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Trouser Trawl Method of Studying Selectivity of American Plaice: Square vs Diamond Mesh Codends

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Abstract

Codend selectivity of two groundfish trawls for American plaice was measured in diamond mesh and square mesh codends. The comparison between the different codends was made by the trouser trawl method. In both trawls, a vertical panel in the front was used for dividing the extension piece and the belly into two equal parts; and the mesh sizes considered were 140 mm and 155 mm.

Selection curves and parameters were derived by two methods: (1) observed curves drawn by eye and (2) theoretical curves drawn by maximum likelihood analysis. Good consistency between both methods was achieved. Selection factors were higher for diamond mesh codends than for square mesh codends. In direct opposite to results obtained for roundfish such as cod and haddock, diamond mesh allow more escapement of small plaice.

Introduction

Conventional otter trawls indiscriminately catch immature fish and this by-catch problem of undersized fish is present in the Canadian groundfish fishery. Canadian fishery regulations have a minimum mesh size of 130 mm in groundfish trawls. Within the last two years, some commercial fishing companies in the Newfoundland Region have switched to using square mesh codends while fishing directly for Atlantic cod. However, when fishing directly for flatfish species, they claim that they catch many undersized flatfish using square mesh codends; thus, they fish with the traditional diamond mesh codends. The Department of Fisheries and Oceans, Scotia-Fundy Region, has been conducting sea trials on selectivity of diamond and square mesh codends with particular emphasis on cod and haddock during the last 2 years. Additional data was also collected on commercial American plaice, Hippoglossoides platessoides. In this paper we analyze trawl selectivity of American plaice using diamond and square mesh codends.

Materials and Methods

Trouser trawls were used to derive selectivity values in diamond and square mesh codends. The trawl was fished with 1 leg of the trawl being a 38 mm small mesh codend while the other was the larger diamond or square mesh codend. In October of 1988, sea trials were carried out using a Western IIA groundfish trawl off the coast of Nova Scotia aboard the Canadian research vessel E. E. PRINCE (Fig. 1). The trawl was modified into a trouser trawl incorporating a vertical panel separator with a 140 mm mesh size diamond and square mesh codend (Fig. 2). A second trial was also conducted in late October of 1988 using a Nordsea 642 Nova groundfish trawl on the Grand Banks of Newfoundland aboard the Canadian research vessel W. TEMPLEMAN (Fig. 1). Again, this trawl was fitted with a vertical separator panel and twin codends with a 155 mm mesh size diamond or square mesh (Fig. 3).

Selection curves for the 140 mm and 155 mm mesh size diamond and square were derived by two methods: (1) by eye, and (2) by maximum likelihood analysis. The latter was used to generate the theoretical selection curves in a manner described by Pope et al. (1975). The 140 mm mesh selection trials were based on 11 hauls using a knotless diamond mesh codend and 20 hauls using a square mesh codend. The 155 mm selection trials were based on 13 hauls using a knotless diamond mesh codend and 16 hauls using a square mesh codend. The performance of the Nordsea trouser trawl were monitored using an underwater remote operated vehicle equipped with a television camera.

Results

The length distributions of plaice from the small and wide (140 and 155 mm) codends are shown for each area in Tables 1 and 2 and Fig. 4.

Catches of plaice between 28 and 36 cm showed a higher percentage retained by the square mesh codend than the diamond mesh codend as both approached the asymptote of 100% (Fig. 4, Table 1). In the 155 mm Nordsea 642 trouser trawl, catches below 26 cm were almost non-existent in the wide mesh codends (Fig. 4, Table 2). Between 28 and 30 cm, both the diamond and the square mesh codends retained a similar percentage of plaice. However, more plaice between 21 and 36 cm were retained in the square mesh codends (Fig. 4 and 5). As was expected, more small plaice were present in the small mesh codends of both trawls.

The percent retained (wide mesh catch/small mesh catch x 100%) of plaice in the 140 mm square mesh codend started to become divergent from the asymptote value of 100% beyond the 40 cm size range (Fig. 5A). The divergence was much greater in the 155 mm square mesh codend (Fig. 5B). However, no divergence was apparent in the diamond mesh codends in both experiments. This divergence away from 100% in large sizes was attributed to the small mesh codends containing more fish than the large square mesh codend and small sample sizes of fish beyond 50 cm (Tables 1 and 2).

140 mm mesh selection

Selected curves derived by both methods are presented in Fig. 6. There was close agreement using both methods in deriving selection values, although the 75% selection values were higher in the maximum likelihood analysis (Table 3). The observed 50% selection value was 34 cm for the diamond mesh codend, somewhat higher than the 30 cm value observed in the square mesh codend. Both the selection range and selection factor was higher for the diamond mesh codends indicating that the square mesh codend retained more smaller fish.

155 mm mesh selection

Selection curves derived by both methods are presented in Fig. 7. Close agreement in selection values were derived for the diamond mesh codend, however, the 50% and 75% values derived by the theoretical method were much higher than the observed values (Table 3). The observed values for the 50% selection were higher for the diamond mesh codend (L50% = 36) than the square mesh codends (L50% = 33), although the theoretical values for both were identical. The observed selection range for the diamond mesh and the selection factor were higher than the square mesh codend.

However the selection range for the square mesh codend derived from the theoretical curve was much higher than the observed range in particular the 25% to 75% selection values (Table 3 and 4, Fig. 7). This is attributed to the fact that in the larger size groups the small mesh codend caught more fish. Maximum likelihood analysis is a very rigorous analysis which tries to give equal weighting to each value point, thus the points that diverge from the asymptote strongly influence the shape of the upper section (and hence lower section) of the theoretical curve. In drawing the cure by eye it is difficult also to be accurate about the shape of the curve beyond 40 cm. Here in Fig. 7 we gave no weight to the divergent points. The 50% selection values were within 2 cm of each other, however, we interpret the large selection range derived by maximum likelihood method as a poor fit to the model.

In summary diamond mesh codends have a higher selection for small plaice in both experiments, with more smaller plaice being retained by square mesh codends.

Discussion

In both experimental trials, the 50% selection value was higher for the diamond mesh codend indicating more retention of small plaice by the square mesh codend. The selection factor was also higher for both diamond mesh codends in comparison to the square mesh codends. The selection ranges in both experiments were also higher for diamond mesh codends. The accuracy of the two methods for deriving selection curves was close in all comparisons except the 155 mm square mesh codends where there was a poor fit to both methods, although fair agreement in the 50% selection values. This discrepancy is attributed to more plaice being caught in the small mesh codend which caused a divergence away from the asymptotic value of 100%. Nicolajsen (1988) reported similar findings in his work on a vertical split Nephrops trawl and indicated that the two halves of the footrope were not fishing equally efficient. Our underwater observations by the ROV in the 155 mm mesh selection experiment showed that the net was fishing evenly. Differences are probably due to low abundance of larger plaice in the area survey and although we assume that the vertical separator panel should split the catch evenly it is unlikely that this would be the case with small sample sizes.

Conclusions

Large diamond mesh codends are more effective in releasing small plaice than square mesh codends. This finding confirms the fishing industry's report. In diamond mesh codends the codend becomes heavy with fish causing the meshes in the lengthening piece and front end to elongate (Fig. 8). In square mesh codends the meshes stay open throughout thus allowing roundfish to escape. Thus diamond meshes present a greater escape area than square meshes since escapement of plaice is related to its breadth rather than through its girth as in the case of roundfish.

References

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Table 1. Length frequency distribution of plaice from the 140 mm mesh Western II A trouser trawl.

Length Group	Diamond Codend	Small Mesh Codend	Diamond % Retained	Square Codend	Small Mesh Codend	Square % Retained
10	0	10	0	0	1	0
12	0	25	0	0	15	0
14	1	26	4	1	58	2
16	1	88	1	0	142	0
18	0	85	0	1	169	1
20	1	69	1	0	221	0
22	2	80	3	1	164	1
24	8	86	9	8	241	3
26	19	114	17	12	252	5
28	16	108	15	37	194	19
30	18	95	19	75	160	47
32	37	102	36	97	139	70
34	43	84	51	83	104	80
36	36	53	68	66	74	89
38	36	37	97	44	51	86
40	28	22	100	26	21	100
42	23	20	100	11	24	46
44	15	11	100	11	12	92
46	13	7	100	19	14	100
48	10	8	100	13	13	100
50	5	2	100	19	18	106
52	3	3	100	15	15	100
54	5	1	100	8	9	89
56	2	0	0	6	8	75
58	0	0	0	3	5	60
60	0	0	0	3	2	100
62	1	1	100	2	1	100
64	0	0	0	1	0	0
Total	323	1147		562	2127	

Table 2. Length frequency distribution of plaice from the 155 mm Nordsea 642 trouser trawl.

Length Group	Diamond Codend	Small Mesh Codend	Diamond % Retained	Square Codend	Small Mesh Codend	Square % Retained
8	0	0	0	0	1	0
10	0	1	0	0	1	0
12	0	0	0	0	1	0
14	0	1	0	0	4	0
16	0	3	0	0	5	0
18	0	4	0	0	19	0
20	0	6	0	0	18	0
22	0	5	0	0	19	0
24	1	11	9	0	21	0
26	0	17	0	0	33	0
28	1	26	4	2	37	5
30	5	39	13	8	56	14
32	18	57	32	37	88	42
34	20	69	29	65	114	57
36	39	74	53	82	104	79
38	56	69	81	76	90	84
40	58	64	91	71	68	100
42	52	62	84	81	88	92
44	60	53	100	71	94	76
46	55	48	100	85	80	100
48	39	41	95	51	80	64
50	28	23	100	37	67	55
52	22	15	100	35	36	97
54	15	5	100	22	24	92
56	10	5	100	9	10	90
58	11	10	100	17	16	100
60	11	4	100	4	4	100
62	10	3	100	5	12	42
64	8	3	100	3	3	100
66	2	2	100	5	1	100
68	0	1	0	1	2	50
70	3	1	100	0	2	0
72	0	0	0	0	0	0
74	1	0	0	0	0	0
Total	525	377		767	407	

Table 3. Codend selectivity values derived from the plot drawn by eye for American plaice, with theoretical values derived from maximum likelihood analysis in brackets.

Gear	Diamond mesh			Square mesh			Selection factor L50/Mesh size	
	L-25%	L-50%	L-75%	L-25%	L-50%	L-75%	Diamond	Square
Atlantic Western IIA 140 mm mesh	29(29)	34(34)	36(40)	28(28)	30(31)	33(36)	2.4(2.4)	2.2(2.3)
Nordsea 642 155 mm mesh	32(31)	36(35)	38(39)	31(27)	33(35)	36(47)	2.3(2.3)	2.1(2.2)

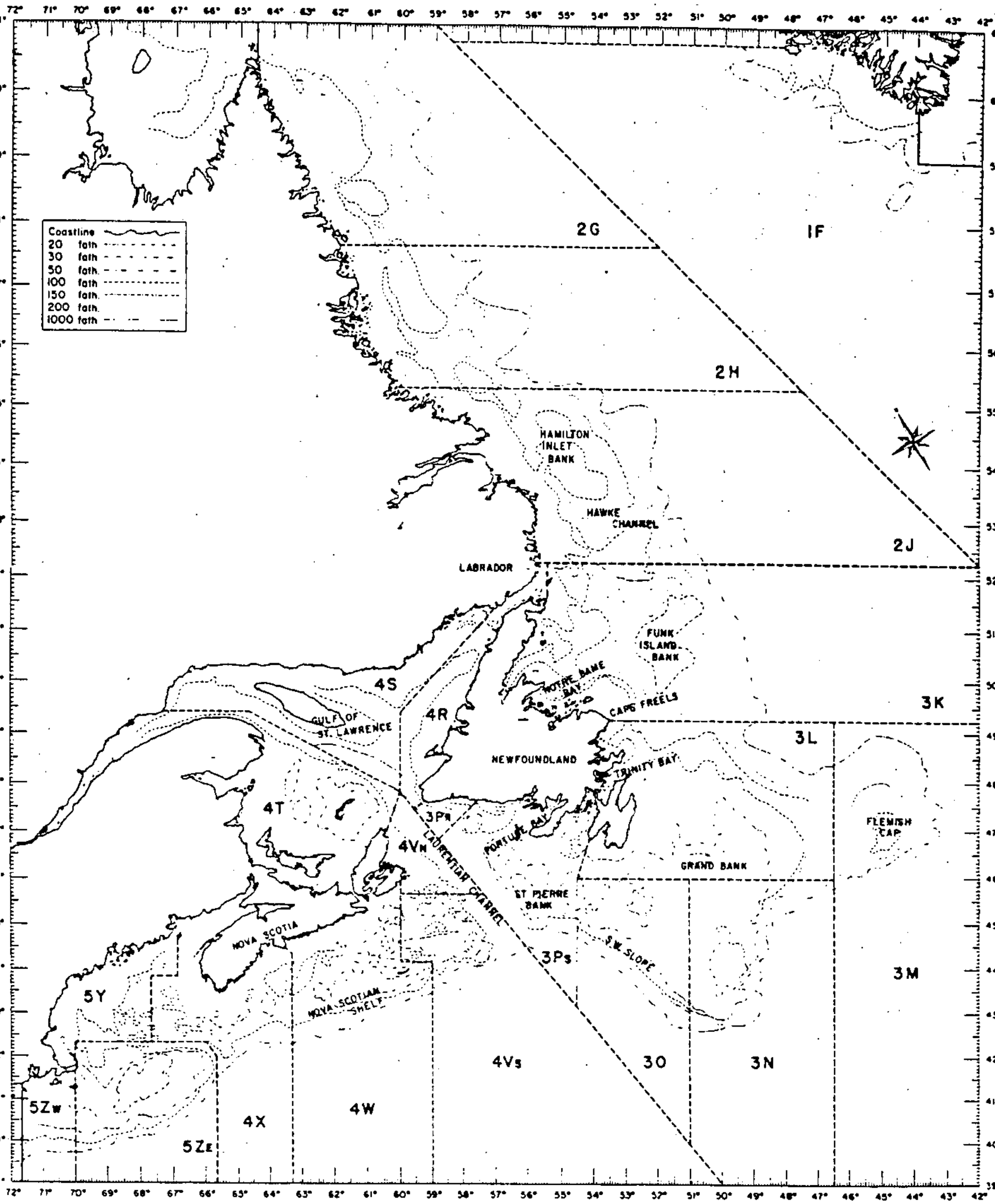


Fig. 1. Chart of Atlantic Canada where diamond and square mesh experiments took place.

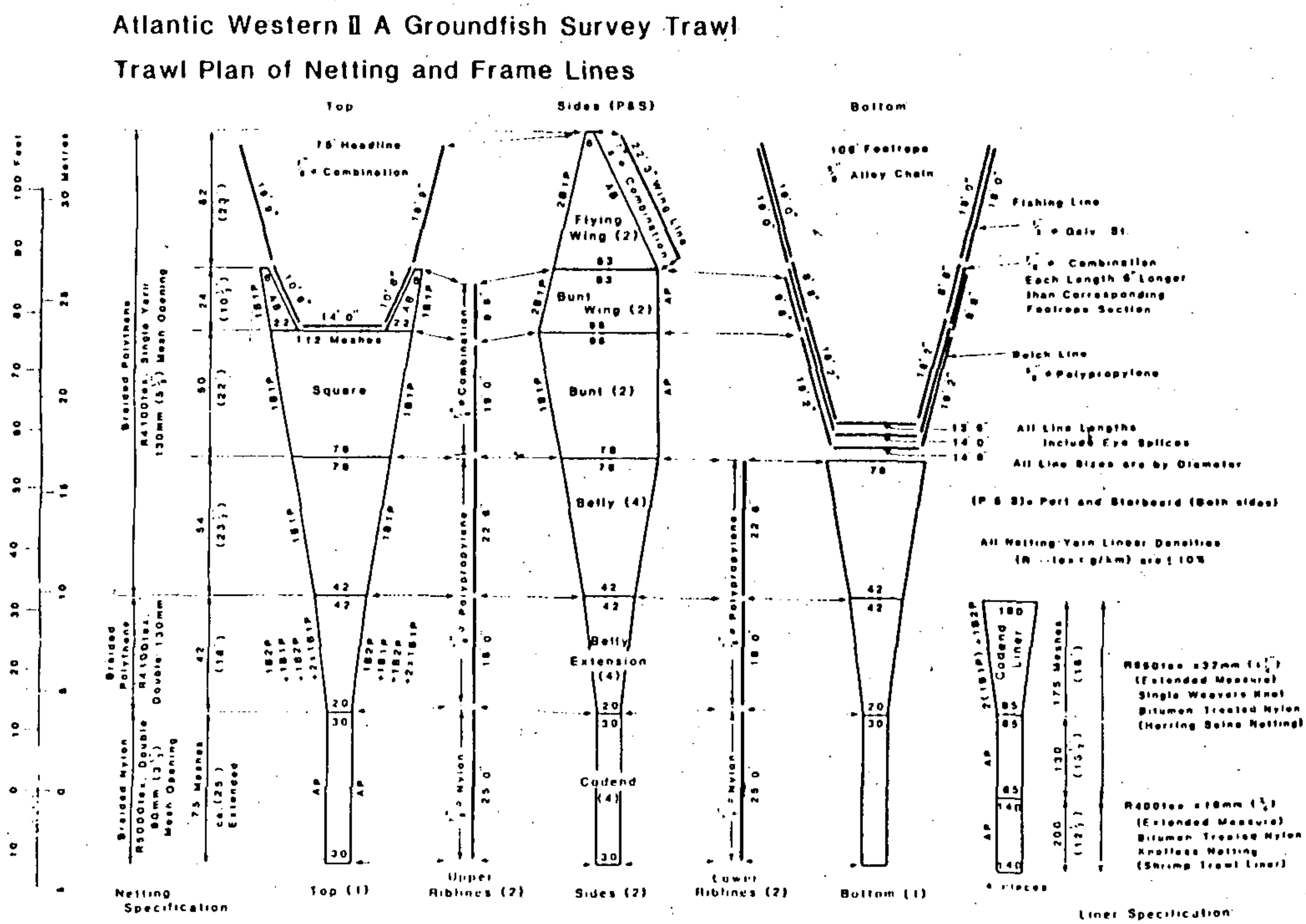


Fig. 2. WESTERN II A Groundfish Trawl.

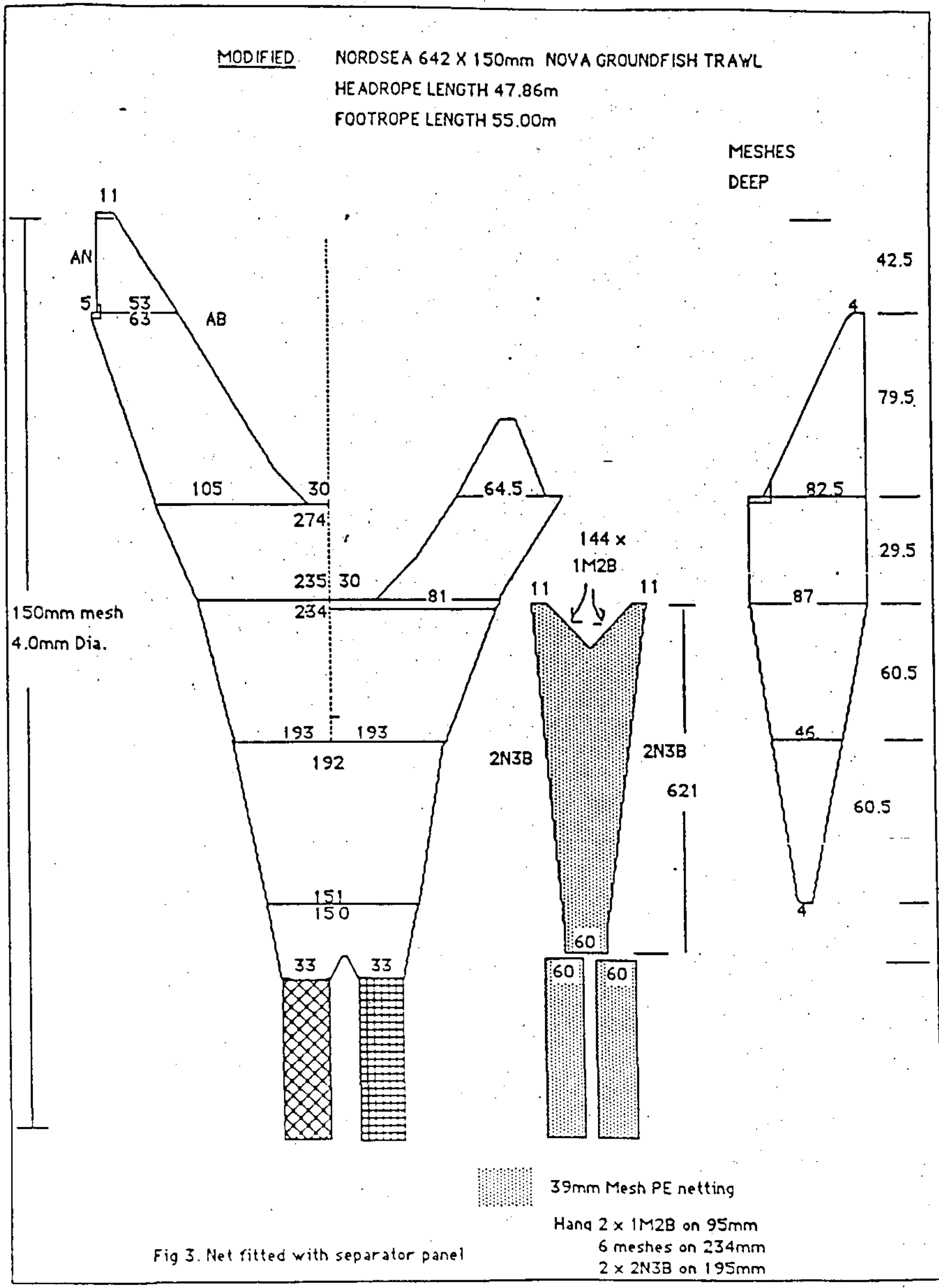


Fig. 3. Schematic diagram of a Nordsea 642 Trouser Trawl (reprinted from Chopin 1988.

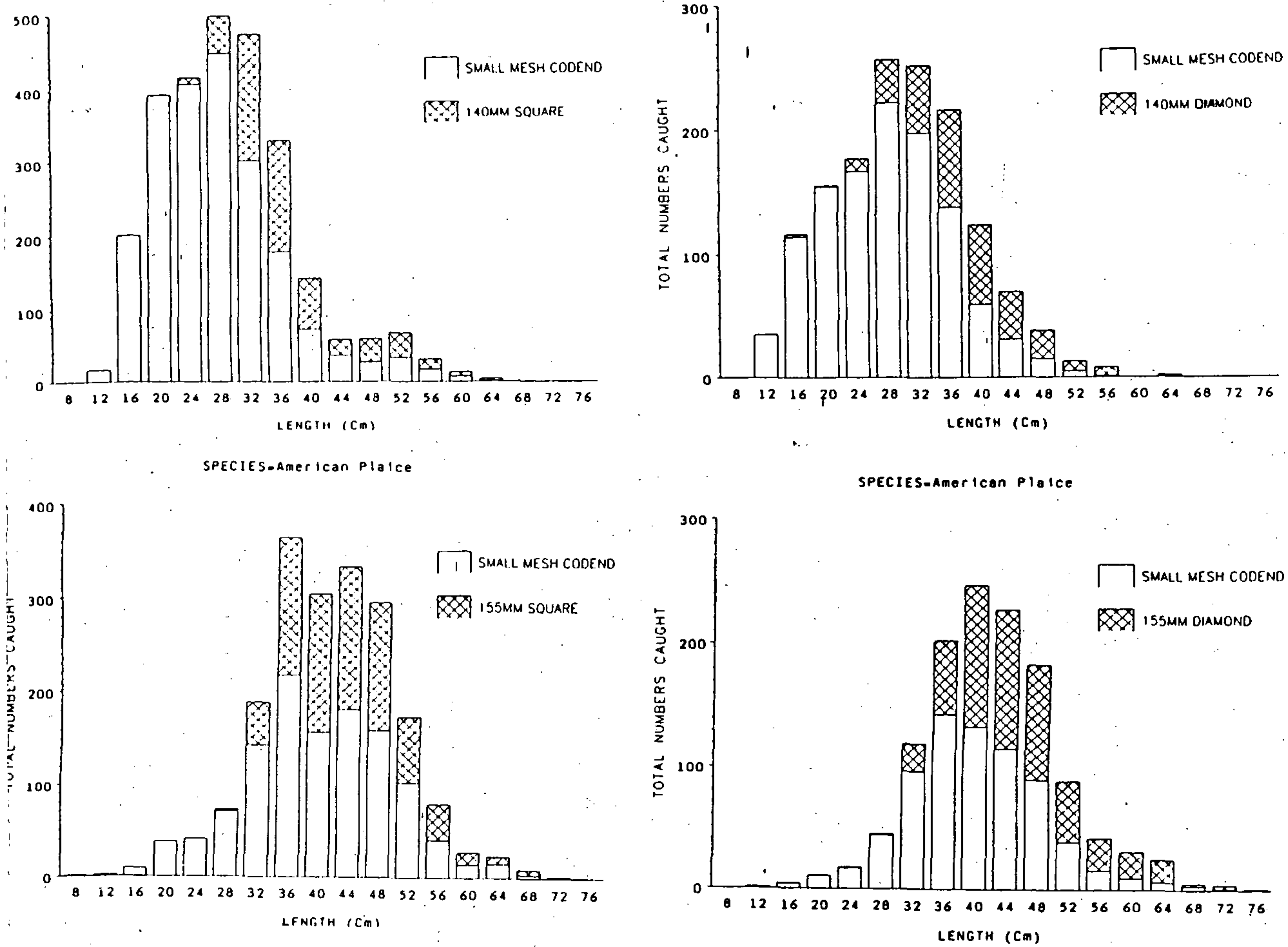
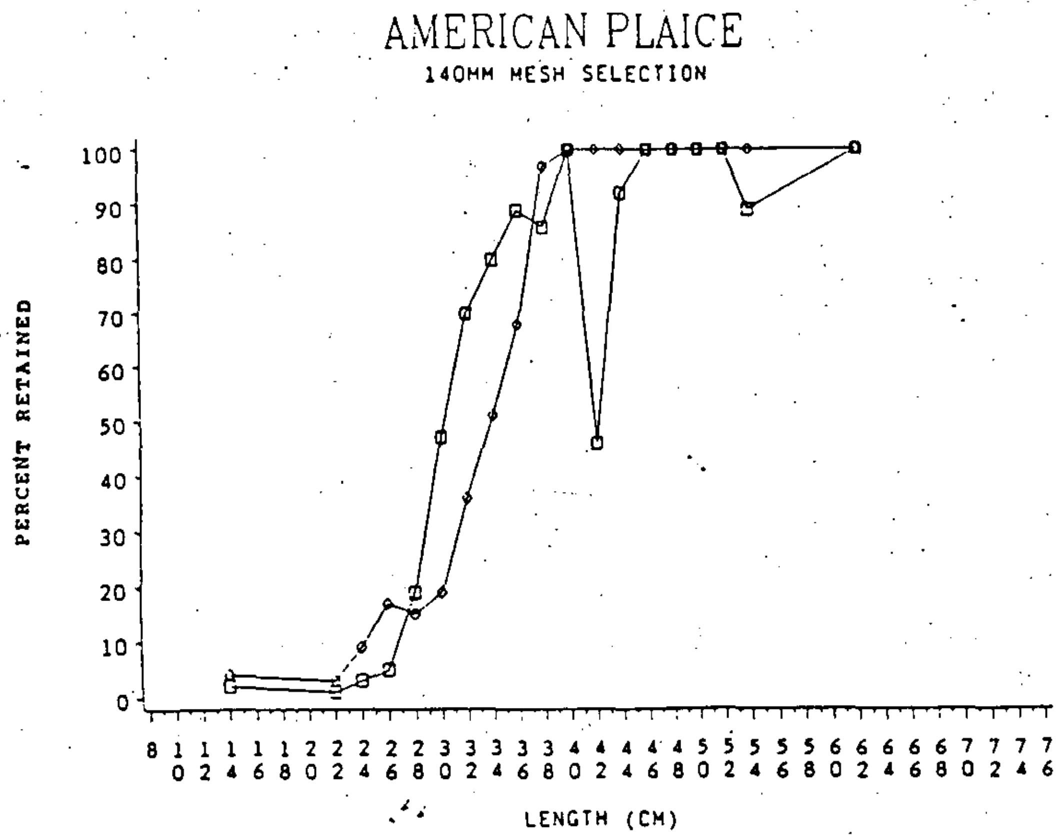


Fig. 4. Length distribution of American plaice caught by WESTERN II A trouser trawl (140 mm mesh codends) and Nordsea 642 trouser trawl (155 mm mesh).



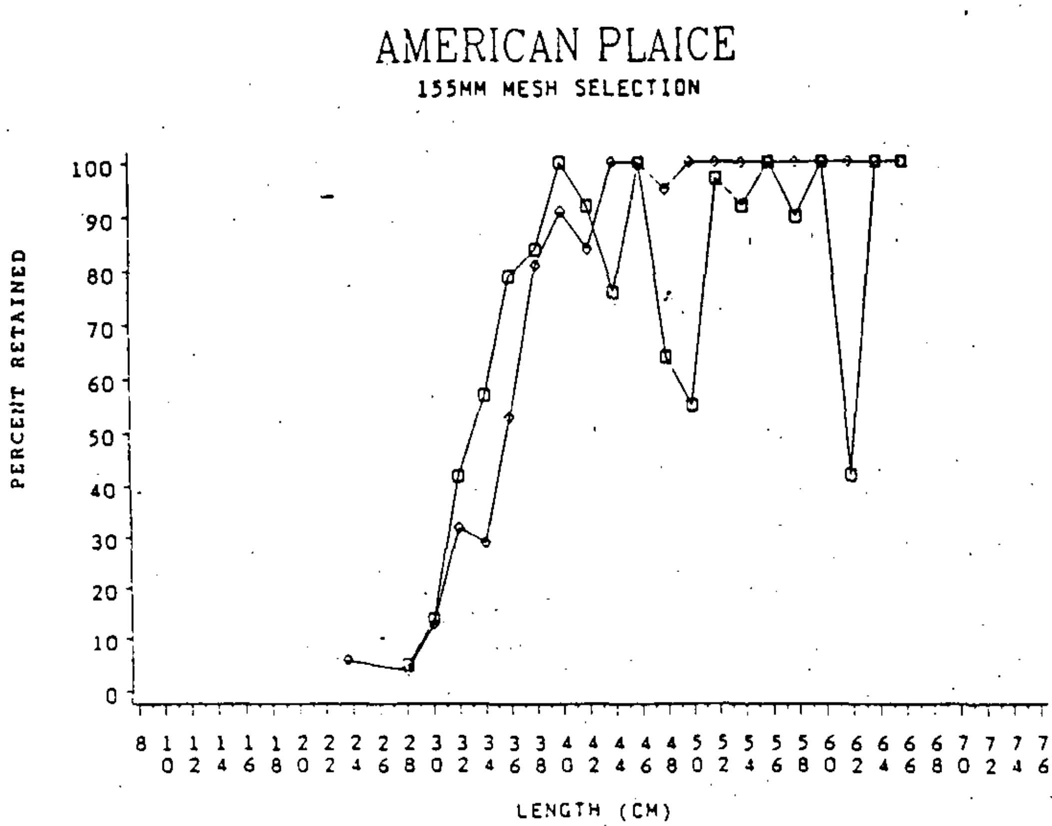


Fig. 5. Percentage of plaice retained in the 140 mm and 155 mm diamond and square mesh codends.

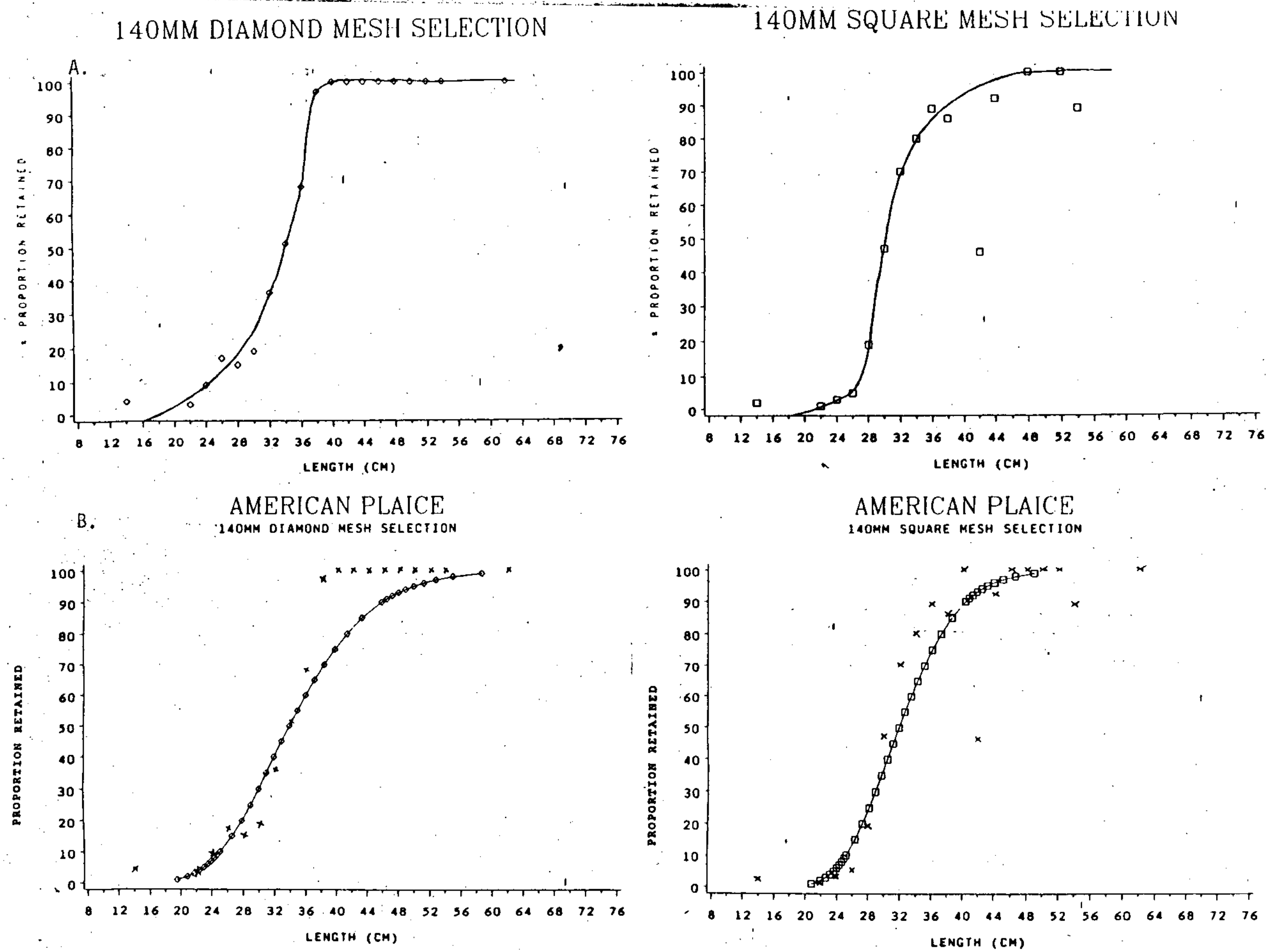


Fig. 6. Selection curves drawn by (A) eye and (B) maximum liklihood analysis for 140 mm mesh codends.

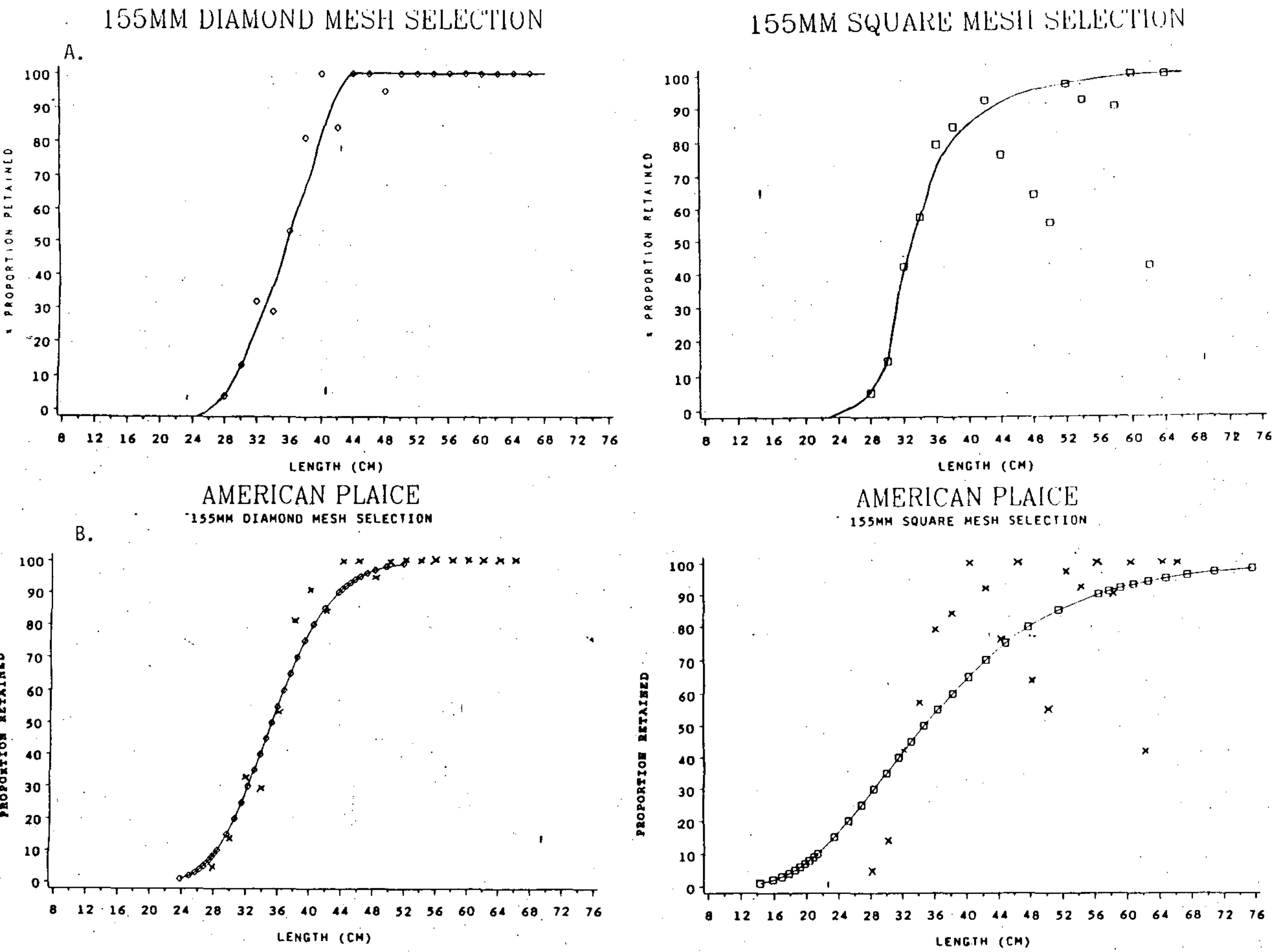


Fig. 7. Selection curves drawn by (A) eye and (B) maximum liklihood analysis for 155 mm mesh codends.

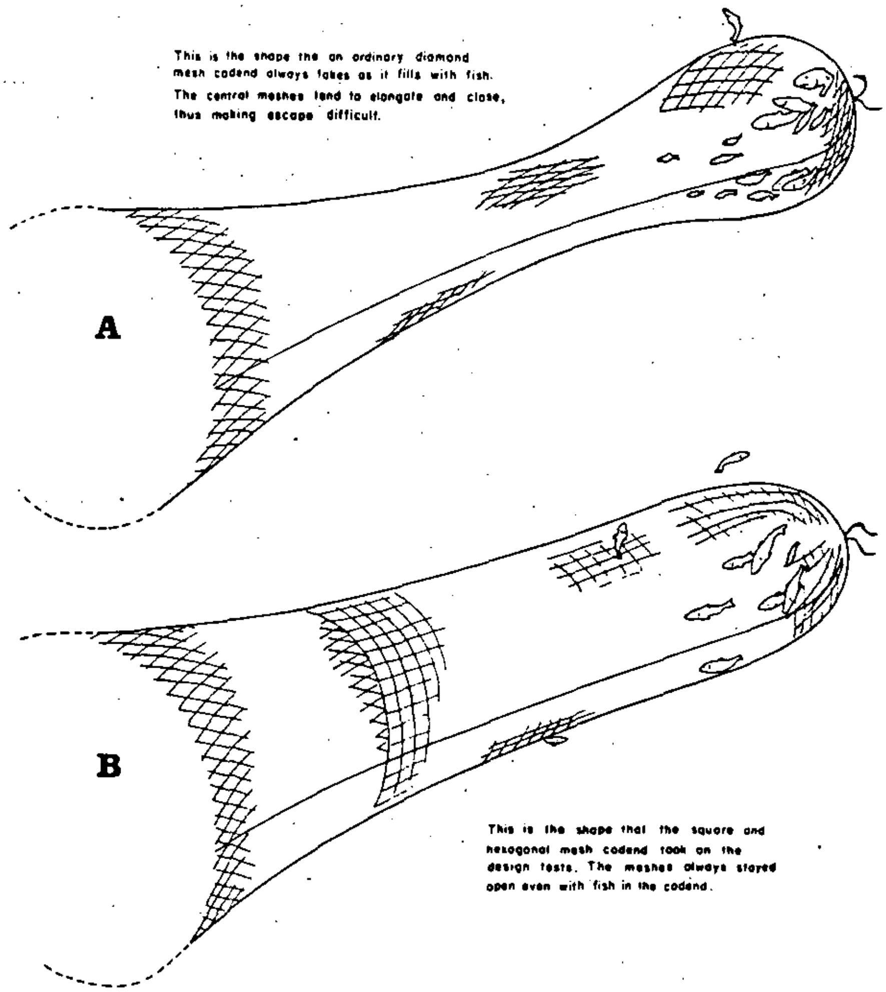


FIG. 8 (A) The shape that an ordinary diamond mesh cod-end always takes up as it fills with fish. The central meshes tend to elongate and close, making escape difficult; (B) The shape that the square and hexagonal mesh cod-end took on the design tests. The meshes always stayed open even with fish in the cod-end.

(Reprinted from Tait and Rycroft,1986)