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Introduction

Since its introduction in the North Sea in 1963 the beam trawl gradually replaced the otter trawl and became the most important fishing gear for flatfish.
In 1979 and 1980 about 95% of the sole landings and more than 60% of the plaice landings came from beam trawlers, the greater part being landed by the Dutch fleet.

In the period 1963 - 1980 the average engine power of the Dutch beam trawlers has increased from about 250 HP to about 1100 HP, which enlarged their fishing power by allowing to carry more thickler chains and heavier gear and to increase their fishing speed.
As a consequence by catches of invertebrates, dead shells, stones and undersized fish increased also, which might influence the selectivity of the cod-end.

In the past mesh selection experiments in North Sea plaice have been reported by BOEREMA (1956, 1958), BEVERTON AND HOLT (1957), ROESSINGH (1960) and BOHL (1964).
These experiments were carried out with the otter trawl.
Recently RAUCK (1980) reported on the selectivity of plaice for a 180 HP German beam trawler. Information on the selectivity of the beam trawl gear under recent conditions is lacking.

The proposal of the EEC to increase the minimum mesh size for otter- and beam trawl from 8.0 to 9.0 cm in 1982 gave the incentive to carry out further mesh selection experiments on plaice and sole with the beam trawl.

In this paper the results of a mesh selection experiment om plaice carried out under the present conditions in the Dutch beam trawl fishery are presented and discussed.

Material and methods

For the experiments a Dutch commercial vessel (JOHANNA CORNELIA) was chartered for the period of two weeks, from the 25th May to the 5th of June 1981.
The JOHANNA CORNELIA (34 m in length; 1015 horsepower, brt 230) fishes with two 10 m beam trawls, each of which carried three 20 mm and two 18 mm thickler chains from the trawl heads and respectively three 18 mm and two 16 mm thickler chains from the chain groundrope. The chain groundrope was 26 m long and wrapped with rope, chains and rubber for 6 m in the bossom.

The selectivity was measured by means of the cod-end cover method (whole cover). Four different cod-ends were used. The cod-end and cover materials and braiding are listed in table 1.
To the cover nine 4 litre floating balls were tied to lift up the cover in order to avoid contact between the top of the cod-end and the cover. (Fig. 1).

At least once a day meshes of cod-end were measured (25 meshes per measurement). All mesh measurements were made with an ICES spring-loaded gauge at an operating pressure of 4 kg.

Most of the hauls were made in an area 7 to 16 miles N.E. of Terschelling. In this area large quantities of young flatfish in the selection range of the cod-ends were present. In the second week part of the hauls with the 12 cm and 14 cm cod-end were made further away from the coast in order to obtain larger fish in the upper range of the selection curves.

The length composition of the plaice catch covered the selection range for all investigated mesh sizes (table 2). For each mesh size a serie of hauls was made. In table 3 the dates, measurements, number of hauls, towing time and volume of the catches are given for each serie.

The fishing speed was 5 nautical miles per hour. The towing time varied between 60 and 90 minutes with an average of about 70 minutes per haul. Starfish, stones and shells e.d. which had escaped through the cod-end meshes were now caught in the cover. Because of these extra large bycatches in the cover it was not possible to increase towing time without loosing speed or running the risk of loosing the cod-end and cover altogether.

Both beam trawls, each rigged with cod-ends of different mesh sizes were shot and hauled simultaniously. In this way two sets of observations were obtained at the same time.

In total 94 hauls were made. From each haul the catches in the cod-end and cover were treated seperately. The volume of the catch was estimated and the catch was sorted for plaice.
In total about 50.000 plaices were caught.
In most cases the plaice catch had to be subsampled for length measurements. The numbers in the subsamples varied between 75 and 150 fish per cod-end or cover.
The length of the fishes in the subsamples was measured to the cm below.

Results

About 70% of the volume of the catches existed of starfish (Asterias rubens), masked crab (Corystes cassivelaunus) and dab (Limanda limanda).
Miscellanious species as sole (Solea solea), whiting (Merlangius merlangus), cod (Gadus morhua), turbot (Scopthalmus)maximus), brill (Scopthalmus rhombus), gurnets (Eutrigla gurnardus and Trigla lucerna), edible crab (Cancer pagurus), swimming crab (Macropipus holsatus), dead and live shells, stones, pieces of wood and "rubbish" as bottles, beer tins, pieces of rope e.g., made up about 10% of the catch, about 20% of the catch was plaice.

Selection factors were determined by reading the 50% retention length off the selection curves fitted to the points by eye. (Fig. 2.).
Table 4 summarizes the total number of fishes caught, the total number in the selection range, the 25%, 50% and 75% retention length and the selection factors for each mesh size.

The selection factor for the cod-ends with a mesh size of 9.04, 10.91 and 12.23 cm was 2.1.
The selection factor for the 13.72 cm cod-end was 2.2.

The shape of the selection curves for the different mesh sizes are not identical. How bigger the mesh size, how flatter the curve. Moreover selection curves for the 12.23 and 13.72 cm cod-ends are asymmetrical.

In order to examine an effect of the total catch in the wide cod-end on the selection factor, the hauls have been divided into four weight classes; 0 - 160 kg, 160 - 320 kg, 320 - 480 kg and 480 - 640 kg. The selection factors for the grouped hauls given in table 5 show a slight tendency of better selection in the smaller catches.

Discussion

The results of the most of the earlier mesh experiments on plaice are summarized in: ICES (1964). The selection factors found in these experiments vary between 2.0 and 2.5 but were generally close to 2.3. BOHL (1964) found selection factors varying between 1.9 and 2.2. THORSTEINSSON (1980) reported a value of 2.0. All these experiments were carried out with otter trawls. The selection factors from the beam trawl experiments of RAUCK (1980) were 1.9 and 2.2. Compared with these values the selection factors presently obtained (2.1 and 2.2) lie within the range of the earlier values.
In the last 20 years the horse power of the vessels went up considerably and consequently the fishing speed. Also cod-end materials as manilla, hemp, sisal and nymplex dissapeared and were replaced by twined or plaited nylon. However, of far more importance was the change from otter trawl to beam trawl with more and heavier thickler chains, resulting in increased bycatch of bottom organisms and "rubbish".
ROESSINGH (1960), BOHL (1964), BURD AND VINCE (1979) and RAUCK (1980) already noted the effect of the amount ot total catch on the selection proces. They all found lower selection factors for flatfish in hauls with more volume or larger numbers in the total catch. This tendency also appeared in our experiments with "9 cm" and "12 cm" cod-end. For the 9 cm cod-end the selection factor decreased 2.2 to 1.9 when total catch in the cod-end increased from 160 - 320 to 320 - 480 kg.
In the 12 cm cod-end the selection factor decreased from 2.1 to 2.0 when total catch increased from 0 - 160 to 320 - 480 kg. There was one haul with a total catch of more than 480 kg.
In the data from this haul no clear picture of a selection curve emerged suggesting that selection was seriously blocked.
SAETERSDAL (1960) found no trend in a plot of selection factors against size of catch for cod and haddock, but plotted against towing speed there was a tendency for the selection factors of cod to increase with decreasing speed. Since towing speed was not varied in our experiments, this effect cannot be assessed for flatfish.

In the present experiment no significant differences were found between the selection factors for the investigated mesh sizes. However there are differences in the shape of the selection curves.
With increasing mesh size the shape of the curves becomes more flat.

This means that with increasing mesh size the selection takes place over a wider range of length categories. This result contradicts the idea that the amount of filling in the cod-end reduces the selectivity by means of masking the meshes because with increasing mesh size also the total catches decreased. Certainly in the cod-end with the largest meshes it was unlikely that the little amount of total catch could have played a role in the selection proces.

The selection ranges of the 9.04 cm, 10.91 cm, 12.23 cm an 13.72 cm cod-ends are respectively 3.2, 3.5, 5.6 and 5.4 cm.
Most of the experiments of BOEREMA, ROESSINGH AND BEVERTON AND HOLT (ICES, 1964) and BOHL (1964) are carried out with mesh sizes varying between 7 and 9 cm. They found steep selection curves with selection ranges between 1.0 and 2.8 cm. Also RAUCK (1980) obtained for a 6.5 cm cod-end selection ranges of 1.1 and 1.8 cm.
In the experiments carried out with larger mesh size, wider selection ranges were found. BEVERTON AND HOLT in ICES (1964) gave selection ranges of 3.4, 2.1 and 3.6 for mesh sizes of 11.3, 11.2 and 14.1 cm.
THORSTEINSSON (1980) gave a selection curve for plaice in a bottom trawl with 16.5 cm mesh size with selecion range of 5.5 cm. His curve is also asymmetrical with the longest traject in the lower part of the curve.
Our results confirm these experiments.

There are two possible explanations for this feature which both may have played a role.
With increasing length plaices become thicker and less flexible. It might be possible then that the change of escape through the meshes relative to the ratio fish length/mesh size becomes smaller.
Selection needs some time. Fishes caught in the last minutes of a haul are exposed only a little time to the selection proces. Part of the fish which,given time, would escape do not do so before the end of the haul and remain in the cod-end. In that situation the fractions in the cod-end are higher than expected. The effect of this feature on the selection curve depends on the length frequency of the total catch. The curves therefore may be biassed, especially for those length groups, which are not or partly selected by the wide cod-end.

The results of this experiment may also be biassed in another way, because the cover may interfere with escape in the cod-end. However, earlier experiments (not published) showed that there was no significant difference in the catch in numbers and in the length composition for both plaice and sole between a cod-end cover combination and a cod-end of the same mesh size without a cover.

The beam trawl fishery is a mixed fishery on flatfish, mainly plaice and sole. Presently the majority of the fleet is fishing with a mesh size of 8.0 cm. This mesh size was not investigated in this experiment because plaice in the selection range of this mesh size (15 - 18 cm) is seldom present on the fishing grounds, which lie outside the 12 mile fishing limit. This means that at present there is hardly any selection on plaice in the beam tarwl fishery.

Taking into consideration the minimum landing size of plaice of 25 cm (in The Netherlands 27 cm) and a selection factor of 2.1 or 2.2 (or the results of our experiments) the most appropriate cod-end mesh size in a specific plaice fishery should not be less than 12 cm. This mesh size would hardly give any loss of marketable plaice and will save the majority of undersized fishes.

In a mixed fishery on plaice and sole, however, this would also mean a loss

of almost all marketable soles, because with a selection factor of 3.3 (RIJNSDORP, VAN BEEK AND VAN LEEUWEN, 1981) the 50 % retention length of sole at this mesh size would be 39 cm.

Summary

Results are presented of mesh selection experiments on North Sea plaice carried out with a commercial Dutch beam trawler. Selection factors of 2.1 and 2.2 were found which lie in the range of earlier found values. The selection factors tend to decrease when total catch in the cod-end increases. The shape of the selection curves become more flat when the mesh size of the cod-end increases.

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Table I - Cod-end material and construction.

Mesh size cod-end	Length in meshes	Contour in meshes	Material and braiding
"9"	50	100	single nylon
"10"	45	90	single nylon
"12"	40	75	single nylon
"14"	35	65	single nylon
cover "4"	150	400	single nylon

Table II - Length distribution of plaice in cod-end and cover, all hauls combined.

Mesh size	9.04			10.91			12.23			13.72		
Length (cm)	cover	cod-end	% ret.	cover	cod-end	% ret.	cover	cod-end	% ret.	cover	cod-end	% ret.
12.5	1		0	1		0				3		0
13.5	2		0	6		0	2		0			
14.5	5		0	18		0						
15.5	13		0	21		0	3		0			
16.5	22	8	27	34	3	8	15		0	13		0
17.5	47	12	20	75	10	12	13		0	17		0
18.5	97	68	41	144	25	15	61	8	12	38		0
19.5	148	217	59	326	30	8	112	27	19	108	9	8
20.5	185	510	73	648	144	18	171	20	10	177	13	7
21.5	126	1158	90	1012	491	33	350	161	32	311	31	9
22.5	40	2079	98	1208	890	42	465	171	27	576	47	8
23.5	22	2395	99	1176	1765	60	641	366	36	764	87	10
24.5	11	2456	99	670	2043	75	666	542	45	905	110	11
25.5	10	2005	99	258	2061	89	619	578	48	835	201	19
26.5	4	1554	99	66	1773	96	436	698	62	638	229	26
27.5	1	1063	99	9	1099	99	264	683	72	453	165	27
28.5	1	670	99	1	678	99	92	501	84	283	136	32
29.5		367	100	3	332	99	34	457	93	145	109	43
30.5	1	274	99		182	100	10	307	97	93	91	49
31.5		144	100	1	103	99		157	100	34	77	69
32.5		60	100		48	100		148	100	16	75	82
33.5		48	100		15	100		87	100	5	61	92
34.5		33	100		9	100		72	100	1	30	97
35.5		31	100		15	100		21	100		32	100
36.5		12	100		8	100		21	100		15	100
37.5		8	100		3	100		12	100		17	100
38.5		6	100		7	100		22	100		10	100
39.5		3	100		1	100		7	100		9	100
40.5		3	100					13	100		5	100
41.5		12	100					8	100		4	100
42.5		1	100					6	100		3	100
43.5					1	100		2	100			
44.5		4	100									
>44.5		1	100		1	100		4	100		2	100
Total	736	15202		5677	11737		3954	5099		5415	1568	

Table III - Technical data for the mesh/size selectivity experiments on plaice in 1981.

date	number of hauls	Tow duration		mesh size in cm						mean catch per* haul, all species	
		mean	range	codend	S.d	n	cover	S.d	n	codend	cover
26-27 May 2-4 June	24	73	60-90	9.04	0.21	100	3.76	0.22	50	6.9	5.5
27-29 May 2-4 June	26	73	60-90	10.91	0.31	125	3.78	0.19	75	5.3	7.2
26-28 May 1-2 June	24	70	60-90	12.23	0.19	100	3.82	0.20	50	4.8	9.2
28-29 May 1-2 June	20	70	60-90	13.72	0.25	125	3.56	0.15	75	2.1	10.3

* baskets of ± 40 kg.

Table IV - Results of the mesh size selectivity experiment on plaice with a beam trawler.

mesh size	50% retention length (cm)	selection factor	25% - 75% selection range (cm)	sel. range (cm)	number of plaices in selection range	total catch of plaices (numbers)
9.04	19.0	2.1	17.5 - 20.7	3.2	1284	15938
10.91	22.9	2.1	21.0 - 24.5	3.5	9305	17414
12.23	25.4	2.1	22.2 - 27.8	5.6	6640	9053
13.72	30.0	2.2	26.6 - 32.0	5.4	2453	6983

Table V - Relation between weight of total catch (fish + rubbish) in cod-end and selection factor.
Between brackets: Number of hauls over which the data were lumped.

	Weight cod-end			
Mesh size	0 - 160 kg	160 - 320 kg	320 - 480 kg	480 - 640 kg
9.04	-	2.2 (18)	1.9 (6)	-
10.91	2.1 (7)	2.1 (17)	2.1 (2)	-
12.23	2.1 (15)	2.1 (5)	2.0 (3)	(- (1))
13.72	2.2 (20)	-	-	-

Figure .1 - Diagram of rigging the cod-end cover with floats.

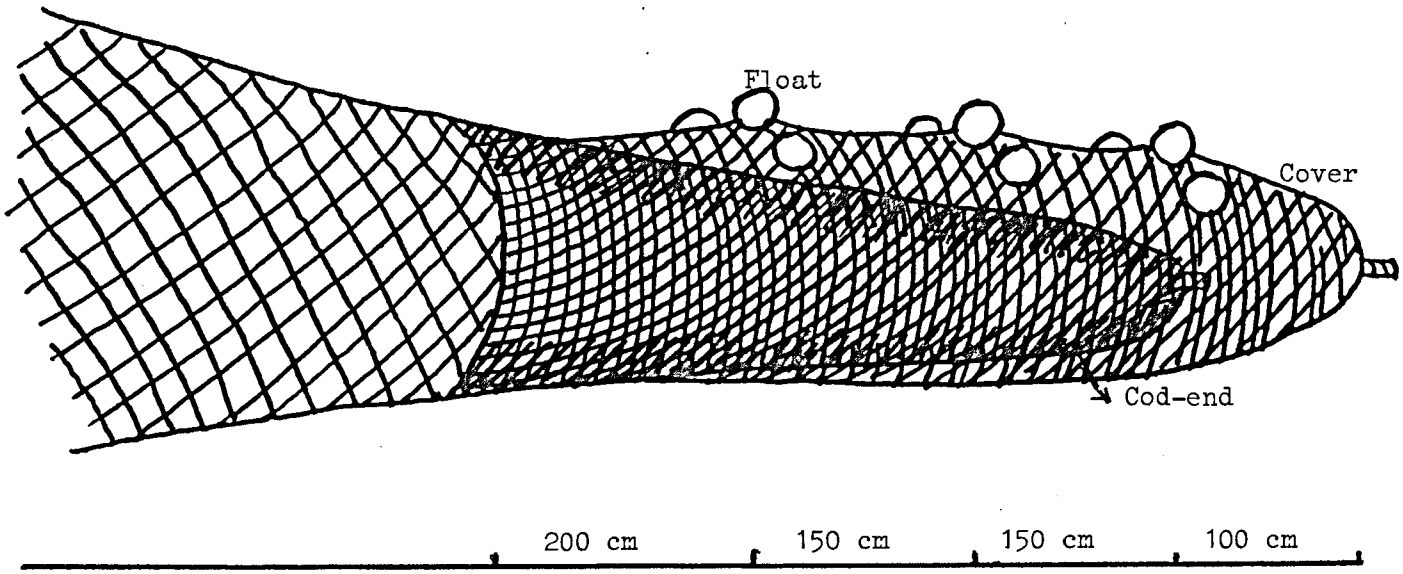

Figure 2 - Selection curves for North Sea plaice.