.

Notes on the Fishing Industry of Plymouth. By Walter Heape, M.A. Journ. M.B.A. Old Series. No. 1. 1887, p. 45.

Monthly Reports on the Fishing in the neighbourhood of Plymouth (with 8 charts). By W. L. Calderwood. Journ. M.B.A. N.S. ii. 1891–92, p. 277 and p. 394. N.S. iii. 1893–95, p. 107.

Preliminary Note on Trawling Experiments in certain Bays on the South Coast of Devon. By F. B. Stead, B.A. Journ. M.B.A. N.S. iv. 1895–97, p. 90.

Report on Trawling in Bays on the South Coast of Devon. By E. W. L. Holt. Journ. M.B.A. N.S. v. 1897–99, p. 296.

Notes on Rare or Interesting Specimens (*Clupea alosa*, *Auxis Rochei*, *Thynnus thynnus*, *Myliobatis aquila*). By J. T. Cunningham, M.A. Journ. M.B.A. N.S. iii. 1893–95, p. 274.

North Sea Investigations. Preliminary. By E. W. L. Holt. Journ. M.B.A. N.S. ii. 1891–92, p. 216.

On the Territorial Fishing Ground of Scarborough and its Neighbourhood. (North Sea Investigations.) By E. W. L. Holt. Journ. M.B.A. N.S. iii. 1893–95, p. 176.

On the Iceland Trawl Fishery, with some Remarks on the History of the North Sea Trawling Grounds. (North Sea Investigations.) By E. W. L. Holt. Journ. M.B.A. N.S. iii. 1893–95, p. 129.

Two Trips to the Eastern Grounds. (North Sea Investigations.) By J. T. Cunningham, M.A. Journ. M.B.A. N.S. iv. 1895–97, p. 33.

Notes on the General Course of the Fishing. (North Sea Investigations.) By J. T. Cunningham, M.A. Journ. M.B.A. N.S. iv. 1895–97, p. 12.

Observations at Sea and in the Markets — Grimsby, Scarborough, Hull, Lowestoft. (North Sea Investigations.) By J. T. Cunningham, M.A. Journ. M.B.A. N.S. iv. 1895–97, p. 108.

Account of a Voyage in the Smack *Albert* to the Newfoundland Fishing Banks. By W. T. Grenfell, M.R.C.S. Journ. M.B.A. N.S. iii. 1893–95, p. 143.

Causes of the Observed Distribution of Fish in the North Sea. (North Sea Investigations.) By J. T. Cunningham, M.A. Journ. M.B.A. N.S. iv. 1895–97, p. 133.

Physical and Biological Conditions in the North Sea. By J. T. Cunningham, M.A. Journ. M.B.A. N.S. iv. 1895–97, p. 233.

Recent Experiments Relating to the Growth and Rearing of Food-fish at the Laboratory. ii. The Rearing of Larval Fish. By J. T. Cunningham, M.A. Journ. M.B.A. N.S. i. 1889–90, p. 370.

Breeding of Fish in the Aquarium. By J. T. Cunningham, M.A. Journ. M.B.A. N.S. ii. 1891–92, p. 195.

Experiments on the Rearing of Fish-Larvae in the Season of 1894. By J. T. Cunningham, M.A. Journ. M.B.A. N.S. iii. 1893–95, p. 206.

Growth of Fishes in the Aquarium. By J. T. Cunningham, M.A. Journ. M.B.A. N.S. iii. 1893–95, p. 167.

Rearing of Fish-Larvae. By J. T. Cunningham, M.A. Journ. M.B.A. N.S. iii. 1893–95, p. 168.

Experiments on Sea-Fish Culture. By W. Garstang, M.A. Report Brit. Assoc., 1899.

Preliminary Experiments on the Rearing of Sea-Fish Larvae. By W. Garstang, M.A. Journ. M.B.A. N.S. vi. 1900, p. 70.

The Sense-Organs and Perceptions of Fishes, with Remarks on the Supply of Bait (with Plate XX.). By W. Bateson, M.A. Journ. M.B.A. N.S. i. 1889–90, p. 225.

Modes in which Fish are affected by Artificial Light. By W. Bateson, M.A. Journ. M.B.A. N.S. i. 1889–90, p. 216.

Experiments on the Production of Artificial Baits. By Frank Hughes. Journ. M.B.A. N.S. ii. 1891–92, pp. 91 and 220.

Notes on How Fish Find Food. (Report on the occupation of Table.) By Gregg Wilson, M.A., B.Sc. Report Brit. Assoc., 1893, p. 548.

The Amount of Fat in Different Fishes. By F. Hughes. Journ. M.B.A. N.S. ii. 1891–92, p. 196.

The Vernacular Names of Common Fishes. By J. T. Cunningham, M.A. Journ. M.B.A. N.S. i. 1889–90, p. 92.

The Regulations of the Local Sea Fisheries Committees in England and Wales. By E. J. Allen, B.Sc. Journ. M.B.A. N.S. iv. 1895–97, p. 386.

2. *The Eel Family.*

The Breeding of the Conger. By J. T. Cunningham, M.A. Journ. M.B.A., Old Series, No. 2. 1888, p. 245.

On the Reproduction and Development of the Conger. By J. T. Cunningham, M.A. Journ. M.B.A. N.S. ii. 1891–92, p. 16.

On a Specimen of *Leptocephalus Morisii.* By J. T. Cunningham, M.A. Journ. M.B.A. N.S. iv. 1895–97, p. 73.

Sudden Colour-changes in Conger. By W. Bateson, M.A. Journ. M.B.A. N.S. i. 1889–90, p. 214.

The Larva of the Eel. By J. T. Cunningham, M.A. Journ. M.B.A. N.S. iii. 1893–95, p. 278.

The Reproductive Maturity of the Common Eel. By J. T. Cunningham, M.A. Journ. M.B.A. N.S. iv. 1895–97, p. 87.

Eels and Sticklebacks in Sea-water. By W. L. Calderwood. Journ. M.B.A. N.S. ii. 1891–92, p. 77.

Note on *Muraena helena*, Linn. By E. W. L. Holt. Journ. M.B.A. N.S. v. 1897–99, p. 91.

3. *The Herring Family.*

Anchovies in the English Channel (with an illustration in the text). By J. T. Cunningham, M.A. Journ. M.B.A. N.S. i. 1889–90, p. 328.

Probable Relation between Temperature and the Annual Catch of Anchovies in the Schelde District (with Plate XXIV.). By G. H. Fowler, B.A., PH.D. Journ. M.B.A. N.S. i. 1889–90, p. 340.

Experiments on the Relative Abundance of Anchovies off the South Coast of England. By W. L. Calderwood. Journ. M.B.A. N.S. ii. 1891–92, p. 268.

The Migration of the Anchovy. By J. T. Cunningham, M.A. Journ. M.B.A. N.S. iii. 1893–95, p. 300.

Ichthyological Contributions. iv. Growth of Young Herring in the Thames Estuary. By J. T. Cunningham, M.A. Journ. M.B.A. N.S. ii. 1891–92, p. 330.

On the Occurrence of Large Numbers of Larval Herrings at the Surface. By Matthias Dunn. Journ. M.B.A. N.S. v. 1897–99, p. 184.

Notes on the Herring, Long-line and Pilchard Fisheries of Plymouth during the Winter 1889–90. By W. Roach. Journ. M.B.A. N.S. i. 1889–90, p. 382.

Notes on Herring, Long-line and Pilchard Fisheries of Plymouth. By W. Roach. Journ. M.B.A. N.S. ii. 1891–92, p. 180.

The Spawn of the Pilchard. By J. T. Cunningham, M.A. Journ. M.B.A. Old Series, No. 2. 1888, p. 247.

The Reproduction and Growth of the Pilchard (with Plate X.). By J. T. Cunningham, M.A. Journ. M.B.A. N.S. ii. 1891–92, p. 151.

Year-old Pilchards. By J. T. Cunningham, M.A. Journ. M.B.A. N.S. ii. 1891–92, p. 398.

The Life History of the Pilchard. By J. T. Cunningham, M.A. Journ. M.B.A. N.S. iii. 1893–95, p. 148.

4. *The Salmon Family.*

The Great Silver Smelt, *Argentina silus*, Nilsson, an addition to the List of British Fishes. By E. W. L. Holt. Journ. M.B.A. N.S. v. 1897–99, p. 341.

Grayling and Loch Leven Trout in Salt Water. By W. L. Calderwood. Journ. M.B.A. N.S. v. 1891–92, p. 76.

5. *Flat-fish Family.*

Diagnostic characters in Flat Fishes. By J. T. Cunningham, M.A. Journ. M.B.A. N.S. iii. 1893–95, p. 247.

The Development of the Egg in Flat Fishes and Pipe-fishes. By J. T. Cunningham, M.A. Journ. M.B.A. N.S. iii. 1893–95, p. 258.

A Treatise on the Common Sole (*Solea vulgaris*), considered both as an organism and as a commodity. Prepared for the Marine Biological Association of the United Kingdom. By J. T. Cunningham. M.A., Plymouth. Published by the Association. 1890 (4to. pp. 147 with eighteen plates).

Reproductive Organs of the Common Sole. By J. T. Cunningham, M.A. Journ. M.B.A. Old Series, No. 2. 1888, p. 248.

Ichthyological Contributions. ii. On a Stage in the Metamorphosis of Solea. By J. Cunningham, M.A. Journ. M.B.A. N.S. ii. 1891–92, p. 327.

Report on the Spawning of the Common Sole in the Aquarium of the Marine Biological Association's Laboratory during April and May, 1895. By G. W. Butler, B.A. Journ. M.B.A. N.S. iv. 1895–97, p. 3.

The Size of Mature Plaice, Turbot, and Brill on different Fishing Grounds. (North Sea Investigations.) By J. T. Cunningham, M.A. Journ. M.B.A. N.S. iv. 1895–97, p. 97.

On the Peculiarities of Plaice from different Fishing Grounds. By J. T. Cunningham, M.A. Journ. M.B.A. N.S. iv. 1895–97, p. 315.

Observations on the Natural History of Plaice. (North Sea Investigations.) By J. T. Cunningham, M.A. Journ. M.B.A. N.S. iv. 1895–97, p. 15.

Proposed Restrictions on the Landing of Undersized Plaice in the light of the New Evidence. (North Sea Investigations.) By J. T. Cunningham, M.A. Journ. M.B.A. N.S. iv. 1895–97, p. 138.

On a Dwarf Variety of the Plaice, with some Remarks on the Occasional Ciliation of the Scales in that Species. (North Sea Investigations.) By E. W. L. Holt. Journ. M.B.A. N.S. iii. 1893–95, p. 194.

A Piebald Plaice. By J. T. Cunningham, M.A. Journ. M.B.A. N.S. iii. 1893–95, p. 271.

Note on *Pleuronectes microcephalus*, Donov. By E. W. L. Holt. Journ. M.B.A. N.S. iii. 1893–95, p. 121.

Rhombus maximus, Linn. (The Turbot). By E. W. L. Holt. Journ. M.B.A. N.S. ii. 1891–92, p. 399.

Note on some Supposed Hybrids between the Turbot and the Brill. (North Sea Investigations.) By E. W. L. Holt. Journ. M.B.A. N.S. iii. 1893–95, p. 292.

Note on *Phrynorhombus unimaculatus*, Risso. By E. W. L. Holt. Journ. M.B.A. N.S. v. 1897–99, p. 343.

Hippoglossus vulgaris, Linn. (The Halibut). By E. W. L. Holt. Journ. M.B.A. N.S. ii. 1891–92, p. 399.

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Note on *Arnoglossus laterna*, Walb. By E. W. L. Holt. Journ. M.B.A. N.S, ii. 1891–92, p. 283.

Note on *Arnoglossus Grohmanni*, Bonaparte. By E. W. L. Holt. Journ. M.B.A. N.S. v. 1897–99, p. 89.

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Young Stages of *Zeugopterus punctatus*. By J. T. Cunningham, M.A. Journ. M.B.A. N.S. iii. 1893–95, p. 202.

6. *The Cod Family.*

Note on *Gadus Esmarkii*, Nilss. By E. W. L. Holt. Journ. M.B.A. N.S. ii. 1891–92, p. 282.

Gadus Esmarkii, Nilsson, the Norway Pout, an addition to the Fish Fauna of the English South-Western District. By E. W. L. Holt and Matthias Dunn. Journ. M.B.A. N.S. v. 1897–99, p. 79.

Note on *Phycis blennioides,* Brünn. By E. W. L. Holt and W. L. Calderwood. Journ. M.B.A. N.S. ii. 1891–92, p. 282.

Sense of Touch in the Rockling (*Motella*). By W. Bateson, M.A. Journ. M.B.A. N.S. i. 1889–90, p. 214.

Note on *Motella cimbria*, Linn. By E. W. L. Holt. Journ. M.B.A. N.S. v. 1897–99, p. 343.

Note on *Raniceps raninus*, Linn. By E. W. L. Holt. Journ. M.B.A. N.S. iii. 1893–95, p. 119.

On some Specimens of *Molva abyssorum*, Nilss., from Iceland and Faroë. (North Sea Investigations.) By E. W. L. Holt. Journ. M.B.A. N.S. iii. 1893–95, p. 200.

7. *The Stickleback Family.*

Note on *Gastrosteus pungitius*, Linn. By E. W. L. Holt. Journ. M.B.A. N.S. iii. 1893–95, p. 120.

8. *Cepolidae.*

Note on *Cepola rubescens*, Linn. By E. W. L. Holt. Journ. M.B.A. N.S. v. 1897–99, p. 197.

9. *The Blenny Family.*

Note on *Lumpenus lampetraeformis*, Walbaum. By E. W. L. Holt. Journ. M.B.A. N.S. iii. 1893–95, p. 120.

10. *The Lepadogaster Family.*

On *Lepadogaster*. By E. W. L. Holt and L. W. Byrne, B.A. Proceed. Zool. Soc. London. 1898, p. 589.

11. *The Dragonet Family.*

On the Breeding of *Callionymus lyra* in the Marine Biological Association's Aquarium at Plymouth. By E. W. L. Holt. Proceed. Zool. Soc. London. 1898, p. 281.

The Egg and Larva of *Callionymus lyra* (with Plate V.). By J. T. Cunningham, M.A. Journ. M.B.A. N.S. ii. 1891–92, p. 89.

Note on *Callionymus maculatus*, Bonaparte. By E. W. L. Holt. Journ. M.B.A. N.S. v. 1897–99, p. 90.

Note on *Callionymus maculatus*, Bonaparte. By E. W. L. Holt. Journ. M.B.A. N.S. v. 1897–99, p. 343.

12. *The Goby Family.*

Note on *Gobius Jeffreysii*, Günther. By E. W. L. Holt. Journ. M.B.A N.S. v. 1897–99, p. 89.

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On some New or Rare Marine Animals discovered on the Coast of Devonshire. By W. Garstang, M.A. Trans. Devon. Assoc. 1892, p. 377.

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Report on the Surface Collections made by Mr. W. T. Grenfell in the North Sea and West of Scotland, (with Plate XXV.). By G. C. Bourne, M.A. Journ. M.B.A. N.S. i. 1889–90, p. 376.

Report on the Surface Drift of the English Channel and Neighbouring Seas for 1897. By W. Garstang, M.A. Journ. M.B.A. N.S. v. 1897–99, p. 199.

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Microscopic Marine Organisms in the Science of Hydrography. By Prof. P. T. Cleve. Journ. M.B.A. N.S. iv. 1895–97, p. 381.

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VARIATION.

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Certain Correlated Variations in *Carcinus maenas.* By Professor Weldon, F.R.S. Proceed. Roy. Soc., vol. liv. 1893, p. 318.

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Presidential Address to the Zoological Section (on Natural Selection and Variation). By Professor Weldon, F.R.S. Report Brit. Assoc. 1898.

On the Variation of the Tentaculocysts of *Aurelia aurita.* By E. T. Browne, B.A. Quart. Journ. Micr. Sci., vol. xxxvii. 1894–95, p. 245.

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The Flora of Plymouth Sound and Adjacent Waters (with a woodcut). By Prof. T. Johnson, B.SC. Journ. M.B.A. N.S. i. 1889–90, p. 286.

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Observations on Brown and Red Sea-weeds. By Prof. T. Johnson. Rep. Brit. Assoc. 1890.

On the Structure of the Thallus of *Delesseria sanguinea* (with Plates XVII. and XVIII.). By M. C. Potter, M.A. Journ. M.B.A. N.S. i. 1889–90, p. 171.

The Callosities of *Nitophyllum versicolor*. By Prof. T. Johnson. Journ. Roy. Dublin Soc. 1892.

Observations on the Phaeozoosporeae. By Professor T. Johnson. Ann. Bot., vol. v. 1891.

Halosphaera viridis, Schmidt. By H. Thompson, B.A. Journ. M.B.A. N.S. i. 1889–90, p. 341.

The Polymorphy of *Cutleria multifida*. By A. H. Church, B.A. Ann. Bot., vol. xii. No. 45. 1898, p. 75.

Algological Notes, by G. Brebner. Journ. M.B.A. N.S. iv. 1895–97, pp. 179, 286.

Marine Biological Association of the United Kingdom.

Report of the Council, 1898–99.

The Council and Officers.

There have been four ordinary meetings of the Council during the year, at which the average attendance has been 8. As in previous years, the meetings have been held at the rooms of the Royal Society, and the Council has again to express its thanks for the courtesy thus extended.

The Council has to record with regret the death of Professor G. J. Allman, F.R.S., who has been one of the Vice-Presidents of the Association since its foundation in 1884.

The Plymouth Laboratory.

The Laboratory continues in a state of efficiency, and is adequately equipped with all the most modern requirements necessary for the prosecution of scientific researches in the various branches of marine bionomics and of the morphology of marine animals and plants.

The tank-room has undergone considerable rearrangement, and has been well stocked with a variety of fishes and of invertebrates, a number of species which have not previously been kept alive for lengthened periods having successfully survived the winter.

The pumps and engines which supply the sea-water and circulate it in the tanks have worked satisfactorily throughout the year, and only repairs due to ordinary wear and tear have been required.

Both the tanks and the Association's exhibition collection of preserved specimens have been open to the public on payment of a small charge, and have been seen by a large number of visitors.

The Laboratory has continued to supply living and preserved specimens of marine organisms to naturalists in all parts of the country for use in their investigations, as well as to numerous teaching institutions and museums for educational purposes.

The Boats.

The Association's steamboat *Busy Bee* has continued to carry on the regular collecting work of the station in the neighbourbood of Plymouth and on the adjoining coast. On two occasions Mr. Garstang, with the aid of a grant made by the British Association, has hired the steam-tug *Stormcock* for runs to Ushant and Parson's Bank, in connection with his researches on the temperature and floating fauna of the waters at the mouth of the Channel.

The Staff.

Mr. Holt, who has been appointed to take charge of the fishery investigations of the Royal Dublin Society, has left Plymouth for the West of Ireland. By arrangement with the Royal Dublin Society, Mr. Holt will still retain his position of Honorary Naturalist on the staff of the Marine Biological Association.

Mr. R. A. Todd, B.Sc., has been appointed Assistant to the Director at a salary of £80 per annum.

In other respects the staff remains as it was last year.

The Library.

The Library continues to grow, and it has been again necessary to increase the shelf accommodation.

The Council has been fortunate in securing a most useful collection of monographs and pamphlets on the Hydrozoa and Polyzoa from the library of the late Rev. Thomas Hincks.

The thanks of the Association are due for the following books and current numbers of periodicals presented to the Library during the year:—

Transactions and Proceedings of the Royal Society of London.
Transactions and Proceedings of the Zoological Society of London.
Zoological Record.
Report of the British Association for the Advancement of Science. (Bristol, 1899.)
Journal of the Royal Microscopical Society.
Microscopical Journal. Vols. i.–xviii. *Journal of the Royal Microscopical Society.* 31 vols. (1878–1897). (Presented by Sir Cuthbert Peek, Bart.)
Quarterly Journal of Microscopical Science. (Presented by Messrs. J. and A. Churchill.)
Report of H.M. Inspectors of Fisheries. (*England and Wales.*)
Catalogue of the Radcliffe Library, Oxford.
Annual Report of the Horniman Museum.
The Fisherman's Nautical Almanack and Tide Table. (O. T. Olsen, Grimsby.)
Zoological Results based on Material from New Britain, New Guinea, Loyalty Islands, and elsewhere. Dr. A. Willey.
The Cambridge Natural History. (Presented by the Editors.)

Transactions and Proceedings of the Royal Society of Edinburgh.
Proceedings of the Scottish Microscopical Society.
Report of the Millport Marine Biological Station.
Annual Report of the Fishery Board for Scotland.
On Stocking Rivers, Streams, etc., with Salmonidae. Howietown Fishery Company.
Scientific Transactions of the Royal Dublin Society. (Presented by the Director of the Royal Gardens, Kew.)
Proceedings of the Royal Irish Academy.
Report of the Inspectors of Irish Fisheries.
Proceedings and Transactions of the Liverpool Biological Society.
Report of the Port Erin Biological Station.
Lancashire Sea Fisheries Committee. *Superintendent's Report.*
Report of the Committee of the Puffin Island Biological Station.
Transactions of the Manchester Microscopical Society.
Northumberland Sea Fisheries Committee. *Report on Trawling Excursions.*
Proceedings of the Bristol Naturalists' Society.
Transactions of the Royal Geological Society of Cornwall.
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Returns of the Inspector of Cornish Fisheries.
Report of the Penzance Natural History and Antiquarian Society.
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Annals of the South African Museum.
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Illustrations of the Zoology of the Royal Indian Marine Survey Ship "Investigator."
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Occasional Papers of the Bernice Panahi Bishop Museum.
Proceedings of the Linnæan Society of New South Wales.
Australian Museum, Sydney. *Report of Trustees.*
Australian Museum, Sydney. *Memoir III. The Atoll of Funafuti.*
Records of the Australian Museum.
Sea Fisheries Report, New South Wales.
Proceedings of the Royal Society of Victoria.
Transactions and Proceedings of the New Zealand Institute.
Bulletin du Museum d'Histoire Naturelle, Paris.
Bulletin des Pêches Maritimes.
Bulletin de la Marine Marchande.
Bulletin Scientifique de la France et de la Belgique.
Bulletin de la Société Zoologique de France.
Mémoires de la Société Zoologique de France, i.–v. *Bulletin de la Société Zoologique de France*, i.–xvii. (Presented by Sir John Murray.)
Bulletin de la Société Centrale d'Aquiculture et de Pêche.
La Feuille des Jeunes Naturalistes.
Wissenschaftliche Meeresuntersuchungen. Aus der Biologischen Anstalt auf Helgoland.
Mittheilungen des Deutschen Seefischerei-Vereins.
Allgemeine Fischerei-Zeitung.
Mittheilungen aus dem Naturhistorischen Museum in Hamburg.
Bulletin de l'Académie Impériale des Sciences de St. Pétersbourg.
Melanges Biologiques. L'Académie Impériale des Sciences de St. Pétersbourg.

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Russian Fishery Journal.
Mittheilungen des Kaukasischen Museums.
Meddelanden af Societas pro Fauna et Flora Fennica.
Acta Societatis pro Fauna et Flora Fennica.
Archiv for Mathematik og Naturvidenskab.
Bergens Museums Aarbog.
An Account of the Crustacea of Norway. By G. O. Sars. (Bergens Museum.)
Report on Norwegian Marine Investigations. (Bergens Museum.)
Norsk Fiskeritidende.
Fiskeforsog i Norske Fjorde. Fra den Biologiske Station i Dröbak.
Meteorologiske Jagttagelser udforte i Trondhjem. M. R. Håkonson-Hansen.
Svensk Fiskeri Tidskrift.
Det Kongelige Norske Videnskabers Selskabs Skrifter.
Bihang till Kongl. Svenska Vetenskaps Akademiens Handlingar.
Selskabet for de Norske Fiskeriers Fremme.
Mittheilungen aus der Zoologischen Station zu Neapel.
Giornale Italiano di Pesca e Acquicoltura.
Neptunia. Revista Italiana di Pesca ed Aquicultura.
La Nuova Notarisia.
Bulletin de l'Academie Royale des Sciences et des Lettres de Danemark.
Report of the Danish Biological Station to the Board of Agriculture. Dr. C. G. J. Petersen.
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Verslag van den Staat der Nederlandsche Zee Visscherijen.
Mededeelingen over Visscherij.
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Het Zoölogisch Station der Nederlandshe Dierkundige Vereeniging. Dr. P. P. C. Hoek.
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Bulletin de la Société Belge de Géologie.
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Bulletin and Report of the United States Commission of Fish and Fisheries.
Bulletin of the Museum of Comparative Zoology at Harvard College.
Annual Report of the Smithsonian Institution. United States National Museum.
Bulletin of the United States National Museum.
Proceedings of the United States National Museum.
Bulletin of the American Museum of Natural History.
Annals of the New York Academy of Sciences.
Contributions from the Pathological Institute of the New York State Hospitals.
Journal of Morphology. Vols. iii.–viii. (Presented by Prof. E. Ray Lankester.)
Memoirs from the Biological Laboratory of the Johns Hopkins University.
Contributions from the Anatomical Laboratory, Brown University, U.S.A.
Bulletin of the Laboratories of Natural History, State University of Iowa.
Bulletin of the Natural History Museum of Illinois.
The Kansas University Quarterly.
Tufts College Studies.

Annual Report of the Director of the Board of Trustees of the Field Columbian Museum.

Publications of the Field Columbian Museum.

Contributions to Biology from the Hopkins Seaside Laboratory of the Leland Stanford Junior University.

Report of the Missouri Botanical Garden.

Proceedings of the Boston Society of Natural History.

Bulletin of the Buffalo Society of Natural Sciences.

Proceedings of the Natural History Association of Miramichi.

Transactions of the Meriden Scientific Association.

Comunicaciones del Museo Nacional de Buenos Aires.

Annales del Museo Nacional de Montevideo.

Revista Chilena de Historia Natural.

Boletina del Museo de Historia Natural de Valparaiso.

Journal of the College of Science, University of Tokyo.

Annotationes Zoologicae Japonenses.

Journal of the Fisheries Society of Japan.

To the authors of the Memoirs mentioned below the thanks of the Association are due for separate copies of their works presented to the Library :—

Om Aplanosporer hos Halosphæra. P. T. Cleve.

Directions for Collecting and Preserving Scale Insects (Coccidae). T. D. A. Cockerell.

Echinoderma. Reprint from *Zoological Record*, 1897. F. A. Bather.

Die Accommodation des Auges in der Thierreiche. T. Beer.

Studien zur Statocystenfunction. T. Beer.

The Skeleton and Classification of Calcareous Sponges. G. P. Bidder.

On a Cancer pagurus *with Supernumerary Chelae.* L. A. Borradaile.

On the Identification of Fish Artificially Hatched. H. C. Bumpus.

Notes on a Tetramerous Specimen of Echinus esculentus. H. C. Chadwick.

Contributions to the Knowledge of the Natural History of the Lobster and Crab. J. T. Cunningham.

Cup-shaped Red Blood-corpuscles. M. C. Dekhuyzen.

Embryons sans Noyau Maternal. Yves Delage.

Die Lokalisation Morphogenetischer Vorgänge. Hans Driesch.

Methode der Morphologie. Hans Driesch.

Über rein-mütterliche Charaktere an Bastardlarven von Echiniden. Hans Driesch.

On the Relations of Certain Stichodactylinæ *to the Madreporaria.* J. E. Duerden.

The Destruction of Immature Fish. Matthias Dunn.

Observations sur L'Arenicola ecaudata, *Johnston.* Pierre Fauvel.

Plankton of the Faroe Channel. G. H. Fowler.

Photographic Records of Pedigree Stock. Francis Galton.

Early Development of Polychœrus caudatus, *Mark.* E. G. Gardiner.

The Growth of the Ovum, Formation of Polar Bodies, and the Fertilization in Polychœrus caudatus. E. G. Gardiner.

The Building of Atolls. J. Stanley Gardiner.

On the Solitary Corals Collected by Dr. A. Willey. J. Stanley Gardiner.

Coral Reefs of Funafuti, Rotuma, and Fiji. J. Stanley Gardiner.

Natural History Notes. H. M. Indian Marine Survey: and Six Papers on Crustacea. Surg.-Maj. G. M. Giles.

Notes sur un Nématode nouveau des Iles Fiji. G. Gilson.

On the Reno-pericardial Canals in Patella. E. S. Goodrich.

The Metamorphosis of Asterias pallida, *with special reference to the fate of the Body Cavities.* S. Goto.

Bestimmungsschlussel für die Indo-Malayischen Landplanarien. L. von Graff.

L'État moniliforme des neurones chez les Invertebrés. J. Havet.

La Girelle royale et la Girelle de Giofredi doivent elles toutes deux être rapportées à l'espèce dimorphique Coris julis (Linn)? E. W. L. Holt.

Report on a Collection of very Young Fish obtained by Dr. G. H. Fowler in the Faeroe Channel E. W. L. Holt.

On Siriella armata *and the reputed occurrence of* S. frontalis *in British Seas.* E. W. L. Holt and W. I. Beaumont.

On the Variability of Characters in Perichaetidae. R. Horst.

On Perichaeta Sieboldi *Horst.* R. Horst.

Aspidosiphon cylindricus. N. Sp. R. Horst.

Contributions to the Anatomy and Histology of Thalassema neptuni. H Lyster. Jameson.

Études sur les Fourmis les Guêpes et les Abeilles. C. Janet.

The Fishing Industry of Japan. K. Kishinouye.

Hints on the Construction of a Tow-net. C. A. Kofoid.

The Freshwater Biological Stations of America. C. A. Kofoid.

The Freshwater Pearls and Pearl Fisheries of the United States. G. F. Kunz.

Beiträge zur Kenntniss der Pedalion-Arten: and five other papers. K. M. Lavender.

Les "Sphères attractives" et le Nebenkern des Pulmonés. A. Bolles Lee.

Spongia (Zool. Centralblatt). R. v. Lendenfeld.

On the Detection and Localization of Phosphorus in Tissue Elements. A. B. Macallum.

On the Gastric Gland of Mollusca and Decapod Crustacea. C. A. MacMunn.

The Pigments of Aplysia punctata. C. A. MacMunn.

On the Origin of the Vertebrate Notochord and Pharyngeal Clefts. A. T. Masterman.

Fourteen Papers on Fishery and Morphological Researches. A. T. Masterman.

The Land Isopoda of Madeira. A Second Recent Shell of Helix Lowei. British Isopoda Chelifera. Museum Normanianum. Rev. Canon Norman.

On Three New Species of Hydroids and one new to Britain. C. C. Nutting.

The Colour of Deep-Sea Animals. C. C. Nutting.

Hydroids from Alaska and Puget Sound. C. C. Nutting.

Observations on the Plankton of Puget Sound. J. I. Peck and N. R. Harrington.

Meteorological Observations, Rousdon, Devon. Sir Cuthbert Peek.

Ueber die Endigung der Nerven im Elektrischen Organ von Raja clavata *and* radiata. Prof. G. Retzius.

The Irish Freshwater Leeches. R. F. Scharff.

Zweckmassigkeit und Anpassung. J. W. Spengel.

Upon the Structure and Development of the Enamel of Elasmobranch Fishes. C. S. Tomes.

On Differences in the Histological Structure of Teeth occurring in a Single Family —the Gadidae. C. S. Tomes.

Degli Studi Intorno Agli Alimenti dei Pesci. G. B. de Toni.

The Relations between Marine Animal and Vegetable Life. H. M. Vernon.

The Relations between the Hybrid and Parent Forms of Echinoid Larvæ. H. M. Vernon.

Crustacea collected by Prof. Herdman in Puget Sound, Pacific Coast of North America. A. O. Walker.
Hippolyte fascigera (Gosse) and *H. gracilis* (Heller). A. O. Walker.
Malacostraca from the West Coast of Ireland. A. O. Walker.

General Report.

The investigation of the natural history of the mackerel, undertaken at the request of H.M. Treasury, has been continued during the year, and a report on the variation, races, and migrations of this fish has been prepared by Mr. Garstang and published in the Journal of the Association. This report establishes clearly that the mackerel of the American and European coasts are two separate races of fish, having different characteristic peculiarities, and also reveals the existence of certain minor peculiarities which appear to distinguish the Irish mackerel from those which inhabit the English Channel and North Sea. The acceptance of these conclusions will profoundly modify the views which have hitherto been prevalent as to the extent of the mackerel's migrations.

Mr. Garstang has also undertaken a study of the physical and biological conditions prevailing in the waters at the mouth of the English Channel, with special reference to the seasonal changes of temperature, the varying set of the currents, and the distribution of the floating and free-swimming organisms which are found at different seasons of the year. It is to be expected that this study will throw light upon the causes which determine the movements of such migratory fishes as the mackerel, the herring, and the pilchard. If this expectation be fulfilled, it will be possible for a naturalist having a properly equipped vessel at his disposal to determine the most probable position of the schools of fishes from his examination of the condition of the water at any given time. Such a result would be of immediate practical benefit to fishermen, as it would lead to the substitution of more intelligent methods of procedure in place of the unsatisfactory empirical practices of the present time.

A final report has been drawn up by Mr. Holt on the examination of the bays on the south coast of Devon, an investigation which was undertaken by the Association at the request of the Devon Sea Fisheries Committee. This report has been submitted to the Committee and also published in the Journal of the Association.

An examination of the fish population in the estuarine waters of the Hamoaze at each season of the year, commenced two years ago by Mr. Holt, has been continued during the present year. Valuable evidence is thus being accumulated on the question of the movements of bottom-living fishes in the inshore waters.

The investigation of the fauna and bottom deposits on the grounds from the neighbourhood of the Eddystone to Start Point, which has been carried on from time to time during the last four years, has been continued by the Director of the Laboratory, and a lengthy paper, illustrated with charts, has been published, embodying the results of this work. Investigations of a similar kind are now being extended to the inshore grounds.

Occupation of Tables.

In addition to the Officers employed by the Association, the following naturalists have been engaged in research work at the Plymouth Laboratory during the year:—

W. I. Beaumont, B.A., Cambridge (Nemertina and Mysidæ).
G. P. Bidder, B.A., Cambridge (Sponges).
G. Brebner, University College, Bristol (Marine Algæ).
E. G. Bullen (General Zoology).
L. W. Byrne, B.A., Cambridge (Teleosteans).
E. G. Gardiner, Ph.D., Woods Holl (Turbellaria).
J. F. Gemmill, M.A., M.B., Glasgow (General Zoology).
Prof. G. Gilson, Ph.D., Louvain (Polychæta).
E. Gurney, B.A., Oxford (Echinoderma).
J. Kimus, Ph.D., Louvain (Crustacea).
Prof. E. W. MacBride, M.A., Montreal (Echinoderma).
C. A. MacMunn, M.D., Wolverhampton (Pigment of Aplysia).
J. E. S. Moore, Royal College of Science (Fishing Apparatus).
G. H. Pethybridge, B.Sc., London (Marine Algæ).
T. H. Taylor, M.A., Yorkshire College (Polyzoa).
R. A. Todd, B.Sc., Yorkshire College (General Zoology).
Prof. W. F. R. Weldon, F.R.S., Oxford (Variation of Crustacea).
M. F. Woodward, Royal College of Science (Mollusca).

Eleven students from Oxford, Cambridge, and Eton attended Mr. Garstang's vacation class in Marine Biology.

Published Memoirs.

The following papers, either wholly or in part the outcome of work done at the Laboratory, have been published elsewhere than in the Journal of the Association:—

Bidder, G.—*The Skeleton and Classification of Calcareous Sponges.* Proceed. Roy. Soc., lxiv., 1898, p. 61.

Cunningham, J. T.—*Contributions to the Knowledge of the Natural History of the Lobster and Crab.* Journ. Roy. Inst. Cornwall, xliv., 1898.

Garstang, W.—*Preliminary Note on the Races and Migrations of the Mackerel* (Scomber scomber). Brit. Assoc. Report, Bristol, 1898.

Garstang, W.—*Recherches sur l'Histoire Naturelle du Maquereau.* Congrès International de Pêches Maritimes, Dieppe, 1898.

Holt, E. W. L.—*Report on a Collection of very Young Fishes obtained by Dr. G. H. Fowler in the Faeroe Channel.* Proceed. Zool. Soc. London, June, 1898.

Holt, E. W. L., and Beaumont, W. I.—*On* Siriella armata (*M.-Edw.*) *and the reputed occurrence of* S. frontalis (*M.-Edw.*) *in British Seas.* Ann. Mag. Nat. Hist., Ser. 7, Vol. iii., 1899.

Holt, E. W. L., and Byrne, L. W.—*On* Lepadogaster. Proceed. Zool. Soc. Lond., Nov., 1898.

Jameson, H. L.—*Contributions to the Anatomy and Histology of* Thalassema neptuni, *Gaertner.* Jena, Fischer, 1899.

MacMunn, C. A.—*On the Gastric Gland of Mollusca and Decapod Crustacea: its Structure and Functions.* Proceed. Roy. Soc., lxiv., 1899.

MacMunn, C. A.—*The Pigments of* Aplysia punctata. Journal of Physiology, Vol. xxiv., 1899.

Nutting, C. C.—*On Three New Species of Hydroids and one new to Britain.* Ann. Mag. Nat. Hist., Ser. 7, Vol. i., 1898.

Donations and Receipts.

The Receipts for the year include the grants from H.M. Treasury (£1,000) and the Worshipful Company of Fishmongers (£400), a grant of £25 from the Publication Fund of the Royal Society, Composition Fees (£15), Annual Subscriptions (£142 13*s.*), Rent of Tables in the Laboratory (£33 6*s.*), Sale of Specimens (£207), Admission to the Tank Room (£78). The total income for the year amounts to £1,930 19*s.*

Vice-Presidents, Officers, and Council.

The following is the list of gentlemen proposed by the Council for election for the year 1899–1900:—

President.

Prof. E. Ray Lankester, LL.D., F.R.S.

Vice-Presidents.

The Duke of Argyll, K.G., K.T., F.R.S.
The Duke of Abercorn, K G., C.B.
The Earl of St. Germans.
The Earl of Morley.
The Earl of Ducie, F.R.S.
Lord Tweedmouth.
Lord Walsingham, F.R.S.
The Right Hon. A. J. Balfour, M.P., F.R.S.
Sir Edward Birkbeck, Bart.
The Right Hon. Joseph Chamberlain, M.P.
The Right Hon. Sir John Lubbock, Bart., M.P., F.R.S.
Sir Wm. Flower, K.C.B., F.R.S.
A. C. L. Günther, Esq., F.R.S.
Prof. Alfred Newton, F.R.S.
Rev. Canon Norman, D.C.L., F.R.S.
Sir Henry Thompson, Bart.
Rear-Admiral Sir W. J. L. Wharton, K.C.B., F.R.S.

Elected Members.

F. E. BEDDARD, Esq., F.R.S.
Prof. F. JEFFREY BELL.
G. P. BIDDER, Esq.
G. C. BOURNE, Esq., F.L.S.
G. HERBERT FOWLER, Esq.
S. F. HARMER, Esq., F.R.S.
Prof. W. A. HERDMAN, F.R.S.
Prof. S. J. HICKSON, F.R.S.
Prof. T. JOHNSON.
J. J. LISTER, Esq.
D. H. SCOTT, Esq., F.R.S.
Prof. CHARLES STEWART, F.R.S.
Prof. D'ARCY W. THOMPSON, C.B.
Prof. W. F. R. WELDON, F.R.S.

Hon. Treasurer.

J. A. TRAVERS, Esq.

Hon. Secretary.

E. J. ALLEN, Esq., The Laboratory, Citadel Hill, Plymouth.

The following Governors are also members of the Council:—

ROBERT BAYLY, Esq.
J. P. THOMASSON, Esq.
THE PRIME WARDEN OF THE FISHMONGERS' COMPANY.
E. L. BECKWITH, Esq. (Fishmongers' Company).
Prof. Sir J. BURDON SANDERSON, Bart., F.R.S. (Oxford University).
A. E. SHIPLEY, Esq. (Cambridge University).
Sir WILLIAM FLOWER, K.C.B., F.R.S. (British Association).

Dr. *Statement of Receipts and Expenditure for the Year ending 31st May, 1899.* *Cr.*

Receipts.	£	s.	d.	£	s.	d.
To Balance from last year, being Cash at Bank and in hand				303	7	10
,, H.M. Treasury				1000	0	0
,, Fishmongers' Company				200	0	0
,, Life Member's Composition Fee— Dr. E. G. Gardiner				15	15	0
,, Annual Subscriptions				142	13	0
,, Rent of Tables	33	6	0			
,, Sale of Specimens	207	0	6			
,, Sale of Journal, &c., including Grant of £25 from Royal Society	34	14	5			
,, Admissions to Tank Room	78	3	5			
				353	4	4
,, Interest on Investment				19	6	8
				£2034	6	10

Expenditure.	£	s.	d.	£	s.	d.	£	s.	d.
By Salaries and Wages—									
Director				200	0	0			
Naturalist				250	0	0			
Director's Assistant				44	0	0			
Wages				509	6	0			
							1003	6	0
,, Stationery, Office Printing, Postages, &c.							116	9	2
,, Printing and Illustrating Journal							56	4	2
,, Sundry Expenses—									
Gas, Water, Coal, &c.	£100	6	0						
Coal for Steam Yacht	43	4	11						
				143	10	11			
Insurance of Steam Yacht, including boiler				12	7	6			
Stocking Tanks, Feeding, &c.				56	9	1			
Glass, Chemicals, Apparatus, &c.	£82	12	8						
Less Sales of Glass, &c.	15	4	6						
				67	8	2			
Maintenance and Renewal of Buildings, Boats, and Nets	£322	2	0						
Less Sales of Nets and Gear	39	11	9						
				282	10	3			
Rates, Taxes, and Insurance				12	15	11			
Boat Hire				5	4	6			
Travelling Expenses				32	2	2			
Library				92	14	4			
							705	2	10
,, Balance forward, being Cash at Bank and in hand, 31st May, 1899							153	4	8
							£2034	6	10

Investment held 31st May, 1899, £500 Forth Bridge Railway 4% Guaranteed Stock.

Examined and found correct,

(Signed) EDWIN WATERHOUSE,
STEPHEN E. SPRING RICE,
FRANK E. BEDDARD,
J. J. LISTER,
} *Auditors.*

Director's Report.

AFTER the completion of the investigation of the fauna and bottom-deposits of the outlying grounds extending from the neighbourhood of the Eddystone to Start Point, a detailed account of which was given in the last number of the Journal of the Association, a systematic investigation upon a similar plan was undertaken of the inshore grounds. The general area originally contemplated for detailed charting may be roughly described as lying between the 30-fathom line and the shore, and extending from the neighbourhood of Bolt Tail to Looe. In such an area the conditions are necessarily much more complicated than those which were met with on the Eddystone to Start grounds, where the depths varied but little from 30 fathoms, and where any effect upon the bottom fauna due to wave action was very slight. A further unfortunate complication has been introduced by the fact that immense quantities of refuse have been deposited all over the grounds immediately to the south and west of Plymouth Sound, by barges working in connection with the harbour improvement schemes in the Hamoaze and at Keyham, as well as by the barges belonging to the Plymouth Corporation, which discharge the refuse from the town. To such an extent has this deposit taken place that many of the most fruitful dredging and trawling grounds in the immediate neighbourhood have been rendered practically unworkable, and we have been compelled to abandon any serious systematic investigation of a considerable portion of the area originally contemplated. This has led to more attention being directed to the grounds to the east and west of that area, and less to those which lie near to Plymouth Sound.

The detailed work in connection with this investigation has been chiefly carried out by Mr. R. A. Todd, who was appointed by the Council, in the autumn of 1898, to act as my assistant. A large amount of information has been collected and systematically recorded, and we hope before long to be in a position to publish a full report of the work.

Mr. Garstang has successfully completed a series of expeditions across the mouth of the English Channel, for the purpose of ascertaining the variations in the physical conditions of the water and in the distribution of the floating fauna at different seasons of the year. The route taken was (1) from Plymouth to Ushant, with stations in mid-Channel (50 fathoms), and off Ushant (60 fathoms); (2) from Ushant in a westerly direction towards the 100-fathom line, with a station near Parson's Bank (75 fathoms); (3) from Parson's Bank northwards towards Mount's Bay, with a station in 50 fathoms; (4) from Mount's Bay to Plymouth. This course was run in February, May, the first week of September, and in November, 1899, and again in February, 1900. Temperature observations were taken at each station at different depths, and collections of the floating organisms were made with nets of various kinds. In connection with this work a net was designed which could be opened and again closed at any required depth, so that what organisms were present in a stratum of water at a particular level could be ascertained. This net, which worked with great effect and precision, will be subsequently described in detail in the Journal, together with the results of the observations made during the expeditions. The expenses of boat-hire in connection with this research were met by a grant made for the purpose by the British Association.

Mr. Garstang has continued his observations on the races and migrations of the mackerel, and the examination of the surface-drift in the Channel by means of floating bottles has also proceeded.

An account of his experiments on the rearing of sea fishes from the larval to the adult form, carried out at the Laboratory last summer, will be found on page 70 of the present number of the Journal. The periodic examination of the fish population in the estuarine waters of the Hamoaze, commenced some years ago by Mr. Holt, has been continued during the last two years, the fishing operations having been kindly undertaken by Mr. Gover, of Saltash.

Through the kindness of Mr. J. W. Woodall, I was enabled, with Messrs. E. T. Browne and W. I. Beaumont, who were working at the Laboratory, in July of last year, to have a week's useful collecting work at Scilly. In addition to personally assisting us in the work, Mr. Woodall placed his steam yacht *Vallota* at our disposal for tow-netting, as well as for moving about amongst the different islands and seeking suitable localities for shore work. The same gentleman has since purchased the hull of a sailing yacht, the *Dawn*, which is being fitted as a small floating Laboratory, and has been placed at our service for the purpose of examining the fauna of the different harbours in the neighbourhood. We propose to take her, during the early part of the present summer, to Salcombe, a place which possesses great interest from the fact that it was the collecting ground of Colonel Montagu in the early part of the century, and many British species were first described from specimens obtained there.

The following is a list of the naturalists who have occupied tables at the Laboratory since the publication of my last report (*Journal M.B.A.*, vol. v. p. 354):—

Aders, W. M., March 20th to April 17th, 1900 (*Hydrozoa*).

Beaumont, W. I., B.A., December, 1898, to May, 1900 (*Nemertina and Crustacea*).

Bidder, G. P., B.A., January 1st to March 31st, 1899 (*Porifera*).

Browne, E. T., B.A., June 21st to August 31st, 1899 (*Medusæ*).

Bullen, E. G., February 20th to June 5th, 1899 (General Zoology).

Byrne, L. W., B.A., May 19th to May 27th, 1899 (Fishes).

Cooper, C. Forster, July 22nd to August 3rd, 1899 (General Zoology).

Cooper, W. F., June 23rd to July 7th, 1899; March 24th to April 14th, 1900 (General Zoology).

Fagan, H., August 19th to September 14th, 1899 (General Zoology).

Gardiner, E. G., October 30th, 1898, to April 28th, 1899 (*Turbellaria*).

Harman, N. Bishop, B.A., M.B., December 29th, 1899, to January 12th, 1900; March 22nd to April 7th, 1900 (Fishes).

Hill, M. D., M.A., January 12th to January 17th, 1900 (*Alcyonium*).

Kimus, J., PH.D., March 25th to August 15th, 1899 (*Crustacea*).

Kent, W. Saville, August 14th to August 18th, 1899 (Fishes).

Lanchester, W. F., B.A., August 15th to September 11th, 1899 (*Phoronis*).

MacBride, Prof. E. W., M.A., May 18th to July 20th, 1899 (*Echinoderma*).

Minchin, Prof. E. A., August 14th to August 23rd, 1899 (*Porifera*).

Philipps, Miss E. G., March 21st to April 10th, 1900 (*Polyzoa*).

Punnett, R. C., B.A., August 19th to September 15th, 1899 (*Elasmobranchs*).

Willey, A., D.SC., April 11th to April 16th, 1900 (*Polychæta*).

Wolfenden, R. N., M.D., April 23rd to June 4th, 1900 (*Plankton*).

Woodcock, H. M., April 3rd to April 18th, 1900 (*Hydrozoa*).

Eleven students attended Mr. Garstang's vacation class in Marine Biology in 1899, and twelve students the class held during the Easter vacation of the present year.

An important improvement in the method of supplying sea-water for experiments in the Laboratory has been made by the carrying out of a scheme for obtaining water from the open sea beyond the Breakwater.

Many experiments in the rearing of marine larvæ during recent years have pointed to the fact that the best results can only be obtained at Plymouth by the use of water taken at some distance from shore; and it has been our practice for some time to bring in water in glass carboys for special work of this kind. By this means, however, only comparatively small quantities of water could be supplied. We have now obtained a tank-boat, capable of carrying about 1,200 gallons, which can be towed by our own steamer. A Tangyes pump ($5'' \times 3'' \times 12''$) has been fixed on the rocks below the Laboratory, and is worked by compressed air from our gas engine in the basement. Two wooden tanks, each capable of holding 500 gallons, have been placed on the top story of the western block of the building, and the pump delivers the water from the boat into these tanks. From the tanks it is carried in a glass tube to the main laboratory, where it can be distributed as required. The whole arrangement, which we are just getting into working order, has involved an expenditure of about £150. Towards this amount £100 has been obtained from a Founder's subscription kindly given by Mr. G. P. Bidder, the balance being met out of the ordinary income of the year.

The Library has recently grown considerably. A large number of books and pamphlets, chiefly dealing with Hydrozoa and Polyzoa, were purchased from the library of the late Rev. Thomas Hincks, and Mrs. Hincks has since presented many additional pamphlets.

In the present number of the Journal the recommendations adopted by the important International Fisheries Conference, which met last year at Stockholm, have been reprinted for general information. So far as I am aware, no steps have yet been taken by the various Governments represented for the practical carrying out of the recommendations of the Conference, and it is of the greatest importance that the matter should not be lost sight of.

There will be found on pp. 115 to 135 a list of the various papers and notes published between 1886 and 1899, which contain the results of work done under the auspices of the Marine Biological Association in the Laboratory at Plymouth or on the North Sea Coast. This list has been arranged according to the subjects treated of, and will not only serve to indicate the great number of questions which from time to time have occupied the attention of investigators at Plymouth, but will also be of value to future workers by bringing together observations upon allied subjects, which are at present much scattered.

E. J. ALLEN.

June, 1900.

OBJECTS

OF THE

Marine Biological Association of the United Kingdom.

THE ASSOCIATION was founded at a Meeting called for the purpose in March, 1884, and held in the Rooms of the Royal Society of London.

The late Professor HUXLEY, at that time President of the Royal Society, took the chair, and amongst the speakers in support of the project were the late Duke of ARGYLL, the late Sir LYON PLAYFAIR, Lord AVEBURY, Sir JOHN HOOKER, the late Dr. CARPENTER, Dr. GÜNTHER, the late Lord DALHOUSIE, the late Professor MOSELEY, the late Mr. ROMANES, and Professor LANKESTER.

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

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

The Association has received some £31,000, of which £15,000 has been granted by the Treasury. The annual revenue which can be at present counted on is about £1,820, of which £1,000 a year is granted by the Treasury, the remainder being principally made up in subscriptions.

The admirable Marine Biological Laboratory at Naples, founded and directed by Dr. Dohrn, has cost about £20,000, including steam launches, &c., whilst it has an annual budget of £7,000.

The purpose of the Association is to aid at the same time both science and industry. It is national in character and constitution, and its affairs are conducted by a representative Council, by an Honorary Secretary and an Honorary Treasurer, without any charge upon its funds, so that the whole of the subscriptions and donations received are devoted absolutely to the support of the Laboratory and the prosecution of researches by aid of its appliances. The reader is referred to page 4 of the Cover for information as to membership of the Association.

CONTENTS OF NEW SERIES, Vol. VI., No. 1.

NOTICE.

TERMS OF MEMBERSHIP.

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

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

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