On what does the Catch of undersized Fish depend?

First Report on the Polish Research on Saving-Trawls.

By

Joseph Borowik.

Department of Fishery Economics, National Institute for Scientific Agriculture, Bydgoszcz, Poland.

1. The problem of Savings gear.

The name "savings gear" (savings trawl) has been accepted for all that fishing gear which makes possible the escape of small, unmarketable, undersized fish.

The determination of "the proper size of fish" is of the greatest importance for the construction of protective gear, and of course "the proper size" depends on the species of fish, the method of catching and the biological, as well as the commercial, points of view. The rate of growth and the time of sexual maturity on the one hand, and the conditions of the market on the other, undergo great fluctuations not only with regard to the species in general, but with regard to one given species in a certain region and at a certain period of catching.

Consequently we see that the construction of a savings gear touches on a great many fishery problems and requires comprehensive research both on the technique of fishing and the biology of the fish; in the first place it should take into consideration the character of the stock with regard to the various year-classes and the rate of growth.

One cannot expect to invent some miraculous protective gear which would work under all conditions and for all species of fish; we are not therefore trying to invent a universal protective gear, but our aim is so to modify the industrial fishing gear that in certain conditions it would allow the escape of certain fish of pre-determined size.

There is no instrument which can catch "the whole composition of the stock of fish" present at the place of operation of the fishing gear. When studying the construction of various types of instruments for industrial fishing we are struck by the fact that the world over fisher-

men have been using fundamentally the same instruments and that in spite of considerable climatic, hydrographic, racial and cultural differences they have been catching fish in the same way — merely the details differ. One of the fundamental characteristics of fishing gear is the ability to "sift" all that the fisherman does not require; the instruments are endowed with a sort of selective ability. Very often when fishing for species which differ greatly with regard to size and conditions of existence, fishermen use instruments of the same type: e.g. fishing for flat fishes, herring, cod, either with trawls, or using fixed nets for the same purpose. The trawl and the net remain, in a general way, the same; but, according to their purpose, there are changes in the size of mesh, the thickness of thread, the method of using and so on.

Consequently we can see clearly why a protective gear can be constructed merely by introducing some changes into the ordinary industrial fishing gear, by modifying its selective capacity in relation to the fish of which the size has been determined as "unmarketable" or immature. These depend to a certain degree on the size of mesh, the thickness of thread and the method of using the instrument.

Before we propose any changes in the construction of the fishing gear, we must get a clear conception of how the various factors influence the changes in the selective ability. There are three fundamental categories of change which can be introduced in the construction of the fishing gear and which ought to be carefully examined with regard to the influence which these changes bear on the composition of the catch. They are:—

1) changes in the size of the mesh,
2) changes in the distribution of the parts of the gear which have various sizes of mesh,
3) changes arising from the method of using the gear, especially as regards:—
   a) the speed,
   b) the width of the instrument.

Of course things work the other way also: the composition of the catch and the conditions of the locality play an important part by stressing or attenuating the selective ability of the fishing gear. When studying the changes in the structure of the gear we should strive to do our comparative experiments under similar conditions of stock and locality. If we then introduce just one change in the construction of the gear and conduct analytical research concerning the catch, we can elucidate gradually and slowly the part played by the various factors.

On the basis of such experiments alone shall we be able to elaborate accurately, and in detail, this or that plan for modification of the industrial fishing gear, aimed at an increase of their protective characteristics in relation to a given species and a given region. We also should take into consideration the principle that a savings gear should give catches which are satisfactory from the industrial point of view: in other words, the changes that are to be proposed should not appreciably lower the income of the fisherman, nor increase the costs of fishing gear and the working of the boats.

In order to obtain satisfactory data we must illustrate in detail the character of the various types of industrial fishing gear that have been used heretofore.

2. Research in Poland.

Research on savings gear which was started before the war was concerned for a long time with the trawl constructed by Captain RIDDERSTADT, proposed by the Swedish scientists and described for the first time by GUSTAV EKMAN in 1916 (1).

Before the war, Prof. BARANOW (2, 3, 4), of Russia, had not only proved the principle that for every size of mesh there is a corresponding size of fish, but he also tried to compute the "composition of the stock" basing it on the mathematical analysis of the results of the catch obtained by several nets with various sizes of the mesh.

The researches of HENKING and FISCHER (5) in the Baltic, conducted approximately at the same time, did not yield any convincing results.

Lately, owing to the interest which the matter of protective fishing gear has raised in the International Council for the Exploration of the Sea, research on the construction of "savings gear" has been taken up again, and we can distinctly perceive the direction it has taken. The works of RUSSELL (6), BOWMAN (7, 8), DAVIS (9) and lately of TESCH (10) tend to prove the close interdependance of the size of the mesh and the composition of the catch.

It is interesting that in his works BOWMAN repeats almost literally the postulate expressed fifteen years ago by Prof. BARANOW, concerning the close relation of the mesh and the size of fish caught.

Thus we may accept as certain that the size of the fish caught depends primarily on the size of the mesh used in the netting material. Therefore it is necessary for research on protective fishing gear to determine at the very beginning this relation for every species and every region having different morphological, hydrographical and biological characteristics.

In Poland research on savings fishing gear was started in 1927. At that time the close relation between the size of the mesh and the size of the fish caught had not yet been generally ascertained, so our research at first aimed only at the determination of the extent to which Prof. BARANOW's postulates had a universal application. Later, in connection with the negotiations which were started in 1928 for the protection of fish in the Baltic, an attempt was made to throw light on the harmfulness of the fishing gear which till then had been in use. Finally, research on the construction of protective fishing gear was added when a representative of Poland was elected member of the Committee on Protective Fishing Gear.

These researches have so far brought abundant data illustrating not only the character of the industrial catches but elucidating in full detail several problems of construction of protective fishing gear — especially:

1) The dependence of the composition of the catch on the size of the mesh.
2) The significance of the various parts of a trawl for the escape of small fish.
3) The influence of the composition of a catch on the protective ability of the gear.

Experiments were also made on the dependence of the size of fish caught on the shape of the mesh and the thickness of the thread: observations of the influence of the speed of trawling on the composition of the catches, and so on. All these researches, as well as those concerning the construction of saving gear, are still being made, and some of the results obtained are not yet ripe for discussion.

In the present paper I intend to present summarily the results obtained in the three above directions. A detailed discussion of this material will be published in Memoirs of the Polish Institute of Scientific Agriculture.

3. Fishing conditions in the Polish Baltic (Gulf of Dantzig).

Polish research has been conducted exclusively on flat fish in the Polish territorial waters, near the peninsula of Hel and in the adjoining parts of Dantzig Bay. According to local regulations, the normal size limit for the plaice (*Pleuronectes platessa*) and the flounder (*Pleuronectes flesus*) is 18 cm.; for *Pleuronectes limanda* and *Rhombus maximus* there are no restrictions. There is also a regulation on the Polish coast determining the size of the mesh of fishing gears: for flounder trawls it has

been temporarily set at 50 mm. There arose, however, great difficulties in putting this regulation into practice. It has become necessary to allow the use of instruments with smaller meshes for catching the small fish, bull head — (*Zoarces vivipara*), found in the same waters as the flounder. Furthermore, the fishermen argued that the 50 mm. size of the mesh would not allow any profit to be drawn from fishing in Dantzig Bay, owing to the scarcity of fish of the requisite size. Consequently a rigorous enforcement of that experimental regulation of the size of the mesh was soon abandoned, and we find in the bay of Dantzig trawls of all sorts of mesh, from 18 to 24 mm. up to 45 and 50 mm. This provided abundant data regarding the character of the mesh in its relation to industrial fishing.

In regard to the fishing gear, and especially trawls, used in Dantzig Bay, there are two fundamental types:—

1) The first, of local origin, made by the fishermen themselves of cotton netting material in the shape of an ordinary cuneiform sack with an upper rope five metres long, and with 140 meshes in the front part and 85 meshes in the cod-end.
2) The second resembles the trawls used by motor cutters in the North Sea, which are described by Davis as frequently used on the Eastern Coast of England. It is a miniature trawl built after the fashion of those used on steam trawlers: the upper rope is 11 metres long: the front part contains 170 meshes in width. These trawls came to Poland from the West and are furnished ready-made from the factory in Altona. They are made of hemp, have meshes of 45 and 50 mm. size, and differ in shape from the first type mainly through being equipped with side wings.

It should be added that all trawls used in Dantzig Bay have always 110 to 140 metres of rope placed between the wings of the trawl and the boards, with bunches of "sea-grass" attached. They remind one of the Vigneron Dahl system.

In both fundamental types of trawl we find a variety of meshes and thread. The majority of trawls have similar dimensions of mesh; there are, however, trawls which have a gradual transition from large meshes in the front part to smaller meshes in the cod-end.

There were eleven types of trawl for which we obtained various results as to catch. The experiments were conducted at a time and in such regions where it was possible to obtain exclusively flat fish of all the four species; and since the plaice (*Pleuronectes platessa*) and turbot

(*Rhombus maximus*) appear very scantily, we have concentrated our attention chiefly on the flounder (*Pleuronectes flesus*) and dab (*Pleuronectes limanda*).

For the experiments the observer made voyages in an industrial fishing cutter and took an average sample from every haul, the sample containing about 20 kg of fish. The measurements were made for the most part on the deck: in cases where the otoliths were to be taken for the determination of the age, or of the rate of growth, the work was done in the coastal laboratory of the Department of Fishery Economics at Hel.

In 1927 we collected data on the general conditions of fishing, with especial regard to the gear used and the regions frequented; a detailed programme of research was laid out and the preliminary research finished. In 1928 abundant data concerning the relation between the size of the mesh and the composition of the catch was collected and discussed, the summarised results of this research are presented in the section below. In 1929 the research on the significance of the various parts of the trawl for the escape of undersized fish was finished, and the results of those experiments are presented in Sections 5 and 6.

4. The dependence of the composition of the catch on the size of the mesh.

The results of an analytical-study of the measurements of fish caught with trawls of 30, 40, 43, and 45 mm. meshes are presented in two tables (I and II) both for *Pleuronectes flesus* and for *Pleuronectes limanda*. In the upper part of the tables we have the number of fish of different sizes calculated in the proportion of one per mille of fish caught by a given trawl. For every dimension the number of undersized fish is also given.

At the bottom of each table the results of the same experiments have been presented in another way. Taking the quantity of commercial fish caught as 1000, the proportion of undersized fish caught has been calculated and the computations were made both in relation to the 18 cm size, now obligatory in the Polish waters, and that of 20 cm. which was proposed in one of the international schemes for the protection of flat fish in the Baltic.

The upper computations are very expressive, especially when we draw the corresponding curves; the lower ones are easy to read and do not require any special explanation, since they show quite plainly the decrease of the quantity of small fish in proportion to the increase of the size of the mesh. If the size of the mesh is changed from 30 to 45 mm.,

Table I. Flounder (*Pleuronectes flesus*).

A. Changes in composition of the catch, depending on the size of the meshes used.

The size of meshes	Size of fish in cm. . . .	to 12	13	14	15	16	17	18	19	20	21	22	23	24	25	26 up
I. 30 mm.																
(5533 fish from	Size frequencies in $^0/_{00}$	23	38	65	91	140	173	173	107	66	35	21	15	13	9	31
15 hauls measured)	The sum of fish below the given size in $^0/_{00}$	..	23	61	126	217	357	*530*	703	810	876	911	932	947	900	969
II. 40 mm.																
(3227 fish from	Size frequencies in $^0/_{00}$	..	1	1	12	40	105	211	195	187	95	52	35	21	14	31
15 hauls measured)	The sum of fish below the given size in $^0/_{00}$	..	..	1	2	14	54	159	370	*565*	752	847	899	934	955	969
III. 43 mm.																
(583 fish from	Size frequencies in $^0/_{00}$	..	2	3	12	60	97	200	204	190	84	48	40	12	12	36
4 hauls measured)	The sum of fish below the given size in $^0/_{00}$	..	..	2	5	17	77	174	374	*578*	764	852	900	940	952	964
IV. 45 mm.																
(1304 fish from	Size frequencies in $^0/_{00}$	..	2	..	1	12	33	108	128	225	165	95	70	50	26	85
12 hauls measured)	The sum of fish below the given size in $^0/_{00}$	..	..	2	2	3	15	48	156	284	*509*	674	769	839	889	915

B. The Quantity of Flounder of unmarketable size kept by trawls with various meshes, computed in proportion to 1000 full sized fish caught (10647 fish measured from 46 hauls).

Trawl with meshes of	Commercial size 18 cm.	Commercial size 20 cm.
30 mm.	1127	4578
40 mm.	189	1298
43 mm.	210	1369
45 mm.	54	526

Table II. Dab (*Pleuronectes limanda*).

A. Changes in composition of the catch depending from the size of the meshes used.

The size of meshes	Size of fish in cm....	to 12	13	14	15	16	17	18	19	20	21	22	23	24	25	26 up
I. 30 mm.																
(2520 fish from	Size frequencies in $^0/_{00}$.....	137	102	85	68	107	116	106	74	59	45	20	17	10	12	42
15 hauls measured)	The sum of fish below the given size in $^0/_{00}$	..	137	239	324	392	*499*	615	721	795	854	899	919	936	946	958
II. 40 mm.																
(1174 fish from	Size frequencies in $^0/_{00}$.....	1	5	9	18	59	89	176	198	164	95	49	23	15	15	84
15 hauls measured)	The sum of fish below the given size in $^0/_{00}$	..	1	6	15	33	92	181	357	*555*	719	814	863	886	901	916
III. 43 mm.																
(288 fish from	Size frequencies in $^0/_{00}$.....	..	..	3	31	52	101	191	194	177	90	37	49	11	18	46
15 hauls measured)	The sum of fish below the given size in $^0/_{00}$	..	..	..	3	34	86	187	378	*572*	749	839	876	925	936	954
IV. 45 mm.																
(866 fish from	Size frequencies in $^0/_{00}$.....	1	5	1	19	28	83	137	150	158	95	64	36	18	20	185
12 hauls measured)	The sum of fish below the given size in $^0/_{00}$	..	1	6	7	26	54	137	274	424	*562*	677	741	777	795	815

B. The Quantity of undersized Dab kept by the trawls with various sizes of meshes; computed in proportion to 1000 full sized fish caught (4857 fish measured from 46 hauls).

Trawl with meshes	Commercial size 18 cm.	Commercial size 20 cm.
30 mm.	1597	3878
40 mm.	221	1247
43 mm.	230	1336
45 mm.	158	733

the range of the changes with 18 cm. size of fish is tenfold, and with 20 cm. size of fish a fivefold decrease of the number of undersized fish.

We should add, however, that trawls with 30 and 40 mm. meshes belong to the type of ordinary cuneiform sacks which we called "local trawls" and trawls with 45 and 43 mm. meshes belong to the type which we agreed to call "the normal trawl". Also it should be added that the trawl with 40 mm. meshes was made of thin cotton, in consequence of which the resistance of the net was much smaller and the gear had to work at a much greater speed, which would explain its retention of small specimens of common dab.

The last feature which strikes us when we compare the two tables concerns the problem of the influence of the stock on the composition of the catch. The presence of fish of various sizes in catches made with the same trawl and in the same locality varies greatly according to the species of fish. Since we are dealing with related species, which differ very little in their rate of growth, the different action of the same gear in regard to the flounder and dab can be explained simply by the fact that in the catches of dab (*Pleuronectes limanda*) the younger year-classes were represented in greater numbers.

If we take all these things into consideration and try to evaluate the fishing gears used in the Polish fishery from the point of view of the protection of flat fish, we must state in the first place the quite obvious harm done by the 30 mm. mesh trawl: it is undoubtedly an instrument of destructive fishing. On the other hand the 43 mm. mesh trawl can be considered as effecting a saving, if the commercial size limit is 18 cm.

In fishing conditions on the Polish coast a trawl of 45 mm. seems to be rather wasteful, because, while keeping a minimal quantity of undersized fish, it undoubtedly allows the escape of full sized fish. Experiments conducted in 1930 with the double covered trawl have proved these ideas to be true. It is obvious that, were we to change the commercial size to 20 cm., the whole matter would be different, but this cannot be taken into consideration on account of industrial difficulties, because fish of the 20 cm. size can form but a small part of the catch.

5. The importance of the front part of the trawl for the escape of undersized fish.

The third table presents the results of experiments with trawls which had even meshes in the cod-end and different, i.e. larger or smaller, ones in the front part or in the wings. There are three series of possible computations:—

Table III. The importance of the front part (wings) of the trawl for the escape of undersized fish.

Flounder. A. Trawls with 30 mm. cod-end meshes and 30, 35—40 mm. and 50 mm. front part meshes. Autumn 1928.

Meshes in front part	Size of fish in cm....	to12	13	14	15	16	17	18	19	20	21	22	23	24	25	26 up
I. 30 mm.																
(5533 fish measured	Size frequencies in $^0/_{00}$.....	23	38	65	91	140	173	173	107	66	35	21	15	13	9	31
from 15 hauls)	The sum of fish below the given size in $^0/_{00}$	..	23	61	126	217	357	530	703	810	876	911	932	947	900	969
II. 35—40 mm.																
(3967 fish measured	Size frequencies in $^0/_{00}$.....	14	10	24	43	100	162	196	166	137	63	31	15	9	9	21
from 19 hauls)	The sum of fish below the given size in $^0/_{00}$	..	14	24	48	91	191	353	549	715	852	915	946	961	970	979
III. 50 mm.																
(409 fish measured	Size frequencies in $^0/_{00}$.....	20	20	50	66	64	122	98	115	110	54	63	41	34	44	99
from 10 hauls)	The sum of fish below the given size in $^0/_{00}$	..	20	40	90	156	220	342	440	555	665	719	782	823	857	901

Number of undersized Flounder held by various trawls in proportion to 1000 full sized fish caught (based on the measurements of 9909 fish from 44 hauls).

In the front part	Commercial size 18 cm.	Commercial size 20 cm.
30 mm.	1127	4578
35—40 mm.	545	2508
50 mm.	522	1249

B. Trawls with 40 mm. cod-end meshes and 30, 40, and 42 mm. front part meshes.

Front part meshes	Size of fish in cm....	to12	13	14	15	16	17	18	19	20	21	22	23	24	25	26 up
I. 30 mm.																
(846 fish measured	Size frequencies in $^0/_{00}$.....	19	11	38	40	84	134	217	174	163	55	20	19	9	9	8
from 4 hauls)	The sum of fish below the given size in $^0/_{00}$	..	19	30	68	108	192	326	543	717	880	935	955	974	983	992
II. 40 mm.[1])																
(3227 fish measured	Size frequencies in $^0/_{00}$.....	..	1	1	12	40	105	211	195	185	95	52	35	21	14	31
from 15 hauls)	The sum of fish below the given size in $^0/_{00}$	..	..	1	2	14	54	159	370	565	752	847	899	934	955	969
III. 42—45 mm.																
(1222 fish measured	Size frequencies in $^0/_{00}$	4	2	2	1	13	86	238	230	200	84	57	30	14	14	25

In the front part	Commercial size 18 cm.	Commercial size 20 cm.
30 mm.	485	2765
40 mm.	189	1298
42—45 mm.	126	1370

C. Trawls with 45 mm. cod-end meshes and 30, 45 and 50 mm. front part meshes.

Meshes in front part	Size of fish in cm....	to 12	13	14	15	16	17	18	19	20	21	22	23	24	25	26 up
I. 30 mm.																
(1356 fish measured	Size frequencies in $^0/_{00}$.....	3	5	15	47	63	92	212	195	182	80	56	21	18	9	2
from 6 hauls)	The sum of fish below the given size in $^0/_{00}$	..	3	8	23	70	133	225	437	632	814	894	950	971	989	998
II. 45 mm.																
(1304 fish measured	Size frequencies in $^0/_{00}$.....	..	2	..	1	12	33	108	128	225	165	95	70	50	26	85
from 12 hauls)	The sum of fish below the given size in $^0/_{00}$	..	..	2	2	3	15	48	156	284	509	674	769	839	889	915
III. 50 mm.																
(767 fish measured	Size frequencies in $^0/_{00}$.....	..	..	4	..	14	27	98	99	228	188	111	75	47	35	74
from 8 hauls)	The sum of fish below the given size in $^0/_{00}$	..	..	..	4	..	18	45	143	242	470	658	769	844	891	926

Number of undersized Flounder held by various trawls in proportion to 1000 full sized fish caught (based on the measurements of 342 fish from 62 hauls).

In the front part	Commercial size 18 cm.	Commercial size 20 cm.
30 mm.	288	1710
45 mm.	54	526
50 mm.	42	309

[1]) Remark: This trawl was made of thin twine.

A. Trawls with 30 mm. meshes in the cod-end and 30, 40, and 50 mm. in the front part.
B. Trawls with 40 mm. meshes in the cod-end and 30 and 50 mm. meshes in the front part.
C. Trawls with 45 mm. meshes in the cod-end and 30, 45 and 50 mm. meshes in the front part.

Our computation has been made only for *Pleuronectes flesus.* The second species, *Pleuronectes limanda,* does not occur so universally nor so numerously. Besides, it would require additional discussion and comparison on account of the abnormal occurence of particularly numerous young year-classes.

Research on the influence of the front part of the trawl was based on the analysis both of industrial catches and of experimental catches made in 96 hauls; the data concerning the fish examined include 18521 measurements: all catches were made in the autumn months in 1928 in the same locality near Hel.

Taking into consideration all. the above remarks and comparing the computations of undersized fish in proportion to the 1000 full sized fish in particular, we must admit that the front part plays a very important rôle in the escape of undersized fish and has a great significance for all modifications of industrial fishing gear planned to increase protective ability.

Thus we see, for example, that if we introduce larger meshes into the front part of the "destructive" trawls they immediately bring about "protective" characteristics, and the quantity of undersized as related to the full sized fish become twice as small with the commercial size limit of 18 cm. and four times as small when the commercial size limit is 20 cm. The same process is to be observed in the activity of the trawl with 40 and 45 mm. meshes in the cod-end.

This would tend to prove the arguments which we might have put forth *a priori,* basing them on the principle of the probability of escape. Each mesh of the net through which a fish can possibly pass represents for it a chance of escape. Since the front part is composed of a much larger quantity of meshes the chances of escape from these parts ought to increase proportionally. It is true that some fish may be squeezed mechanically through the meshes of the cod-end. On the other hand,

from the trawl become much smaller.

6. The influence of the lower part and the sides, as compared to that of the upper and middle parts.

It remains to be seen which parts of the front section of the trawl have anything to do with the escape of fish. Up to the present day the idea seems to be universally prevailing that the lower part of the trawl has nothing to do with the escape of the fish.

In order to elucidate this problem the experiments in 1928 were conducted by using alternately trawls which had either the whole lower net made of 24 mm. meshes, and the whole upper net of 45 mm. or *vice versa*. In another series of experiments the sides (i.e. $^1/_4$ of the whole circumference on each side) had 24 mm. meshes and the middle parts (i.e. $^1/_4$ of the circumference on the top and $^1/_4$ of the circumference on the bottom) had 45 mm. meshes.

The results obtained have been presented in part A of Table IV. The research was based on the measurements of the whole catch of 35 hauls, comprising altogether 5998 fishes of both species. Comparing the curves of the catch of all these trawls and the computation of the relation of undersized to the full sized fish, we do not find fundamental differences within a given species. This compels us to accept the conclusion that all parts of a trawl play more or less the same rôle in the escape of fish, and differences depend only on the species caught and the size of the fish.

In order to test this conclusion experimental catches were made in 1929 with the double trawl; the inner trawl had 45 mm. meshes, the cover — 24 mm.; the covering trawl had been sewn together lengthwise with the inner trawl in four places so that it was divided into four equal parts, one upper, one bottom and two side ones.

At first the catches were made on two hauls with an inner trawl with 50 mm. meshes: unfortunately this trawl was lost on the third haul. The results obtained in these two first experiments agree entirely with the later ones.

In part B of Table IV there is a rough computation of the results of these experiments comprising the measurements of 5387 fish caught in 7 hauls during September and October 1929.

Even a rough presentation of these numbers proves to us that the escape takes place in all directions and at very much the same rate. The fact that the lower part of the trawl is as important as the sides and the upper part is of special importance. There are deviations in this or that direction, which depend not only on the species and the size of fish caught but on the locality in which the catch has been made.

Part C of Table IV contains the results of the same experiments

Table IV. The importance of the bottom

A. The number of undersized fish held by

1. Influence of the bottom part:

The size of meshes in the bottom part of trawl	Commercial size 18 cm.		Commercial size
	Flounder	Dab	Flounder
I. 24 mm.....	259	1202	1291
II. 45 mm.....	236	1985	1049

B. The number of fish escaped from the 45 mm. tr

Size of fish in cm....	8	9	10	11
Flounder (3386 fish measured on 7 hauls).				
Number of fish escaped through (total 3066):				
the upper part	1	40	113	159
the bottom part.....	5	88	140	248
side parts.....	..	8	100	230
Number of fish remained inside the trawl (320)	..	..	1	..
Dab (2001 fish measured on 7 hauls).				
Number of fish escaped through (total 1445):				
the upper part	..	..	4	11
the bottom part.....	4	14	32	53
side parts.....	..	..	2	16
Number of fish remained inside the trawl (556)	..	..	..	..

C. The influence of the upper, bottom and side parts of the

Size of fish in cm....	8		9		10		11		12	
A. Flounder:	pieces	%	pieces	%	pieces	%	pieces	%	pieces	%
The upper part.....	1	17	40	29	113	32	159	25	196	32
The bottom part	5	83	88	65	140	39	249	39	141	23
The side parts	..	..	8	6	100	28	230	36	275	44
Inner trawl	..	..	..	..	1	1	..	..	6	1
Total...	6	100	136	100	354	100	638	100	618	100

Size of fish in cm....	22	23	24	25	26
Inner trawl, pieces (100 %)	20	18	8	10	3

Size of fish in cm....	8		9		10		11		12	
B. Dab:	pieces	%	pieces	%	pieces	%	pieces	%	pieces	%
The upper part.....	..	..	..	..	4	20	11	19	38	20
The bottom part	..	..	4	100	14	70	32	54	52	27
The side parts	..	..	..	..	2	10	16	27	96	50
Inner trawl	..	..	..	..	..	..	..	..	5	3
Total...	..	..	4	100	20	100	59	100	191	100

Size of fish in cm....	22	23	24	25	26
Inner trawl, pieces (100 %)	46	28	28	24	17

f the trawl in the escape of undersized fish.
in proportion to 1000 full sized fish caught.

2. Influence of the side part:

size of meshes in the ide part of trawl	Commercial size 18 cm.		Commercial size 20 cm.	
	Flounder	Dab	Flounder	Dab
nm.....	143	3265	600	746
nm.....	195	883	636	2676

the various parts of the covering trawl (25 mm.).

5	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
0	64	45	27	13	12	..	..	..	..	..	..	..	..	..	..
6	23	17	1	1	..	..	..	..	..	..	..	..	..	..	..
6	93	44	21	7	2	1	..	..	..	..	..	..	..	..	..
2	27	34	44	30	45	32	20	16	8	10	3	3	4	..	..
5	59	47	30	10	5	2	..	..	..	..	..	..	..	..	..
9	4	4	1	..	..	..	..	..	..	..	..	..	..	..	..
2	136	83	30	6	2	..	..	..	..	..	..	..	..	..	..
1	33	29	88	47	94	28	46	28	28	24	17	15	13	8	31

aping of unmeasured fish. (The trawl 45 mm. cover 25 mm.)

	15		16		17		18		19		20		21	
%	pieces	%	pieces	%	pieces	%	pieces	%	pieces	%	pieces	%	pieces	%
31	80	29	64	31	45	32	27	29	13	25	12	20	..	..
20	56	20	23	11	17	12	1	1	1	2	..	..	..	..
47	126	46	93	45	44	32	21	23	7	14	2	4	1	3
2	12	5	27	13	33	24	44	47	30	59	45	76	32	97
100	274	100	207	100	139	100	93	100	51	100	59	100	33	100

	29	30	31	32	33	34	35
	4	1	2	2	3	1	1

	15		16		17		18		19		20		21	
%	pieces	%	pieces	%	pieces	%	pieces	%	pieces	%	pieces	%	pieces	%
25	55	25	59	24	47	26	30	20	10	15	5	5	2	6
16	23	10	22	9	19	11	4	3	4	6	1	1	..	..
56	132	60	136	54	83	47	30	20	6	9	2	2	..	..
3	11	5	33	13	29	16	88	57	47	70	94	94	..	..
100	221	100	250	100	178	100	152	100	67	100	102	100	2	..

	29	30	31	32	33	34	35

Table V. The detailed computation of fish escaped through different parts of the inner trawl in separate hauls.

A. The number of fish and $^0/_{00}$ — separately for undersized — > 17 cm. and full sized — < 18 cm.

Date	Trawl		Number of fish caught		Number of fish retained		Number of fish retained by								
							Inner trawl		Cover Trawl						
									upper part		bottom part		side parts		
			> 17 cm	< 18 cm	inside	cover	> 17 cm	< 18 cm	> 17 cm	< 18 cm	> 17 cm	< 18 cm	> 17 cm	< 18 cm	
Flounder:															
28.9.29	55 mm.	pieces	413	48	5	456	..	5	134	22	78	4	201	17	pieces
	with cover	$^0/_{00}$	..	..	..	..	..	104	324	458	189	84	487	354	$^0/_{00}$
	25 mm.														
31.9.29	—	pieces	523	40	9	554	1	8	114	13	249	8	159	11	pieces
		$^0/_{00}$	..	..	..	..	2	200	218	325	476	200	304	275	$^0/_{00}$
14.9.29	45 mm.	pieces	199	36	33	202	4	29	54	3	32	1	109	3	pieces
	with cover	$^0/_{00}$	..	..	..	..	20	804	271	84	161	28	548	84	$^0/_{00}$
	25 mm.														
14.9.29	—	pieces	131	23	20	134	7	13	11	3	27	2	86	5	pieces
		$^0/_{00}$	..	..	..	..	54	565	84	131	206	86	656	217	$^0/_{00}$
21.9.29	—	pieces	257	57	62	252	20	42	75	2	53	..	109	13	pieces
		$^0/_{00}$	..	..	..	..	78	735	292	35	206	..	424	228	$^0/_{00}$
25.9.29	—	pieces	263	23	39	247	21	18	78	3	43	..	121	2	pieces
		$^0/_{00}$	..	..	..	..	80	782	297	131	163	..	460	87	$^0/_{00}$
25.9.29	—	pieces	124	14	14	124	3	11	46	2	16	1	59	..	pieces
		$^0/_{00}$	..	..	..	..	24	786	371	143	129	71	476	..	$^0/_{00}$
16.10.29	—	pieces	810	80	77	813	20	57	362	17	26	3	402	3	pieces
		$^0/_{00}$	..	..	..	..	25	713	447	213	32	37	496	37	$^0/_{00}$
24.10.29	—	pieces	591	87	75	598	17	58	281	22	59	2	234	5	pieces
		$^0/_{00}$	..	..	..	..	29	665	475	253	100	24	396	58	$^0/_{00}$
Dab:															
28.8.29	55 mm.	pieces	308	31	4	335	..	4	157	13	75	3	76	11	pieces
	with cover	$^0/_{00}$	..	..	..	..	..	130	510	419	243	97	247	354	$^0/_{00}$
	25 mm.														
31.8.29	—	pieces	395	33	1	427	..	1	132	15	141	9	122	8	pieces
	45 mm.	$^0/_{00}$	..	..	..	..	..	30	334	455	357	273	309	242	$^0/_{00}$
14.9.29	with cover	pieces	244	150	156	237	22	134	74	7	32	1	116	8	pieces
	25 mm.	$^0/_{00}$	..	..	..	..	90	893	303	47	131	7	476	53	$^0/_{00}$
14.9.29	—	pieces	280	110	121	269	23	98	11	3	27	2	219	7	pieces
		$^0/_{00}$	..	..	..	..	82	891	39	27	97	18	782	64	$^0/_{00}$
21.9.29	—	pieces	184	49	52	181	12	40	64	3	53	..	55	6	pieces
		$^0/_{00}$	..	..	..	..	65	816	348	61	288	..	299	123	$^0/_{00}$
25.9.29	—	pieces	390	90	67	396	17	67	54	9	43	..	236	14	pieces
		$^0/_{00}$	..	..	..	..	43	744	249	100	110	..	605	156	$^0/_{00}$
25.9.29	—	pieces	100	31	34	97	7	27	24	1	16	1	53	2	pieces
		$^0/_{00}$	..	..	..	..	70	871	240	32	100	32	530	65	$^0/_{00}$
16.10.29	—	pieces	70	50	40	80	4	36	20	11	26	3	20	..	pieces
		$^0/_{00}$	..	..	..	..	58	720	285	220	372	60	285	..	$^0/_{00}$
24.10.29	—	pieces	160	102	86	174	4	84	50	15	59	2	47	1	pieces
		$^0/_{00}$	..	..	..	..	25	823	312	147	369	20	294	10	$^0/_{00}$

The number of fish in proportion to 1000, which escaped from the inner trawl and were retained by different parts of the cover.

Size of fish in cm....	8	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	34	35	Total
1. The inner trawl 55 mm. cover 25 mm.																													
Flounder (991 fish measured on 2 hauls):																													
Escaped through the upp. part.	20	37	40	57	135	125	168	165	104	61	30	27	24	7	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1000
Escaped through the bottom p.	57	182	155	41	125	137	72	105	48	42	21	3	6	6	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1000
Escaped through the side parts	18	62	85	54	95	131	164	144	116	57	15	26	8	8	8	3	3	3	..	..	..	..	..	..	..	..	..	..	1000
Remained inside the inner trawl.	..	..	..	..	..	..	..	..	..	71	..	71	71	17	215	144	..	71	71	..	..	144	..	..	..	..	..	..	1000
Dab (776 fish measured on 2 hauls):																													
Escaped through the upp. part.	..	17	23	40	36	116	194	135	165	119	33	63	23	23	3	7	3	..	..	..	..	..	..	..	..	..	..	..	1000
Escaped through the bottom p.	4	13	31	26	197	338	123	105	62	48	13	18	18	4	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1000
Escaped through the side parts	9	41	152	226	124	166	120	74	37	28	9	..	..	..	..	..	..	..	9	..	5	..	..	..	..	..	..	..	1000
Remained inside the inner trawl.	..	..	..	..	..	..	..	..	..	..	..	250	250	..	250	..	..	250	..	..	..	..	..	..	..	..	..	..	1000
2. The inner trawl 45 mm. cover 25 mm.																													
Flounder (3386 fish measured on 7 hauls):																													
Escaped through the upp. part.	1	42	118	166	204	124	94	83	67	47	28	14	13	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1000
Escaped through the bottom p.	6	103	164	291	165	91	66	65	27	20	1	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1000
Escaped through the side parts.	..	6	80	184	220	168	107	101	74	35	17	5	2	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1000
Remained inside the inner trawl.	..	..	3	..	19	19	19	37	84	106	138	94	141	100	63	50	25	..	31	9	9	14	3	6	6	9	3	3	1000
Dab (2001 fish measured on 7 hauls):																													
Escaped through the upp. part.	..	..	10	29	99	168	155	142	153	122	78	26	13	5	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1000
Escaped through the bottom p.	..	15	53	121	196	200	140	87	83	71	15	15	4	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1000
Escaped through the side parts.	..	..	3	20	121	198	109	160	171	104	38	7	3	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1000
Remained inside the inner trawl.	..	..	..	..	9	7	13	20	59	52	158	85	170	50	83	50	50	43	31	27	23	14	20	5	14	11	4	2	1000

calculated in percentages for each size of fish. This computation shows more clearly how important the bottom part of the trawl is for saving immature fish, especially for sizes 8, 9, 10 cm.; flounders of these sizes escaped in the proportions 83 %, 65 % and 39 % through the bottom part; as regards dabs, even fishes of a larger size, 9, 10, 11 cm., escaped through the same part in the proportions 100 %, 70 % and 54 %.

In Table V we find the detailed records of each haul; the fishes are divided into two groups with reference to the commercial size 18 cm.: undersized and full sized; the results are computed for each group in proportion to 1000. We can observe that in all cases, without exception, we find the undersized fish escaping through the bottom part of the inner trawl; this part of the catch in some hauls is very considerable and consists mostly of the smallest specimens.

The above considerations, based on the results of experiments with trawls in Polish waters, authorise us to state that:—

1) The catch of undersized fish depends primarily on the size of mesh used, and a "savings mesh" could be established for each commercial size.
2) If a "savings mesh" is used, the chances of retaining or losing undersized fish depend on the number of meshes; therefore not only the cod-end but also the front part of the trawl is of great importance.
3) The undersized fish, try to escape through "savings meshes" not only in the sides of the trawl, but also in the upper and even in the bottom part, the last being especially important for the smallest fish.

References:

1) "Om trålfisket och dess inverkan på fiskebestandet". — Ur Svenska Hydrografisk-Biologiska Kommissionens Skrifter VII.
2) Baranow, T. The methods of seine-net fishing. Materials for knowledge of Rus. Fish. No. 4. Petersburg 1913.
3) Baranow, T. The herring fishery with set-nets. Ibidem T. III. No. 6. Petersburg 1914.
4) Baranow, T. On the productivity of the Seine-Fishery. Rep. of Icht. Lab. Astrahan. Vol. V. No. 1. 1923.
5) Henking und Fischer. Die Scholle und Flunder im Ostseegebiet. Berlin 1912.
6) Russell, E. S. and Edser, T. The relation between cod-end mesh and size of fish caught. Journal du Conseil. Vol. I. Nr. 1.
7) Bowman, A. The qualitative effect of different fishing gears on the stock of the marketable species. Rapp. Cons. Int. Vol. LII.
8) Bowman, A. The saving effect of an increase in the size of the cod-end meshes of the haddock of unmarketable sizes. (MS.)
9) Davis, F. Preliminary note on experimental trawling with cod-end meshes of different sizes. Journal du Conseil. Vol. IV.
10) Tesch. Report of experimental fishing with Savingstrawl-Gelder. (MS.)
11) Davis, F. An account of the fishing gear in England and Wales. Fish. Inv. Vol. IX, No. 6.