SVENSKA

HYDROGRAFISK-BIOLOGISKA KOMMISSIONENS

SKRIFTER

Ny serie: Hydrografi VII

THE SWEDISH SAVING-TRAWL

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THE President of the International Council for the Exploration of the Sea, has in a circular of October 26th 1929 invited each of the experts engaged in improving the fishing gear used in sea fishery, with a view to saving undersized fish, to submit reports of their experiences and experiments.

The experiments I have to report were carried out partly on board the research vessel »Skagerak» under Captain K. L. Sunde and partly with motor boats using the Danish seine with a saving gear — recommended by our Government for use in the catch of the witch (Pleuronectes cynoglossus) which forms an important part of the Swedish fishery — under the superintendence of Dr. A. Molander and Mr. A. Nilsson, trawling master.

I.

REGARDING THE CONSTRUCTION OF THE SAVING GEAR

The first suggestion for improving the trawl was submitted by the undersigned in 1909 and appears in Rapports & Procès-Verbaux Vol. XII, p. 14.

»Nowhere in the International Study of the Sea were there made greater advances during the last seven years than with regard to the subtlety of the analytic methods and to the perfection of the apparatus. At present we have an 'embarras de richesse' of new constructions of water-bottles, currentmeters, plankton-nets etc. But all these inventions only mean progress with regard to the technics of the scientific study. In our annals not a single progress in the development of the technics of the practical fishery is recorded. And still an improvement of the nets used for the highsea-fishery to the end that they might counteract the annihilation of the young fishes would be of far greater interest than the invention of new scientific apparatus.»

»I should like to propose the Council to charge the Bureau with deliberating the best way to further the invention and testing of less destructive nets for highsea-fishery.»

(O. Pettersson)

Experiments with saving gear constructed in accordance with the principle stated by me, of allowing the small fish to escape through a window with unalterable rectangular meshes were carried out by Ridderstad in 1911—1918 and led to the following results:

a) The saving section must not be placed in the cod-end of the trawl but between the belly and the cod-end so that the fish to be saved pass by the window and can escape uninjured through its meshes before they come into the cod-end.

b) The passage below the window must be so constructed that the fish are compelled to pass close under the meshes of the escape-window.

This is achieved by an inner net being stretched under the window so that the fishes on their way to the cod-end are obliged to pass between this net and the window.

Ridderstad[1] wished to accomplish this by fitting the trawl with an iron contrivance that was to keep the minor net at a certain distance from the window: This mechanism made the trawl unwieldy and is now obsolete and has been replaced by a lighter construction.

This saving gear is sewn between the belly-bating and the codend in an ordinary fishing trawl. All Swedish saving gear are made on board the vessel or at Bornö station by the trawling master with the assistance of one of the crew.

The method of testing the effect of the saving trawl is:

a) To examine the stock of fish in that part of the sea under consideration. This is done by an experimental trawling with an ordinary fine mesh trawl (what is called a herring trawl).

b) The size of mesh to be used for the window is determined on basis of the knowledge gained regarding the number, age-classes and dimensions of the stock of fish. The Swedish Commission is of opinion that all round fish under 30 cm. in length and all flat fish under 26 cm. ought to be spared.

c) The herring trawl is then divided into two parts and the intermediate part, which contains the saving gear, is fitted between the bating and the codend. This can be done in half an hour.

d) Finally fishing experiments are made with this composite trawl with fine-mesh saving net fitted over its openings (the window etc.) to receive the undersized fish.

[1] G. Ridderstad: A new construction of trawl-net intended to spare undersized fishes, Svenska Hydrografisk-Biologiska Kommissionens skrifter VI.

II.

DIMENSION OF MESHES

If we go to details the first question is to choose the dimension of meshes, which of course depends upon what kind of fish we want to capture. The most valuable fishes in the North sea are

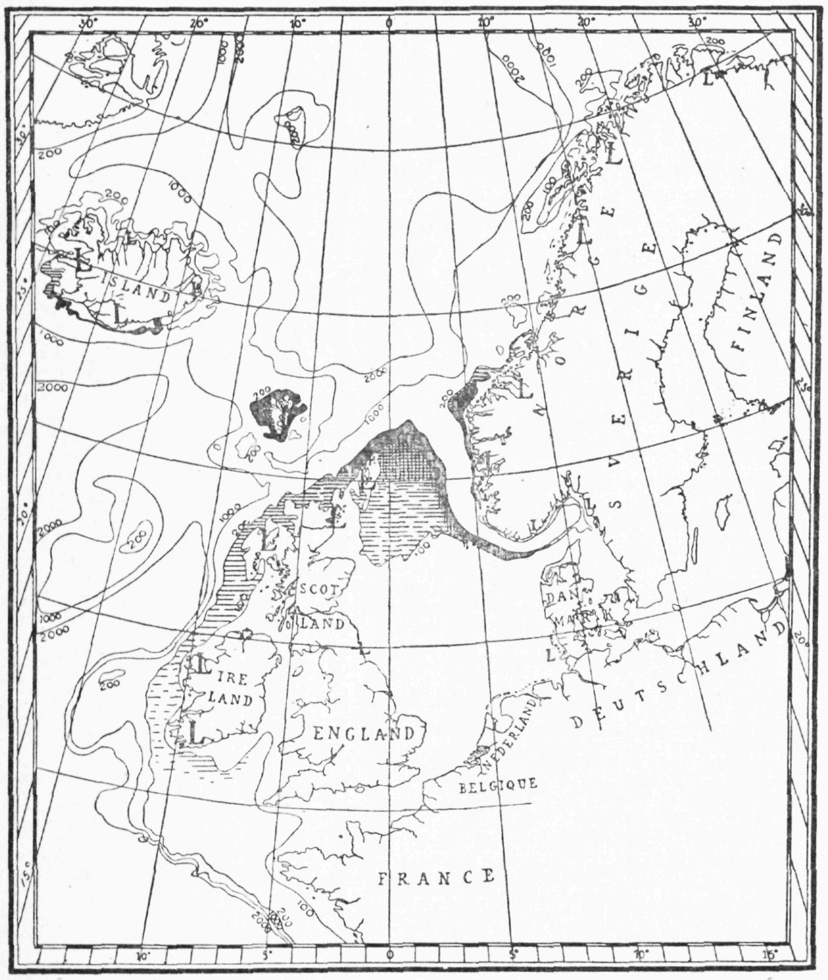
	average value of the annual catch
Haddocks	130,000,000 Kronor
Cods	63,000,000 »
Plaice	59,000,000 »

The next species of importance is the sole the catch of which amounts to $7\frac{1}{2}$ million kronor. As we can not expect to find a dimension of mesh that will serve equally well for all species of fish we must concentrate our efforts upon the catch of the most important food fishes: the haddock and the plaice, and choose the meshes so that roundfishes of the type of the haddock and flatfish of the type of the plaice can escape together. After long experience we have chosen the following size $8 \times 2\frac{1}{2}$ centimeters, for the following reasons.

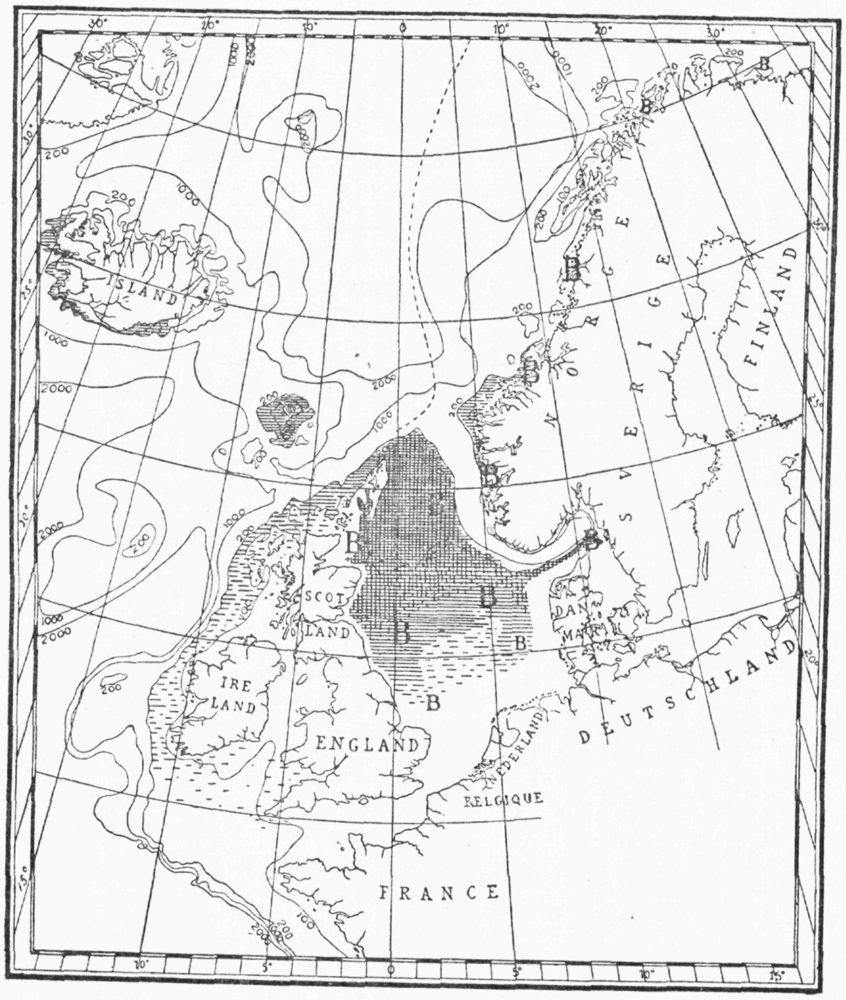
All our foodfishes are migratory fishes. Of their migrations we know very little, and still less we know of the causes of these wanderings. The knowledge we really possess concerns the average geographical distribution of each species, the age, growth, nourishment and breeding places of the fishes and the hydrographical conditions under which their propagation takes place. This information was acquired during the first period of the international research 1902 to 1907 by simultaneous systematic investigations by English, Scottish, German, Hollandish, Danish and Norwegian research-steamers at different seasons of the year, according to the scheme laid down by the conference in Stockholm 1899. Dr Johan Hjort, leader of this international research, has published its results in Rapports sur les travaux de la Committee A (Vol. X of Rapports et Procès-Verbaux) which contains the first general results of the international investigation of the sea and counts among the classical litterature of marine biology, because it contains new and fundamental information about the life-cycle of the foodfishes of the North sea, widened but never surpassed by the enormously increasing production of later years. Let us rehearse some parts of the chapters which have a bearing on the life of the gadoids in the North Sea and see if we can come to some conclusion regarding the size of meshes most fit to serve our purpose to economize with the resources of the sea.

The first problem to solve for the Committee A was to locate the breeding places of the foodfishes.

This investigation of Commission A headed by Hjort, Schmidt, Helland-Hansen, Damas, Redeke and D'Arcy Thompson was not restricted to the haddock but embraced the life-cycle of all gadoid fishes living in the North sea,



Spawning region of the Coal-fish



Spawning region of the haddock

17 species enumerated on p. 48 of their Report (see the charts on p. 49 to 66). If we compare these charts, especially the most typical of them all, viz. those on p. 72 and 74 of the said Report Vol. X which represent the spawning regions of the Coal-fish and the Haddock, we find that these regions are all centered at the bordering zone on the slope of the North sea bank and the Norwegian channel where the warm and salt water of the Atlantic current encounters the upwelling cold water from the depths of the Norwegian sea.

To this area of the sea the wanderings of the gadoids are directed when they become ripe for spawning early in spring. The cause of this is unknown and subject for several conjectures. One of these is my supposition that the final developement of the eggs requires a lesser osmotic pressure than that existing in the water of the Atlantic current.

The organisms which inhabit the ocean live under the influence of the osmotic pressure of the water which is caused by the molecules and ions of dissolved salts. It is evident that this physical influence of the medium in which they live must cause a physiological reaction which increases in strength when the animals are ripe for spawning. The eggs will be deformed or burst if there is a notable inequality of osmotic pressure inside the cell membrane and the seawater outside. The »instinct» which guides the fishes to their spawning grounds seems to be the physiological effect of the osmotic pressure[1] of the surrounding water upon their reproductive organs which leads them thithere with infallible accuracy: the haddocks from the Belt sea back to the North sea, the mature eels from the innermost recesses of the Baltic to the Sargasso sea, etc. To discuss the spontaneity of such migration is idle. A closer study of the oceanic circulation and its periodicity, so long neglected, and of which we know so little at present, will solve the mystery. Another hypothesis is that the accumulation of plankton in this part of the ocean in spring is necessary for the maintenance of the young fry when it has passed its larval stage (Grans hypothesis); or that the abundance of organic matter on the sea-bottom at a certain depth (the s. c. »mud-line») favours the growth and developement of the bottom stage (the 0 group of the haddocks) (hypothesis of Sir John Murray).

The haddock which from the first stages of its growth up to adult age is found widely spread over the N. Sea, the Skagerak and Kattegat must migrate to these breeding grounds when it is ripe for spawning. As young fry it can be carried by strong inflowing currents as far as into the Baltic but when its breeding time comes it must out again »seawards». In 1923 we had a striking example of this law. There was a great invasion of young haddocks in the Belt-sea which lived and thrived there for two years but disappeared in the third year when they had grown up to adult age. If we use nets of such mesh-size that no fish of more than 24 cm. length can escape, no haddock in spawning conditions would reach their breeding grounds. The present opinion is that this is an old-fashioned view.

[1] An increase in the salinity of 1 ‰ corresponds to an increase of the osmotic pressure of about $^2/_3$ of an atmosphere.

The production of eggs and fry is so enormous that the number of breeders has no influence on the brood. Nevertheless we would be on the safer side if we choose a network with meshes of less prohibitive effect, and get a far more valuable catch in the bargain.

The Commission A has by the charts mentioned first drawn the attention to the fact that there is a close connection between the breeding of the gadoids and the hydrographic conditions existing on the breeding grounds. We know that both are liable to great variations from year to year and the important question yet to solve is the causality of this connection. Are these variations simultaneous? Are they periodical?[1]

As the spawning of the haddock begins at the age of 3 to 4 years when that fish, according to Damas,[2] has an average length of 35,6—36.3 cm., it seems reasonable from a physiological point of view to choose a size of mesh which would let haddocks up to 35—36 cm. escape. It remains to see if this holds also from an economical point of view. That it would be considered highly impractical under the present depredatory state of the North Sea fishery is evident when we consider the effect of the commercial trawl now in use as described by Dr. A. Bowman:

»The trawl begins to take toll of an upgrowing haddock shoal when the fastest growing fish attain a size of 14 centimeters (i. c. at the end of the first six months of life). When an average size of about 20 cms. has been reached as many haddocks escape as are retained, and after 26 cms. length is reached no fish escape. At Iceland this size is reached on the average after 1¾ years growth. That is to say, for more than a year the slower growing members of a shoal have the better chance of escape with the result that the trawl is continually sifting out a disproportionally large number of the better growers. In an area which is rather intensively fished over the effect would be considerable.»[3]

On an area incessantly swept over by trawls of this kind there would be very little chance of economical fishery for a fishing-gear that releases haddocks up to 35 cm. at present.

But our aim was not to perpetuate the present depredatory state but to better it. Dr. Bowman recommends the use of trawls with meshes of larger size in the codend.

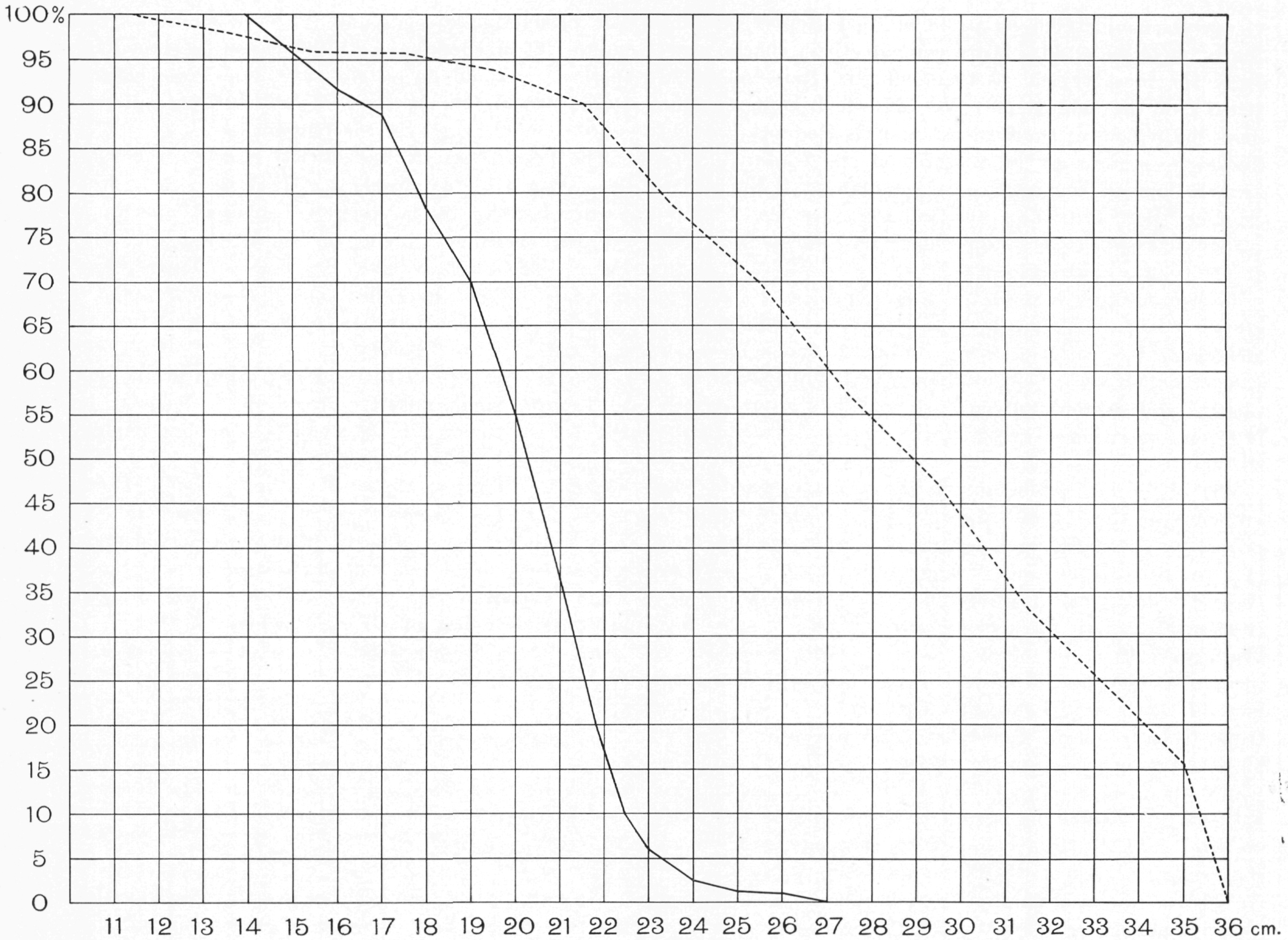
The following diagram represents the percentage numbers of haddock which at certain sizes pass through the meshes of a commercial trawl with codend meshes of 3—3½ inches (the fulldrawn line) (after Bowman) and through the windows of a similar trawl with codend meshes of the ordinary size and a saving gear with $8 \times 2\frac{1}{2}$ cm. meshes inserted between the bating and the codend (the dotted line).

We infer from this diagram that by introducing the saving trawl with meshes of $8 \times 2\frac{1}{2}$ cm. in common use 20 % of the 4 year old haddocks and 60 % of the 3 years class would be released during the first year. On the other

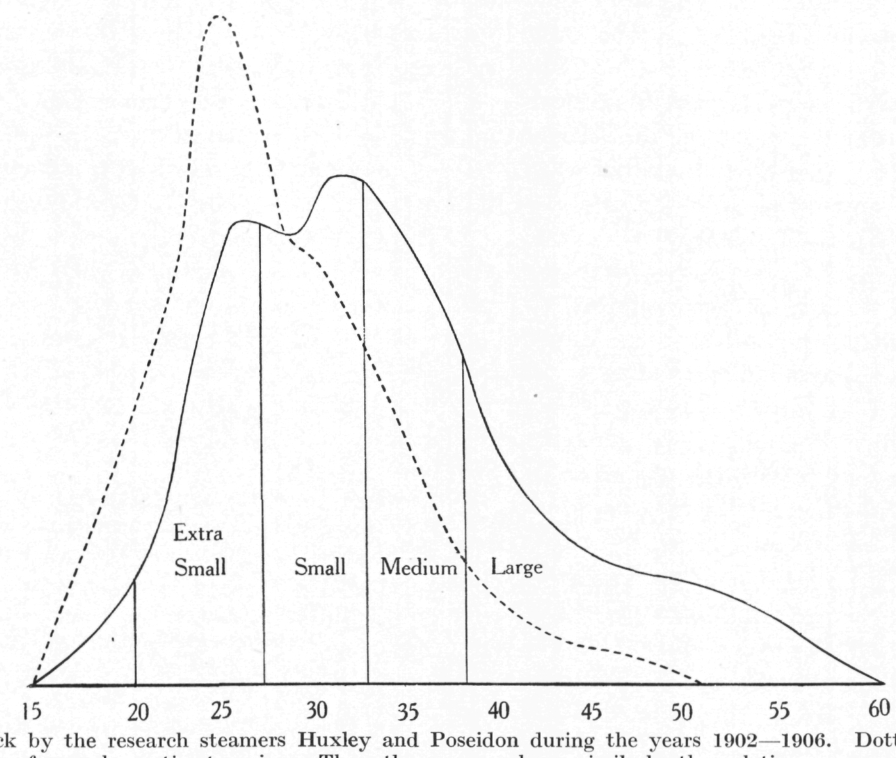
[1] The flow of the Atlantic current which sends a branch along the northern slope of the N. sea plateau into the Norwegian channel has a marked influence upon our climate. Does its influence also rule the fish life in the North Sea? The *prœterea censeo* of the author is this: Keep watch over the Atlantic and improve the fishing gear in order to economize with the resources of that ocean and its tributaries.

[2] D. Damas: Contributions à la biologie des gadides, Rapport de la Commission A. Vol. X. p. 150.

[3] A. Bowman: The quantitative effect of different fishing gears on the stock of marketable species. Cons. Int. Rapp. et Procès-Verbaux. Vol. LII, 1928.



Effect of the saving gear (8 × 2½ cm.) and of the commercial trawl with 3—3½ inch meshes in the codend



Average total catch of haddock by the research steamers Huxley and Poseidon during the years 1902—1906. Dotted curve represents the relative average number per trawlhour for each centimeter size. The other curve shows similarly the relative average weight per trawlhour for each centimeter size without regard to time or place.

hand we could hope that after two years the living stock of haddocks in the North sea would be restored to the same condition as in the beginning of this century when according to the statistics given by Helland Hansen,[1] the length of haddocks in relation to their frequency in the catch and marketable value was as shown in the figure.

With a stock of fish of this composition, viz. as it was in 1902—1906, it would not seem inopportune to choose the mesh of the trawl so that haddocks of medium size, up to 4 years old and about 35 cm. length be set free uninjured to live and increase the catch of the following year, considering:

»that the haddock of the N. Sea as a weight-producer does not attain its best growing size until it is about 5 years old, whereafter it gradually falls off in efficiency. A haddock of three years of age (average size 11½ inches) is five times the weight of one at the end of its first year (6¾ inches) and almost double that of a two year old fish (ca. 9½ inches). Haddocks just under two years of age are of practically no marketable value.»[1]

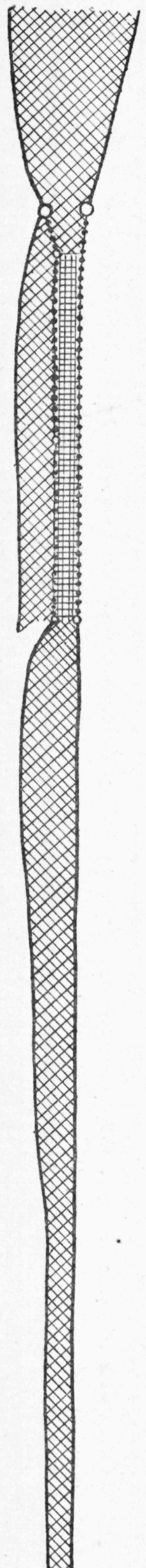
How far we are from this state of things existing 25 years ago we infer from the following statement in a report of Dr. H. Thomson on Haddock fluctuations:

»At an average age of sixteen months haddocks reach a size at which escape through the trawl meshes becomes impossible and thereafter a heavy toll of the young fish continues to be taken. The net result is that by the end of the fourth year more than 75 % of the brood have been fished out. Fishery for that brood alone becomes unprofitable, and for further copious supplies it is necessary to have recourse to the next oncoming successful brood which may be only in its second year of life and is thus in turn well depleted at an early stage. It will be seen that with an average period of 5 to 6 years separating highly successful North Sea broods the major portion of a brood is removed at too young a stage to avoid the occurrence of occasional periods of much reduced yields, since the North Sea fishery has, under present conditions, definitively become one for small and medium sized haddock.»

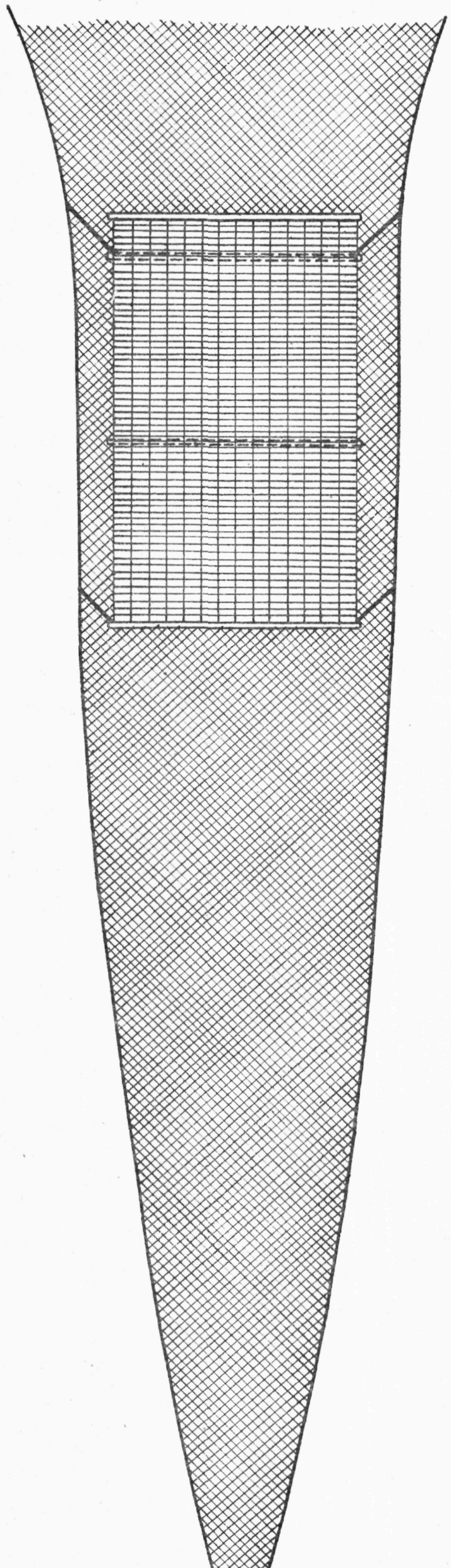
There is no other remedy if we will restore the resources of the N. Sea and the Skagerak than to improve the fishing gear. We have then to choose between enlargement of the meshes of the codend, as Dr. Bowman recommends, or introduction of some kind of escapement for undersized fishes before they reach the codend.

A circumstance which seems to have escaped notice hitherto is that the North Sea at present and since many years ago is at its limit of production. The Bulletin statistique of the international council for the exploration of the sea shows that the total weight of fish landed from the N. Sea and the Skagerak & Kattegat has been nearly constant since 1913 to the present time.

Saving-gear.



The Dimensions of the »windows» through which the immature fishes escape are 2 × 1,20 metres.



The Dimensions of the rectangular inalterable meshes are 8 × 2½ centimeters

[1] Helland Hansen: Statistical research into the biology of the haddock and cod in the North sea. Report of Commission A. (Rapp. et Procès-Verbaux, Vol. X).

[2] cited from Dr. A. Bowmans Report to the International Council for the Study of the Sea (1929).

I. *North Sea.*

1913	1,277,317	Tons
— — —	— — —	
1919	1,114,839	»
1920	1,197,354	»
1921	930,404	»
1922	943,240	»
1923	956,027	»
1924	1,069,591	»
1925	1,021,644	»
1926	1,055,554	»
1927	1,101,540	»

II. *Skagerak and Kattegat.*

1913	79,242	Tons
— — —	— — —	
1919	121,032	»
1920	100,566	»
1921	68,300	»
1922	63,472	»
1923	91,738	»
1924	104,995	»
1925	101,582	»
1926	105,978	»
1927	116,509	»

The yield in weight of the fishery depends upon the resources of available foodstuff. When the yield keeps constant year after year in spite of the increase of the fishery industry we are inevitably led to the conclusion that the natural resources of the production of fishfood have reached their limit. A closer inspection of the statistical data from earlier times shows that this limit was reached already before the war in the years 1911—1912 and 1913. If we augment the number of vessels or the efficiency of the fishing-year, e. g. by use of the Vigneron-Dahl-trawl we will obtain a greater number of fish of minor size and value but the average weight of the catch will be the same.

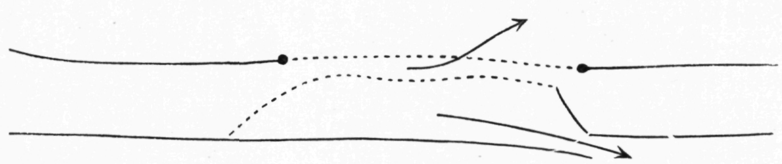
From the numbers above given we arrive at the conclusion that we can not expect to get more than one million tons of fish a year from the N. Sea and about $^1/_{10}$ part of that weight from the Skagerak and Kattegat. The problem then is to take out this tribute in a rational manner which we are far from doing at present.

With regard to flatfishes our experience is that the same net which releases cods and haddocks up to 30—32 cm. spares flatfishes of the following species

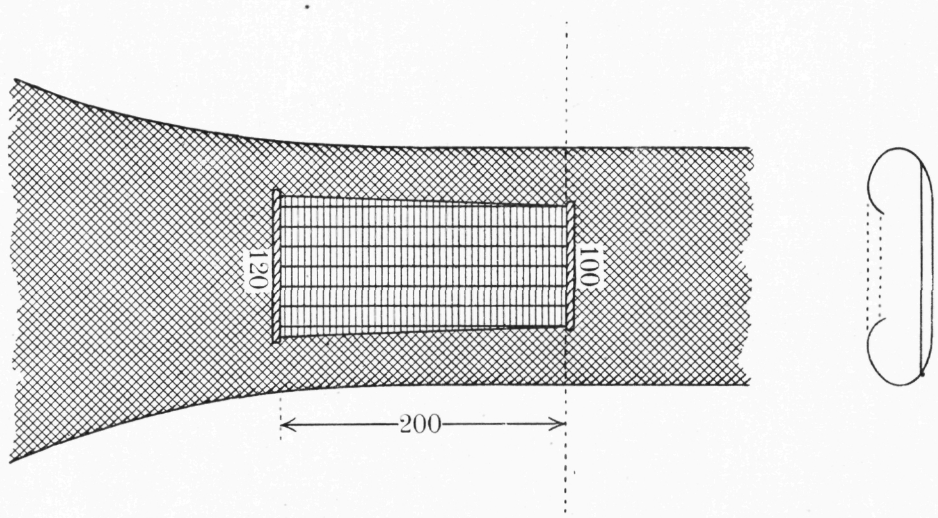
Pleuronectes platessa	up to 24—26	cm.
Pleuronectes limanda	» » 26—28	»
Pleuronectes cynoglossus ..	» » 28—30	»

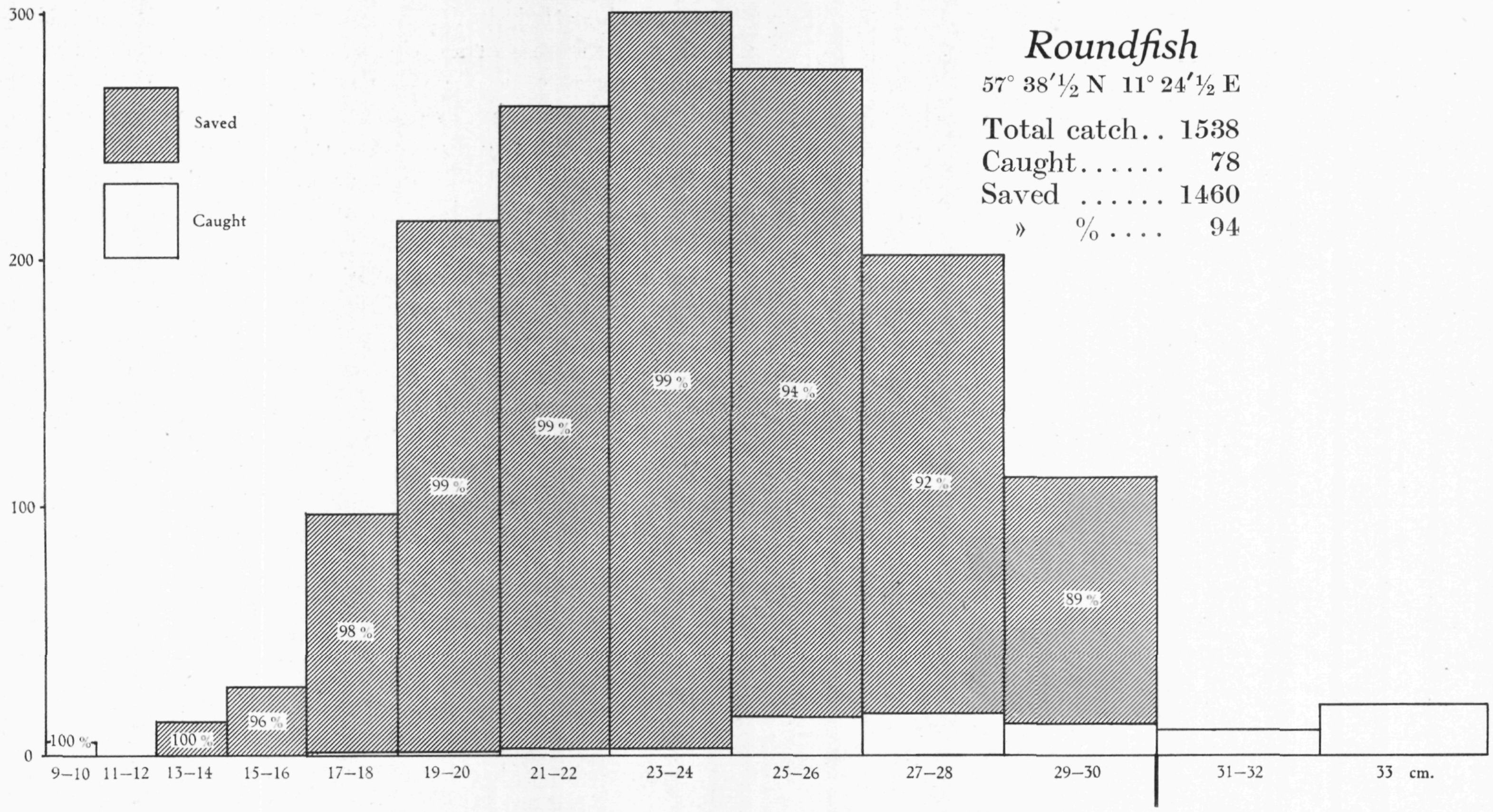
If it would release soles of the same dimension (30 cm.) is still unknown and deserves a careful study* as this valuable fish is highly important for the fisheries of England,[1] Holland,[2] Germany[3] and Denmark.[4]

[1] Where 1.165.000 ko were landed in 1926.
[2] » 1.551.001 » » » » 1926.
[3] » 67.000 » » » » 1926.
[4] » 64.000 » » » » 1926.
* We have not been able to do that because the sole is extremely rare in our parts of the Sea.

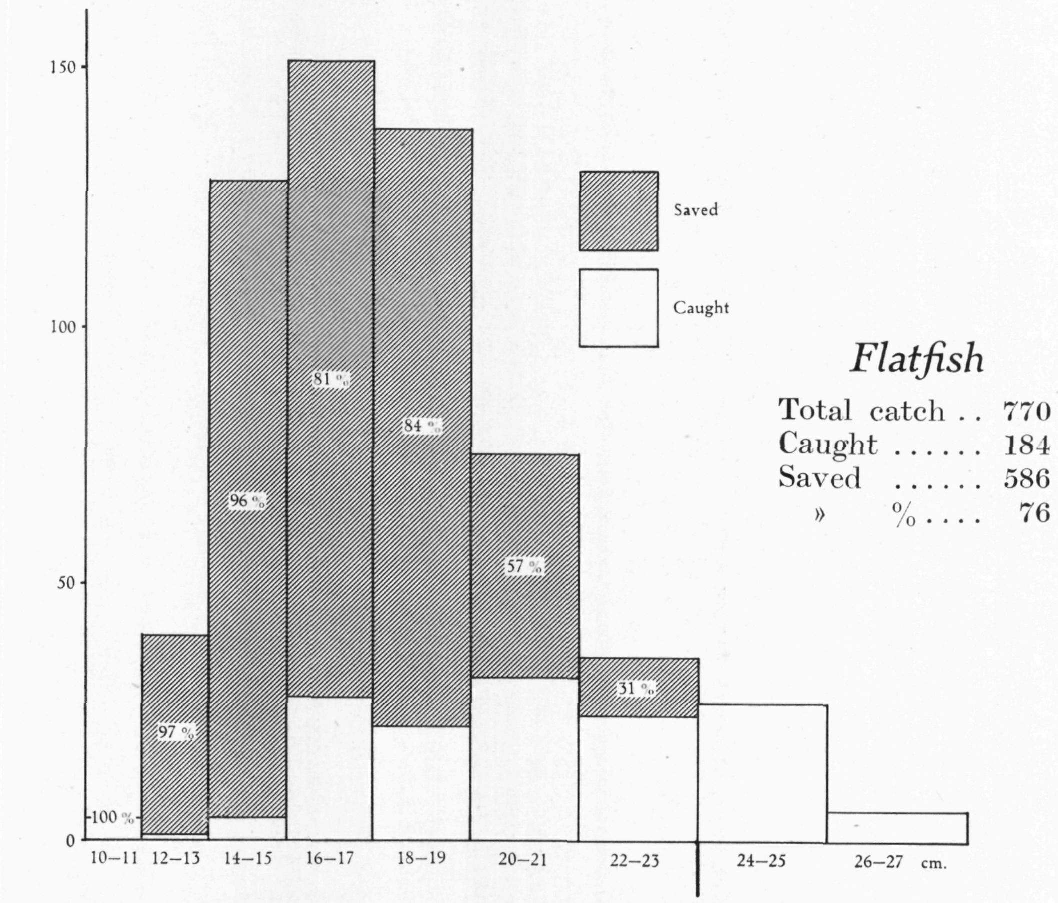


Schematic representation of Saving-gear.





Cm.	9—10	11—12	13—14	15—16	17—18	19—20	21—22	23—24	25—26	27—28	29—30	31—32	33
Saved	5	—	13	26	96	215	260	298	262	185	100	—	—
Caught	—	—	—	1	1	1	2	2	15	16	12	9	19



Cm.	10—11	12—13	14—15	16—17	18—19	20—21	22—23	24—25	26—27
Saved	5	49	158	157	148	55	14	—	—
Caught	—	1	6	35	28	41	31	34	8

Mezäta
WALD. ZACHRISSONS BOKTRYCKERI A.-B.
GÖTEBORG 1930