# North Sea Investigations.

(*Continued.*)

By

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## Introductory.

I have again so many acknowledgments to make for help received that it would be invidious to select names, whilst to enumerate all would unduly trespass on the space allotted to me.

The work, as before, has been carried on at the Marine Fisheries Society's Laboratory at Cleethorpes.

## I. On the Relation of Size to Sexual Maturity in Round Fish.

Since the flat fishes appeared to be of more immediate importance, and time did not suffice for the thorough examination of both forms, I have deferred to deal with the round fishes until the present spawning season. Up to the time of writing only cod and haddock have been spawning, and neither species has ceased to do so. My records are therefore incomplete, even for these two forms, and especially for the last named, owing to the difficulty which has been experienced in procuring specimens from which the viscera have not been removed. Sufficient information, however, has been gained to justify the proposition of provisional size-limits, which will be useful in considering the statistics given below (p. 81) as to the destruc-

tion of undersized fish. For this purpose the observations of Dr. Fulton, who has now (Rep. S. F. B., 1892) enhanced the value of his former records by adding particulars as to sex, are of great assistance, since the conditions of the area from which his information was derived are, in great measure, identical with those of the parts of the North Sea with which I am here dealing.

The standards of maturity which I have proposed below are founded on the same basis as those put forward in the case of flat-fish. It seems preferable to deal with the methods of distinguishing the different conditions when the inquiry is more complete, but, of course, it may be taken that, *exceptis excipiendis*, what is true of one group of Teleosteans applies, in great measure, to others.

### *Cod* (*Gadus morrhua*).

Provisional size-limit, 25 inches.

Examined during the spawning season.

| Length. | MALES. | | | | FEMALES. | | | |
|---|---|---|---|---|---|---|---|---|
| | No. examined. | Ripe or recently spent. | Approaching ripeness. | Immature. | No. examined. | Ripe or recently spent. | Approaching ripeness. | Immature. |
| At 12 inches | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 |
| „ 14 „ | 2 | 0 | 0 | 2 | 2 | 0 | 0 | 2 |
| „ 16 „ | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 |
| „ 18 „ | 5 | 0 | 0 | 5 | 5 | 0 | 0 | 5 |
| „ 20 „ | 9 | 0 | 0 | 9 | 8 | 0 | 0 | 8 |
| „ 22 „ | 16 | 1 | 0 | 15 | 17 | 0 | 1* | 16 |
| „ 24 „ | 18 | 1 | 1 | 16 | 14 | 0 | 0 | 14 |
| „ 26 „ | 30 | 8 | 1 | 21 | 22 | 3† | 2 | 17 |
| „ 28 „ | 43 | 10 | 9 | 24 | 37 | 0 | 15 | 22 |
| „ 30 „ | 32 | 6 | 16 | 10 | 31 | 2 | 9 | 20 |
| „ 32 „ | 27 | 12 | 11 | 4 | 29 | 2 | 22 | 5 |
| „ 34 „ | 15 | 5 | 9 | 1 | 17 | 3 | 13 | 1‡ |
| „ 36 „ | 2 | 0 | 2 | 0 | 2 | 0 | 2 | 0 |

Some larger and smaller fish examined were all mature and immature respectively. On account of the large size of this fish, I have used divisions of two inches instead of one inch as in smaller forms.

From consideration of the fish obtained during the survey on the west coast of Ireland, I expressed the opinion that the limit for the female should be about 26 or 27 inches. The above table seems to show that such a limit would not be too high for the North Sea; all the fish, however, were caught on the hook, and gravid females,

* Three parts ripe: exact length 22¾ inches.

† Smallest ripe fish: 26½ inches.

‡ Largest immature fish: 35 inches.

though in this respect the species before us is less particular than some others, are known not to take a bait very readily. Moreover a good part of them are inshore fish, and on this coast the cod appears to spawn chiefly off shore. Hence it may be that the percentage of immature indicated by the table is somewhat too high to be applicable to the whole species. My inquiries are not yet complete, and I have therefore chosen a provisional limit which is very unlikely to have to be lowered.

It appears from Fulton's observations (Rep. S. F. B., 1892, Tab. v, p. 239*a*) that on the east coast of Scotland the female may be nearly mature at 21 inches, and this, no doubt, occurs in exceptional cases in other parts of the North Sea. My own results show very little difference between males and females in the size at which maturity is reached, which is the less remarkable since the two sexes do not greatly differ in size ; indeed, according to Fulton (op. cit., 1890, p. 247), the male is the larger fish of the two. The same authority, however, found the females to be the most numerous, and such is my own experience as regards specimens of all sizes. It is, therefore, rather singular that my table, which includes all the fish of the given sizes which I could procure here, shows an almost exact equality of number. The manner in which they were caught, which has a tendency, as I have mentioned, to be less efficacious in the case of gravid females, may partly explain the phenomenon so far as it is apparent in the case of the larger sizes in the table.

*Haddock* (*Gadus æglefinus*).

Provisional size-limit, 13 inches.

It appears from the limited number which I have as yet examined that the average size at which the female begins to spawn is about 13 or 14 inches. The largest immature and the smallest nearly mature examples of this sex measured 16 and 11 inches respectively, and the smallest fully mature specimen 15 inches. The male seems to mature at a somewhat smaller size, viz. about 11 inches ; all males of less than 10 inches were immature, and in fish of less than 9 inches it was very difficult to find the testes at all. All of more than 12 inches were mature or nearly so. Fulton's table (loc. cit.) appears to indicate a very similar experience as to facts, and it is evident that the pre-eminence in size which this authority ascribes to the male is no bar to the latter attaining maturity at a smaller size than the female. If we assume that rate of growth is proportional to size, it would seem to follow that the duration of reproductive life must in this case be greatest in the male. That the same difference in attaining maturity is less apparent in the cod is

probably explained by the greater advantage in size which Fulton's figures indicate for the male in that species: the male haddock being only very slightly larger than its mate, and having a longer reproductive life, the difference in the size at which the sexes spawn is more marked than in the cod, in which species the male, also fertile for the longer period, has a more noticeable advantage in size over the female.

## II. On the Destruction of Immature Fish in the North Sea.

I propose to resume this subject at the point at which I left it in the last number of the Journal, and to arrange my remarks under the same headings.

### *Beam-trawling by Large Vessels.*

That the destruction of small fish in this area is far greater in the summer than in the winter months is a fact which is probably sufficiently familiar to most readers of this Journal; the explanation being that it is only at the former time that young flat-fish congregate on certain grounds, alluded to in the last number of the Journal, in sufficient numbers to attract many boats to the grounds. Nevertheless a certain amount of small flat-fish appeared to be destroyed at all seasons of the year, whilst the destruction of young round-fish by trawlers is, as I shall endeavour to show, greatest in the winter months. The different species will be dealt with separately.

*Plaice.*—We have seen that the number of boxes containing only small fish landed here from the beginning of April to the end of August reached a total of 10,119. If we examine the figures for the different months we find the destruction at its maximum in June, each succeeding month showing a sensible diminution. I was given to understand, by those who should be well qualified to impart information on this point, that very little fishing would be done on the eastern grounds after the end of June; but, as the event proved, this was far from being the case. My informants, I have no doubt, spoke from their experience in former years, so that it would appear that the grounds in question remained productive, or were fished, to a later period than usual. If, as I suppose, the latter solution is in part correct, it does not appear that we have much to hope from the effect of public opinion on the fishing community in general, though, as I have already said, there are honorable exceptions.

In September the diminution continued, the total number of boxes landed during that month being 1184, as against 1924 in August. To this number the small fleet on the Terschelling ground contributed

the largest number. I understand that the vessels ceased "fleeting" some time during this month, but some of them continued to work the same ground while "single boating." Only one steam trawler brought in small plaice—viz. 295 boxes in three trips.

In October the total falls suddenly to 295 boxes, of which 133 were contributed by a Hamburg steam trawler, fishing to and from Grimsby on account of the cholera at home. Before this the German steam-vessels do not seem to have molested the small plaice much. I do not know whence the bulk of the small fish caught this month was derived, except that part, and I believe a large part, came from the Terschelling ground, where the very minute fish are not found. Examination of the catches brought in from this ground during the whole of the season failed to reveal any noticeable increase in size, and since we know that individual fish grow rather rapidly, the inference is that there is a constant succession, the fish passing from shallow to deeper water as they grow larger.

October is the last month (for 1892) of the small plaice fishery, and, indeed, it may be said that the season was practically over in September. In November and December no boxes containing only small fish were observed in the market.

About October a migration of fine plaice to the grounds lying off the "Holman" (Hantsholm) lighthouse is always expected, and occurred in 1892 as usual. In the same neighbourhood in the summer only small fish can now be obtained, and these rather closer inshore than the fine autumn fish; but, as I have been told by many old fishermen, all the grounds north of the Horn Reef formerly yielded fine fish in the summer, without any very small ones; thus forming a contrast to the more southern grounds along the east coast, where small fish seem always to have abounded, though plenty of fine examples are said to have been also obtainable. In fact, my information goes to the effect that the wholesale destruction of small fish on these grounds had been going on every summer for many years (ever since about 1830, when British trawling vessels seem first to have taken to fishing the Dutch grounds) before it attracted public attention. It escaped notice for this reason,—that as long as the supply of fine fish held out, the small ones, which were at least as numerous as they are now, were shovelled overboard, and thus never made their appearance in the market. The same thing is going on at the present day, only the items of the catch which are too small for the present market are indeed minute.

In January, 1893, twenty-one boxes, and in February forty-seven boxes of small plaice were observed in the market, but of these a considerable proportion were not derived from Grimsby boats. The

fish had been culled out from large consignments of plaice sent by rail from Lowestoft, but I could not discover what were the proportions of large and small in the whole consignment, nor was it possible to trace their origin any further than the port at which they were landed. The trawlers from Yarmouth, Lowestoft, Barking, &c., usually fish to the westward of the Terschelling ground during the winter, but I have no knowledge as to the quality of the fish caught there. Early in March a Grimsby steam trawler visited the Dutch and German coasts, but brought in no small plaice. About the middle of the same month two vessels visited the same or adjacent grounds and landed moderate catches of plaice, mostly answering to the market description of "half-fish," *i. e.* short of the biological standard of maturity, but too large to be classified in this connection as small. Thus it would appear that the "body" of small fish is not yet on the eastern trawling-grounds, but, if last year's experience be repeated, they may be expected to make their appearance there early in April.

Whilst enumerating the quantities of small plaice landed during the different months of the year it may be as well to give the quantities of larger fish landed at the same time. This cannot be done with absolute accuracy, as the only possible way of recovering the total quantity is by accepting the returns furnished by the Board of Trade statisticians. I found it impossible last year to take account of all fish, even of any one important species, landed at the pontoon; and the method adopted by the statistician, who bases his estimate mainly on information furnished by the railway company as to the amount despatched on their line, depends for its accuracy on the correctness of the deductions made for weight of packing material, additions for difference in condition of fish, home consumption, &c.

Now the fish arrives at the pontoon either whole ("live") or with the viscera removed. It may leave Grimsby in almost any condition. It may be sent off *in statu quo*, or may be cleaned, beheaded, boned; only a small part of it may be worth transmission. It may be wet or dried, pickled or smoked; it may come in as a codling, and go out as a "Finnon" haddock!—be caught as the head of Anarrhichas and tail of Lophius, and go out as the masseter muscles of Raia! The last instance, however, would not affect the correctness of the return, as these three kinds are not thought by the Board of Trade authorities to be worthy of discrimination, but go, in company with lemon soles, witches, conger-eels, dabs, &c., to swell the column for "All other except shellfish."

It will be admitted that the circumstances noticed above furnish rich opportunities of error, and in my opinion the statisticians deserve

the greatest credit for the large degree of accuracy which I believe to exist in their returns.

These returns deal with values and weights only, but the latter can easily be converted into boxes, the term of which I have hitherto made use in these reports. Nine stone may be taken as the average weight of fish in a box packed in the ordinary manner for sale in the market, that is with the fish piled to some height above the top of the box. A box which is only filled up to the top is spoken of as a "level." No other measures are now in use in the Grimsby market, turbot, brill, and halibut, and large round-fish being sold either separately, or in the rows in which they are laid out when first landed. Inferior fish, such as gurnards, are generally sold in heaps.

The subjoined table gives the figures arrived at by accepting the Board of Trade totals expressed in the first column. They are intended here to comprise only North Sea fish.

| 1892. Month. | 1. Total weight. cwt. | 2. Total number of boxes. | 3. Boxes containing only "small" fish. | 4. Other boxes. | 5. Percentage of total formed by No. 3. |
|---|---|---|---|---|---|
| April . . | 11,000 | 9,777 | 1,836 | 7,941 | 18 |
| May . . . | 12,000 | 10,666 | 830 | 9,836 | 7 |
| *June . . | 10,400 | 9,244 | 3,470 | 5,774 | 38 |
| *July . . . | 17,000 | 15,111 | 2,059 | 13,052 | 13 |
| *August . . | 10,600 | 9,422 | 1,924 | 7,498 | 24 |
| September . | 15,000 | 13,333 | 1,184 | 12,149 | 8 |
| October . . | 20,000 | 17,777 | 295 | 17,482 | 1 |

It will be noticed on consulting columns 3 and 5 that the gradual diminution of the actual numbers of boxes of "small" is not accompanied by a similarly regular decline in the same item when converted into percentages of the total. This is, I think, to some extent due to my having deducted too little for the Iceland fishery in July and August; but there must also be other causes, of which I have no knowledge. Apart from abundance or scarcity of fish there must always be some irregularity in the supply, as individual boats are constantly shifting from the pursuit of one species to that of another, according to the luck or inclination of the skippers.

It must be borne in mind that the boxes of "small" are very far from exhausting the number of undersized fish brought to market.

* In June, July, and August I have deducted 1000 cwt. from the Board of Trade totals as representing a very moderate estimate of 800 boxes, in this case packed so as to contain 10 st., derived from the Iceland grounds, and therefore not products of the North Sea Fishery proper.

In fact, it is my experience that, taking one box with another, at least a third of the fish contained in the boxes enumerated in column 4 fail to reach the proposed biological standard of maturity, and, indeed, we should still be in no danger of exaggeration if we were to assume that that proportion is actually sexually immature. I am here speaking of a proportion of numbers, which is a very different matter from one of weight or bulk, such as is given in the case of boxes of "small" in column 5.

We might certainly arrive approximately at the proportional number of small fish derived from all sources by converting boxes into numbers contained therein, but I have to confess that my confidence in the accuracy of column 1 is not such as to tempt me to elaborate further on that basis. Certain items of work, which during last season engrossed a great deal of time, having now been dealt with, it is my intention during the forthcoming small-fish season to take steps for obtaining statistical information which shall not be dependent for its accuracy on the correctness of any estimate whatsoever.

*Turbot.*—So long as boats continued to work the eastern grounds for small plaice last year, they continued to bring in with them a large proportion of immature turbot, not essentially differing from that noticed for the earlier months in the last number of the Journal (p. 383). As soon as the eastern grounds were abandoned immature turbot ceased to be a conspicuous feature in the market. It is not, however, clear that the small turbot leave the eastern grounds at the same time as the plaice, or, if they do so, it would appear that they may return earlier. Thus a smack returned on the 3rd March, 1893, from the Dutch and German grounds, bringing fifty-five turbot, of which thirty-five were immature, but no plaice. On the other hand, another smack, also from "across," brought in a good lot of small plaice, but no considerable number of small turbot.

It may be not uninteresting to compare the price of turbot now with that which could be obtained some twenty-five years ago.

From an account belonging to my friend Mr. G. L. Alward I find that in April, 1867, two boxes of turbot were sold in Billingsgate Market for £2. On one day in March of the present year the price in Grimsby Market rose as high as 2*s.* per lb. We may reckon about 9 st. of fish to a box, which at 2*s.* per lb. would make the price £25 4*s.* for the two boxes. The comparison is not altogether a fair one, as Mr. Alward tells me that prices were extraordinarily low on the occasion mentioned even for that period ;* whereas 2*s.* per lb. is the highest price, at first hand, of which I have heard even in Lent in recent years. To what extent the difference is explicable by decrease

* Nevertheless large turbot were often sold for only 1*s.* each.

though it must not be imagined that the grounds they fish are within the three-mile limit or anywhere near it. Such vessels are also known as "Cleethorpers," the name conveying, as I gather, a delicate insinuation on the part of more adventurous spirits that they never get beyond the mouth of the Humber. Fish of all sorts having become very scarce during the winter, it appears that these vessels, finding a fair supply of codling at and near a ground known as the "Yorkshire Hole," continued to fish there regularly in default

of fish and increase of demand respectively it is hard to say, but surely the former factor is not the least significant in the case.

*Soles.*—Immature soles have not been a conspicuous feature amongst the catch of large trawling vessels belonging to this port at any time since I have been at Grimsby, but on the 21st February of the present year a consignment of soles from Lowestoft included about 200 pairs, measuring from $6\frac{3}{4}$ to $7\frac{3}{4}$ inches. On the following day a similar consignment was also received in the market. I have no actual knowledge as to where or how these fish were caught, but am informed that they were most probably taken by Lowestoft boats off the Hook of Holland, which appears to be the earliest ground for soles on that coast, or near the English coast.

*Cod.*—Local custom divides the individuals of this species into four sizes. Up to about 20 inches they are "codling," thereafter they rank as "sprags," until at about 30 inches the dignity of "half-cod" is attained. Larger fish are spoken of simply as cod. A sprag is therefore on the borderland of sexual maturity, a condition of which all codling fall short.

My own experience on the North Sea grounds, and the records of a great number of hauls kept for me by my friends amongst the trawling fraternity, point to the fact that rather more immature than mature fish are caught by trawling, but that the number during most months of the year and on most grounds is not such as to call for special attention. On occasions, when a shoal of herring or some less patent cause has attracted large cod to a particular ground, good takes are often made; but, as a general rule, the species appears to be, in point of numbers, rather an insignificant product of the fishery. Nevertheless, having regard to the high price commanded by fish of fair size, and their relative and, as is asserted, increasing scarcity, it is obvious that the destruction of young and comparatively worthless examples is a matter to be exceedingly regretted, though it may not be easy to suggest a remedy. The most notable instance of their destruction which has come under my own observation occurred on the Great Fisher Bank in July. A great part of this important ground is covered by a very dense growth of *Flustra foliacea* (locally termed "scented" or "lemon weed"), and the net often brought up a cart-load or more of it. Very few large or even fair-sized codling were taken, but whenever the net came near the surface any number of minute examples, 2 to 4 inches long, would float out from among the Flustra, dead or dying, marking the wake of the ship with the gleam of their silvery abdomens. Others would be found when the net was got in, and though it was of course a difficult matter to count them, I should say that some hundreds must have perished with each haul on the "weed"-covered part of the ground. It is

evident that a number of vessels working in this locality must effect a serious injury to the species, the smallest members of which appear to suffer sufficient persecution from a natural enemy, the long rough dab.

Observations of fish brought to market up to the end of the autumn of 1892 supported the conclusion derived from consideration of records kept at sea, viz. that no very considerable number of codling (apart from the very small examples which suffered in the way I have just indicated) were destroyed. A boat would bring in one or two boxes, or there would be a certain number of codling mixed up with the haddock, but I never noticed any large quantity. In the winter, however, there was a marked change, and codling began to be quite a conspicuous feature in the market. A number of experienced men have drawn my attention to this as something quite unprecedented, though I understand it is not unusual for fish of this sort to be rather more abundant in winter than at other times of the year.

The number of boxes landed, from the time at which they first became noticeable, is as follows :

| | | |
|---|---|---|
| 1892 | November (last week only) | 180 boxes. |
| | December | 825 „ |
| 1893 | January | 1605 „ |
| | February | 1763 „ |
| | March 1st to 20th | 896 „ |
| | Total | 4469 „ |

There are about 100 fish in a box, so that the above figures represent over 400,000 fish. They are from 12 to 20 inches in length, but an odd fish amongst several boxes may reach a length of 25 inches or a little more. Thus all but an utterly insignificant proportion are sexually immature. A box fetches about 5*s.* 6*d.*, more or less, according to the state of the market, and is therefore worth not very much more than one full-grown fish in good condition.

By far the greater number of these fish were caught by a firm of steam trawlers, which, from their habit of making short trips and never going very far off port, are locally termed " inshore " boats, though it must not be imagined that the grounds they fish are within the three-mile limit or anywhere near it. Such vessels are also known as " Cleethorpers," the name conveying, as I gather, a delicate insinuation on the part of more adventurous spirits that they never get beyond the mouth of the Humber. Fish of all sorts having become very scarce during the winter, it appears that these vessels, finding a fair supply of codling at and near a ground known as the " Yorkshire Hole," continued to fish there regularly in default

of prospects of more legitimate success elsewhere. The pecuniary results seem to have been sufficient to attract other vessels, steam and sailing, to the same grounds, which thus furnished by far the greater part of the codling landed up to the last week of February. The greatest number landed by any vessel in a single trip was 122 boxes. A "voyage" of 23 boxes from the Great Fisher Bank at the end of January, one of 48 from "Botney Gut," and two of 78 and 104 from the "N. N. E. Hole" in February, assisted to swell the total, but the two last grounds are not far from the Yorkshire Hole. Of course the contributions from all other grounds, however insignificant individually, form collectively a sensible quantity.

Towards the end of February the chief agents in this matter shifted to the (Flamborough) "Head ground," attracted by good catches of plaice which were being made there. A diminution in the number landed has therefore been noticed, though at first codling were rather abundant on that ground also, one vessel bringing in a "voyage" of 40 boxes. They have since become less abundant, 13 boxes being the average catch of six steam trawlers at the end of the period with which my records deal. There is also, I think, a steady diminution on other grounds, though a good number still continue to be brought in. The fish appear to be scattering, though the decrease may be due in part to an involuntary migration to Grimsby. At any rate, there can be no doubt that the injury inflicted this winter on the cod fishery in general is out of all proportion to the profit derived.

*Haddock.*—North Sea haddock are divided by Grimsby fishermen into large and small, the limit between the two lying at about twelve inches. They are always cleaned at sea, and the larger fish become either "kits," *i. e.* suitable for packing in tubs of the same name, or "gibbers," according to the method in which the offal is removed. In "gibbing" the viscera are withdrawn through an incision along the abdomen, which does not extend as far forward as the isthmus, and therefore spoils the external appearance less than the ordinary process to which "kit" and small fish are subjected. Whilst the larger fish are mostly cured, the ultimate destiny of the small is the fried-fish shop. Consequently, whilst boxes of the former may contain a considerable admixture of sizes, the latter are always packed separately. On this account I have found it convenient to adopt the local standard of size in recording the quantity of undersized fish landed. Of course a certain number of immature fish, mixed up with others in boxes of "kit," are excluded, but I do not see that it is possible to recover the exact or even approximate numbers. It must therefore be remembered that while all the fish included in the figures given below are short of the provisional

biological standard, in point of fact less than 13 inches in length, the figures are not intended to be inclusive of all sexually immature fish.

Being occupied with other matters, I made no attempt to record the quantity landed during the earlier part of 1892, but noticed that the quantity decreased towards the summer and began to increase again in the autumn. My statistical inquiries were commenced towards the end of September.

The figures are as follows :

| | | |
|---|---|---|
| 1892 | September (last week only) | 366 boxes. |
| | October | 542 „ |
| | November | 1335 „ |
| | December | 1440 „ |
| 1893 | January | 1416 „ |
| | February | 1471 „ |
| | March 1st to 20th | 1551 „ |

As a rule, no considerable number of haddock in the market are of less than ten inches, the limit advocated by Dr. Fulton, but once or twice during the summer tug-boats not belonging to the regular fishing fleet brought in a good many smaller fish, mixed up with small whitings, gurnards, lemon soles, and dabs. I am not sure where they were caught, but was given to understand that they were probably from some of the "roughs" off the Yorkshire coast. Mr. Cunningham, in the last number of this Journal (p. 359), in estimating the age of some of these specimens, places the limit between those of one and two years old at 9 inches.

My own experience at sea, confined so far as haddock grounds are concerned to the spring and summer, is that many more mature than immature fish are trawled during that period, and the bulk of the evidence afforded by records kept for me by trawling skippers supports the same conclusion, and extends it to all seasons of the year. Still in several hauls, in each case on some part of the Dogger Bank, more small than large fish seem to have been caught. I have never trawled many haddock so small as to be unmarketable, but have got a few very small ones entangled amongst Flustra. On this occasion no sizes intermediate between $3\frac{1}{2}$ and 10 inches were represented. From various grounds I have occasionally received a number of very small fish, specially saved for me, but usually when these were caught there were no large fish. Similarly, it is the common experience of liners on the east coast of Scotland that the large and very small fish are not taken on the same ground at the same time.

We know that the haddock is gregarious to a greater extent even

than the cod, though our information as to its earlier life-history remains singularly meagre. Speaking generally, we may say that the shoals containing large fish—in fact, the only shoals of which we have definite knowledge—contain also fish of all sizes that are marketable, and some which are usually considered too small to be included in this definition; but the very small fish live apart. The explanation seems to be that young fish do not join the shoals until they have attained such a size as enables them to prey on similar organisms, and to keep up with the frequent and very rapid migrations of their larger brethren. Such size or condition appears to be reached at about 8 to 10 inches. Now, if the young haddock attains a length of about 6 to 9 inches in the first year of its life, it is evident that, as this fish is an early spawner, there will be a considerable accession of young fish to the shoals in the winter months. The period during which such increase would be noticeable might be expected to be somewhat more extended than that during which the species spawns, since it must be some time before these recruits attain a size which places them outside the category of "small" haddock. It remains to be seen whether a continuation of statistical inquiries will confirm the general impression, and my own, that small fish are more plentiful in the winter and early spring than at other times of the year; but if such prove to be the case, the above speculations as to the cause may be not devoid of interest.

### *Shrimp-trawling.*

It will be remembered that in my last report I alluded to a bye-law of the North-eastern Sea Fisheries District Committee which prohibited the use of shrimp-trawls in the Humber, and in certain other inshore waters with which I have no acquaintance, between the beginning of April and the end of September, and altogether prohibited the use of fish-trawls in the same waters. I also found it necessary, owing to the very general disregard of such part of the regulation as referred to fish-trawls, and the difficulty of discriminating in the market between Humber fish taken by the different kinds of trawl, to include all such fish in one category.

Since the report was published I have had an opportunity of obtaining a more intimate acquaintance with the conditions of the industry. Complaints were numerous on the part of those dependent, wholly or in part, on the Humber fisheries, that the season closed by the bye-law was too long, and a petition was presented to the Committee, praying that shrimp-trawling might be allowed from the beginning of March to the end of October; in other words, that the open season might be extended by a month at each end.

With a view to satisfy themselves as to the wisdom of granting such concession, the Committee asked me to carry out a series of investigations on the subject, for which purpose Mr. J. W. Woodall, a member of the Committee, and one whose interest in the welfare of our fisheries as well as in marine biology for its own sake is too widely known to need more than a passing reference here, offered the use of his steam yacht, the "Vallota," R.Y.Y.C., for a month. The Council of this Association accorded the necessary permission, and I propose here to give a brief account of the work done and the conclusions arrived at.

The "Vallota" draws only 4 feet of water, and is therefore eminently suited for work in a shallow estuary, such as the Humber. The gear we used consisted of a professional shrimp- or prawn-trawl, beam 13 feet, mesh $\frac{7}{8}$ inch "from knot to knot," or $\frac{7}{16}$ inch square, in cod end. No pockets. Hemp ground-rope $9\frac{3}{4}$ inches in circumference. False bellies of leather, cork, and coarse netting. We also carried a small fish-trawl of ordinary pattern, $17\frac{1}{2}$ feet beam, and a naturalist's trawl, 9 feet beam, of sprat-mesh lined with mosquito net, and fitted with a heavily chained ground-rope.

The services of a professional shrimp- and prawn-trawler were secured to pilot the yacht, point out the different grounds, and work the gear.

The chief object of the investigations was to arrive at a knowledge of the amount of destruction of young fish of valuable kinds which would be likely to ensue from the regular working of the grounds by shrimp- and prawn-trawlers during the season then closed by the Committee's bye-law, or during such part of it as was included in the time when the investigations were carried on, viz. from October 19th to November 17th. For this purpose a number of hauls were made on all the grounds with the professional gear, and the results accurately recorded, the *modus operandi* being as far as possible assimilated to that of the small sailing-boats engaged in the industry. The fish-trawl was used on the grounds affected by sole-trawlers, so as to ascertain the quantity and sizes of fish present during the current season, and also in various parts of the river not usually accessible to sailing-boats, partly with a view to obtaining all possible information as to the distribution of fish in the river, and partly, in conjunction with cod ends of different mesh, to test the relation between size and pattern of mesh and size of fish caught. As these operations do not intimately concern the subject under discussion, I shall not refer to them further in this place. The naturalist's trawl was used at the same time as the fish- and shrimp-trawls, in order to find out what fish or other organisms passed through the meshes or beneath the ground-rope of those engines.

*Fishing-grounds.*—The same boats and gear are employed for the capture of both shrimps (*Crangon vulgaris*) and prawns (*Pandalus annulicornis*), but as the latter are the more valuable, they receive by far the greatest share of attention.

Subjoined is a list of the grounds, with local names, and soundings at low water.

*Prawn Grounds.*

| | |
|---|---|
| "Inside the Middle Sand" . . . | 23 to 50 feet. |
| "Outside the Trinity Sand" . . . | 30 to 70 „ |
| (Clee) "Ness Channel" . . . | 13 to 40 „ |
| "Back of the (Clee) Ness" . . . | 15 to 30 „ |
| "Tetney" . . . . . | 24 to 30 „ |

*Shrimp Grounds.*

| | |
|---|---|
| "Paull Middle" (Sand) . . . | 8 to 16 feet. |
| "Sand Haile" . . . . . | 8 to 16 „ |

Shrimps are represented to some extent on all the grounds, but very few large prawns are present on the shrimp grounds.

Owing to the prevalence of wrecks and other obstructions, such as clay banks and accumulations of "ross" (Sabellaria), the grounds are very sharply defined, so that a sailing boat is absolutely dependent on favorable conditions of weather to allow her to work at all. Except at slack water, it is only possible for her to trawl with the tide, and it will be readily understood that it is not every day that the wind allows a sailing boat to keep her course drifting along a very narrow strip of ground. In the "Vallota," owing to her large size and comparatively high freeboard, it was difficult to go slow enough when wind and tide happened to be in the same direction. As a rule, however, we were fortunate in being able to work at the required speed, and, when the wind was abeam, an occasional use of the engines enabled us to keep our course in a manner impossible to a sailing vessel, while at slack water we could, of course, choose our own direction.

*Method of working gear.*—To avoid damage to the net professional shrimp-trawlers attach one buoy by a long line to the cod end, and another to the end of the warp, which is made fast to the boat by a stop of small cord. Thus, if any obstruction is met with, the stop will break before much damage is done to the net, which can afterwards be lifted by whichever end is most convenient.

*Capture of fish.*—In dealing with the results it will be necessary to consider the shrimping and prawning grounds separately, since, as might be expected from the difference in soundings, they differ

considerably from each other in relation to the capture of small fish. Further, the different prawning grounds are not all alike in this respect.

The fish of any known value which we met with consisted of sole (*Solea vulgaris*), plaice, common dab, lemon sole, flounder, cod, whiting, whiting-pout, sprats, thornback, and spotted ray (*Raia maculata*). Besides these we took a number of unmarketable kinds, viz. "hard-heads" (*Cottus scorpius*), "bull-routs" (*Agonus cataphractus*), "gobblers" (*Liparis Montagui*), gunnels (*Centronotus gunnellus*), viviparous blennies (*Zoarces viviparus*), "eel-pouts" (*Motella mustela*), "Williams" or "sweet fish" (*Gobius minutus*), a few *Raninus raniceps*, and one long rough dab: the vernacular names in inverted commas are those in local use; some species have no local designation.

I have never come across a solenette (*Solea lutea*) in the Humber, and am pretty certain that the species does not exist there. Hence the confusion which is so abundantly evident in the mind of the fisherman and amateur fishery expert wherever solenettes and young common soles are found together does not exist in this locality.

*"Trinity" ground.*—As this is the most important ground, especially at the season during which our operations were carried on, we devoted especial attention to it. In eleven hauls with the professional gear we always obtained a fair catch of prawns, considering the lateness of the season.

Only nine soles were taken, four hauls being blank so far as this species was concerned. The largest number taken in any one haul was two. The fish measured as follows: two less than 2 inches, two small, exact size not recorded, two at $5\frac{1}{2}$ inches, one at $9\frac{1}{2}$ inches, and one at $13\frac{1}{2}$ inches.

Early in October I had made the discovery that young lemon soles occur in the Humber in autumn, all previous information having induced a general belief amongst those interested in the matter that the early life of this form was passed in comparatively deep water, and consequently at some distance from land on most coasts. Only a few were taken on the occasion referred to, and it was therefore with the greatest interest that we found fresh specimens yielded by almost every haul on the ground now under consideration. The number was in no case large, sixteen being the most in one haul. Another yielded eleven, but no other more than seven. The smallest fish measured 2 inches in total length, and the usual size was from $2\frac{1}{2}$ to $3\frac{1}{2}$ inches; a few were taken at sizes ranging from that last mentioned up to $8\frac{1}{2}$ inches, and there was one specimen of 11 inches.

Plaice were very scarce; in the eleven hauls we only got eight fish, viz. five in one haul, one each in other three, and none in the remainder. Six of these fish measured from $5\frac{1}{2}$ to $9\frac{1}{2}$ inches, and

the others 14½ and 17½ inches respectively. I may add that this last is the only instance of the capture of a fair-sized plaice in the Humber that has come under my notice.

Common dabs were more numerous. They occurred in October in the first eight hauls, but were absent from the remaining three, which were made in November, but I do not know that we are justified in attaching much importance to this circumstance. The largest number taken in a haul was twenty, no other haul yielding more than seven. With the exception of one translucent metamorphosing example of ½ an inch, the smallest size taken was 1½ inches, the largest being 10½ inches. Taking 7 inches as a convenient limit for dividing large and small of this species, about two thirds of the fish caught must be included in the last category.

Small cod and whiting were always taken. The average of eight hauls (the exact number taken in the remainder was not recorded) was 79 of the former and 78 of the latter, but the two kinds did not occur with equal regularity. Thus the extreme numbers taken in single hauls were for cod, 15 and 179; and for whiting, 36 and 156. All sizes of cod from 2½ to 7 inches were present, but the majority were under 5 inches. A solitary example measured 21 inches. Whiting were from 3 to 7½ inches, but mostly less than 6 inches.

Except a small ray, and an inconsiderable number of sprats, no other fish of known value occurred on this ground.

All the kinds of unmarketable fish which I have mentioned above were represented, but Liparis predominated. Small Cotti and half-grown Agoni and Gobies were also abundant.

Besides the prawns, which exhibited a very deep red colour whenever we dropped into the 9-fathom hole near the lower end of the ground, a few shrimps were always taken. Other Invertebrates included a few sun-stars (*S. papposa*) and common star-fish, a few shore-crabs and common hermits, a good many swimmer-crabs (*P. holsatus*), masses of "ross" (*Sabellaria alveolata*), and a few whelks. A good many mussels would occur when we kept rather too close to the Trinity Sand. A little Delesseria was the only algoid noticed.

It appears from the above that, save for a sprinkling of lemon soles and an occasional irruption of common dabs, this ground is very little affected by flat-fish, small or large, at the time when our investigations were made. On the other hand, it is evident that young cod and whiting must be extensively trawled by prawners at that season, should the conditions of their distribution be alike in all years.

"*Middle Sand*" *ground.*—This is an important ground earlier in

the season, but, at the time we visited it, yielded very few prawns. Only three hauls were made there.

With the exception of lemon soles, which were not represented, the supply of flat-fish was much the same as on the last ground. Soles were only taken in one haul, viz. three from $2\frac{7}{8}$ to $6\frac{1}{8}$ inches. Plaice occurred also in only one haul, viz. four at from $2\frac{1}{4}$ to $4\frac{1}{4}$ inches. Common dabs were absent from one haul; in another twenty-seven were taken, the sizes ranging from $1\frac{1}{4}$ to $8\frac{1}{2}$ inches, but all but four were less than 7 inches. The number taken in the remaining haul is not recorded; it was not considerable.

Small cod and whiting were about as numerous as on the last ground. Of unmarketable fish, Liparis were less numerous, as might be expected from the comparative scarcity of their prey, the prawns. Other conditions were much the same as on the Trinity ground.

"*Ness Channel*" *ground.*—This ground seems to rank next to the two foregoing in importance, but yielded only very moderate catches of prawns when worked by the "Vallota." Five hauls were made, but of these one resulted in a foul net, and in two others we came fast. The ground is very intricate, and can only be worked in security in clear weather, as the marks are not easily seen if it is at all hazy.

Flat-fish were poorly represented. No very small soles were taken, the only two captured measuring $9\frac{1}{2}$ and 10 inches respectively. Plaice were not more numerous than on the Trinity ground, and ranged in size from 5 to $9\frac{1}{2}$ inches. Dabs were scarcer than on any other ground, only five from 2 to $7\frac{1}{2}$ inches being taken. Lemon soles occurred in three hauls, five being the largest number taken, the sizes ranging from $2\frac{1}{2}$ to $7\frac{3}{4}$ inches.

Round-fish, viz. young cod and whiting, were numerous in two hauls, but very scarce on the occasions when the net came fast. Probably some escaped, though little else seemed to have been lost.

Of unmarketable fish Cottus, Agonus, and Liparis were the most abundant. A few edible crabs and a good many shrimps were taken.

"*Back of the Ness*" *ground.*—This is worked by professional trawlers either in one haul or two. We tried it in both ways, making in all six hauls with the professional gear. A moderate catch of prawns was always obtained, and shrimps were more plentiful than on the grounds that have already been discussed. It appeared that most prawns were yielded by the upper half, the converse holding good with regard to shrimps.

There were very few soles on any part of the ground, four being the largest number taken in any haul. The sizes were from $2\frac{3}{4}$ to $8\frac{3}{4}$ inches. Lemon soles were present in only three hauls, one of which, however, yielded 12 fish, of the usual size. I could not

find that they specially affected any particular part of the ground. Plaice and dabs, on the contrary, appeared to be much more abundant on the lower half. Of the former, 35 was the largest number taken in a haul on the whole ground; on the upper half 5, and on the lower half 27 were taken in two consecutive hauls. The same hauls yielded 6 and 38 dabs respectively, whilst 80 were taken in one haul over the whole ground. The sizes of the plaice were from $1\frac{1}{4}$ to $10\frac{3}{4}$ inches, most being less than 6 inches, whilst the dabs measured from 1 to $8\frac{1}{2}$ inches, the great majority being less than 7 inches. Small cod and whiting were as plentiful as on other grounds, but the bulk of them appeared to be derived from the lower half. Two whiting-pout, 8 inches in length, were taken on this ground.

Unmarketable fish, including Cottus, Agonus, Liparis, Centronotus, and Gobius, occurred in variable numbers, but it was not noted that they were more plentiful on one part of the ground than another.

A good many sun-stars, hermits, shore and swimmer crabs were taken. Sabellaria was very abundant towards the upper end of the ground. Hydroids were represented by *Thuiaria thuia, Antennularia ramosa, Halecium* sp., &c.

*"Tetney" ground.*—During the period of our investigations this ground was very effectively closed to trawling by the prevalence of whelkers' gear, the buoys on which are so arranged as to watch only at certain states of tide. Consequently we were unable to use the professional shrimp-trawl there. Early in October, however, Mr. Woodall having kindly lent his yacht for some work in connection with this Society's mesh investigations, several hauls were made on the prawn ground with the naturalist's trawl used to check the results obtained with the fish-trawls.

The take of prawns varied, but was never very large; but of course it is not possible to judge from such a net the results likely to be yielded by one specially designed for the capture of this species.

Small soles were rather abundant, as many as eleven being taken in one haul, though usually the number was less. A few large fish were also present on the ground, but were caught only in the fish-trawl. Very few lemon soles were taken, this form apparently preferring the deeper part of the river, or it may be that the immigration was only just commencing. There were a great many small dabs, over 300 being taken in an hour's haul on one occasion. Twenty-eight small plaice were caught at the same time, but once, when we went rather too close inshore to catch many prawns, we took over 200 small plaice. Generally there were a few small flounders, and once we got a "chicken" turbot, 13 inches in length. Small whiting were as numerous as on the other grounds later in the season, but cod were comparatively scarce, as, indeed, at the end of

September and beginning of October, they proved to be in all parts of the river which we visited.

We sometimes took enormous numbers of half-grown Agonus and Centronotus, while Cottus, Liparis, and Gobius were always fairly plentiful. *Callionymus lyra* ("dragon"), a species not observed on other grounds, occurred pretty often, *Trachinus vipera* less frequently.

The ground includes the site of the old Tetney native oyster bed, but whilst we always got a lot of shells we only once obtained a living native, probably well-nigh the last survivor of its race. Edible crabs were caught now and then, and there was always a large assortment of shore, hermit, and swimmer crabs, and sometimes a few *Hyas araneus*. *Solaster papposa* was rather abundant.

*"Paull Middle" ground.*—Of the shrimping grounds this appears to be the most important, as the Paull boats often take a haul over it whilst dropping down with the ebb to the lower reaches of the river. The "Vallota" was only able to make two hauls there. The most productive yielded a quart of shrimps, the rest of the catch consisting of 35 plaice at $1\frac{7}{8}$ to 11 inches, 18 dabs at 3 to 8 inches, 250 small whiting, 8 small cod, and a few flounders, besides a few fish of less importance.

*"Sand Haile" ground.*—Here we made one haul of an hour's duration, and caught a quart of shrimps and a pint of prawns, some unmarketable fish, and the following :

One sole at 13 inches, and 12 at $3\frac{1}{2}$ to $8\frac{1}{2}$ inches ; 1 lemon sole at 6 inches ; 554 dabs at $1\frac{1}{4}$ to 4 inches, and 17 at $4\frac{1}{4}$ to $7\frac{1}{2}$ inches ; 6 plaice at 2 to $2\frac{1}{4}$ inches, 4 at 5 inches, and 59 at 7 to 13 inches ; 115 small cod ; 410 small whiting.

*Summary of capture of fish.*—It will be seen from the detailed statements given above that very few flat-fish are liable to be caught at the season under discussion on the "Trinity," "Middle Sand," and "Ness Channel" prawning grounds ; that the upper part of the "Back of the Ness" ground is also comparatively free from flat-fish, but that some quantity may occur on the lower half. It also appears that the most abundant species is the comparatively worthless common dab.

The "Tetney" prawning ground, however, yielded a good many flat-fish, though here again dabs were the chief sufferers ; but it must be remembered that this ground was worked with a trawl furnished with a narrow chained ground-rope, specially designed to pick up very small flat-fish, and, so far as I could judge, rather more efficacious for this purpose than the thick hemp rope of the professional shrimp-trawl.

It is, however, evident that great numbers of small cod and whiting are liable to be caught on all the prawning grounds.

Turning to the shrimping grounds, we find a moderate quantity of small flat-fish on Paull Middle, less than on Tetney, but considerably more than on the other prawn grounds; whilst of round-fish, cod are but poorly represented. On the Sand Haile we find a great quantity of flat-fish, very much reduced if we eliminate the dabs.

*Destruction of fish.*—Having thus dealt with the *capture* of fish on different grounds, it behoves us next to consider how many of them are thereby *destroyed.*

In the ordinary course of the industry, when the trawl comes on board the catch is shot into a box, or on to the deck, and as many as possible of the unsaleable products are picked out by hand and pitched overboard. In this way the Cottus, Liparis, Agonus, crabs, &c., are at once returned to the water, and being all hardy forms, are none the worse. I question very much whether it would not be wiser to destroy the Cottus and Liparis, as their appetite for prawns is inordinate, and they do not appear to subserve any function useful to the fisherman. Swimmer crabs, also, I am inclined to regard as deserving scant consideration. By the same process the whiting and cod, having no value at such a small size, are returned to the sea—to be out of the way, if for no more provident intent. Such flat-fish as are saleable are put aside, the remainder being thrown overboard, at least such as are large enough to attract attention.

The catch of prawns or shrimps, having thus been roughly cleared, is placed on the sieve and riddled over the side of the boat. In this way the smaller prawns and shrimps find their way back to the sea uninjured, and any flat-fish which have previously escaped detection also pass through the wires. The fisherman's object being to get the prawns ready for cooking as soon as possible, it is evident that no time will be lost in getting the unsaleable items of the catch out of the way. It remains to be seen whether the small fish of valuable kinds are in any way the worse for their temporary sojourn in the net and on deck.

No doubt the most delicate forms are the young whiting and cod, but I have found occasion to modify an opinion expressed in the last number of this Journal, that the former would not survive even if immediately returned. Both species are always full of life when they come on board (except such as may have been nipped by a shore or swimmer crab in the net, or gorged by a Cottus), but, if allowed to lie on the deck for any time, very soon become sickly and die. If, however, they are at once thrown overboard they swim away apparently little the worse. With a view to ascertaining the degree of vitality as far as possible, on several occasions the small whiting and cod were thrown into a tub of water instead of overboard, and examined at the end of an hour. The conditions might have been more

favorable, as the tub was small, and the water stagnant or only occasionally renewed. The percentage of dead at the end of the hour varied. On one occasion 24 cod and 34 whiting, being the total catch of these species, were placed in the tub. At the end of an hour 21 cod and all the whiting were alive and vigorous, two cod were sickly, and one was dead. The haul on this occasion yielded the usual quantity of prawns, crabs, and lumps of Sabellaria, &c., and I believe the favorable result of the experiment was simply due to the small number of fish, the capacity of the tub being insufficient for the respiration of larger numbers.

Another time the catch included 111 cod and 99 whiting, which were placed in the tub. At the end of an hour (an hour and a half before all were counted) the number of living was 99 cod and 63 whiting. There was some delay in getting the fish into the tub, in which, moreover, they were very much crowded. I do not think that, when fish are returned to the river in the ordinary way, the mortality is ever greater than in this last experiment, and probably it is much less. Other experiments support the conclusion that the cod are more hardy than the whiting, and it was noticed that fish of both species, which appeared moribund when first placed in the water, gradually recovered and ultimately seemed none the worse.

Of course the survival of a fish for an hour cannot be said to prove its absolute recovery, and I had no further means of testing it. The two miles' jolting in a cart involved in conveying fish from the dock to the Cleethorpes tanks proved very fatal to the young cod and whiting, and few of the latter survived it for any length of time. They seemed to suffer much more than the cod from any injury to the skin, such as must necessarily occur from the rostra of the prawns in the net, as well as from handling. Nevertheless, my own opinion, based on the facts which I have recapitulated, is that a large proportion of these returned at once to their natural surroundings escape any serious injury.

Soles and lemon soles, of whatever size, are seldom injured by capture in the shrimp-trawl. Lemon soles are especially hardy. A large number of those which were caught by the "Vallota" were placed in the Cleethorpes tanks. There was slight mortality amongst them for the first few days, probably more due to the journey than to any other cause, but the bulk of them, five months later, are still alive and apparently in excellent health. Soles which had been chafed, either in the net or in handling, ultimately died in the tanks, as at Plymouth (*teste* Mr. J. T. Cunningham, The Common Sole) ; but I do not think it follows that they die if returned to the sea, as soles which have evidently recovered from rather serious

injuries are sometimes trawled. Moreover the very small mesh of the shrimp-net appears to lessen the percentage of chafed fish, since it is in struggling to get through larger meshes that injuries to this species usually occur.

Plaice of all sizes suffer no injury from being caught in the shrimp-trawl, and may even be allowed to lie on the deck a considerable time without being any the worse. There has been very little mortality amongst a great many of all sizes which were placed in the Cleethorpes aquarium, whereas I have always experienced a difficulty in getting similar specimens, taken in the shove-net, to live. This may be due to the amount of mud and sand in suspension in the only water available for conveying shove-net specimens to the aquarium, or it may be that the buoy of the shrimp-trawl is beneficial in slightly lifting the cod end off the ground.

Flounders are about as hardy as plaice under similar circumstances.

Dabs, unlike plaice, will not survive a long exposure on deck, the very small specimens being particularly delicate. The mortality amongst those sent to Cleethorpes was at first considerable, though a good many survived. Still, if they are returned to the sea at once, they dart away apparently uninjured. This species appears even more susceptible to injuries arising from chafing than the sole.

*Conclusions.*—It appears to me that the facts I have set forth show that capture in a shrimp-trawl in the ordinary course of the industry is not essentially injurious to any considerable proportion of young fish of marketable species. If shrimp-trawlers bring to market some small plaice and soles which ought really to be returned to the sea, it is not easy to blame them as long as the same practice, as far as plaice are concerned, is carried on with perfect impunity on an infinitely larger scale by the larger boats which visit the eastern grounds. The remedy for this evil lies so evidently in the imposition of a size-limit applicable to all North Sea fisheries alike that the subject needs no discussion here. Moreover it is apparent that the bulk of the small flat-fish, which, for reasons explained at the time, I found it necessary to class as caught by shrimp-trawling, were in reality derived from the illegal use of fish-trawls.

I have made it, I hope, sufficiently evident that, except off Tetney, flat-fish are so exceedingly scarce on the prawning grounds that there is not even the risk of them being injured thereon.

I am not prepared to say that, in the case of so large a catch of small fish as has been enumerated from the Sand Haile shrimp-ground, some considerable number of small dabs and, to a less extent, plaice, might not have suffered, since to sort them out would

take a good time; but as a matter of fact the take on this occasion was so worthless that the fishermen, after picking out the few saleable fish, would, no doubt, have shot the remainder straight overboard. Indeed, both shrimping grounds might be said to be effectually closed, at the time we visited them, by their very unproductiveness.

It must be remembered, also, that whenever any number of small flat-fish occurred, the majority of them were always common dabs, and I would call attention to the opinion expressed by Fulton (Rep. S. F. B., 1890) that it is questionable whether any benefit is to be derived from protecting the young of this species, since it is never of great value, and is a most severe competitor with fish of greater value, *e. g.* soles and plaice, in the matter of food.

In any case it appeared to me that by confining the operation of the closure to the shrimp grounds and the Tetney prawn ground, enough would be done at that season of the year to practically eliminate the risk of destruction of immature flat-fish, whilst the legitimate conduct of the industry would be hardly at all affected thereby.

My recommendations to the Fisheries Committee, in reporting the results of the operations under their auspices, were accordingly made on the above lines, though it was expressly stated that they could only claim to hold good for the period during which the investigations were made. The Committee subsequently repealed their former bye-law, and substituted one which granted the extension of the open season prayed for in the petition to which I have alluded. The use of the shrimp-trawl is therefore now lawful in the waters with which the bye-law deals from the 1st March to the end of October. Though it has not appeared, from the results obtained during last March (1893), that either prawns or shrimps are to be had in sufficient numbers to make their pursuit profitable so early in the season, I have little doubt that the measure will be found on the whole satisfactory, once the enforcement of the existing prohibition against fish trawling shall have removed the imputation which the conduct of a few individuals now allows to rest on the whole fraternity.

For my own part, I have always advocated legislation which deals with the size of fish landed, so far as flat-fish are concerned, rather than with the kind of trawl in which they are caught. Since I am satisfied, from the whole of my experience of the Humber fisheries, that the absolute lack of mature fish in the river would preclude the existence of a legitimate plaice fishery, whilst flounders and dabs are neither sufficiently numerous nor valuable to attract pursuit by themselves, the imposition of a size limit would in effect limit the use of fish-trawls to a short period in the summer when there are some

mature soles in the river, if it did not abolish it altogether. This may seem, as it were, an academic discussion, since it is allowed that the same or nearly the same end is attained by either means; but the method I favour would be an effectual safeguard against the abuse of shrimp-trawls for catching small plaice on grounds where neither prawns nor shrimps are to be had. I have found such a practice to be quite feasible, and have no doubt it might be occasionally remunerative, but I must confess that I have no knowledge that the possessors of shrimp-trawls ever divert them from their legitimate prey.

*Migrations and spawnings of shrimps and prawns.*—Shrimps and prawns seem to arrive at about the same time, viz. the beginning of April, on those grounds in the Humber which they respectively frequent, but the time of arrival, as of departure, is said to vary according to the weather. My own experience is too short to enable me to offer any comments on this point.

The shrimp season for shove-nets usually closes about November, though in very open winters it is said to last longer. The quantity present on the sandy margin, so far as this can be gauged by the takes, is at all times subject to rather sudden variation, and becomes, I believe, especially variable after the end of September. Any diminution in the normal turbidity of the water, more readily perceived by those engaged in the industry than others, is regarded as prejudicial to good catches. The variation of the trawling grounds appears to be even greater than on the margin. Some few shrimps are found in all parts of the river throughout the year, but I do not know what becomes of the remainder in the winter. In digging for lugworms, in February, near high water mark I have found a shrimp, living but very torpid, some few inches below the surface of the sand, at a time when none were obtainable in the shove-net; but it would be unwarrantable to conjecture from this single instance that any considerable number take refuge in this manner during the winter months.

I have made no effort to ascertain the chief spawning period; here, as elsewhere, some shrimps are found carrying ova at all seasons.

Prawns are certainly most abundant in the Humber in summer. It is commonly asserted that a north-westerly gale in autumn has the effect of driving large numbers of them out of the river, and I had the opportunity of observing last year that the number obtainable certainly decreases after such weather. It is also said that once their bellies turn green they begin to leave the river. The green colour is that of the ova attached to the abdominal appendages. We found only a few with spawn at the beginning of October, but later in the same month and in the early part of November the

proportion in that condition increased rapidly, whilst there was a considerable decrease in the total number as compared with that obtainable on the same grounds earlier in the season. Our operations were not carried on late enough to show the final disappearance of the species, but I am given to understand that none, or hardly any, are to be found in the Humber in December. I am told, on authority which I have found reliable in other matters, that the prawns, on leaving the Humber, pass to the deeper grounds along the Yorkshire coast, and I know that the species is to be found there in the winter. It has a very wide vertical range, extending well beyond the 100-fathom line on our western coasts.

*Recent literature.*—The very interesting report of Professor Herdman "On the Lancashire Sea Fisheries Laboratory" (Liverpool, 1893) deals with shrimp-trawling in some detail. From certain statistics collected by Mr. Dawson it is evident that the number of small fish captured in that district by shrimp-trawlers is infinitely greater than anything we have to deal with here. Both shrimps and "shanks" (the local name for our prawn, *Pandalus annulicornis*) appear to be taken by trawlers, but it is not remarked whether there is any difference, as here, in the amount of fish taken in company with these two crustaceans. Mention is made of a prawn-net, presumably a trawl, devised by Mr. Dawson, in which a horizontal bar, 3 inches above the ground, is substituted for the ordinary ground-rope. This is an adaptation, probably an unconscious one, of a principle which has been employed for some years in the bottom tow-nets used at the St. Andrews Marine Laboratory.* The object is to catch prawns and pass over small flat-fish, and, according to Mr. Dawson, this object is achieved. It is also claimed that such a net picks up less débris than one of the ordinary pattern, and therefore fishes better on dirty ground. This is of some importance, as, although a very thick ground-rope is used by Humber fishermen to avoid the capture of "ross," they often catch a good deal, especially early in the season, before the winter's accumulations of the Sabellaria have been to some extent trawled flat. Still it is open to doubt whether a rigid bar would not be an additional difficulty in case of contact with a clay bank, and it would perhaps be better to replace this by a taut rope. In any case I do not see how such a contrivance would lessen the capture of young cod and whiting, which are the only important fish caught in any numbers on our prawn grounds.

* I understand that a similar contrivance has long been used for fishing rough grounds at Yarmouth.

*Shore Fisheries.*

*Stake-netting.*—This industry has again proved a failure at the Cleethorpes station. Nets were first set up there in January, but proved so unproductive that they were soon taken down again. Another trial in February was not more successful. At Humberstone, however, the nets did much better. They were first erected in the early part of January, and by the end of that month tolerable catches were obtained, 16 stone for one day being the largest amount of which I have a note. This was on the 28th of the month. Two days earlier only 5½ stone were found in the nets, after they had been fishing for nine days; there were also, according to my estimate, about two stone of young whiting, from 4 to 6 inches long, besides a few codling about 3½ inches long, and a certain number of plaice from 6 to 8 inches. As after this date the catch of sprats improved so much that it was worth while to lift the nets every day, or sometimes every tide, the number of young whiting became much less noticeable, though the total number destroyed in the same number of days may not have been any less. A few very small plaice, about 1 to 3 inches, were always to be found. The sprats at first comprised a good many that had hardly got beyond the whitebait stage, but towards the end of January and in February the size as well as the numbers increased. More nets were added to the Humberstone station, as many as 30 being down altogether. Thirty-five stone is the largest catch for one tide which I observed. The industry continued to be remunerative up to about the middle of March.

*Shove-net and "seine" shrimping.*—These industries closed for last year about the end of September, and up to the end of March of the present year shrimps have not been found in sufficient numbers to encourage the fishermen to make a regular start. A few small plaice, however, and a brill of 9 inches were taken in a shrimp-seine on the 10th March. It is worthy of remark that regulations affecting the use of shrimp-trawls apply equally to the shrimp-seine, which is undoubtedly a trawl in spite of its name.

*Flat-fish netting.*—This is a shore fishery to which I omitted to allude in my last report. The net resembles an ordinary ground seine. It consists of a piece of netting, mesh about the same as in a herring-net, about 20 yards long by a yard high, corked and leaded. The ends are kept open by pieces of wood. The net is worked by two men, each having a rope attached to one end of it, who wade about 10 yards apart along the shallow water near the margin and haul the net behind them. In the summer a considerable number of small plaice and some soles are said to be procurable in this

way, but the nets are not very often used. On the only occasion, in February, when I saw one worked, the only thing in the catch worth having was a smelt. As the nets are preferably hauled when the tide is rising no injury is done to the fish which are not saleable.

### III. Remedial Measures.

Whatever success may attend the enforcement of a size-limit for flat-fish, there can be no doubt that this remedy will not be efficacious in the case of all round-fish, since (1) there is no area (such as the eastern grounds for small plaice and turbot) exclusively, or almost exclusively, inhabited by immature members; and (2) round-fish are liable to absolute destruction by the mere fact of being caught in the big beam-trawl as at present worked.

I have shown elsewhere that the shrimp-trawl worked in short hauls in shallow water is not in this district (and need not be, I suppose, in any district) particularly injurious to the small round-fish which frequent the areas where such engines are used, but the case in the deep sea is very different.

The approach of the trawl to the surface, even in such very moderate depths as 20 to 30 fathoms, is always marked by the appearance of a number of haddock, which float up with distended air-bladder through the mouth of the net or larger meshes of the "square," and drift helplessly about, a prey to the sea-gulls. When the net is boarded, a number of the smaller haddock are found meshed by the gills and perfectly dead, and very few are particularly lively. I have made efforts to keep those which appeared the healthiest alive in a tub of water, frequently changed, but never with success. I have, however, known a haddock, caught in the deep sea, to be brought into the Cleethorpes aquarium alive, but it died very soon. The skin is very delicate and easily inflamed, but I think the pressure of the weight in the trawl is more fatal, since line-caught haddock, which must get more or less handled, live well enough in the ship's well. Liners find it necessary, unless the fish are from very shallow water, to let the air out of the bladder if they wish the fish to live; and this they do, as also with cod, by a prick with a needle above the pectoral fin, care being taken to avoid the liver. Cod treated in this way live for months in the floating boxes in Grimsby Docks, and I suppose haddock would as well. I am told that even ling, in which the stomach has been everted by the pressure of the air-bladder, can be kept alive by the same means, though in this case the puncture is usually made above the anus. Now this process is well enough for the liner, who finds it tend, moreover, to his immediate profit, but I do not think it is feasible to

any very great extent on board a trawler. Though cod are somewhat hardier, haddock, especially small ones, succumb very rapidly if kept out of water; and it is certain that, even if they were attended to before the second trawl (where two are carried) was shot away, many out of a large catch would be beyond surgical aid before it arrived. Flat-fish, on the other hand, are better fitted, by the structure of their gill-covers, to stand exposure to the air, and, in general conformation, to resist pressure, whilst they are, of course, subject to no difficulty arising from an air-bladder. Hence, since only moderate hauls are now to be obtained on any grounds other than the eastern, a large proportion of the undersized members of the hardier kinds would probably survive if returned. Of the less robust species, two, the common and long rough dabs, are of small account, and undersized specimens of the third, the witch, appear to be seldom taken by our trawlers.

To return to round-fish. If, as I hold, no great number of those taken in our large trawls would survive if returned, it would serve no useful purpose to throw them back. Hence the only possible remedy lies in some scheme of mesh restriction, as to which I am not prepared to make suggestions. Though, thanks to much assistance from Mr. Woodall, my inquiries as to relation between size and pattern of mesh and size of fish caught have made considerable progress, I do not consider them as yet complete or conclusive.

It may be pointed out, however, that while it may be hoped that all immature whiting and at least a great proportion of immature haddock may be afforded a reasonable degree of protection by a successful adjustment of the mesh difficulty, there can be no hope by this method of protecting cod beyond a size which is far short of that at which sexual maturity is attained, and of course no net can be devised which will not be liable to get choked by weeds or other rubbish. Every one, I suppose, admits that a fish should have a chance of spawning before it is killed, but I really cannot say how this advantage is to be secured for the codfish. If it were possible to persuade those trawlers who, as I have shown, have been responsible for most of the destruction of codling during the past winter, that it would tend to their ultimate advantage to avoid the grounds most frequented by these fish, one might hope for a sensible mitigation of the evil. It is, however, sufficiently difficult to persuade a man of what is absolutely true, whereas, since adult cod are the prey of the liner rather than the trawler, the proposition perhaps hardly falls into such category.