Preliminary Note on Experimental Trawling with Cod-End Meshes of Different Sizes.

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1. General.

The general lines on which work is being developed by the Ministry of Agriculture and Fisheries with regard to fishing apparatus to which the term "Savings Gear" has come to be applied may briefly be stated as follows:— The testing of new apparatus designed to spare undersized fish and the modification of the existing gear used by commercial trawlers, in such a way that fish which are of almost marketable size may be allowed to escape and live until they have reached at least the lowest market category.

It is clear that the simplest problem is that presented by round fish, and most of the research work has been carried out on such fish and principally on haddock. The intense conservatism of the fishing industry has been borne in mind, and, as far as possible, work is confined to schemes entailing no radical departure from the ordinary design of the otter-trawl.

The problem has been treated as being of a practical and economic rather than of a purely biological nature, since it is obvious that, although it would appear impossible completely to fish out any species (regardless of size and age), the present method of capturing and killing large numbers of a species just below the size at which they become of commercial value is extremely wasteful.

For example, say the size at which the members of a certain species become marketable may be represented by a length of x cm. and the mean growth of individuals during the year before they reach that length is y cm. per annum; it is then obviously wasteful to capture any

fish between x—y and x, since the fish of length x—y cm. will in the course of a year's growth reach length x cm. The extra months of life for these, the smallest of the fish under consideration, would convert them from a useless litter on a trawler's deck into a useful, marketable article. The extra life necessary for fish greater than x—y but less than x would of course be less.

Although it is obvious that the catching and killing of fish just before they are of marketable size is wasteful, we have little or no knowledge as to the effect of sparing all fish of under-marketable size. It is conceivable that a consequent accumulation and overcrowding of the lower sizes might produce a slow growth-rate for the species. Such a phenomenon appears, at first sight, conducive to irrational and uneconomical "farming of the sea". The writer is inclined to believe that did such an accumulation occur, even if accompanied by overcrowding, it would react favourably rather than unfavourably on fisheries.

For instance, supposing the mesh in use released the majority of a certain species below x cm. then a certain amount of fish of that species would pass length x every year and become of commercial value. It seems to the writer that the fact that the growth might be slow is immaterial. The accumulated stock would form a "pool" and act as a "shock absorber" which will damp down the effect of a bad survival year of the 0-group producing a bad fishing year. On the other hand, a fishery which is dependent on a sparse, fast growing population of, on the average, only sufficient magnitude to supply the demand, is extremely hard hit by any year of bad survival and therefore very unstable.

It may be taken that 26 cm. is the size at which the haddock becomes regularly and consistently marketable, and this length coincides roughly with the end of the second year of growth.

2. Methods.

The data on which this paper is based consist of hauls with a standard No. 4 Granton Trawl (headline 80 feet, ground rope 120 feet) fitted with cod-ends of various meshes. The cod-ends were in some cases fitted with a cover of fine meshed net. Throughout the experiments the cod-ends were made of material such as would normally be used by commercial trawlers, the only difference being in the size of the mesh. This material was 3 ply manilla 100[1]) doubled as is the general rule on commercial steam trawlers.
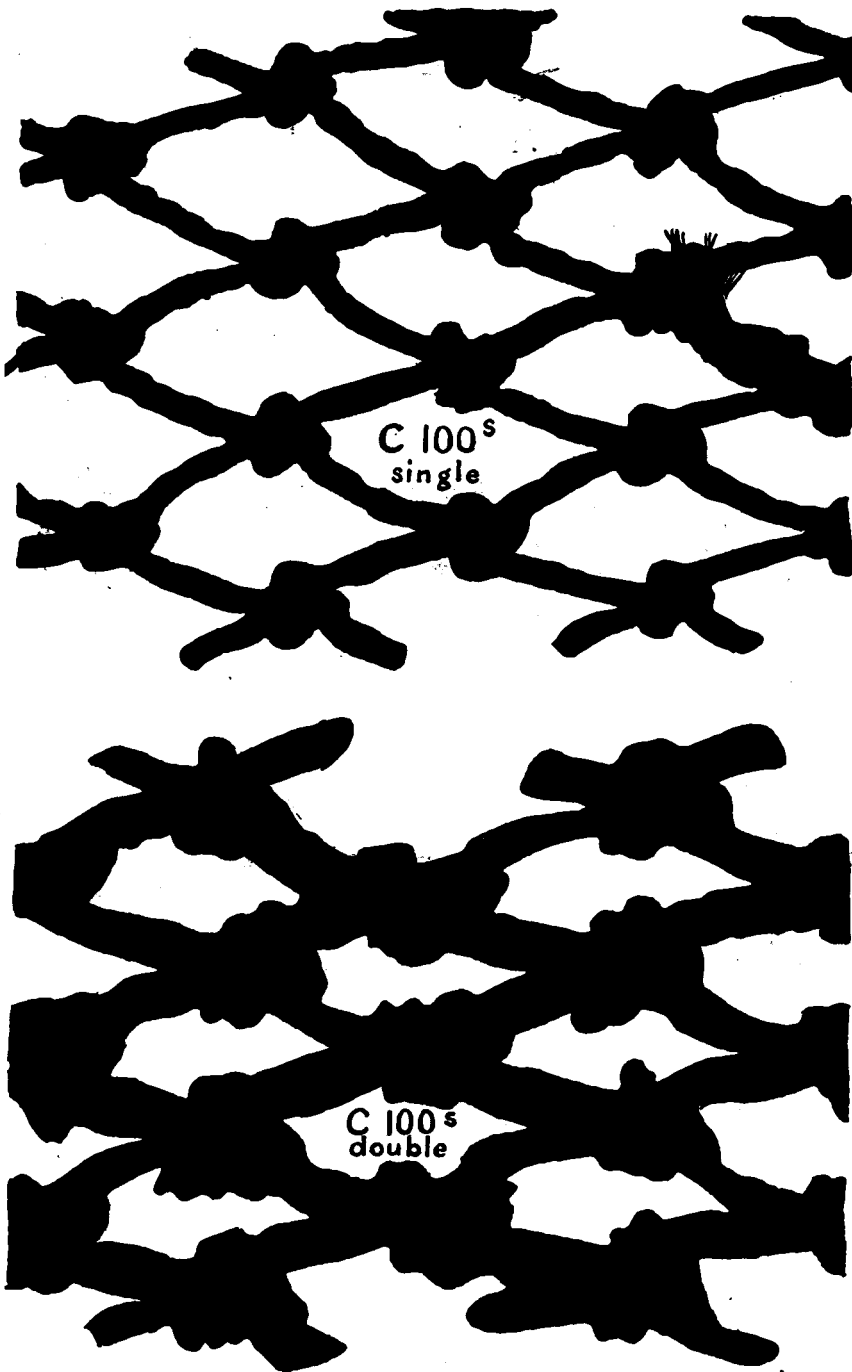
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1) i.e. 100 yards to the pound.

C 100^s
single

C 100^s
double

Fig. 1.

D. 200ˢ
single

D. 200ˢ
double

D. 100ˢ
single

D. 100ˢ
double
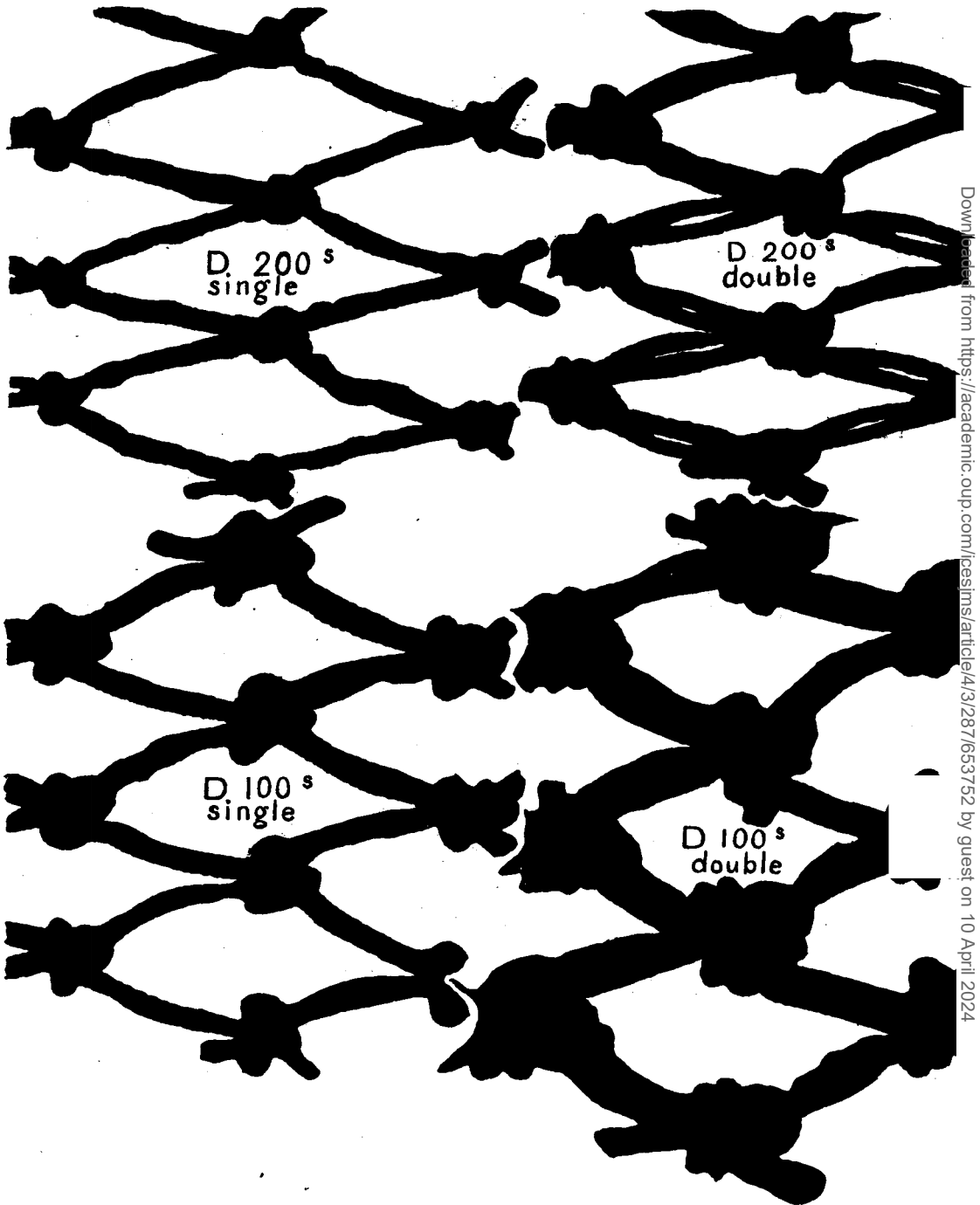
Fig. 2.
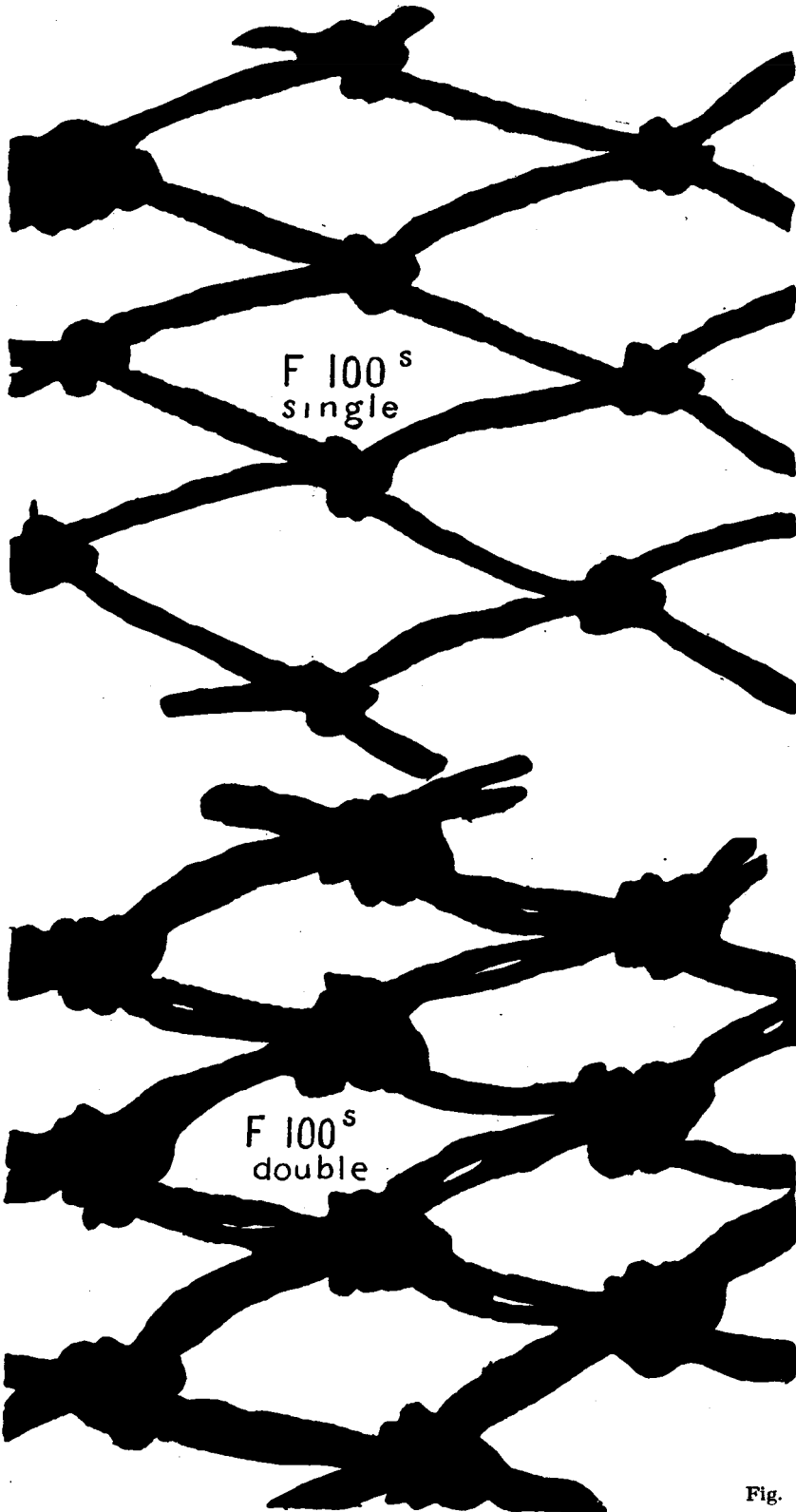
F 100^s
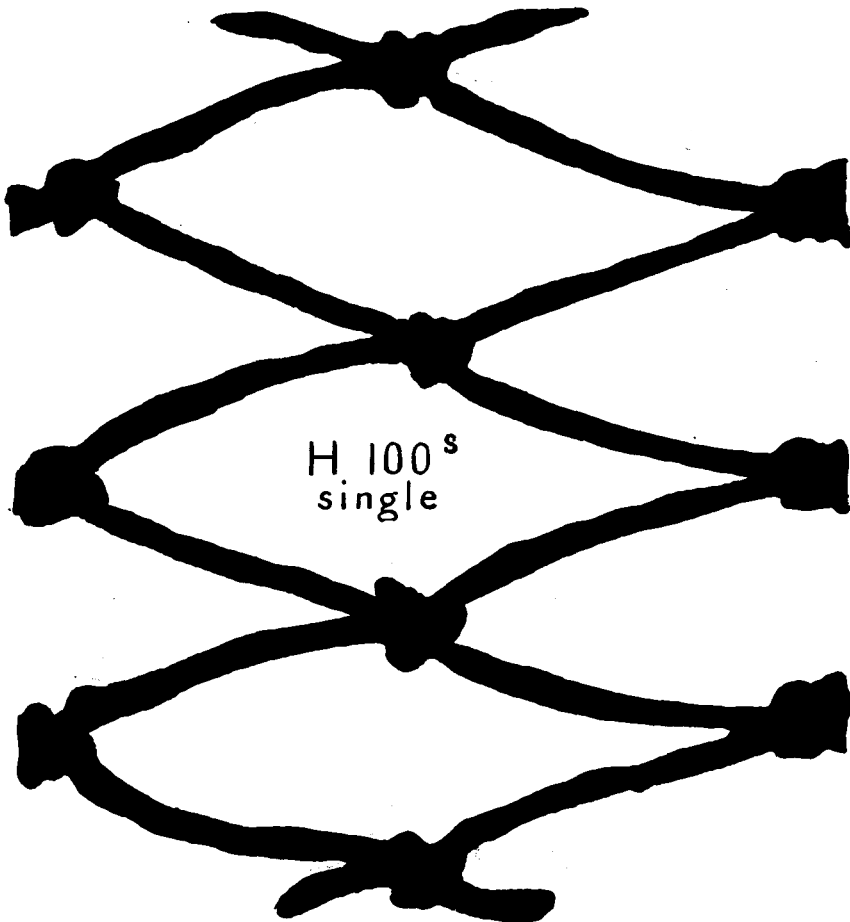single

F 100^s
double

Fig. 3.

H 100^s
single

Fig. 4.

Previous to the actual experiments at sea a certain amount of work was carried out with a view to discovering the probable effective lumen of meshes made on spools of various sizes and of twine of various sizes both single and double. The circumference of the spool may be considered as being roughly equal to half the circumference of the lumen of the mesh, or to the total length of the lumen of the mesh when stretched to its fullest extent in a fore and aft direction, due allowance having been made for the thickness of the twine. The spools used were as follows:—

C, circumference 5 cm.   F, circumference 8 cm.
D,   —   6 -   G,   —   9 -
E,   —   7 -   H,   —   10 -
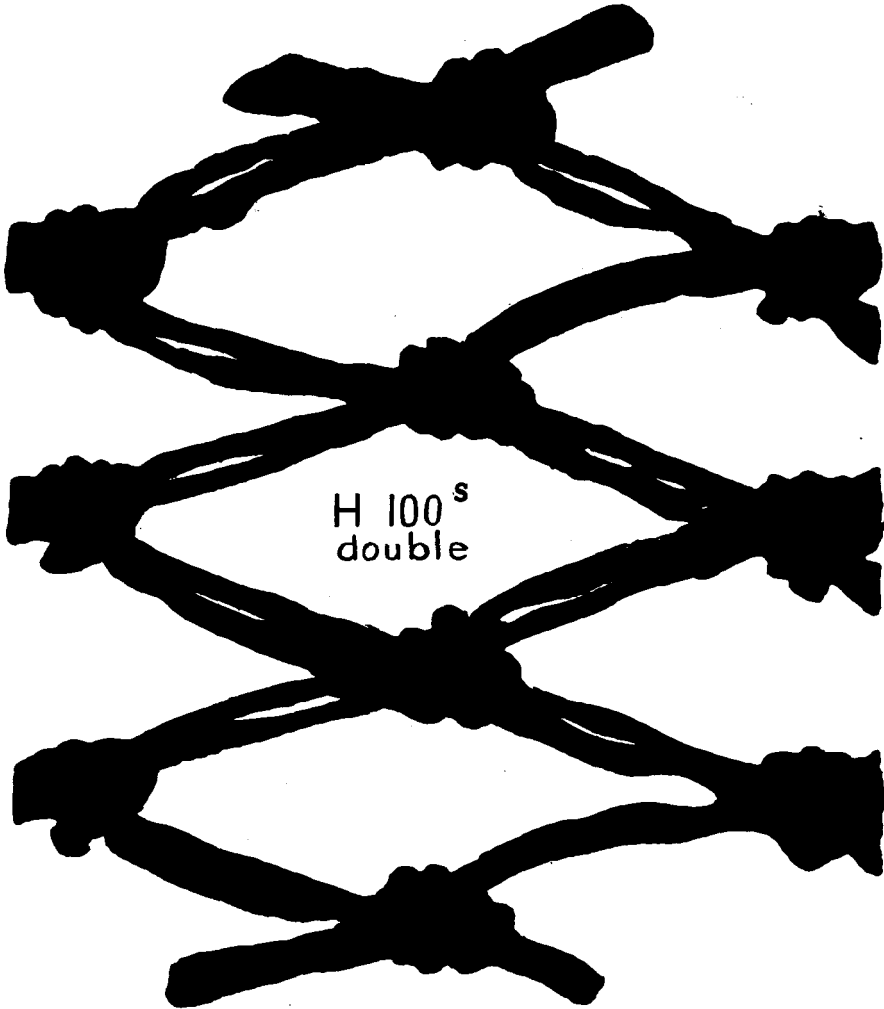
H 100 ^{s}
double

Fig. 5.

Contact prints were made of samples of net made on these spools and tracings of them are shown in figures 1—5. The great difference in lumen according as to whether the mesh is made of single or double twine and according to the size of the twine is obvious as is also the great reduction of lumen produced by the knots in some cases.

In general, the laboratory work with gauges seemed to indicate that one of the main factors influencing the size at which a fish would pass through a mesh of a given size was the maximum breadth of the fish whether flat or round.

As regards the sea work, experiments were continued with the trouser

cod-end previously described in this Journal[1]), but were eventually discontinued after they had given indications of the best sizes of mesh with which to carry out the main experiments. The trouser cod-end, though most useful for providing rough indicative data at small cost, is not considered reliable for fundamental experiments, as, in addition to its obvious limitations, as compared with a normal commercial cod-end, it shows a tendency for the after[2]) leg to take a considerably larger amount of fish.

The main experiments were carried out in the North Sea on haddock grounds with cod-ends made on the 10 cm. spool and to the South-west of Ireland on hake grounds with cod-ends made on spools of 6, 8 and 10 cm. circumference, the twine being that specified above (3 ply manilla 100[s]) and untarred. The measurements of the meshes made on the 10 cm. spools averaged 23 rows per yard under working conditions with very little variation under all conditions. This represents a knot to knot lumen of 7—8 cm. (ca. 3 inches) when the mesh is stretched fore and aft.

It has often been stated verbally, and it is the belief of many workers, that the covering of a cod-end with shrimp netting causes it to retain a higher proportion of small fish than does a cod-end fished without a cover. It is stated that either the cover "spoils the draught" of water through the net or lies close against the meshes of the cod-end, thus preventing the passage of fish through them. The writer therefore carried out preliminary experiments to find out whether a well made and well set cover had any effect on the proportions of the fish retained at various sizes.

It is obvious that if the cover is closely applied to the main cod-end and does not form a clear bag when the net is being towed, there must be a blanketing effect. A cover that will flow clear and not sag onto the cod-end is therefore a necessity. The cover used by the writer was similar to that used in the Swedish experiments on the Savings Trawl. The shrimp netting was supported clear of the cod-end by means of rattan canes and there was thus formed above the cod-end a spacious chamber which continued backwards. The underside of the main cod-end was also lined with shrimp netting. This reason for this step was that, as the underside of a cod-end is already blanketed to a certain extent by "false bellies" or "rubbers" and by its close application to the bottom, it was thought that the data would be easier to interpret if the escape

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[1]) Russell and Edser. Vol. I, No. 1.

[2]) i.e. the leg which lies aft when the net is being hauled alongside the vessel. When the gear is being hauled on the starboard side it is the port leg.
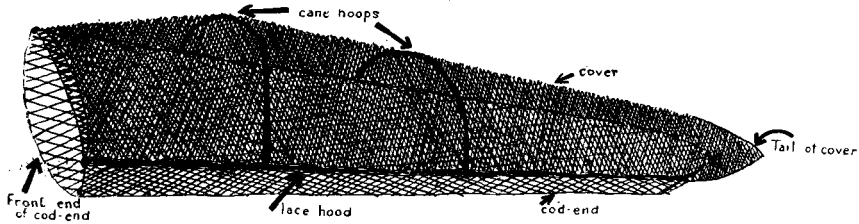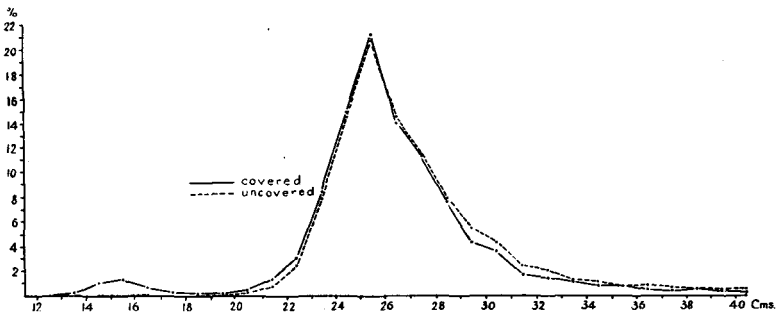
Fig. 6.

Fig. 7. Voyage C 1929. Percentage of Haddock retained at each centimetre length in cod-end both covered and uncovered. (12 hauls of each.) Ordinary Otter-Trawl.
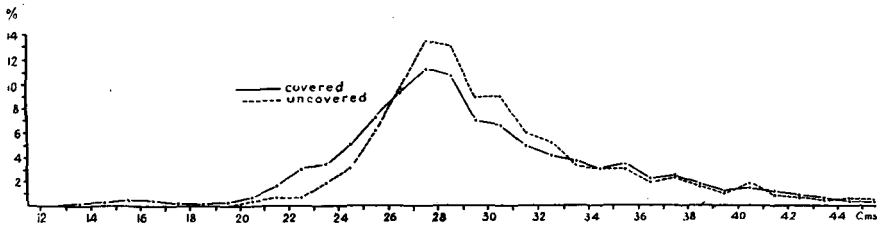

Fig. 8. Voyage D 1929. Percentage of Haddock retained at each centimetre length in cod-end both covered and uncovered. (5 hauls of each.) Modified V.D.
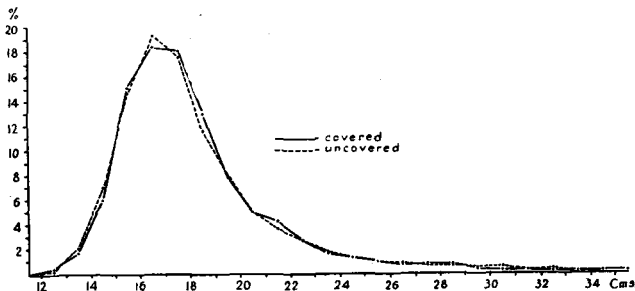

Fig. 9. Dabs. Cruise C 1928 and D 1928. Percentage of Dabs retained at each centimetre length in cod-end both covered and uncovered. (6 hauls of each.) Ordinary Otter-Trawl.

of fish from the underside of the net were completely eliminated. Figure 6 shows the cod-end and cover but not the lining of the underside.

24 hauls were taken with the trawl, and the 10 cm. cod-end was fished, covered and uncovered in alternate series of three hauls each.

The percentage of each length of fish retained in the cod-end was calculated for the covered and uncovered series. The results, which are based on 7,767 haddock in the uncovered and 7,805 in the covered cod-end, as shown in fig. 7, show little difference in the two frequency distributions.

A further experiment was carried out with 10 hauls of the same trawl fitted with 30 fathom ground warps, Dan Lenos, and glass balls on the headline, in other words fitted as a "modified Vigneron-Dahl." This experiment (Fig. 8) did not give such satisfactory results, but the fishing appears to have taken place on a very irregular population; 2,814 haddock were taken in the uncovered cod-end and 4,158 in the covered.

Earlier tests on small dabs with a standard $2^1/_2''$ cod-end which released 46 $^0/_0$ of fish of 19 cm. and under gave strikingly good results (Fig. 9).

In the light of this evidence the writer is of the opinion that a well made, roomy cover well supported by canes gives reliable results, and that the use of covered cod-ends is superior to the more laborious method of alternate hauls or series of hauls with a small meshed cod-end and the large meshed cod-end under investigation.

3. Results.

The results of the main experiments on haddock are shown in Fig. 10 where the numbers of fish taken in the cod-end and cover are shown for the ordinary otter-trawl (A) modified V.D. (B), and the total for both types (C) the points on the graphs being the results of 3-point smoothing of the actual figures. It is obvious that in the two former cases and, of course, consequently, for the latter the lengths at which 50 $^0/_0$ are taken and 50 $^0/_0$ released are practically the same, namely 23.5 to 24 cm.

Fig. 11 shows the percentage of haddock released at each cm. length based on all hauls with the covered normal Granton Trawl and the same net modified as a V.D. and covered. It would be convenient at this point to have a rough and ready index of the sharpness of selection of a net. Now a net with a 100 $^0/_0$ sharpness of selection would release all fish being released below the selection point and retain all above it.
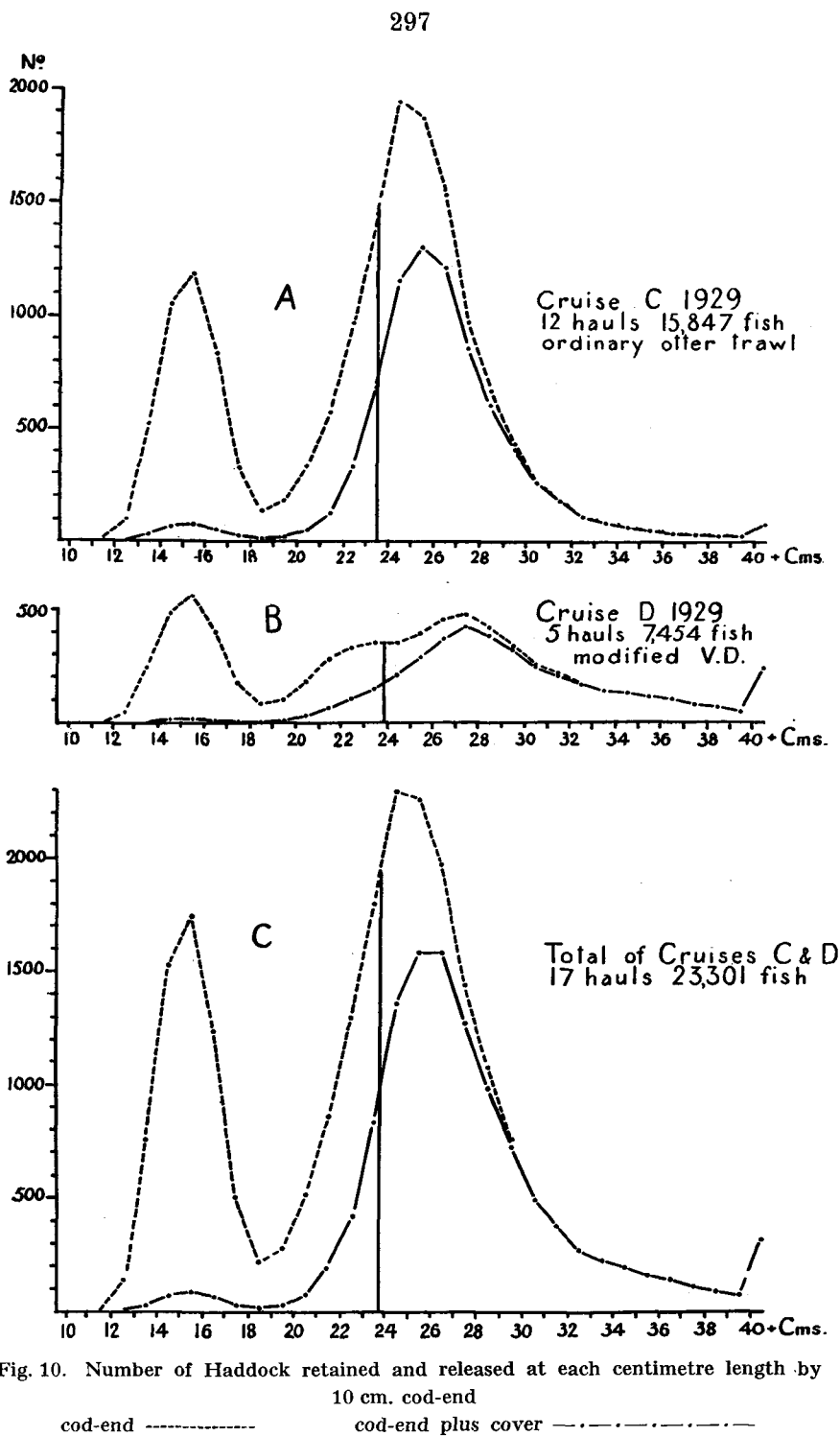
Fig. 10. Number of Haddock retained and released at each centimetre length ·by
10 cm. cod-end

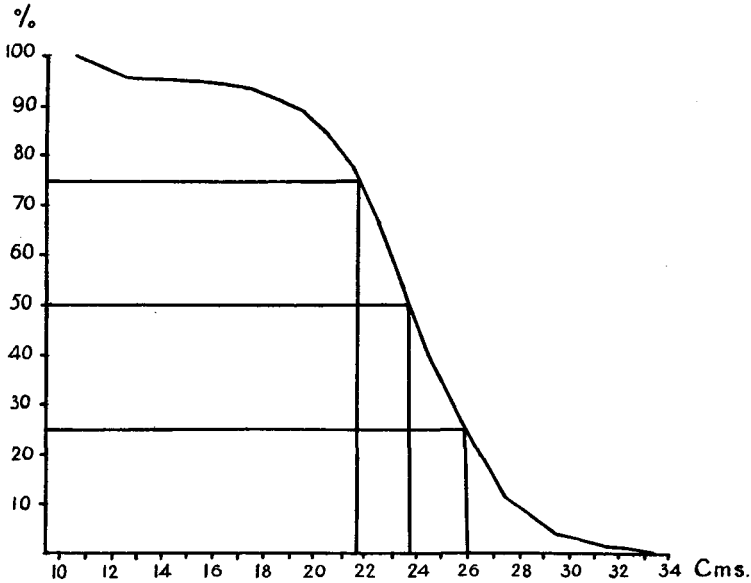cod-end ---------------   cod-end plus cover —·—·—·—·—·—·—

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Fig. 11. Haddock. Percentage released at each centimetre length by 10 cm. mesh. Otter and Modified V.D.

My colleague, Mr. H. J. B. WOLLASTON, suggested the following formula which in common with others[1]) would give for the net of 100 % efficiency of selection, the number 100. $x = 100 \left(\dfrac{M - i.r.}{M} \right)^2$). In the case of the data taken graphically from Fig. 11 the result would be

$$x = 100 \left(\frac{23.8 - 4.3.}{23.8.} \right) = 82.$$

This question of the sharpness of selection is important since the greater the sharpness of selection the less marketable fish are released along with the unmarketable.

Assuming that 26 cm. is the limit above which haddock are always marketable, then this cod-end, according to the experimental data, loses 11 % of marketable fish up to 33 cm. and releases 52 % of the unmarketable above 18 cm. the latter being exclusive of the fish of less than 18 cm. which of course mostly escape capture. Actually the saving of fish below 18 cm. amounted to 95 %.

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[1]) See paper in this number pp. 300 et seq.

[2]) M = Mean-Length at which 50 % are released and 50 % retained. i.r. = Interquartile range = difference between lengths where 75 % are released and 25 % are released.

The net result is that given a mesh of this type in common use practically the whole of the 0-group (i.e. under 18 cm.) is able to survive and 50 % of the I-group (i.e. under 26 cm.) has a chance of attaining marketable size. The loss of the 11 % of the fish of 26 to 33 cms. of course may be a much smaller percentage of the total marketable catch (in this case 9 %). The actual percentages released at each cm. length were as follows:—

cm. 26   27   28   29   30   31   32   33   34 & over
%................ 20.0 11.4 8.1 4.5 3.3 1.5 1.1 0.4 0.0

The data on which these results are based are for the beginning of the growth period and the end of the period of least growth, i.e. March. Before the results can be considered sound and authoritative it is necessary for the experiments to be repeated towards the end of the growth period when a larger number of fish near the point of release are present. This is being done during the present year.

Work has also been carried out on the hake grounds to the SW. of Ireland with covered cod-ends made on spools of 6 cm., 8 cm. and 10 cm. clear, 13 hauls being taken with the first (5359 fish), 22 hauls with the second (5716 fish) and 17 with the last (6271 fish). It is not proposed to discuss in detail the possible effects on the hake stock of using larger meshes as the data are not yet sufficiently extensive. The actual results were as follows:—

6 cm. mesh.   All fish retained at 22 cm. and only 3.5 % released at 16 cm.
8 cm. mesh.   75 % released at 17 cm., 50 % at 21 cm., 25 % at 23 cm. All retained at 30 cm.
10 cm. mesh. 75 % released at 22 cm., 50 % at 26 cm., 25 % at 29 cm. All retained at 41 cm.

In general it appears that the use of the 10 cm. mesh would have a beneficial effect on hake as well as on haddock.

Further experiments with the 10 cm. mesh both on haddock and hake are due to be carried out in the near future.