International Commission for the Northwest Atlantic Fisheries

Serial No. 3227
(B.g. 14)

ICNAF Res.Doc. 74/41

ANNUAL MEETING - JUNE 1974

Selectivity and relative efficiency of salmon drift nets[1]

by

W.H. Lear
Fisheries and Marine Service
Environment Canada
Biological Station
St. John's, Newfoundland, Canada

and

O. Christensen
Danmarks Fiskeri-og Havundersøgelser
Charlottenlund Slot
Denmark

Introduction

During research vessel cruises for Atlantic Salmon in the West Greenland-Labrador Sea area, drift nets of different mesh sizes and fibre types were used to attempt to sample the whole range of the population of salmon in the area. Records were kept of the sizes and numbers of salmon caught by nets of various mesh sizes and fibre types in an attempt to quantify the relative catching capabilities of the various net types. Nets used on the Canadian research vessel A. T. Cameron during 1969, 1970, and 1971 were of twisted ulstron (polypropylene) or monofilament nylon (polyamide) and were approximately 46 metres in length and 3 metres deep. Mesh sizes varied between 115 mm and 150 mm.

Nets used by the A. T. Cameron, Adolf Jensen, Scotia and Cryos during the International Joint Salmon Tagging Experiment in 1972 were of monofilament nylon 46 metres long, 3 metres deep with mesh sizes of 130 mm and 150 mm.

Observations on selectivity and relative efficiency of drift nets used by commercial drift netters at West Greenland are also discussed.

Methods

During the A. T. Cameron cruises in 1969-71, the drift nets were arranged by mesh sizes in groups of 20 up to 35 nets. These were arranged in a string of approximately 3000 fathoms (3 nautical miles). During the Tagging Experiment all four research vessels used 130 mm and 150 mm mesh monofilament nets arranged in basic units of 20 nets each (10-130mm followed by 10-150 mm mesh nets). Usually 6 units were used unless weather or ice conditions or proximity to the coast precluded this in which case fewer units were fished. Nets were 46 metres long and 3 metres deep and each had a headrope on which plastic or sponge floats were mounted every 3 feet (0.9 metres). An exception to this was the Adolf Jensen which used a floating braided nylon headrope into which the floats were enclosed. The footropes were braided nylon with a lead core. On the Adolf Jensen there was a hauling rope installed below the footrope for hauling in the nets. The other 3 ships used a ½ inch polypropylene strengthening rope attached to the headrope which was used for hauling back the nets.

[1] Presented to the ICES/ICNAF Joint Working Party on North Atlantic Salmon, ICES, Charlottenlund, March 1974.

Nets were usually set at or before dawn and patrolled when weather and sea conditions permitted until fish no longer entered the nets at which time the nets were hauled back on board the ship. During the 1969-71 cruises the tagged salmon were measured from the snout to the fork of the tail to the nearest centimetre while the dead specimens were measured to the nearest millimetre. All lengths were later expressed to the nearest centimetre for purposes of analysis in determining size selectivity of mesh sizes and fibre types.

The effort is expressed in terms of miles of net fished for one hour and the catch per unit effort is expressed as the number of salmon caught per mile-hour of nets fished.

Results

(a) Size selectivity by mesh size and fibre type

Analyses of variance (Snedecor, 1956) indicate that statistical differences in fork lengths exist at the .01 level between mesh sizes and fibre types for the 1969, 1970 and 1971 data. Duncan's multiple range tests (Kramer, 1956) define those with fork lengths not statistically different at the .05 level. During 1969 the average fork length of salmon increased with increasing mesh size (Table 1). The 115 mm ulstron caught fish significantly smaller than did the 130 mm ulstron which in turn caught fish significantly smaller than the 150 mm monofilament nets. The 150 mm ulstron and 150 mm monofilament nets caught the same size fish. During 1970 and 1971 a similar trend is evident but the degree of similarity changes. During 1970 the 130 mm and 140 mm nets of both fibre types caught fish which were statistically the same length. The fish taken by the 150 mm nets of monofilament and ulstron fibre were significantly larger than those taken by 130 mm and 140 mm mesh nets. During 1971 the 130 mm monofilament nets caught significantly larger salmon than the 115 mm and 130 mm ulstron but smaller than those caught by the 150 mm ulstron and 150 mm monofilament nets. The fork length distributions of salmon taken by the A. T. Cameron in nets of different mesh size and fibre type during 1969-71 are shown in figures 1 to 3.

Comparison of the average fork lengths of salmon taken by each of the four research vessels during the International Tagging Experiment in 1972 (Fig 4) indicate that for each vessel the 150 mm monofilament nets catch fish with significantly higher average fork lengths ($P < .01$) than nets of 130 mm monofilament.

Analysis of variance and Duncan's Test indicate that for the 130 mm monofilament nets during 1972 there are statistical differences ($P < .01$) in average fork lengths between vessels. The Adolf Jensen caught significantly larger fish ($P < .05$) than the other three research vessels. The A. T. Cameron and Scotia caught intermediate size fish while the Cryos caught significantly smaller fish than the A. T. Cameron but similar in size to those caught by the Scotia (Table 2).

Similar analyses (Table 2) on fork lengths of salmon caught in 150 mm monofilament indicate that the Cryos caught significantly larger fish ($P < .05$) than the Adolf Jensen and A. T. Cameron but similar to those of the Scotia. Average fork lengths of the fish caught by Adolf Jensen, A. T. Cameron and Scotia were not statistically different.

A comparison between the length distribution of 1970 commercial catches by 160 mm multifilament and 130 + 140 mm monofilament nets (Fig. 5) discloses an amazing uniformity in spite of the difference in mesh size. For monofilament nets the modal lengths taken by each mesh size increase with increasing mesh size (Fig. 6).

(b) Relative efficiency of nets by mesh size and fibre type

Catch rates of Atlantic salmon obtained by the A. T. Cameron during 1969-71 in various mesh sizes and fibre types (Table 3) indicates that there is no consistency from year to year in catch rates by the different mesh sizes and fibre types. The 1969 data, because of the non-normality of distribution of catch per unit effort didn't lend itself to analysis of variance and because of the unequal effort for each mesh size a chi-square test wasn't valid. However, there is a great variation in catch rates which ranged from 1.00/mile-hour for 115 mm ulstron to 3.72 salmon/mile-hour for the 150 mm monofilament nets (Table 3.) According to the 1969 data the 150 mm monofilament nets are the most efficient followed by 130 mm, 140 mm and 115 mm ulstron (Table 4).

There was a significant differance during 1970 between numbers caught using equal effort between 130 mm ulstron, 130 mm monofilament, 140 mm monofilament, 150 mm ulstron and 150 mm monofilament nets ($\chi^2 = 32.16$, df = 5). The 130 mm ulstron nets were the most efficient followed by the 130 mm monofilament, 150 mm monofilament, 140 mm monofilament, 140 mm ulstron and 150 mm ulstron (Table 4).

During 1971 there was a significant difference between total numbers caught using an equal amount of effort between 130 mm ulstron, 130 mm monofilament 150 mm ulstron and 150 mm monofilament ($\chi^2 = 47.55$, df = 3). The 130 mm monofilament was the most efficient followed by 130 mm ulstron. The 115 mm ulstron, 150 mm ulstron and 150 mm monofilament were essentially the same being approximately 45% as efficient as the 130 mm monofilament.

Results of paired comparisons tests on catches per mile-hour for 130 mm and 150 mm monofilament nets used during 1972 at West Greenland do not give consistent statistical differences in catches per unit effort for all four research vessels. For the A. T. Cameron and Cryos the differences in catch rates by 130 mm and 150 mm mesh nets are not statistically different ($.1 < p < .2$ for A. T. Cameron and $.05 < p < .1$ for Cryos). However, statistical differences ($P < .01$) do occur between 130 mm and 150 mm mesh nets for both Scotia and Adolf Jensen. When all the 1972 research vessel data are combined in a paired comparisons test, it indicates that the catch per mile-hour for the 130 mm mesh is significantly greater ($P < .01$) than that for the 150 mm mesh monofilament nets.

The efficiencies of the 130 mm mesh nets relative to the 150 mm mesh nets vary from 1.61 with Adolf Jensen to 3.29 with the Cryos for an overall average efficiency of 1.86 for 130 mm when compared to 150 mm mesh for all research vessel catches combined (Table 4).

In commercial drift netting during 1969 and 1970 it was shown that multifilament nets of 160 mm were superior to monofilament nets of approximately the same mesh size in catching salmon, but are outnumbered by monofilament nets of 130 mm and 140 mm (Table 5).

Discussion and Conclusions

The A. T. Cameron data for 1969-71 indicate in general that the average fork length of salmon caught at West Greenland increases with increasing mesh size. The 150 mm monofilament caught larger fish than the corresponding multifilament during 1969 and 1971 but caught smaller fish in 1970. The 140 mm and 150 mm monofilament caught larger fish than the corresponding multifilament nets. These results are also confirmed by May (MS, 1970). Larkins (1963) found that the mean lengths of red, chum and the pink salmon in the Pacific taken in monofilament nets were larger, though not statistically different, than those taken in multifilament nets. Larkins (1964) stated similar results for sockeye and chum salmon taken in monofilament and multifilament gillnets.

During 1972 at West Greenland the fork lengths of salmon taken by each of four research vessels in 150 mm monofilament nets were significantly larger than those taken in 130 mm monofilament nets. Larkins (1964) experienced similar results from 90 mm and 115 mm monofilament nets with catches of sockeye and chum salmon in the Pacific Ocean. Fork lengths of salmon taken by each mesh size during 1972 differed significantly between research vessels but results were not consistent. For example, with the 130 mm mesh nets the Cryos caught the smallest fish and the Adolf Jensen caught the largest while with the 150 mm mesh nets the Adolf Jensen caught the smallest while the Cryos caught the largest fish. This was probably in part due to differences in size composition of the salmon available to the gear in the areas fished by different research vessels.

In terms of relative efficiency of nets of various mesh sizes and fibre types it would appear that monofilament nets were superior to multifilament nets of the same size for catching Atlantic salmon. During the 1972 tagging experiment at West Greenland the 130 mm monofilament nets were superior to the 150 mm monofilament nets by a factor varying from 1.6 for the A. T. Cameron to 3.3 for the

Cryos. The high value for the Cryos is undoubtedly a reflection of size distribution of fish in the Labrador Sea area where there was a greater proportion of smaller fish which were not vulnerable to the larger 150 mm mesh size. In general however the 130 monofilament nets are superior to the 150 mm monofilament nets by a factor of approximately 2 in the West Greenland area.

Results of commercial vessel data (Christensen, MS 1971) however indicates in general 160 mm multifilament nets outfish monofilament nets of approximately the same mesh size by a factor of approximately 2, the reverse of that found by research vessel data. However, nets of 130 and 140 mm monofilament were superior to nets of 160 mm multifilament.

The apparent inconsistency between the relative efficiency of multifilament versus monofilament nets by the A. T. Cameron and commercial vessels can possibly be partly explained by the different methods of fishing [illegible] by research and commercial vessels. The A. T. Cameron set her nets at dawn and hauled them back at noon or early afternoon while the commercial vessels generally set their nets before susset and begin hauling at or before dawn the next day. In the case of the research vessels fishing the multifilament nets would possibly be more visible during daylight hours than the monofilament nets. The salmon would follow along the multifilament nets until they came to a "window" formed by the monofilament nets through which they would possibly attempt to pass and be caught. In experiments in the Pacific using combinations of multifilament and monofilament nets it was found (Larkins, 1964) that the relative efficiency was highest for alternate monofilament-multifilament, moderate for all-monofilament and lowest for all - multifilament. Thus it would appear that the efficiency of the monofilament nets is increased by alternating them in the fleet with multifilament nets which possibly serve as leaders to guide fish into the monofilament nets.

In the case of the commercial gear the multifilament nets would not be so visible during the night and hence would be equally effective in catching salmon. Since the multifilament nets are weighted less heavily and the fibres are less rigid, hence they would possibly be more effective for entangling salmon than monofilament which are strictly speaking gill nets rather than entangling nets.

That salmon sometimes "run" along a fleet of nets in an attempt to avoid the barrier presented can be supported by three observations (May, MS, 1970).

(1) Less salmon are usually caught when nets were tightly stretched in a straight line than when wind and current conditions caused them to assume a meandering configuration.

(2) When wind and sea conditions caused one end of the fleet to drift back toward the centre of the gear, larger numbers of salmon were caught in the loop or trap so formed than along the straight part of the fleet.

(3) Salmon lying on the nets were occasionally driven in by the small boat used for tagging.

References

Christensen, O. MS 1971. Observations on selectivity and relative efficiency of salmon drift nets in connection with population studies on salmon at West Greenland. Intern. Comm. Northw. Atlant. Fish.Res. Doc. 71/65. Ser. No. 2535, 8 p.

Kramer, C. Y. 1956. Extension of the Multiple Range Tests to group means with unequal numbers of replications. Biometrics 12 (3): 307-310.

Larkins, H. A. 1963. Comparison of salmon catches in monofilament and multifilament gill nets. Comm. Fisheries Review 25 (5): 1-11.

1964. Comparison of salmon catches in monofilament and multifilament gill nets Part 11. Comm. Fisheries Review 26 (10): 1-7.

May, A. W. MS 1970. Relative catching efficiency of salmon drift nets and relative viability of salmon caught. Intern. Comm. Northw. Atlant. Fish. Res. Doc. 70/9. Ser. No. 2330, 8p. C 5

Snedecor, G. W. 1956. Statistical methods, 5th ed. Iowa State Univ. Press. Ames, Iowa, 534 p.

Table 1. Results of analyses of variance and Duncan's Multiple Range Tests on average fork lengths of Atlantic salmon taken by nets of various mesh sizes and fibre types at West Greenland by the A. T. Cameron during 1969-71. Any two means not underscored by the same line are significantly different at the 5% level, and any two lines underscored by the same line are not significantly different.

A. T. Cameron 1969

Mesh size	115 mm ulstron	130 mm ulstron	140 mm ulstron	150 mm ulstron	150 mm MF
Number of fish	54	176	186	43	164
Av. fork length	63.74	66.40	67.03	67.79	68.35

A. T. Cameron 1970

Mesh size	130 mm ulstron	140 mm ulstron	130 mm MF	140 mm MF	150 mm MF	150 mm ulstron
Number of fish	80	40	78	41	45	38
Av. Fork length	65.85	66.43	66.99	67.39	68.58	69.39

A. T. Cameron 1971

Mesh size	115 mm ulstron	130 mm ulstron	130 mm MF	150 mm ulstron	150 mm MF
Number of fish	35	112	142	62	64
Av. fork length	62.91	63.76	66.56	68.37	68.94

Table 2. Results of analyses of variance and Duncan's Multiple Range Test on average fork lengths of Atlantic salmon taken by four research vessels in 130 mm and 150 mm monofilament nets at West Greenland during the International Tagging Experiment, 1972. Any two means not underscored by the same line are significantly different at the 5% level, and any two lines understored by the same line are not significantly different.

130 mm Monofilament

Ship	Cryos	Scotia	A. T. Cameron	Adolf Jensen
Number of fish	181	206	290	453
Average fork length	64.35	65.37	65.51	66.68

150 mm Monofilament

Ship	Adolf Jensen	A. T. Cameron	Scotia	Cryos
Number of fish	288	174	97	54
Average fork length	68.34	69.05	69.47	71.11

Table 3. Total catch per unit effort (number of salmon/mile-hour) for various mesh sizes and fibre types fished by several research vessels at West Greenland-Labrador Sea during 1969-72.

		Mesh Size						
Ship	Year	115 mm ulstron	130 mm ulstron	130 mm MF	140 mm ulstron	140 mm MF	150 mm ulstron	150 mm MF
A. T. Cameron	1969	1.00	1.60	*	1.47	*	1.18	3.72
A. T. Cameron	1970	*	1.00	0.87	0.48	0.51	0.46	0.56
A. T. Cameron	1971	1.00	1.73	2.27	*	*	0.98	1.03
A. T. Cameron	1972	*	*	0.95	*	*	*	0.57
Adolf Jensen	1972	*	*	1.55	*	*	*	0.96
Scotia	1972	*	*	1.18	*	*	*	0.56
Cryos	1972	*	*	0.92	*	*	*	0.28
All Ships	1972	*	*	1.17	*	*	*	0.63

*Denotes that this mesh size was not fished during this trip.

Table 4. Relative efficiency of various mesh sizes and fibre types for catching Atlantic salmon. Efficiency is rated by using the 150 mm monofilament net as a standard.

		Mesh size						
Ship	Year	115 mm ulstron	130 mm ulstron	130 mm MF	140 mm ulstron	140 mm MF	150 mm ulstron	150 mm MF
A. T. Cameron	1969	0.27	0.43	*	0.40	*	0.32	1.00
A. T. Cameron	1970	*	1.79	1.55	0.86	0.91	0.82	1.00
A. T. Cameron	1971	0.97	1.68	2.20	*	*	0.95	1.00
A. T. Cameron	1972	*	*	1.67	*	*	*	1.00
Adolf Jensen	1972	*	*	1.61	*	*	*	1.00
Scotia	1972	*	*	2.11	*	*	*	1.00
Cryos	1972	*	*	3.29	*	*	*	1.00
All Ships	1972	*	*	1.86	*	*	*	1.00

*Denotes that this mesh size was not used during this trip.

Table 5. Number of salmon retained pr. 100 nets in relation to type of twine of the nets. Information from 2 commercial vessels at West Greenland. October-November 1969 and August-November 1970.

				Monofilament Nets		
Vessel No	Date	ICNAF Stat. Area	Multi-filament nets 160 mm	130 + 140 mm	150 + 160 mm	Basis of Calculation (number of nets)
	1969					
1	18 Oct.-2 Nov.	1B	32.7	46.3	-	6260
	1970					
11	10-31 Aug.	1B	27.8	-	18.3	4000
	1-15 Sept.	1A	25.1	-	13.4	3680
	25 Sept.	1D	6.0	-	3.5	700
	26 Sept.-13 Nov.	1B	24.6	-	14.8	7050

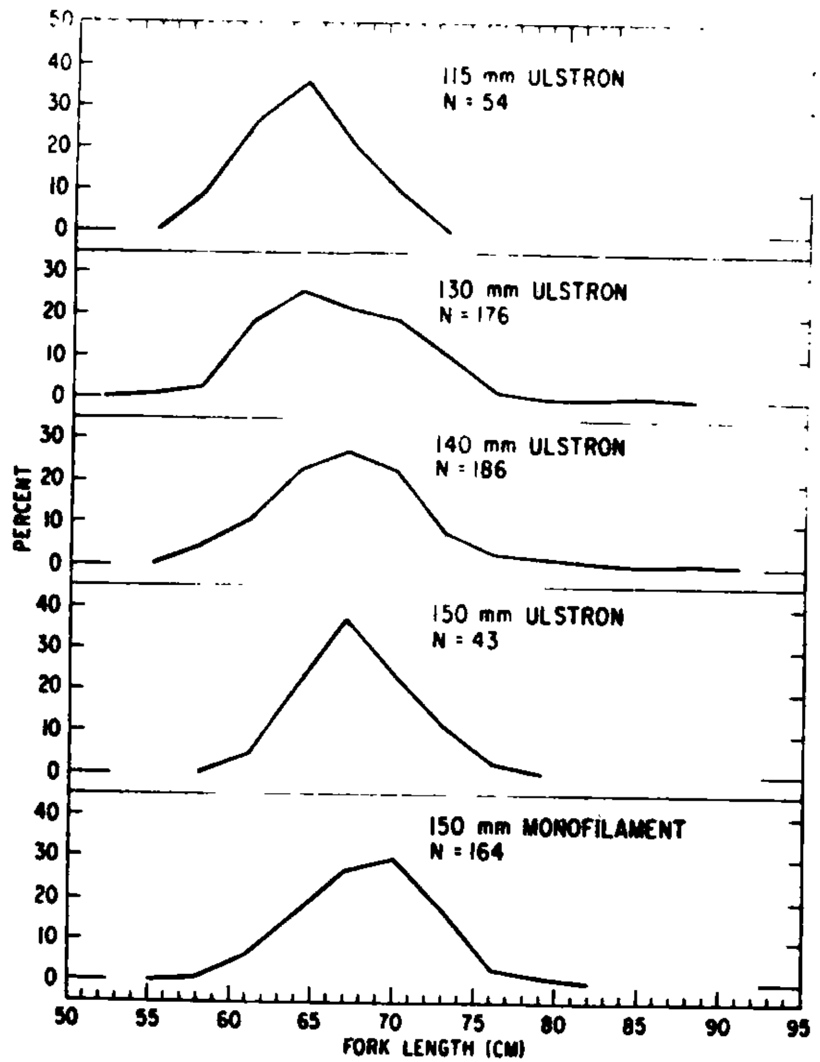

Fig. 1. Fork length distributions of Atlantic salmon caught during 6 Sept - 2 Oct 1969, at West Greenland by the A.T. Cameron in drift nets of various mesh sizes and fibre types.

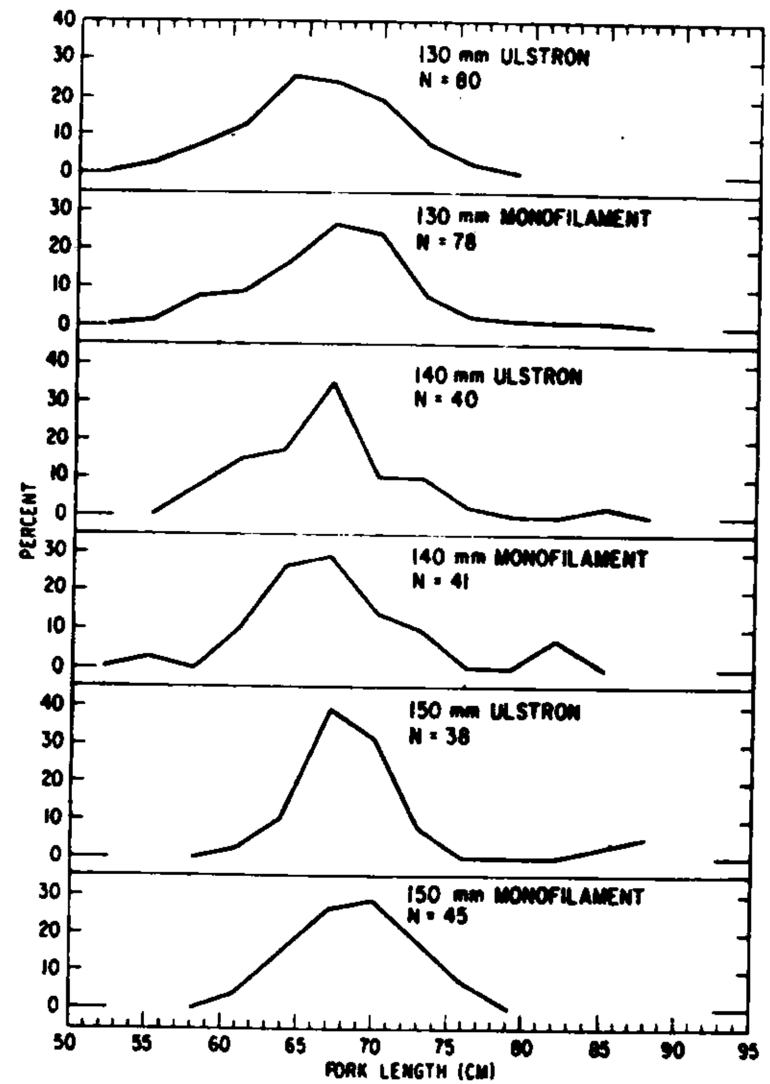

Fig. 2. Fork length distributions of Atlantic salmon caught during 3 Sept - 4 Oct 1970, at West Greenland by the A.T. Cameron in drift nets of various mesh sizes and fibre types.

C 9

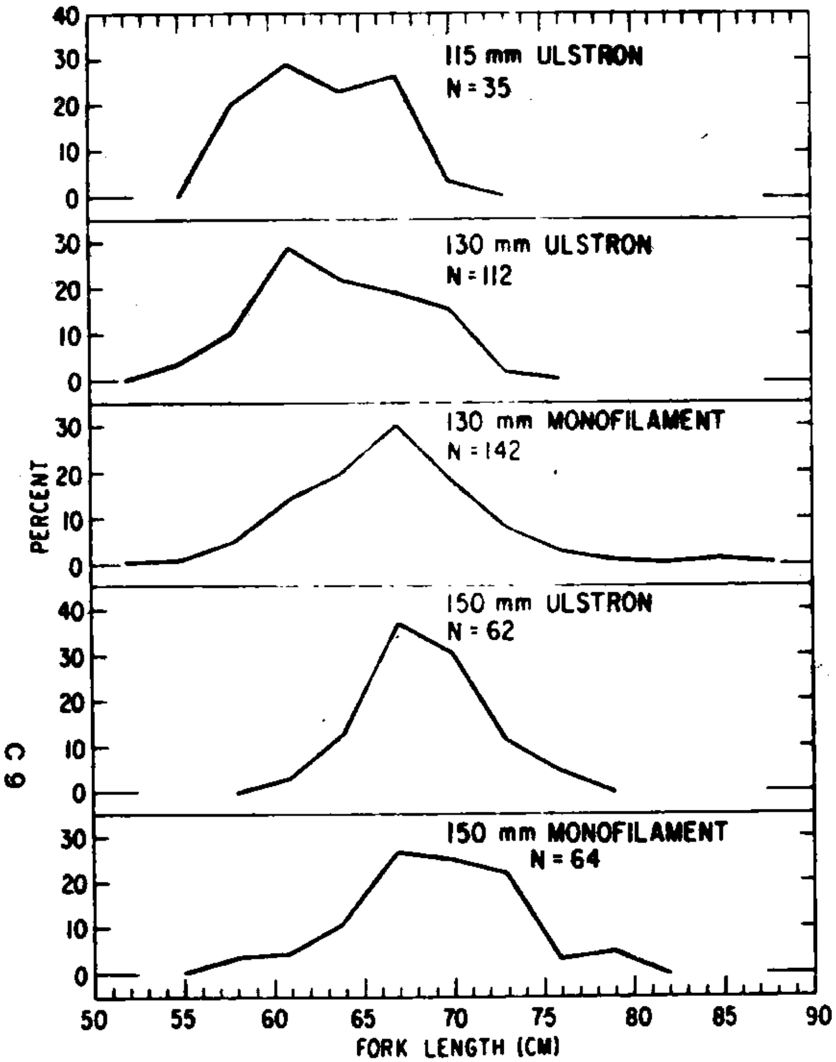

Fig. 3. Fork length distributions of Atlantic salmon caught during 6-23 Sept 1971, at West Greenland by the <u>A.T. Cameron</u> in drift nets of various mesh sizes and fibre types.

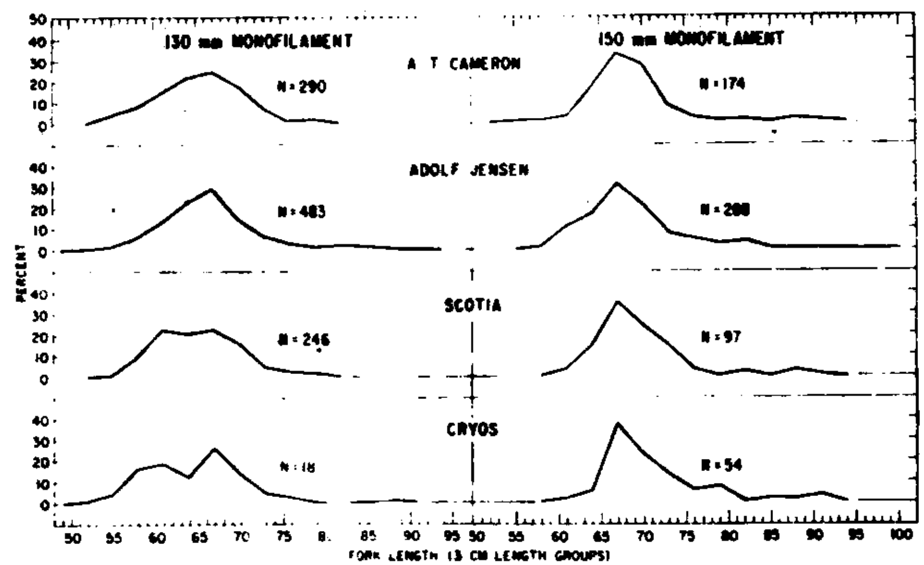

Fig. 4. Fork length distribution of Atlantic salmon caught in 130 mm and 150 mm monofilament drift nets during the International Salmon Tagging Experiment, Aug-Oct 1972, at West Greenland by <u>A.T. Cameron</u>, <u>Adolf Jensen</u>, <u>Scotia</u> and <u>Cryos</u>.

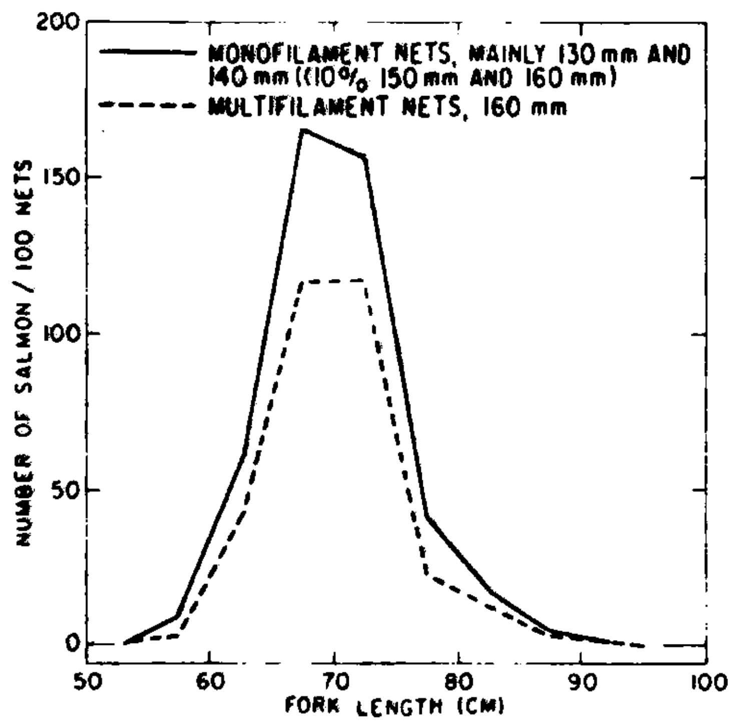

Fig. 5. Number of salmon in 5-cm-length groups retained per 100 nets during fishing within the area 67°00'N-67°37'N and 54°15'W-55°00'W, 18 October - 2 November 1969.

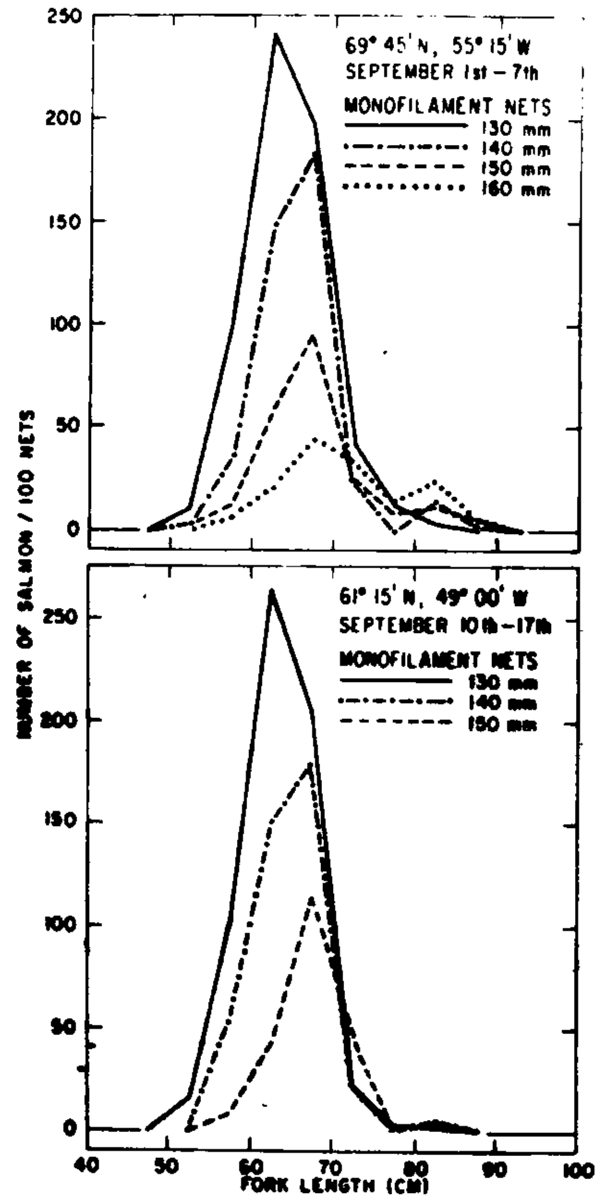

Fig. 6. Number of salmon in 5-cm-length groups retained per 100 nets during fishing within the areas about 69°45'N, 55°15'W and about 61°15'W, 49°oo'W, 1-17 September 1970.