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Report of

Joint ICES/ICNAF Working Group on Selectivity Analysis

Comparative Selectivity of Bottom Trawls made of Different Materials

(Moscow, March 1969, and Charlottenlund, September 1969)

CONTENTS

INTRODUCTION

Following the report of its Subcommittee on Fishing Gear and Selectivity, the Standing Committee on Research and Statistics (R&S) at the 18th Annual Meeting of ICNAF held in London from 4 to 8 June 1968 recommended:

i) that an ICNAF Working Group on Selectivity Analysis be formed to undertake a review of variability in selection data, including the scientific basis of mesh size differentials for different twine materials;

ii) that the Chairman of R&S appoint a convener for this Working Group;

iii) that experts be appointed to the Working Group by interested member countries;

iv) that ICES be invited to participate, in order to make a joint study of these problems;

v) that the Working Group meet at a mutually convenient time so that its report could be available for the next meeting of both ICNAF and NEAFC.

(ICNAF Redbook 1968, Pt.I, p.12)

At its 56th Annual Meeting held in Copenhagen from 30 September to 9 October 1968, ICES accepted ICNAF's invitation to take part in the activities of the Group (C.Res.1968/3:3).

A preparatory meeting was held in Copenhagen on 4 October 1968 attended by representatives of those countries which expressed their wish to participate in the activities of the Group, at which time, place and program of work were agreed upon.

The Joint ICES/ICNAF Working Group on Selectivity Analysis held its meetings at VNIRO, Moscow, from 26 to 29 March 1969 and at ICES, Charlottenlund, from 2 to 6 September 1969.

The Working Group was to prepare working papers covering the following subjects:

1) Comparison of the properties of net materials of trawls in the North Atlantic and investigation of the effect of trawl construction on selectivity;

2) Analysis of the variability of marine experiments on selectivity and the validity of selectivity data;

3) Compilation of the selectivity data for cod, haddock and redfish, including a tabulation of equivalents for different net materials.

Prof. von Brandt was asked to prepare the first working paper, Mr Pope the second, and Dr Treschev the third. These three papers appear as Parts A, B, and C of this report. A bibliography was prepared by Dr Bohl and Mr Holden which appears as Part E.

The meeting participants were as follows:

Both meetings
Dr A.I.Treschev, USSR (Chairman)
Mr M.J.Holden, UK (Secretary)
Mr J.A.Pope, UK
Dr H. Bohl, FRG
Prof. A. von Brandt, FRG

First meeting only
Dr J. Reuter, Netherlands
Mr S. Prüffer, Poland
Dr W. Strzyzewski, Poland
Dr G.N.Stepanov, USSR
Mr B.I.Danilov, USSR
Mr A.A.Volkov, USSR

Second meeting only
Mr V.S.Belov, USSR
Mr L.M.Zheltov, USSR
Mr J. Møller Christensen, Secretary of the Liaison Committee

PART A

COMPARATIVE EVALUATION OF THE PROPERTIES OF NET MATERIALS USED FOR MAKING TRAWLS

by
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According to different investigations, the selectivity of codends in trawls may be influenced by different facts:

a) fish (species, quantity, behaviour);
b) gear (material, rigging, hanging, mesh size, shape of the mesh);
c) operation of the gear (speed, towing force, towing time).

Most investigations underline that the net material has a decisive influence on the selectivity of a trawl. However, there are also examples, *e.g.* size of the catch or shape of the mesh, that may have an influence.

The selection factor, sf., that means the relation between fish length and mesh size, is considered to be more or less constant for the different net materials used for codends in bottom trawling. According to the results of many tests for the same material (*e.g.* polypropylene), the construction (*e.g.* twisted or plaited) and the type of material (*e.g.* fibre or film) have no influence.

It has been found that different net materials used for codends in the ICNAF and ICES areas have similar or the same selection factor. There are at least two groups:

1) manila, sisal, polyethylene (PE), and polypropylene (PP);
2) cotton, hemp, polyamide (PA), and polyester (PES).

Nevertheless, sometimes doubt arose about the classification of some materials. There may be some overlapping according to the complexity of the problem.

The different selectivity of different net materials used for codends in trawling has been explained by other authors with the different properties of the net materials. Extension, flexibility, and roughness have been mentioned as the main reasons for different selectivity.

The difficulty is that the properties of a netting twine are changeable in some degree with the type of manufacture. A hard twisted twine can have not only less strength but also less flexibility compared with a soft twisted one. The tension of netting twines increases with their numbers or diameters, etc. This means that there must be more than one property responsible for the selectivity, even when the net material is taken into consideration.

In the case where different net materials have almost the same selectivity as mentioned before, and their properties are responsible for the selectivity, they must have similar properties. To find them could give an explanation for the theory of the selection process in codends.

Only those net materials which can be exchanged with each other are comparable. According to the differences of properties, it seems unwise to compare net materials used for inshore fishing with small boats with those used for deep sea fishing with big trawlers. Therefore, member countries have been asked for materials used for <u>bottom</u> trawls in the ICES or ICNAF areas only. It may be useful to limit the net materials to R 2,500 tex and 400 m/kg.

The following countries have been kind enough to send samples of net materials: Belgium; Canada; Denmark; Finland; France; Germany, Fed. Rep.; Iceland; Ireland; Italy; Netherlands; Poland; Portugal; Romania; Spain; Sweden; UK; USA; USSR. Samples are missing from Norway only.

The data for the properties of the netting twines are given in Tables A-1 to A-7. These tables show the local designations of the materials and the real ones in R.tex and m/kg (yds/lb.). Moreover, the following properties are included: diameter, knot breaking load, elongation at a load corresponding to the half knot breaking load in percent and the flexibility. The testing methods follow the rules under discussion in the International Organization for Standardization (ISO), Technical Committee 38/Textiles, Subcommittee 9: Textile Products for Fishing Nets. For the test of the flexibility, a method not yet accepted has been used in spite of some objections made in a previous ICES paper 10 years ago.

A preliminary comparison between the properties of the net materials used for codends and the two groups of similar selectivity mentioned above show some relation with the flexibility (Fig. A-1). The net materials made of PA, PES, and also unexpectedly PP have almost the same range of flexibility in contrast to net materials made of manila and PE, though there are some extreme values outside the main range, shown by dotted lines.

Moreover, a diagram with the relation of tension and flexibility shows on one side PA and PES and on the other manila and PE with some overlapping by the data for PP in both areas (Fig. A-2).

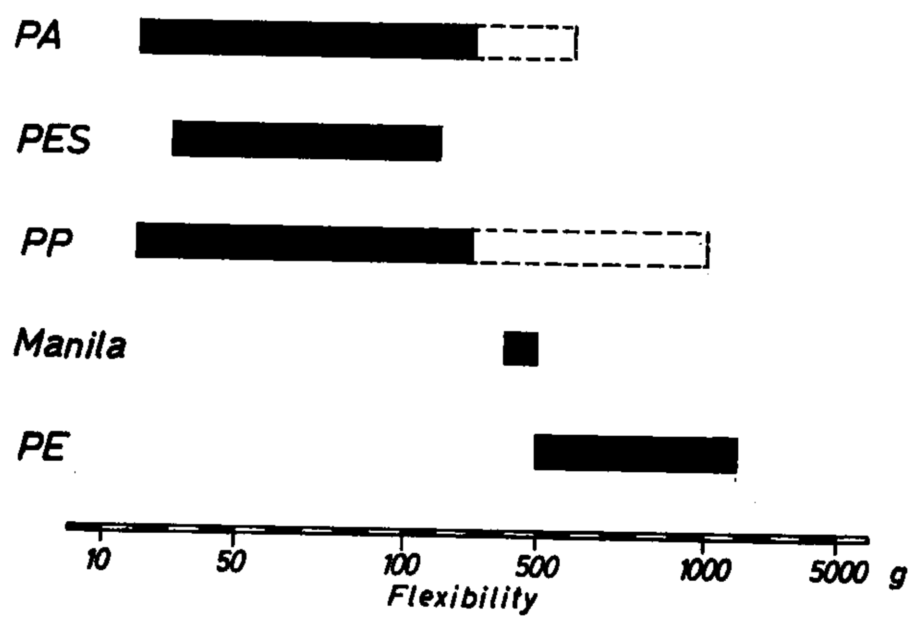

Fig. 1. Comparison of flexibility of net materials used for codends.

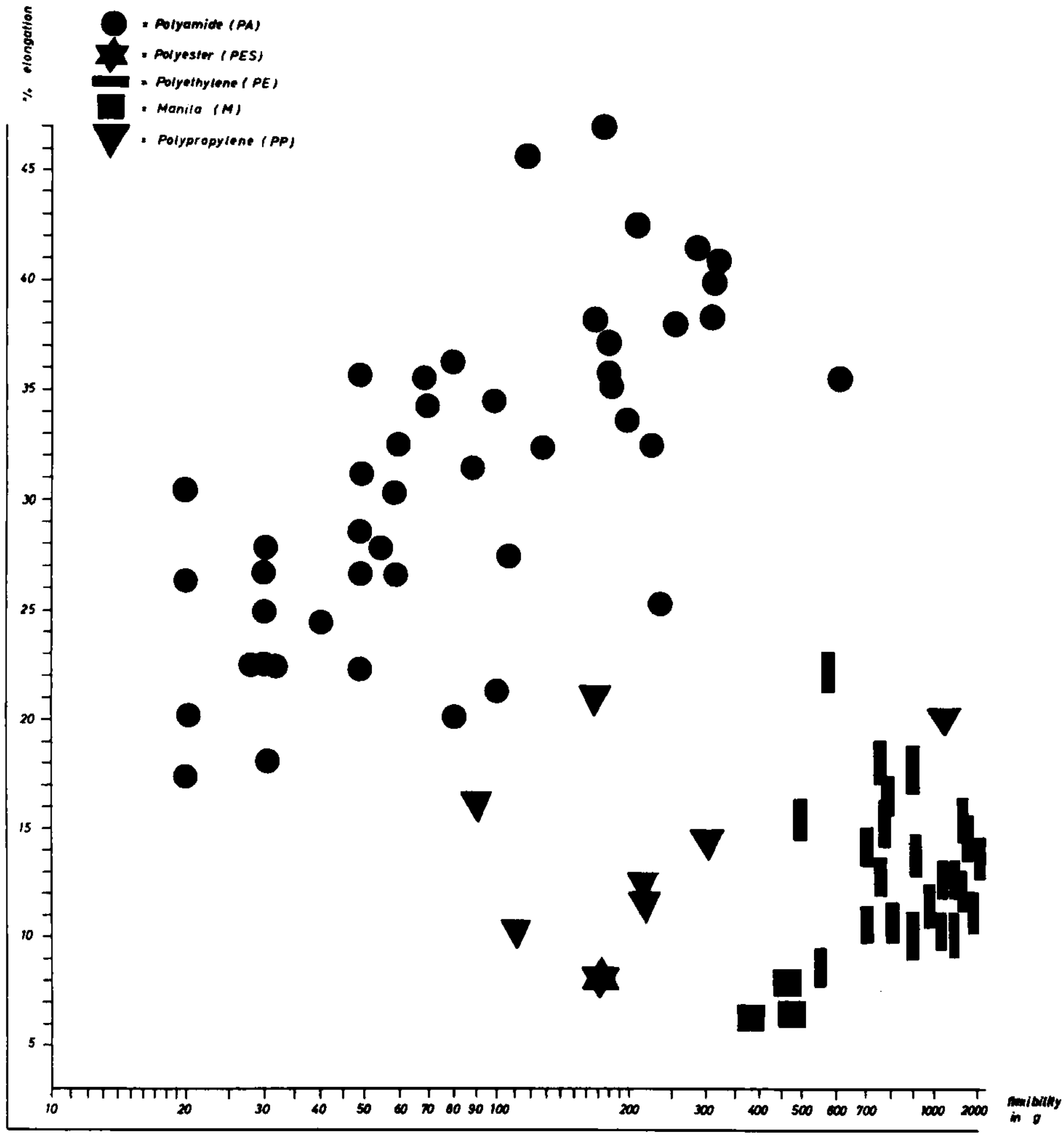

Fig. 2. Elongation/flexibility (only values > R.2500 tex or < 400 m/kg).

Table A-1.

Trade number	R.tex (g/1,000 m)	Runnage m/kg	Runnage yds/lb.	Twine construction	Diameter (mm)	Knot breaking load, wet (kp)	Elongation at a load corresponding to the half knot breaking load (%)	Flexibility (g)	Remarks
Belgium: Polyamide (PA)									
	500	2,100		twisted	0.75	30.4	20.2	<2	
	600	1,700		"	0.91	29.9	28.8	10	
	750	1,300		"	1.00	37.6	29.7	10	
	950	1,050		"	1.11	41.4	29.2	20	
	1,150	850		"	1.26	45.9	31.8	30	
	1,450	700		"	1.44	52.9	29.6	50	
	2,000	500		"	1.68	76.9	30.3	40	
	2,300	450		"	1.84	93.4	31.2	50	
	2,850	350		"	1.89	116.6	26.9	50	
	3,600	300		"	2.22	133	32.4	130	
	4,800	200		"	2.55	190	35.1	180	
Polyethylene (PE)									
	850	1,200		"	1.10	34.9	11.0	170	orange
	1,400	700		"	1.65	58.9	12.0	250	green
	1,550	650		"	1.68	65.4	13.2	220	orange
	1,800	550		"	1.65	105.6	15.4	270	"
	2,000	500		"	1.78	106.3	12.3	370	"
	2,150	450		"	2.06	104.0	10.5	580	"
	2,850	350		"	2.27	130.4	10.6	700	"
	3,250	300		"	2.47	143	10.4	800	green

Table A-2.

Trade number	R.tex (g/1,000 m)	Runnage m/kg	Runnage yds/lb.	Twine construction	Diameter (mm)	Knot breaking load,wet (kp)	Elongation at a load corresponding to the half knot breaking load (%)	Flexibility (g)	Remarks
Canada: Polyethylene (PE)									
4.5 mm	6,100	150		plaited	(4.5)	242	10.3	1,550	orange
4.5 mm	6,400	150		"	(4.5)	239	12.5	1,590	"
5.5 mm	8,950	100		"	(5.5)	371	15.2	1,890	red
5.5 mm	10,150	100		"	(5.5)	451	13.1	2,140	orange
CP-90	5,100	200		"		208	10.6	1,180	"
CP-160	3,250	300		"		164	15.5	780	"
Terylene (PES)									
T-50	7,200	150	75 (70)	"		288	8.5	170	
Nylon (PA)									
N-50	5,800	150	75 (75)	"		288	31.6	90	
Ulstron (PP)									
UP-120	3,850	250		"		237	10.4	110	
UP- 63	7,550	150		"		402	12.1	220	
UP- 76	7,450	150		"		393	11.3	220	
UP- 76	6,950	150		"		389	14.9	300	
3/16 in.	14,500	50		"		676	20.3	1,140	golden, with core
Denmark: Polyamide (PA)									
Td 210/24	600	1,600		twisted	0.77	39.3	16.0	< 2	
Td 210/30	750	1,300		"	0.88	47.7	16.2	< 2	
Td 210/36	950	1,050		"	0.96	61.8	17.9	5	
3 mm	5,350	200		plaited	(3.0)	242	26.8	60	
4 mm	7,050	150		"	(4.0)	336	27.4	110	

Values shown in parentheses are nominal and/or given by the factories.

Table A-3

Trade number	R.tex (g/1,000 m)	Runnage m/kg	Runnage yds/lb.	Twine construction	Diameter (mm)	Knot breaking load, wet (kp)	Elongation at a load corresponding to the half knot breaking load (%)	Flexibility (g)	Remarks
Finland: Polyamide (PA)									
Td 210/12	300(320)	3,300(3,300)		twisted	0.52	22	17.3	<2	
Td 210/18	450(480)	2,200(2,210)		"	0.67	31	17.8	<2	
Td 210/36	1,000(960)	1,000(1,100)		"	1.05	49	23.2	5	
Td 210/12	350(320)	2,950		"	0.69	22	16.6	5	treated, black
Td 210/18	550(480)	1,850		"	0.88	33	16.4	20	" "
Td 210/36	1,200(960)	800		"	1.40	66	22.1	40	" "
France: Polyamide (PA)									
Fil. 2.4 Ø	2,850 (2,857)	350		plaited	(2.4)	134	20.2	20	
Fil. 3 Ø	3,750 (3,571)	250		"	(3.0)	194	25.0	30	
Fil. 3.5 Ø	6,850 (5,555)	150		twisted	3.53 (3.5)	291	28.4	50	
Fil. 4.5 Ø	6,100 (7,518)	150		plaited	(4.5)	285	21.3	100	
Fil. 5.5 Ø	13,550(11,363)	50		"	(5.5)	494	41.7	290	
Fil. 6 Ø	15,250(14,285)	50		"	(6.0)	579	25.4	240	
Filin 6 Ø	24,700(21,276)	50		twisted	5.97 (6.0)	890	44.0	1,490	
Germany: Polyamide (PA)									
Td 210/21	550	1,800		"	0.80	32		<2	
Td 210/24	650	1,550		"	0.84	38	20-25	<2	
Td 210/27	700	1,400		"	0.90	41		<2	
Td 210/60	1,600	650		"	1.50	90		20	
Td 210/60	1,800	550		"	1.6-1.7	80-85	29	60	
Td 210/72	2,000	500		"	1.65	100		20	
Td 210/108	3,050	350		"	2.00	140-152		30	
Td 210/120	3,400	300		"	2.10	160	20-25	30	
Nt 3/500	6,250	150		"	3.00	270		30	
Nt 3/400	8,300	100		"	3.50	340-390		50	
5 mm Ø	11,000	100		plaited	(5.0)	480	20	80	
7/16	18,000	50		"	(7.0)	777	22	740	
Polyethylene (PE)									
4 mm Ø	4,650	200		"	(4.0)	228	14.1	700	
5 mm Ø	7,550	150		"	(5.0)	352	17.5	890	

Values shown in parentheses are nominal and/or given by the factories.

Table A-4.

Trade number	R.tex (g/1,000 m)	Runnage m/kg yds/lb.	Twine construct-ion	Diameter (mm)	Knot breaking load, wet (kp)	Elongation at a load corres-ponding to the half knot breaking load (%)	Flexi-bility (g)	Remarks (p=producer)
Holland: Polyamide (PA)								
Td 210/144	4,850 (4,650)	200 (215.1)	twisted	2.64	185.2	37.2	180	p V
Td 210/132	3,800 (3,800)	250 (262.2)	"	2.30	164.4	30.2	20	p I
Td 210/120	3,350 (3,350)	300 (298.3)	"	2.13	163.6	26.4	20	p I
	3,500 (3,500)	300 (287.8)	"	2.20	155.5	34.5	70	p II
	3,800 (3,750)	250 (266.4)	"	2.49	151.6	38.2	170	p III
	3,850 (3,750)	250 (267.0)	"	2.36	157.3	34.8	100	p V
Td 210/108	3,150 (3,150)	300 (318.0)	"	2.11	142.9	35.5	70	p II
	3,000 (3,000)	350 (335.6)	"	2.11	123.8	30.5	60	p IV
	3,500 (3,400)	300 (294.8)	"	2.25	148.5	36.6	80	p V
Td 210/96	2,650 (2,600)	400 (381.5)	"	1.83	130.9	23.8	10	p I
	2,800 (2,750)	350 (362.3)	"	2.00	141.6	35.8	50	p II
	3,250 (3,150)	300 (317.7)	"	2.26	127.7	42.6	210	p III
	3,050 (3,000)	350 (331.4)	"	2.12	131.9	32.7	60	p V
Iceland: Polyethylene (PE)								
4 mm Ø	5,950	150	plaited	(4.0)	260	12.6	750	green, p I
5 mm Ø	7,400	150	"	(5.0)	323	13.7	910	" "
4 mm Ø	5,800	150	"	(4.0)	217	17.9	740	" p S
4 mm Ø	5,200	200	"	(4.0)	229	12.0	1,170	" p P
5 mm Ø	8,150	100	"	(5.0)	302	10.9	1,740	" "

Values shown in parentheses are nominal and/or given by the factories.

Trade number	R.tex (g/1,000 m)	Runnage m/kg	Runnage yds/lb.	Twine construction	Diameter (mm)	Knot breaking load, wet (kp)	Elongation at a load corresponding to the half knot breaking load (%)	Flexibility (g)	Remarks
Ireland: Polyethylene (PE)									
	4,300 (4,240)	250	125 (117)	twisted	2.93	184	10.0	890	red
	3,650 (3,674)	250	125 (135)	"	2.55	171	11.2	990	orange
	3,450 (2,756)	300	145 (180)	plaited	-	162	16.4	790	red
	2,900 (2,970)	350	175 (167)	twisted	2.53	147	22.2	580	orange
	2,950 (2,835)	350	175 (175)	"	2.27	133	8.4	540	red
	2,700 (2,611)	350	175 (190)	"	2.17	153	15.1	500	orange
Polyamide (PA)									
	1,900 (1,575)	550	270 (315)	"	1.84	69.1	18.7	15	
	750 (636)	1,350	670 (780)	"	1.00	37.4	15.9	20	black
	650 (557)	1,500	750 (890)	"	0.94	31.8	15.5	30	"
Italy: Polyamide (PA)									
	3,900	250		plaited		173	28.8	55	
Poland: Polyamide (PA)									
Td 210/7x3	600 (600)	1,700		twisted	0.85 (0.95)	31.0	23.7	5	
Td 840/5x3	1,750 (1,620)	600		"	1.62 (1.6)	71.4	29.1	30	
Td 840/6x3	1,850 (1,690)	550		"	1.64 (1.8)	87.7	26.7	20	
Td 840/7x3	2,250 (2,370)	450		"	1.69 (2.0)	108.9	24.8	20	
Td 840/2x5x3	3,350 (3,560)	300		"	2.13 (2.5)	146	26.8	30	
Td 840/4x5x3	6,550 (7,000)	150		"	2.96 (3.0)	253	24.5	40	
Portugal: Polyethylene (PE)									
5 mm ø	7,850	150		plaited	(5.0)	290	11.4	1,650	green
Romania: Polyamide (PA)									
5.5 mm ø	17,055	59		twisted	(5.5)	261	41.3	310	
Spain: Polyamide (PA)									
	11,050	100		plaited		377	35.4	630	
Polyethylene (PE)									
	8,150	100		"		318	13.9	1,700	green

[d] Values shown in parentheses are nominal and/or given by the factories.

Table A-6

Trade number	R.tex (g/1,000 m)	Runnage m/kg	Runnage yds/lb.	Twine construction	Diameter (mm)	Knot breaking load, wet (kp)	Elongation at a load corresponding to the half knot breaking load (%)	Flexibility (g)	Remarks
Sweden: Polyamide (PA)									
No.4:20	1,950	500		twisted	1.57	102	18.4	10	black
3 mm	5,900	150		plaited	(3.0)	243	35.6	180	
Polyester (PES)									
No.10	1,050	950		twisted	1.21	42	8.3	30	
No.14	1,450	700		"	1.44	52	9.2	70	
No.20	2,400	400		"	1.76	79	12.3	140	black
Polypropylene (PP)									
No.36	900	1,100		"	1.33	46	12.4	20	
USSR: Polyamide (PA)									
No.10.7	7,000 (7,100)	150		"	3.39 (3.6)	237	45.8	120	
No.10.7	10,750(10,860)	100		"	4.28 (4.33)	332	47.0	180	
Great Britain: Polyamide (PA)									
	1,600 (1,710)	600	300 (290)	"	1.41	70	16.5	10	treated for knot slippage
	2,550 (2,480)	400	200 (200)	"	1.73	116	17.5	20	
	3,900 (3,307)	250	125 (150)	"	2.66	136	27.8	30	
	5,050 (4,960)	200	100 (100)	"	2.82	183	18.0	30	
Polypropylene (PP)									
	1,500 (1,710)	650	300 (290)	"	1.53	80	10.5	30	treated for knot slippage
	2,600 (2,480)	400	200 (200)	"	2.30	110	16.8	60	
	3,450 (3,307)	300	150 (150)	"	2.57	142	16.1	90	green
	5,450 (4,960)	200	100 (100)	"	3.19	196	21.3	170	green
Manila (Ma)									
	4,200 (4,409)	250	125 (112.5)	"	2.57	116	6.5	380	treated all green
	5,550 (5,512)	200	100 (90)	"	3.15	152	7.8	460	
	6,300 (6,614)	150	75 (75)	"	3.18	163	6.7	460	

Values shown in parentheses are nominal and/or given by the factories.

Table A-7.

Trade number	R.tex (g/1,000 m)	Runnage m/kg	Runnage yds/lb.	Twine construct-ion	Diameter (mm)	Knot breaking load,wet (kp)	Elongation at a load corres-ponding to the half knot breaking load (%)	Flexi-bility (g)	Remarks
USA: Polyamide (PA)									
3x840x16	5,750	150		twisted	2.93 (3.0)[a]	227	33.9	200	
	10,350 (9,948)	100	50 (49.86)	plaited	(.187)[a]	338	32.5	230	
	12,600 (12,313)	100	50 (40.28)	"	(.2187)[a]	416	40.0	320	
	13,300 (13,050)	100	50 (38.01)	"	(.187)[a]	386	38.0	260	
	14,550 (14,558)	50	25 (34.01)	"	(.2187)[a]	373	38.4	320	

[a] = App. diameter given by USA

PART B

THE STATISTICAL ANALYSIS OF SELECTIVITY DATA

by
J.A.Pope
Marine Laboratory, Aberdeen, Scotland

1. Introduction

The length-selection curve of a trawl codend gives the relationship between the probability of retention of a fish by that codend and its length. Expressed in general mathematical terms, the form of the relationship is $P = f(l|\underline{\theta})$, where P is the probability of retention, f is some function of the length of fish (l) and $\underline{\theta}$ is a vector of parameters defining the characteristics of the length-selection curve.

From both theoretical considerations and practical evidence, the function $f(l|\underline{\theta})$ is taken to be monotonic increasing with $f_{max} = 1$ and $f_{min} = 0$. Largely because of these mathematical properties, it has been generally accepted that $f(l|\underline{\theta})$ can be realistically and accurately described by some continuous probability distribution function and, in particular, by the symmetric distribution function of the Normal (Gaussian) frequency distribution. Jones (1957) has shown how, on the basis of some specific assumptions concerning variation in codend mesh size and fish body girths, the length-selection curve is exactly expressible as a Normal distribution function. However, this result is entirely dependent on the assumed normality of the frequency distributions of both mesh size in the codend and fish body girth. Other assumptions would lead to other expressions for the length-selection curve.

Pope and Hall (1960) expressed $f(l|\underline{\theta})$ as a logistic function which is also symmetric and, in fact, differs little from the Normal distribution function. These writers did not attempt nor imply any theoretical justification for this form of curve. A full description of the fitting of this form to experimental data is given by Pope (1964).

Both the Normal distribution function and the logistic function are completely specified by two parameters θ_1 and θ_2 (say) in terms of which all points on the selection curve (in particular the 50% selection length) may be determined.

There does exist, however, an extensive body of experimental data indicating that a selection curve is not necessarily symmetric about the 50% selection length. A more suitable and flexible mathematical model for the selection curve is clearly desirable.

In practice, however, interest is generally confined to the 50% selection point rather than to the curve as a whole. Little attention appears to have been paid to the selection range (*i.e.* the length interval between the 25 and 75% selection points). The most important practical problem has, therefore, been that of estimating 50% selection points from experimental results.

2. Estimation of a Single Selection Curve

Before attempting any estimation, consideration ought to be given to whether the data to be used are sufficiently reliable to warrant any form of treatment at all. Such consideration, of course, begs the questions, "what is to be estimated?" and "what accuracy is required in the estimates?" Although a complete selection curve is usually desired, the main requirement, as already noted, is an estimate of the 50% retention length and accordingly particular attention will be paid to methods of achieving this.

First we must distinguish between various sources of statistical error. We consider the results from a single covered codend haul as being a single realization of how the codend selects fish under the conditions pertaining at the time of towing. These conditions refer to the composition of the fish population encountered, the flow of water through the codend during towing, the speed of the vessel, etc. Another haul with the same codend will not be made under precisely the same conditions and it must be regarded as a single realization of another situation. Whether the two sets of conditions result in closely similar or widely dissimilar average selection curves depends simply on how similar the different conditions are on these two occasions. If $p_j(l_k)$, k = 1, 2, 3, ... are the observed proportions retained at lengths l_1, l_2, l_3, ... in a particular haul, say haul j, and $f_j(l_k|\underline{\theta})$ the expected proportions derived on the basis of some theoretical law (*e.g.* that the probabilities of retention follow a Gaussian distribution function law), then we may write

$$p_j(l_k) = f_j(l_k|\underline{\theta}) + \varepsilon_{jk} \qquad (2.1)$$

The fitting of $f_j(l_k|\underline{\theta})$ to the data from this single haul consists of finding estimates of the parameters $\underline{\theta}$. Such estimates ($\hat{\underline{\theta}}$, say) will be functions of the statistical errors (ε_{jk}) and the best estimates are those which involve these errors in such a way as to make their generalized variance (given by $\det\{E(\hat{\underline{\theta}}-\underline{\theta})'(\hat{\underline{\theta}}-\underline{\theta})\}$) as small as possible. Maximum likelihood estimators have this property in large samples, but, in general, it is not difficult to find, by simpler methods, estimates of the parameters, or functions of them, which have sufficiently small variance.

Whilst the Gaussian distribution function, $f_G(l|\underline{\theta})$ say, or the logistic, $f_L(l|\underline{\theta})$ say, are strictly at best only assumed forms for the function $f(l|\underline{\theta})$, these curves are, at least on empirical evidence, sufficiently realistic for them to be regarded as equally plausible "true" models in a great many situations. The fitting of either curve may thus be regarded as being the most advanced form of treatment of the data. The parameters of these curves may be estimated by maximum likelihood using suitable routines and their variances, or more often the variances of functions of them (*e.g.* their ratio), evaluated. For example, the logistic curve is given by

$$1/f_L(l|\underline{\theta}) = \{1+\exp(\theta_1-\theta_2 l)\} \qquad (2.2)$$

and the ratio θ_1/θ_2 is the 50% retention length.

Any method of fitting other than maximum likelihood will not be more efficient, in the sense that it will lead theoretically to variances of the estimates as large as or larger than those of the maximum likelihood estimates. Also, any form of curve other than $f_L(l|\underline{\theta})$ or $f_G(l|\underline{\theta})$ can be regarded as an approximation to the true model and, like all approximations, will theoretically be less accurate than the true model. Nonetheless, the amount of calculation involved in the maximum likelihood approach and the need for special tables makes it very desirable to seek alternative simpler ways of treating the data.

Simpler approaches are

i) curve fitting by eye
ii) approximating to the middle part of the curve by a straight line and fitting by weighted or unweighted least squares
iii) using moving averages of the observed values of $f_j(l_k)$ to estimate the 50% point only.

The results of two sets of comparisons of different methods of fitting curves are given in Tables B-1, B-2, B-3 and B-4. The first two tables are taken from Pope (1966) and give the estimated 50% points and variances respectively of 15 actual selection curves provided by (a) the logistic curve fitted by maximum likelihood, (b) the fitting of an unweighted regression line to the observed proportions retained over approximately the 25-75% range, (c) the 3-point moving average method. Tables B-3 and B-4 give similar data for 9 actual curves provided by methods (a), (b) and (c) above, and (d) eye-fitted curves. These sets of data were taken from two series of replicate hauls made by the same research vessel during two cruises. Within each set the results refer to the same codend. The average values of the variances of the maximum likelihood estimates of θ_1/θ_2, the 50% retention lengths, are 0.1023 and 0.0968. These figures imply a percentage standard deviation of between 1.1 and 1.3% on average in the maximum likelihood estimates of a 50% retention length (and hence of a selection factor) from a single set of data (*e.g.* single haul). This is a very small component of error.

The unweighted linear regression estimates are satisfactorily close to the maximum likelihood estimates and, although all but one of the estimates in Table B-3 are below the maximum likelihood values, there is no reason to suspect bias in this method. The variances of the regression estimates differ appreciably from those of the maximum likelihood estimates in some, but certainly not all, cases. The average value of the regression variances in Tables B-2 and B-4 are 0.1758 and 0.1202 respectively, corresponding, on average, to percentage standard errors of 1.7 and 1.2% respectively, that is, slightly larger than the maximum likelihood estimates.

The estimates provided by the use of 3-point moving averages are, like the regression estimates, close to the maximum likelihood values with no evidence of bias. The variances are similar in some cases to those for the above methods but are generally higher, sometimes appreciably so.

The estimates from eye-fitted curves, given in Table B-3, were obtained by asking seven people to draw curves by eye, independently of one another, to each of the nine sets of points. None of the seven people had previously drawn a selection curve so that it was necessary to give them some guidance beforehand. This consisted of outlining the principles of curve fitting to any sort of data, giving a brief account of codend mesh selection and stating simply the properties of the logistic and Normal distribution function curves. Each person was asked to fit a curve to all the points over the whole range, not merely in the neighbourhood of the 50% point. Thus the deviations of each observed proportion from each eye-fitted curve could be measured and compared. The sums of squares of these deviations are given in Table B-5.

It will be seen immediately from the last column of Table B-3 which gives the averages of the seven eye estimates for each haul, that eye estimation can give 50% points very close to maximum likelihood estimates. What is interesting and of significance in this context is that differences between the seven estimates are small in each of the nine cases. This is reflected in the variances calculated from the seven estimates and shown in the last column of Table B-4. These variances are not estimating precisely the same thing as the variances in the first three columns of Table B-4. They do indicate the degree of reproducibility of eye estimates, however, which is the important point here.

We may conclude from the results of this investigation that, with data of the type examined here, unbiased estimates of 50% points can be obtained by eye. Such estimates are very close to those obtained by the method of maximum likelihood and differences between individuals are likely to be very small indeed so that eye estimation provides a satisfactory substitute for the maximum likelihood approach. Fitting a straight line by least squares is slightly easier and quicker than a complete maximum likelihood approach but this method cannot really be preferred to eye estimation and is not a completely satisfactory substitute for maximum likelihood fitting of either $f_L(l|\underline{\theta})$ or $f_G(l|\underline{\theta})$. The moving-average method is not to be recommended generally. It can, even with moderately good data, give occasional rise to ambiguity by providing more than one 50% point for a given set of points. It only estimates the 50% point without bias and the calculation of the variance of the estimated 50% point is tedious.

A further interesting feature of the eye method is brought out in Table B-5 which gives the mean squared deviations of the eye-fitted curves, *i.e.* the values of $\sum_{k=1}^{n} (p_j(l_k)-f^*(l_k))^2/n$, $f^*(l_k)$ being the eye-estimated proportion at length l_k. It will be seen that differences between the eye-fitted curves are not too large, indicating that all seven people drew fairly similar curves <u>over the whole range</u>. These mean squared deviations are also similar to the same quantities calculated for the logistic curves fitted by maximum likelihood. Despite this the selection ranges estimated by the two methods do show consistent differences, the maximum likelihood estimates being larger in seven out of the nine cases (see Table B-6). The variances of the maximum likelihood estimates were obtained using

$$\mathrm{Var}\,(l_1-l_2) = (l_1-l_2)^2/b^2 S(nwl^2) \qquad (2.3)$$

and are shown in Table B-6. The variances of the average eye-fitted values, also shown in Table B-6, were obtained in the usual way from the seven estimates for each haul. The variances of the eye-estimated selection ranges are more homogeneous than those of the maximum likelihood estimates, but both methods give similar percentage standard errors of around 10%.

This study has shown that the percentage standard error in the 50% retention length (or selection factor) estimated by somewhat elaborate statistical techniques is of the order of 1-2%, while that of the selection range is of the order of 10%. This sort of accuracy can be obtained, in general, without recourse to statistical procedures, simply by drawing free-hand curves by eye, although there is evidence that selection ranges estimated from eye-fitted curves may be smaller than by other methods, particularly for curves $f_L(l|\underline{\theta})$ and $f_G(l|\underline{\theta})$.

These results give some guidance in answering the problem posed at the beginning of this section, namely, how good are the basic data? Any set of data giving a percentage standard error in an estimate of the 50% retention length much in excess of 2%, say ≥ 5%, may be taken as unreliable. Any data suspected of being unreliable would have to have the accuracy of any estimate drawn from it estimated, and this could be done by either submitting the data to a complete statistical treatment or by having several people independently fitting curves by eye.

The studies discussed here were based on relatively good data, and the number of fish in each haul in the estimated selection ranges was in most cases quite large. For example, in the data corresponding to Tables B-3 and B-4, the numbers in the selection range varied between 273 and 4,160 fish. The variances of the maximum likelihood estimates quoted in Table B-4 are almost perfectly correlated with the number of fish in the selection range, but, even for the haul with the smallest number of fish, the percentage standard errors of the 50% point and the selection range are 1.3 and 13.5% respectively, both close to the average values quoted above.

In the next section it is pointed out that haul-to-haul variability is a much larger component of error than within-haul variability so that errors of estimation for a single haul are relatively unimportant in comparison with other errors.

3. Haul-to-Haul Variability Within Experiments

It is customary to make replicate hauls for selectivity study on the same ground and within a short space of time. Such replication is necessary if data are to be useful. The hauls to which the data in Tables B-1, B-2, B-3, and B-4 refer, for instance, were made within a space of three weeks, in both cases on the same fishing ground. They indicate the sort of variability encountered in such replicate hauls.

With $p_j(l_k)$ and $f_j(l_k)$ defined as at equation (2.1) we may write for the j^{th} haul

$$\begin{aligned} p_j(l_k) &= f_j(l_k) + \varepsilon_{jk} \\ &= f(l_k) + \left\{ f_j(l_k) - f(l_k) \right\} + \varepsilon_{jk} \\ &= f(l_k) + \beta_j + \varepsilon_{jk} \end{aligned} \tag{3.1}$$

where $f(l_k)$ denotes the "true" selection curve for the conditions of the experiment and $\beta_j = f_j - f$ is the deviation of the expected curve for haul j from $f(l_k)$. The random term β_j is the haul-to-haul error. An equation, similar to (3.1), may be written in terms of any parameters estimated from individual haul data. Thus, without introducing any modification to the notation we might write

$$l_j(50) = \lambda(50) + \beta_j + \varepsilon_{je} \tag{3.1}$$

where ε_{je} represents the error of estimation in the fitted 50% point for the j^{th} haul and β_j represents, as before, haul-to-haul variability in the 50% points. If $\sigma_{\varepsilon j}^2$ and σ_β^2 are used to denote the true variances of the errors ε_{je} and β respectively, then

$$\mathrm{Var}(l_j(50)) = \sigma_\beta^2 + \sigma_{\varepsilon j}^2 \tag{3.2}$$

and, if $l_1(50)$, $l_2(50)$, ..., $l_n(50)$ are the estimated 50% lengths from n replicate hauls, on average the following equation is true,

$$\begin{aligned} \frac{1}{n-1}\sum\left\{l_j(50) - \bar{l}(50)\right\}^2 &= \sigma_\beta^2 + \Big(\sum_{j=1}^{n} \sigma_{\varepsilon j}^2\Big)/n \\ &= \sigma_\beta^2 + \bar{\sigma}_\varepsilon^2 \end{aligned} \tag{3.3}$$

where $\bar{\sigma}_\varepsilon^2$ is the average variance of the errors of estimate for each haul. Using the maximum likelihood estimates of the 50% points given in Tables B-1 and B-3, we find that the value of the quantity on the left-hand side of (3.3) is 14.2407 and 2.4225 respectively. The estimates of σ_β^2 and $\bar{\sigma}_\varepsilon^2$ for Sets 1 and 2 are therefore

$$s_\beta^{\ 2} = 14.1384 \qquad s_\beta^{\ 2} = 2.3257$$

$$\bar{s}_\varepsilon^{\ 2} = 0.1023 \qquad \bar{s}_\varepsilon^{\ 2} = 0.0968$$

respectively, the quantities $\bar{s}_\varepsilon^{\ 2}$ being calculated from the variances given in the first columns of Tables B-2 and B-4. The variance of the between-haul component within an experiment is thus seen to be considerably larger than the within-haul component and, clearly, errors of estimation of the 50% point are insignificant. As pointed out by Pope (1966), in such situations, the most appropriate way to combine estimates from replicate observations is to employ a simple unweighted mean.

The value of $s_\beta^{\ 2}$ for the two sets treated here are quite different and reflect the much greater variability in the 50% points quoted in Table B-1 than in those quoted in Table B-3. In set 1 there is one quite low value (namely 18.2) and three relatively high values (namely 28.2, 31.2, and 32.9). Naturally the question arises whether or not one or more of these estimates should be rejected before calculating the experimental mean.

There are many possible reasons for encountering outlying observations. Selection may be reduced, for example, by quantities of weed blocking the codend meshes, etc. On the other hand the 50% point may be raised because of tears or large holes in the codend meshes, etc. It is clearly necessary in selection experiments to keep accurate records at the time, to which reference may be subsequently made for the possible elucidation of abnormal results. Of course this procedure is not without its pitfalls as it is deceptively easy to find, after an outlying observation has been observed, plausible reasons for its occurrence. Probably the most common situation is that in which there is no real evidence of a causal mechanism for the occurrence of a divergent observation and in such situations the idea of a test procedure for deciding whether to reject an observation or not has some apparent attractions. However, uncritical use of any such procedure is clearly dangerous. It is always advisable, wherever possible, to carry out any projected analysis of data both with and without the outlying observations. If the general conclusions are different in the two analyses then clearly the outlying observations are in a position to sway action one way or another. In such a situation no firm conclusion is warranted.

Reference has already been made to the extreme observations of Set 1 given in Table B-1. The unweighted mean and standard deviation of all 15 values of the 50% point are 25.3 and ± 3.77 respectively. The observation with the maximum deviation is 32.9 and the deviation (+7.6) is twice the observed standard deviation. This is in no sense a large deviation, but, for interest, the mean and standard deviation have been recalculated omitting this observation. They are found to be 24.7 and ± 3.25 respectively, not very different from the previous values.

The percentage standard deviations for the two sets of data considered here are 14.9% and 5.2% for Set 1 and Set 2 respectively. The latter figure is close to values quoted by Gulland (1964) for three sets of data obtained by the English research vessel *Sir Lancelot*, namely 5.2, 5.3, and 7.3%, and also to a value of 6.1% obtained by the author from a set of 20 replicate hauls. The average of these figures is 7.3% which may be taken as the percentage standard deviation of a single 50% point or selection factor within an experiment. The percentage standard error of the mean of a set of n replicate hauls (*i.e.* hauls within an experiment on the same ground) is then of the order of $(7.3/\sqrt{n})$%. The actual standard errors of the mean 50% points for Sets 1 and 2 (data of Tables B-1, B-2, B-3, and B-4) are ± 0.973 and ± 0.519 respectively. These give rise to 95% confidence limits of 23.2 to 27.4 for Set 1 and 28.2 to 30.6 for Set 2. In terms of selection factors these limits are 3.31 to 3.91 for Set 1 and 3.48 to 3.78 for Set 2.

4. Variability Between Experiments

When several experiments have been conducted on the same codend material, the mathematical model given by equation (3.1) may be extended to include a component accounting for differences between experiments. Thus we may write

$$p_{ij}(l_k) = f(l_k) + \left\{ f_i(l_k) - f(l_k) \right\} + \left\{ f_{ij}(l_k) - f_i(l_k) \right\} + \varepsilon_{ijk} = f(l_k) + \alpha_i + \beta_{ij} + \varepsilon_{ijk} \tag{4.1}$$

where now $f(l_k)$ represents the true "global" selection curve for the codend material, $f_i(l_k)$ represents the true selection curve for the i^{th} experiment, $f_{ij}(l_k)$ represents the true curve for the j^{th} haul of the i^{th} experiment and ε_{ijk} is the true deviation of $p_{ij}(l_k)$ from $f_{ij}(l_k)$.

The component α_i may be a function of a large number of factors, *e.g.* season of year in which experiment was conducted, particular research vessel employed, experimental techniques such as duration of hauls, rigging of codend covers, etc. Gulland (1964) in a study of North Sea whiting selection factors for manila and sisal codends found significant differences between results reported by different scientists. Quoting Gulland, this "is not very surprising, as data presented by the same author are likely to be derived from observations on the same ground as well as with much the same gear". As an example of the sort of variation encountered in different experiments, the data given in Table B-7, taken from Pope and Hall (1964), are considered. These data refer to experiments using double polypropylene codends and the selection factors are for haddock.

The final column in Table B-7 gives the actual coefficients of variation for each separate set of results and they average about 5%. This agrees well with the between-haul within-experiment figure given in the previous section.

From equation (4.1), expressed in terms of selection factors x_{ij} instead of proportions $p_{ij}(l_k)$, the variance of a randomly selected value is given by:

$$\mathrm{Var}(x_{ij}) = \sigma_\alpha^2 + \sigma_\beta^2 + \sigma_\varepsilon^2 \text{ or } \sigma_\alpha^2 + \sigma_\beta^2 \qquad (4.2)$$

(σ_ε^2 being small, as we have already seen). The variance of the unweighted mean selection factor of the i^{th} experiment is:

$$\mathrm{Var}(\bar{x}_i) = \sigma_\alpha^2 + \sigma_\beta^2/n_i \qquad (4.3)$$

where n_i is the number of replicate hauls in the i^{th} experiment. For the data given in Table B-7, the quantities σ_α^2 and σ_β^2 may be estimated from a one-way analysis of variance. This is shown below, the quantity n_o being $\left\{\Sigma n_i - \Sigma n_i^2/\Sigma n_i\right\}/11 = 3.53$

	df	S. of S.	m.s.	E(m.s.)
Between experiments	11	1.22	0.1109	$\sigma_\beta^2 + n_o\sigma_\alpha^2$
Within experiments	41	1.14	0.0278	σ_β^2
Total	52	2.36		

The estimates of σ_β^2 and σ_α^2 are 0.0278 and 0.0235 respectively. Thus the component of variance between experiments is comparable with that within experiments. From these figures the variances of the experiment means are estimates as:

Experiment	$\mathrm{Var}(\bar{x}_i)$ $(0.0235 + 0.0278/n_i)$
1.1	0.0235 + 0.0139 = 0.0374
1.2	" + 0.0139 = 0.0374
2.1	" + 0.0139 = 0.0374
2.2	" + 0.0070 = 0.0305
3.1	" + 0.0139 = 0.0374
4.1	" + 0.0139 = 0.0374
5.1	" + 0.0278 = 0.0513
6.1	" + 0.0093 = 0.0328
7.1	" + 0.0139 = 0.0374
8.1	" + 0.0011 = 0.0246
9.1	" + 0.0070 = 0.0305
9.2	" + 0.0093 = 0.0328

Since the values of n_i are, with one exception, much the same in each experiment, the values of $\mathrm{Var}(\bar{x}_i)$ are very nearly equal. Hence a satisfactory mean for double polypropylene based on the 12 sets of data discussed here is an ordinary unweighted mean. In this case, the mean selection factor is 3.47 with a variance given by $\left\{Var(\bar{x}_1) + Var(\bar{x}_2) + \ldots + Var(\bar{x}_{12})\right\}/12^2$ = (0.0235 + 0.0121)/12 = 0.002967. The square root of this quantity is ± 0.0545. Thus approximate 95% confidence limits for the mean selection factor are 3.47 ± 0.11 = 3.36 and 3.58. The two variance components, 0.0278 and 0.0235, correspond to percentage standard deviations of about 5%, thus confirming the magnitudes quoted in Section 3.

When combining the results of several experiments, especially in those cases where individual haul values are not available, a sufficiently reliable weighting system may be derived by assuming average percentage standard deviations for the within-experiment and the between-experiment components of 7% in both cases. For example, the ICES Cooperative Research Report, No.2 (1964) quotes an experimental value obtained by G. Saetersdal of 4.2, based on 11 hauls, for the selection factor of cod by a double nylon codend of 140-mm mean mesh size. The variance of this value may be taken as being approximately $(0.294)^2 + (0.294)^2/11 = 0.0943$. This method has been applied to data compiled by Treschev (see Part C) for double polyamide codends. Treschev divided published figures for this material into two groups which he referred to as polyamide A and polyamide B. The values of the cod selection factors and their estimated variances are shown in Table B-8. The latter will be seen to be fairly uniform, largely because the number of hauls in each experiment was reasonably large and similar from experiment to experiment. The inverses of the variances are quoted in Table B-8 and the weighted mean selection factors ($\Sigma w_i x_i / \Sigma w_i$) for polyamides A and B are respectively 3.90 and 3.57. The weighted mean for both sets of data combined is 3.83. The variance of such a type of weighted mean is $^1/\sum w$ and so the standard errors of these values are roughly ± 0.051 and ± 0.097 for polyamides A and B respectively and ± 0.045 for both combined. This indicates approximate 95% confidence limits of 3.83 ± 0.09 = 3.74 and 3.92 for double polyamide codends.

An additional form of weighting, not related to the accuracy of determinations of selection factor, may be deemed necessary when combining results derived from different experiments. It was pointed out that α_i may be a function of a number of factors operating during any experiment. Thus, for example, suppose it were known that the selection factor for a particular species was definitely lower in spring (say during February, March and April) than at any other time of year. If the majority of experimental results available referred to the spring period it might be more appropriate to calculate, in the above manner, two weighted means, one from experiments conducted in the spring ($\bar{x}_1$ say) and one from the remaining experiments ($\bar{x}_2$ say). If, for some purpose, an average figure for the year as a whole were required and if the fishing effort by the commercial fleets was uniform throughout the year, a possible weighted mean would be $0.25\bar{x}_1 + 0.75\bar{x}_2$. Similar considerations would apply if it were known that selection factor was related to size of catch.

5. Mesh Differentials

We have seen in the preceding sections that the two main components of variance in an experimental value of a 50% selection length, or a selection factor, are the between-haul within-experiment and the between-experiment components. The coefficients of variation of both components are of the order of 5-10%, say 7% on average. Thus, for a codend material with an average selection factor of 3.3, the variance of a single determination would be 0.1067. If we assume that experimental values are normally distributed and further that such values are representative of the actual factors operating in the commercial fleets then 95% of all hauls made in a given period of time would have actual selection factors lying approximately between 2.7 and 3.9. Furthermore, if the average selection factor for another codend material were 3.6, and if selection factors for this material were also normally distributed with a variance of 0.1067 (standard deviation = 0.33), then some 18% of all commercial hauls by the second material would have actual selection factors below 3.3, the mean of the first material. There will in fact be a considerable overlap of two distributions with means differing by only 10%. This is quite a different matter from the question as to whether or not the mean selection factors for two different materials are really different or not, on which basis present mesh differentials have been established. But the existence of such overlapping distributions should not be lost sight of in defining mesh differentials. The problem of establishing the existence of differences in mean selection factors for different materials has been discussed by Gulland (1964) who noted that, with the data available to him at the time, confidence limits were wider than the actual differentials than in existence.

With the accumulation of more and more data, however, greater precision in mean values should be achieved. In the previous section the average cod selection factor for double polyamide was given as 3.83 ± 0.09. If the mean selection factor for another codend material were established with the same accuracy, then it would be deemed to differ significantly from 3.83 if it were some 5-6% higher or lower.

The establishment of mesh differentials does not rest solely on statistical considerations, of course. Questions of distinguishing between different materials, and law enforcement are also very relevant.

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Table B-1. Comparison of 50% points obtained by different methods of estimation.

Maximum likelihood	Linear regression	Moving averages
24.6	24.5	24.5
26.5	26.5	26.6
25.5	25.6	25.7
21.9	21.7	20.7
23.0	23.0	23.0
25.5	25.4	25.7
18.2	18.2	18.2
21.7	21.7	21.6
27.5	27.5	27.5
22.0	22.1	21.8
25.6	25.6	25.6
24.7	24.4	24.5
28.2	28.2	28.5
31.2	31.1	31.1
32.9	32.6	32.5

Table B-2. Comparison of variances of 50% points obtained by different methods of estimation (Set 1).

Maximum likelihood	Linear regression	Moving averages
0.0395	0.0757	0.0371
0.0530	0.0350	0.0645
0.2707	0.3922	0.0557
0.1377	0.9239	0.6999
0.0905	0.0182	0.1713
0.1810	0.3094	0.4199
0.0046	0.0038	0.0053
0.0134	0.0045	0.0161
0.0629	0.0471	0.0784
0.1423	0.0319	0.2515
0.0533	0.1166	0.0593
0.1469	0.5138	0.2356
0.0776	0.0708	0.0876
0.2154	0.0182	0.1970
0.0453	0.0759	0.0305

Table B-3. Comparison of 50% points obtained by different methods of estimation (Set 2).

Maximum likelihood	Linear regression	Moving averages	Eye fitting							
			(1)	(2)	(3)	(4)	(5)	(6)	(7)	Avg
28.2	27.6	28.3	28.2	27.8	28.1	27.7	28.1	28.1	27.6	27.9
29.6	29.4	29.8	29.8	29.7	29.7	29.8	29.7	29.9	29.7	29.8
29.7	29.5	29.3	29.3	29.4	29.0	29.4	29.4	29.4	29.4	29.3
26.3	26.6	26.2	26.5	26.3	26.6	26.4	26.4	26.2	26.4	26.4
29.0	28.5	29.2	29.2	29.1	29.2	29.2	29.3	29.0	28.9	29.1
30.5	30.4	30.4	30.8	30.5	30.7	30.4	30.6	30.7	30.5	30.6
31.6	30.8	31.1	30.5	30.6	30.5	30.3	30.4	30.4	30.7	30.5
29.2	28.9	29.1	29.6	29.2	28.9	28.9	28.8	28.4	28.8	28.9
30.8	30.5	30.9	30.8	30.9	30.8	30.8	30.8	30.9	30.8	30.8

Table B-4. Comparison of variances of 50% points obtained by different methods of estimation (Set 2).

Maximum likelihood	Linear regression	Moving averages	Eye fitting
0.2715	0.1663	4.7599	0.0562
0.0072	0.0524	0.0124	0.0062
0.0234	0.0173	0.2567	0.0224
0.0500	0.0536	0.0602	0.0167
0.0211	0.0648	0.0225	0.0190
0.0329	0.0535	0.0301	0.0200
0.2500	0.1935	0.0942	0.0181
0.0632	0.1604	0.0825	0.1395
0.1521	0.0794	0.2495	0.0024

Table B-5. Mean squared deviations from eye-fitted and logistic selection curves.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	Maximum likelihood
0.0110	0.0108	0.0058	0.0101	0.0079	0.0086	0.0080	0.0091
0.0005	0.0022	0.0002	0.0009	0.0008	0.0016	0.0010	0.0013
0.0008	0.0014	0.0013	0.0013	0.0098	0.0014	0.0009	0.0012
0.0017	0.0020	0.0023	0.0026	0.0013	0.0015	0.0024	0.0027
0.0032	0.0022	0.0009	0.0035	0.0016	0.0054	0.0018	0.0031
0.0018	0.0013	0.0011	0.0003	0.0012	0.0016	0.0009	0.0014
0.0057	0.0072	0.0053	0.0099	0.0062	0.0097	0.0063	0.0062
0.0091	0.0085	0.0066	0.0086	0.0075	0.0103	0.0090	0.0068
0.0019	0.0011	0.0015	0.0011	0.0008	0.0010	0.0012	0.0017

Table B-6. Comparison of selection ranges estimated from logistic curves and eye-fitted curves.

Logistic curve (maximum likelihood)		Eye-fitted curve	
S.R.	Variance	Mean S.R.	Variance
6.35	2.7217	4.34	0.2162
5.17	0.0455	4.86	0.0662
5.87	0.1273	5.96	0.1262
5.13	0.3647	4.30	0.0600
6.27	0.1800	5.26	0.1462
4.05	0.0890	4.06	0.3195
9.97	2.0325	6.07	0.1290
5.22	0.4380	4.31	0.1581
5.16	0.4841	4.90	0.1533

Table B-7. Haddock selection factors for double polypropylene codends from different experiments.

Experiment	Grounds	Selection factors	Mean	Variance	Coefficient of variation
1.1	Fair Isle	3.5 3.7	3.6	0.0200	3.9
1.2	Buchan Deeps	3.5 3.8	3.6	0.0450	5.9
2.1	Buchan Deeps	3.5 3.6	3.6	0.0050	2.0
2.2	Auskerry	3.7 3.9 3.6 3.8	3.8	0.0167	3.4
3.1	Orkney/Shetland	3.4 3.0	3.2	0.0800	8.8
4.1	Scalloway	3.0 3.0	3.0	-	-
5.1	Moray Firth	3.7	3.7	-	-
6.1	Buchan Deeps	3.5 3.2 3.3	3.3	0.0234	4.6
7.1	Moray Firth	3.4 3.3	3.4	0.0050	2.1
8.1	Faroes	3.2 - 3 3.3 - 1 3.4 -10 3.5 - 4 3.6 - 4 3.7 - 1 3.8 - 3	3.5	0.0298	4.9
9.1	Auskerry	3.7 3.6 3.4 3.3	3.5	0.0333	5.2
9.2	Scalloway	3.5 3.3 3.2	3.3	0.0234	4.6

Table B-8. Average cod selection factors, variances and weighting factors for double polyamide polyamide codends.

(a) Double Polyamide A

S.F. $(\bar{x}_i)$	$V(\bar{x}_i)$	$w = 1/V(\bar{x}_i)$	S.F. $(\bar{x}_i)$	$V(\bar{x}_i)$	$w = 1/V(\bar{x}_i)$
4.0	0.0844	11.8	3.2	0.0753	13.3
4.2	0.0943	10.6	3.7	0.0894	11.2
4.4	0.1186	8.4	3.5	0.0720	13.9
4.2	0.0951	10.5	4.0	0.0941	10.6
4.4	0.1044	9.6	3.8	0.0849	11.8
4.3	0.0951	10.5	4.0	0.0941	10.6
4.1	0.0865	11.6	3.9	0.0894	11.2
4.2	0.0951	10.5	3.5	0.0675	14.8
4.3	0.0997	10.0	3.9	0.0870	11.5
3.8	0.0778	12.9	3.7	0.0745	13.4
4.4	0.1044	9.6	3.8	0.0825	12.1
4.4	0.1044	9.6	3.4	0.0629	15.9
4.0	0.0862	11.6	4.1	0.0855	11.7
4.2	0.0951	10.5	3.8	0.0729	13.7
4.0	0.0862	11.6	3.7	0.1006	9.9
3.6	0.0762	13.1	3.5	0.0686	14.6
4.1	0.1098	9.1			

(b) Double Polyamide B

S.F. $(\bar{x}_i)$	$V(\bar{x}_i)$	$w = 1/V(\bar{x}_i)$	S.F. $(\bar{x}_i)$	$V(\bar{x}_i)$	$w = 1/V(\bar{x}_i)$
3.7	0.0805	12.4	3.6	0.1270	7.9
3.7	0.0783	12.8	3.51	0.0679	14.7
3.6	0.0688	14.5	3.38	0.0700	14.3
3.8	0.1061	9.4	3.38	0.0840	11.9
3.5	0.1200	8.3			

PART C

COMPILATION OF SELECTIVITY DATA FOR COD, HADDOCK AND REDFISH

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Introduction

The Working Group decided at a preliminary meeting held at ICES in October 1968 to restrict its analyses to data obtained from bottom trawl selectivity experiments made in ICNAF Subareas 1, 2, and 3 and ICES Sub-area I and Divisions IIa, IIb and Va in which cod, haddock, and redfish were the species being studies. Tabulation of the data was also limited to experiments conducted with double-braided twines because few, if any, trawls used in the above-mentioned areas of the North Atlantic are made of single-braided twines. All the data collected are given in Tables C-1 to C-12.

Only results from experiments based on the covered codend method were used. Experiments in which a topside chafer of any design was used were not included in the analysis. Experiments in which the selection factor was given in brackets or followed by a question mark were included but not those in which the number of fish in the selection range formed a very small proportion of the total catch. In those experiments in which the average duration of tow was not given, it was assumed to be 60 min. In the three component method of analysis described below, the total number of fish caught of the species studied was used as a weighting factor if the number of fish in the selection range was not stated; otherwise the result was not used in any of the four methods of analysis. Insofar as possible, all experiments made on one ground at one time were combined, that is, single hauls were grouped. This gave the following number of experiments which could be used:

	Manila	PP	PE	PES	PA
Cod	69	27	6	2	33
Haddock	47	16	1	2	16
Redfish	25	0	0	0	12

The Working Group was unable to investigate the effect of trawl construction on selectivity because there were insufficient data.

The Three Component Method of Weighting

In determining the mean value, the "weight" of the values investigated is usually determined by their frequency of occurrence and the mean is obtained from the formula:

$$\bar{x} = \frac{\Sigma(x_i m_i)}{\Sigma\ m_i} \qquad (1)$$

where x_i is the value investigated,

m_i is frequency of occurrence (weight) of value.

From the mathematical (statistical) viewpoint, this method of obtaining the mean value is fully justified. However, a more penetrating insight into the essence of the averaged trawl selectivity data obtained from different experiments easily shows that the true "weight" of each value of the selection factor is determined not only by its frequency of occurrence but also by the conditions of the experiment under which it is obtained. The most important factors are the number of fish within the selection range, which is a factor characterizing in each experiment the relation between the fish and the gear, and the duration of the experiment, *i.e.* the number and the duration of hauls.

Proceeding from this, a method of combining experimental data on trawl selectivity has been developed in the USSR (A.I.Treschev, VNIRO, Proceedings, v. LXI, 1966).

According to this method, the mean weighted value of the selection factor is obtained from the formula:

$$\bar{k}_s = \frac{\Sigma n_i t_i N_i k_i}{\Sigma n_i t_i N_i} = \frac{n_1 t_1 N_1 k_1 + n_2 t_2 N_2 k_2 + \ldots + n_n t_n N_n k_n}{n_1 t_1 N_1 + n_2 t_2 N_2 + \quad + n_n t_n N_n} \qquad (2)$$

where $\bar{k}_s$ is the mean weighted trawl selection factor;

$n_1, n_2 \ldots n_n$ are the number of hauls in the first, second and n^{th} experiments;

$t_1, t_2 \ldots t_n$ are the durations of haul in the first, second and n^{th} experiments;

$N_1, N_2 \ldots N_n$ are the numbers of fish within the selection range in the first, second and n^{th} experiments;

$k_1, k_2 \ldots k_n$ are selection factors in the first, second and n^{th} experiments.

It follows from (2) that the mean selection factor is directly dependent on the number of hauls, the duration of hauls and the number of fish within the selection range and, through all specific selection factors ($k_1, k_2 \ldots k_n$), on all other factors involved.

Thus, in applying this formula the numerical values of the selection factors obtained by the experimenters are taken as they are and in so doing it is assumed that the value of each specific selection factor reflects the heterogeneity of the populations fished, the size of catch, the peculiarities of the trawl design and the fishing process as well as the method of combining data from different hauls, the method of constructing graphs and calculating selection factors, and many other factors. As far as the reliability (weight) of each specific selection factor is concerned, it is assumed that in all experiments it is mainly dependent on the duration of the experiment (the number of hauls multiplied by their durations) and on the number of fish involved, *i.e.* the number of fish within the selection range. The higher these two values, the greater its share of influence on the mean value of the selection factor.

Tables of Selectivity Data

The following notes explain the headings of some of the vertical columns in Tables C-1 to C-12:

1) SOURCE - refers to Bibliography, Part E;

2) Number of fish in selection range - refers to the total number of fish of the species studied in the selection range from all hauls combined.

TABLE C-1. Gear: Bottom trawl Material: Double Manila Area: ICNAF 1, 2, 3, ; ICES I, IIb, Va.

AUTHOR	SOURCE	LOCALITY		DATE	COD-END			METHOD	HAULS		Speed of tow (knots)	Mesh gauge	Mean mesh size (mm)	50% length (mm)	SELECTION		No. of fish in selection range		Total No. of fish studied		Av. weight (kg) of			
		Division	Depth (m)		Material Const.	R Tex (g/1000 m)	Runnage (m/kg)		No.	Average Duration (min)					Factor	Range (mm)	Cod-end	Cover	Cod-end		Fish		Bycatch	
																					Cod-end	Cover	Cod-end	Cover
SAETERSDAL	1963	ICES II b		V 1954				Parallel Hauls	12	85			100	540	4.1	100	5485	Boat 1						
"	"	"		"				"	"	"			130	"	"	"	2111	Boat 2						
"	"	"		"				"	"	105			130	580	4.4	"	856	Boat 1						
"	"	"		"				"	"	"			110	"	"	"	6065	Boat 2						
"	"	"		"				"	10	80			100	570	4.3	"	1932	Boat 1						
"	"	"		"				"	"	"			130	"	"	"	416	Boat 2						
TEMPLEMAN	1957 d 1963	ICNAF 3L,O,P		1954				Cover	56		3.0-3.8		102	334	3.3	62[d]	108[d]	113[d]	4069	675				
"	"	"		1955				"	61		"		66	173	2.6	?	?	?	4517	229				
BEVERTON	1956	ICES II b		VII-VIII 1956	Twisted Continuous		121	"	1	60	3.5	[c]	109	395	3.6	80	120	197	-525-					
"	"	"		"	"		121	"	6	60	3.5	[c]	109	415	3.8	70	124	97	-206-					
BRANDT	1963	"		"	"		160	"	[b]	17			112	380	3.4	80	340	353	4394	732				
"	1956	"		"	"		"	"	6				133	460	3.5	105	746	650	4968	1010				
SAETERSDAL	1963	ICES I		XI 1956				"	7	90	3	Aberdeen	144	515	3.6	100	215	119	1926	627				
TEMPLEMAN	1956d 1963	ICNAF 3L,O,P.		1956				"	67		"		112	355	3.2	109[d]	367[d]	399[d]	2535	1598				
SAETERSDAL	1963	ICES I	190-240	III 1957				"	1	90	3	Aberdeen	144	550	3.8	90	42	33	141	90				
"	"	"	100-290	IV 1957				"	5	90	3	"	144	495	3.4	160	352	416	1225	578				
MESTORFF	1958	ICNAF IF		VIII 1957	Double		160	"	12			ICNAF 4kg	127	470	3.7	105	350	420	3232	595				
SAETERSDAL	1958 b	ICES I	180	VII 1958				"	1	100	3	Aberdeen	110	445	4.0	100	195	187	451	399				
"	"	"	180-200	VII 1958				"	5	90	3.9	"	111	405	3.6	120	202	234	1084	533				
"	"	"	190-200	"				"	2	105	3.8	"	112	385	3.5	140	492	417	1522	656				
JONSSON	1960	ICES V a		VII 1958				"	5	60				330	3.7				768	242				
"	"	"		VIII 1958				"	3	"				348	4.0				674	106				
SAETERSDAL	1958 b	ICES I	110-200	VII 1958	Twisted			"[a]	3	90	3.6	"	108	385	3.7	120	370	354	1107	539				
"	"	"	200-230	"	"			"[a]	2	"	3.8	"	109	395	3.7	120	485	412	1485	898				

[a]ICNAF Chafer; [b]Given as 22 in Brandt,1956; [c]Fixed Load Direct Pull Gauge 3 kg; [d]Estimated From Published Graphs and Tables.

According to this method, the mean weighted value of the selection factor is obtained from the formula:

$$\bar{k}_s = \frac{\Sigma n_i t_i N_i k_i}{\Sigma n_i t_i N_i} = \frac{n_1 t_1 N_1 k_1 + n_2 t_2 N_2 k_2 + \ldots + n_n t_n N_n k_n}{n_1 t_1 N_1 + n_2 t_2 N_2 + \quad + n_n t_n N_n} \qquad (2)$$

where $\bar{k}_s$ is the mean weighted trawl selection factor;

$n_1, n_2 \ldots n_n$ are the number of hauls in the first, second and n^{th} experiments;

$t_1, t_2 \ldots t_n$ are the durations of haul in the first, second and n^{th} experiments;

$N_1, N_2 \ldots N_n$ are the numbers of fish within the selection range in the first, second and n^{th} experiments;

$k_1, k_2 \ldots k_n$ are selection factors in the first, second and n^{th} experiments.

It follows from (2) that the mean selection factor is directly dependent on the number of hauls, the duration of hauls and the number of fish within the selection range and, through all specific selection factors ($k_1, k_2 \ldots k_n$), on all other factors involved.

Thus, in applying this formula the numerical values of the selection factors obtained by the experimenters are taken as they are and in so doing it is assumed that the value of each specific selection factor reflects the heterogeneity of the populations fished, the size of catch, the peculiarities of the trawl design and the fishing process as well as the method of combining data from different hauls, the method of constructing graphs and calculating selection factors, and many other factors. As far as the reliability (weight) of each specific selection factor is concerned, it is assumed that in all experiments it is mainly dependent on the duration of the experiment (the number of hauls multiplied by their durations) and on the number of fish involved, *i.e.* the number of fish within the selection range. The higher these two values, the greater its share of influence on the mean value of the selection factor.

Tables of Selectivity Data

The following notes explain the headings of some of the vertical columns in Tables C-1 to C-12:

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TABLE C-1. Gear: Bottom trawl Material: Double Manila Area: ICNAF 1, 2, 3, ; ICES I, IIb, Va.

AUTHOR	SOURCE	LOCALITY		DATE	COD-END			METHOD	HAULS		Speed of tow (knots)	Mesh gauge	Mean mesh size (mm)	50% length (mm)	SELECTION		No. of fish in selection range		Total No. of fish studied		Av. weight (kg) of			
																					Fish		Bycatch	
		Division	Depth (m)		Material Const.	R Tex (g/1000 m)	Runnage (m/kg)		No.	Average Duration (min)					Factor	Range (mm)	Cod-end	Cover	Cod-end		Cod-end	Cover	Cod-end	Cover
SAETERSDAL	1963	ICES II b		V 1954				Parallel Hauls	12	85			100	540	4.1	100	5485	Boat 1						
"	"	"		"				"	"	"			130	"	"	"	2111	Boat 2						
"	"	"		"				"	"	105			130	580	4.4	"	856	Boat 1						
"	"	"		"				"	"	"			110	"	"	"	6065	Boat 2						
"	"	"		"				"	10	80			100	570	4.3	"	1932	Boat 1						
"	"	"		"				"	"	"			130	"	"	"	416	Boat 2						
TEMPLEMAN	1957 d 1963	ICNAF 3L,O,P		1954				Cover	56		3.0-3.8		102	334	3.3	62 [d]	108 [d]	113 [d]	4069	675				
"	"	"		1955				"	61		"		66	173	2.6	?	?	?	4517	229				
BEVERTON	1956	ICES II b		VII-VIII 1956	Twisted Continuous		121	"	1	60	3.5	[c]	109	395	3.6	80	120	197	-525-					
"	"	"		"	"		121	"	6	60	3.5	[c]	109	415	3.8	70	124	97	-206-					
BRANDT	1963	"		"	"		160	"	[b]	17			112	380	3.4	80	340	353	4394	732				
"	1956	"		"	"		"	"	6				133	460	3.5	105	746	650	4968	1010				
SAETERSDAL	1963	ICES I		XI 1956				"	7	90	3	Aberdeen	144	515	3.6	100	215	119	1926	627				
TEMPLEMAN	1956d 1963	ICNAF 3L,O,P.		1956				"	67		"		112	355	3.2	109 [d]	367 [d]	399 [d]	2535	1598				
SAETERSDAL	1963	ICES I	190-240	III 1957				"	1	90	3	Aberdeen	144	550	3.8	90	42	33	141	90				
"	"	"	100-290	IV 1957				"	5	90	3	"	144	495	3.4	160	352	416	1225	578				
MESTORFF	1958	ICNAF IF		VIII 1957	Double		160	"	12			ICNAF 4kg	127	470	3.7	105	350	420	3232	595				
SAETERSDAL	1958 b	ICES I	180	VII 1958				"	1	100	3	Aberdeen	110	445	4.0	100	195	187	451	399				
"	"	"	180-200	VII 1958				"	5	90	3.9	"	111	405	3.6	120	202	234	1084	533				
"	"	"	190-200	"				"	2	105	3.8	"	112	385	3.5	140	492	417	1522	656				
JONSSON	1960	ICES V a		VII 1958				"	5	60				330	3.7				768	242				
"	"	"		VIII 1958				"	3	"				348	4.0				674	106				
SAETERSDAL	1958 b	ICES I	110-200	VII 1958	Twisted			" [a]	3	90	3.6	"	108	385	3.7	120	370	354	1107	539				
"	"	"	200-230	"	"			" [a]	2	"	3.8	"	109	395	3.7	120	485	412	1485	898				

[a]ICNAF Chafer; [b]Given as 22 in Brandt,1956; [c]Fixed Load Direct Pull Gauge 3 kg; [d]Estimated From Published Graphs and Tables.

TABLE C-1 (continued).

AUTHOR	SOURCE	LOCALITY		DATE	COD-END			METHOD	HAULS		Speed of tow (knots)	Mesh gauge	Mean mesh size (mm)	50% length (mm)	SELECTION		No. of fish in selection range		Total No. of fish studied		Av. weight (kg) of			
		Division	Depth (m)		Material Const.	R Tex (g/1000 m)	Runnage (m/kg)		No.	Average Duration (min)					Factor	Range (mm)	Cod-end	Cover	Cod-end	Cover	Fish		Bycatch	
																					Cod-end	Cover	Cod-end	Cover
SAETERSDAL	1958 b	ICES I	200–250	VII 1958	Twisted			Cover[a]	1	90	3.5	Aberdeen	113	440	3.9	110	204	234	575	397				
BEVERTON	1959 1964	ICES II b	90–130	VII 1959	Twisted Continuous		101	Cover	5	90	3.5	b	120	412	3.4	86	494	363	3059	657				
"	"	"	"	"	"		"	"	3	"	"	b	118	390	3.3	110	183	148	1206	214				
ICES	1964	"		VIII 1959			125	"	2	60			103	370	3.6	(100	205	163	385	241				
"	"	"		"			"	"	2	"			"	347	3.4	80	423	330	1330	455				
"	"	"		"			"	"	1	"			120	406	3.4									
"	"	"		"			"	"	4	"			"	410	3.4									
"	"	"		"			"	"	"	"			137	454	3.3									
"	"	"		"			"	"	1	"			"	512	3.7									
"	"	"		"			"	"	3	"			"	506	3.7									
"	"	"		"			"	Alternate Hauls	5	"			101	384	3.8	50	1300	–	3877	–				
"	"	"		"			"	"	3	"			119	(476)	(4.0)	(100	227	–	471	–				
"	"	"		"			"	"	5	"			137	548 570	4.0 4.2	60 90	141	–	627	–				
"	"	"		"			"	"	12				116	390	3.4	90	8087	–	16654	–				
"	"	"	200	"	Twisted			Cover	10	90	3.5		105	353	3.4	80	452	452	4133	1017				
"	"	"	"	"	"			"	10	90	3.5		128	437	3.4	110	492	504	3061	2278				
ICES	1964	ICES II b		VIII 1959			125	"	5	60			123	449	3.5	120	1014	1236	1805	4059				
"	"	"		"			"	"	4	"			"	371	3.0	160	2428	2061	4082	2502				
"	"	"		"			"	"	1	30			"	350	2.8	140	1985	1197	2996	1370				
"	"	ICES II b	155	"			"	"	4	72		Scottish	109	380	3.5	70	807	899	2602	1935				
"	"	"		"			"	"	1	90			131	440	3.4	(80)	137	93	593	167				
"	"	"		"			"	"	1	60			"	410	3.1	(120	427	283	1048	402				
"	"	"		"			"	"	3	60			128	450	3.5	90	130	197	230	1269				
"	"	"		"			"	"	2	60			128	398	3.1	80	1275	1504	2314	2955				

[a] ICNAF Chafer; [b] Fixed Load Direct Pull Gauge 3kg.

Table C-1 (continued).

AUTHOR	SOURCE	LOCALITY: Division	LOCALITY: Depth (m)	DATE	COD-END: Material Const.	COD-END: R Tex (g/1000 m)	COD-END: Runnage (m/kg)	METHOD	HAULS: No.	HAULS: Average Duration (min)	Speed of tow (knots)	Mesh gauge	Mean mesh size (mm)	50% length (mm)	SELECTION: Factor	SELECTION: Range (mm)	No. of fish in selection range: Cod-end	No. of fish in selection range: Cover	Total No. of fish studied: Cod-end	Total No. of fish studied: Cover	Av. weight (kg) of Fish: Cod-end	Av. weight (kg) of Fish: Cover	Av. weight (kg) of Bycatch: Cod-end	Av. weight (kg) of Bycatch: Cover
ICES	1964	ICES II b		VIII 1959			125	Cover	3	80			126	480	3.8	(80)	43	35	304	162				
"	"	"		"			"	"	3	72			129	477	3.7	90	137	152	425	472				
"	"	"		"			"	"	1	90			130	470	3.6	(140)	112	83	535	182				
"	"	"		"			"	"	3	60			129	455	3.5	70	169	149	345	784				
"	"	"		"			"	"	3	80			129	457	3.5	100	1086	1226	2071	2662				
"	"	"		"			"	"	3	60			130	480	3.7	90	152	182	525	1759				
BEVERTON	(1959) (1964)	ICES II b	90–130	VII 1959	Twisted Continuous		101	Cover Chafer [c]	4	90	3.5	[a]	118	440	3.7	85	253	313	491	648				
"	"	"		"	"		"	"	5	50	3.5	[a]	119	386	3.2	82	687	495	6268	1095				
"	"	"		"	"		"	"	2	45	3.5	[a]	119	385	3.2	80	1233	772	5710	1193				
ICES	1964	ICES I	200	IV 1960	"		125	"	10	90	3.5		106	378	3.6	50	264	307	1231	1147				
"	"	"		"	"		"	"	10	90	3.5		125	475	3.8	80	986	1153	3031	7895				
JONSSON	1960	ICES Va		VII 1960			"	Cover	4	60				333	3.0				1023	119				
"	"	"		"			"	"	4	60				340	2.9				2255	840				
"	"	"		"			"	"	4	60				369	3.2	160			1212	358				
"	"	"		"			"	"	4	60				324	2.8	180			387	116				
SAETERSDAL	1960	ICES I	148–160	VIII 1960	Twisted		125	"	2	90	3.5	Aberdeen	132	447	3.4	100	495	536	1185	1890				
"	"	"	150–170	"	"		"	"	2	90	3.5	"	132	494	3.8	100	158	186	456	921				
"	"	"	160	"	"		"	"	4	90	3.5	"	132	470	3.6	80	80	85	500	699				
"	"	"	100–180	"	"		"	"	4	90	3.5	"	132	493	3.8	120	117	134	342	259				
"	"	"	160–185	"	"		"	Cover Chafer [b]	7	105	"	"	104	254	2.4	70	108	99	3075	304				
"	"	"	140–200	"	"		"	" [b]	4	90	"	"	104	296	2.8	80	565	393	3181	677				
"	"	"	120–200	"	"		"	Cover Chafer [c]	6	90	"	"	130	489	3.8	100	336	380	708	830				
"	"	"	100–165	"	"		"	" [c]	5	90	"	"	130	512	3.9	100	97	122	690	339				
ICES	1965	ICES V a	138	VI 1962	Twisted	6623	151	Cover	7	60	4.0	ICES	112	376	3.4	80	180	170	472	552	366	132 [d]		

[a] Fixed Load Direct Pull Gauge 3kg; [b] Double Codend Mesh Size 105 mm; [c] Multi-Flap Chafer Mesh Size 110 mm; [d] Total Catch of all Species (Codend & Cover)

TABLE C-1 (continued).

AUTHOR	SOURCE	LOCALITY		DATE	COD-END			METHOD	HAULS		Speed of tow (knots)	Mesh gauge	Mean mesh size (mm)	50% length (mm)	SELECTION		No. of fish in selection range		Total No. of fish studied		Av. weight (kg) of			
		Division	Depth (m)		Material Const.	R Tex (g/1000 m)	Runnage (m/kg)		No.	Average Duration (min)					Factor	Range (mm)	Cod-end	Cover	Cod-end		Fish		Bycatch	
																					Cod-end	Cover	Cod-end	Cover
ICES	1965	ICES V a	161	VI 1962	Twisted	6623	151	Cover	8	60	4.0	ICES	127	401	3.2	160	330	370	1154	566	674	177[a]		
"	"	"	179	"	"	6623	151	"	3	60	4.0	"	132	429	3.3	180	60	90	401	150	552	309[a]		
"	"	"		VII 1962	"		100	"	9	60	3.5	West-hoff	120	350	2.9	110	2880	1860	13218	3758	2447	268[a]		
"	"	"	70-150	"	"	6135	163	"	17	84	4.0	Aber-deen	138	402	2.9	122	467	404	2770	728	275	20	280	150
"	"	"	250	VII 1962	"		100	"	5	97	3.5	West-hoff	141	490	3.4	120	340	370	1988	1613				
"	"	"	83-147	VII 1962	"		151	"	6	60	3.5		132	(375)	(2.8)	(160)	3240	2000	9946	2673	2640	310[a]		
"	"	"		"	"		150	"	6	60	3.5		117	390	3.3	120	110	110	287	184				
"	"	"		"	"		150	"	12	60	3.5		138	470	3.4	160	660	920	1264	1230				
"	"	"		"	"		100	Paired	8	60	3.5	West-hoff	120	(320)	(2.7)	(120)	380	-			628			
"	"	"	119-202	"	"		151	"	4	60	3.5		132	(420)	(3.2)	(80)	340	-			755			
"	"	"		"	"		150	Alternate	10	54	3.5		97	(398)	(4.1)	(80)	95							
HODDER AND MAY	1965	ICNAF 2 J	160-275	VIII 1962	"	9925	101	"	8	60	3.5	West-hoff	98	350	3.6	97	1272	1128	2896	1744	305	70	catches almost entirely cod (this and following 6 rows)	
"	"		214-223	"	"	"		"	4	60	3.5	"	113	383	3.4	109	904	732	1920	2348	430	190		
"	"		221-260	"	"	"		"	8	60	3.5	"	120	475	4.0	105	912	1272	1680	5160	240	320		
"	"		220-255	"	"	"		Alternate Hauls	16	60	3.5	"	-	-	3.5	-	-	-	12176		520	-		
"	"		220-255	"	"	"		"	8	60	3.5	"	106	340	3.6	124	2112	-	4912		465			
"	"	ICNAF 2 J	220-255	"	"	"		"	16	60	3.5	"	106	380	3.6	87	1952	-	5872	-	345			
"	"	"	220-255	"	"	"		"	8	60	3.5	"	113	390	3.4	94	1328	-	2904	-	2640			
HOLDEN	1966 d	ICES I	165-260	X 1963	"	"		Cover	5	100	40	ICES	125	500	4.0	68	147	127	978	723				
HODDER and MAY	1965	ICNAF 2J	160-170	X 1963	Twisted	9925	101	Alternate Hauls	9	60	3.5	"	109	372	3.4	100	792	693	6165	1170	1075	65	catches almost entirely cod (this and following 2 rows)	
"	"	"	140-165	"	"	"		"	12	60	"	"	120	422	3.5	104	780	828	5364	2640	810	120		
"	"	"	145-185	"	"	"		"	8	60	"	"	130	450	3.5	106	688	624	2264	1792	475	140		
OLSEN	1962	ICES I	160	III 1964	"	"		Cover	2	60	3.5	"	113	434	3.8	74	524	508	1693	826				
"	1966	"	250-260	III	"	"		"	2	110	3-4	"	141	519	3.7	104	205	227	444	907				

[a] Total Catch of all Species (Codend and Cover).

TABEL C-1 (continued).

AUTHOR	SOURCE	LOCALITY		DATE	COD-END			METHOD	HAULS		Speed of tow (knots)	Mesh gauge	Mean mesh size (mm)	50% length (mm)	SELECTION		No. of fish in selection range		Total No. of fish studied		Av. weight (kg) of			
		Division	Depth (m)		Material Const.	R Tex (g/1000 m)	Runnage (m/kg)		No.	Average Duration (min)					Factor	Range (mm)	Cod-end	Cover	Cod-end		Fish		Bycatch	
																					Cod-end	Cover	Cod-end	Cover
CRATBERG	1965	ICNAF 1D	230-250	IV 1964	Twisted		125	Cover	2	80	3.0	ICES	133.5	450	3.4	105	806	734	1533	1257				
HOLDEN	1966 a	ICES II b	460	VI 1964	"		101	"	1	55	3.5	"	131	504	3.8	57	15	15	186	50				
"	"	"	"	"	"		"	"	1	120	3.5	"	131	542	4.1	86	79	89	363	260				
"	"	"	"	"	"		"	"	1	180	3.5	"	131	566	4.3	71	38	34	154	153				
"	"	"	"	"	"		"	"	1	120	3.5	"	131	536	4.1	32	21	22	211	148				
"	"	"	460-480	"	"		"	"	1	240	3.5	"	131	559	4.3	70	86	94	372	255				
"	"	"	460-480	"	"		"	"	1	180	3.5	"	131	535	4.1	56	34	32	265	83				
"	1966 c	"	"	"	"		"	Cover Chafer [a]	5	120	3.5	"	128	474	3.7	68	116	100	1223	183				

[a] Double Codend Manila, 126-mm mesh

TABLE C-2. Gear: Bottom trawl Species: Cod Material: Double Polypropylene Area: ICNAF 1.3; ICES I, IIb, Va

AUTHOR	SOURCE	LOCALITY		DATE	COD-END			METHOD	HAULS		Speed of tow (knots)	Mesh gauge	Mean mesh size (mm)	50% length (mm)	SELECTION		No. of fish in selection range		Total No. of fish studied		Av. weight (kg) of			
		Division	Depth (m)		Material Const.	R Tex (g/1000 m)	Runnage (m/kg)		No.	Average Duration (min)					Factor	Range (mm)	Cod-end	Cover	Cod-end	Cover	Fish Cod-end	Fish Cover	Bycatch Cod-end	Bycatch Cover
HOLDEN	1966 d	ICES I	170	X 1963	Plaited		216.0	Cover	18	90	4	ICES	134.0	561	4.0	107	250	258	803	854				
OLSEN	1966	ICES I	260-265	II 1964	?			"	4	60	3.0	"	145	506	3.5	179	478	490	736	575				
BRATBERG	1965	ICNAF 1D	140-290	IV 1964	Braided	4500		"	7	80	3.0	"	141.5	460	3.3	120	1420	1344	3642	2618				
HOLDEN	1966 a	ICES II b	460-480	VI 1964	Plaited		216.0	Cover	1	120	4	"	134.7	571	4.2	89	87	87	284	163				
"	"	"	460	"	"		"	"	1	120	4	"	134.7	546	4.1	70	41	48	335	270				
"	"	"	"	"	"		"	"	1	120	4	"	134.7	559	4.2	65	96	68	208	114				
"	"	"	"	"	"		"	"	1	120	4	"	134.7	567	5.2	111	58	58	240	123				
BOHL	1966 a 1967 e	ICES V a	80-100	VI 1964	Continuous	4905	204	"	11	120	N.D.	"	125.3	436	3.5	101	208	253	741	1294	65	35	355	160
MARGETTS	1965 b	ICES V a	120-200	II-III 1965	Plaited		400	"	5	120	3.5	"	114	395	3.5	60	67	75						
"	"	"	"	"	"		"	"	7	120	3.5	"	112	402	3.6	70	155	114						
BOHL	1967 c	ICNAF 1 B	180-220	XI-XIII 1965	Continuous	4905	204	"	8	70	4.6	"	121.6	399	3.3	103	1274	1218	4909	2015	1145	135	1490	120
"	"	"	"	"	Monofilament	4800	208	"	8	75	4.4	"	121.6	391	3.2	82	850	850	3605	1663	755	105	1235	395
OLSEN	1967	ICES I	220-250	III 1966	Braided	4500		"	4	72	3.0-3.5	"	141	498	3.5	114	85	92	516	232				
BOHL	1967 a	ICNAF 1 F	100-135	X 1966	Monofilament	4800	208	"	4	90	4	"	119.8	391	3.3	69	351	329	1682	730	530	90	205	105
"	"	"	"	"	Continuous	4905	204	"	4	100	4	"	119.9	396	3.3	82	1386	1287	5756	2101	1865	320	270	170
UNPUBLISHED (LOWESTOFT)	"	ICES I	248	XI 1966				"	7	75	325	Lowestoft	120.2	495	4.1	105	(185)	(164)	824	318				
"	"	"	"	"				"	6	75	325	Scissors	127.9	510	4.0	123	(231)	(236)	1033	460				
"	"	"	"	"				"	6	75	325	"	107.4	405	3.8	110	(109)	(77)	1309	265				
OLSEN	1968	ICES I	220-250	III 1966	Braided	4510		Cover Chafer [a]	4	72	3-3.5	ICES	141	498	3.5	113	85	92	516	232				
OLSEN	1966	ICES I	290	III				Cover Chafer [b]	3	90-120	3-4	"	146	404	2.8	160	72	57	265	84				
HYLEN	1967	ICES I	60-360	V 1966	Braided	4510		Cover Chafer [a]	11	80	3/5	"	126	410	3.2	130	5470	6685	8090	9731				
HOLDEN	1969	ICNAF 3L	220-230	XI 1967	Braided Split-Fibre	6203	1615	Cover	4	200	3.5-4.0	"	130.6	570	4.4	59	34	35	427	189			670	70
"	"	"	210-230	"	"	"	"	"	4	180	3.5-4.0	"	130.6	561	4.3	64	51	49	471	815			230	20
"	"	"	250-260	"	Continuous Multifilament	5012	2018	"	1	180	3.5-4.0	"	115.9	504	4.4	67	129	136	433	977			600	0

[a] Topside Chafer of Double Mesh Size (Polish Chafer); [b] Double Codend: Chafer made of Manila.

Table C-2 (continued).

AUTHOR	SOURCE	LOCALITY		DATE	COD-END			METHOD	HAULS		Speed of tow (knots)	Mesh gauge	Mean mesh size (mm)	50% length (mm)	SELECTION		No. of fish in selection range		Total No. of fish studied		Av. weight (kg) of			
		Division	Depth (m)		Material Const.	R Tex (g/1000 m)	Runnage (m/kg)		No.	Average Duration (min)					Factor	Range (mm)	Cod-end	Cover	Cod-end		Fish		Bycatch	
																					Cod-end	Cover	Cod-end	Cover
HOLDEN	1969	ICNAF 3 L	240	XI 1967	Continuous Multifilament	5012	2018	Cover	1	120	3.5–4.0	ICES	115.9	482	4.2	119	648	1150	1574	2290			0	0
"	"	"	"	"	"	"	"	"	1	110	"	"	"	496	4.3	88	124	194	414	1122			0	0
"	"	"	"	"	"	"	"	"	1	150	"	"	"	465	4.0	100	398	597	708	1455			150	0
"	"	"	"	"	"	"	"	"	1	180	"	"	"	504	4.4	66	88	99	474	1068			180	30
"	"	"	240	"	"	"	"	"	3	180	"	"	"	485	4.2	76	59	91	552	1669			190	80
HOLDEN	1969	ICNAF 3 L	210	XI 1967	Continuous Multifilament	5012	2018	Cover[a] Chafer	1	160	3.5–4.0	"	116.4	437	3.8	90	144	180	239	309			390	30
"	"	"	210	"	"	"	"	"	1	180	"	"	"	414	3.6	69	53	44	253	87			1200	60
"	"	"	230	"	"	"	"	"	1	195	"	"	"	440	3.8	85	190	267	303	423			1050	45
"	"	"	240	"	"	"	"	"	1	175	"	"	"	445	3.8	73	63	72	151	216			2750	600
"	"	"	250	"	"	"	"	"	1	180	"	"	"	434	3.7	39	19	40	105	281			3150	300
"	"	"	80–220	"	"	"	"	"	3	160	"	"	"	442	3.8	72	37	56	157	167			440	0
"	"	"	155–230	"	"	"	"	"	3	190	"	"	"	434	3.7	90	80	129	183	341			130	300
"	"	"	250	"	"	"	"	"	2	185	"	"	"	448	3.9	94	61	83	827	139			440	0
UNPUBLISHED		ICES I	235	XI–XII 1967				Cover	13	60	3.5	"	105.5	418	4.0	28	218	158	2904	808				
(LOWESTOFT) "		"	"	"				"	12	60	3.5	"	104.7	430	4.1	50	280	138	2247	736				
BOHL	1968 1969	ICES II b	120–210	VII 1968	Continuous	4905	204	"	6	85	4	"	122.0	396	3.3	82	1485	1299	6349	2117	1360	210	285	70
"	"	"	"	"	Monofilament	4800	208	"	10	120	4	"	121.1	388	3.2	80	865	869	5434	1397	815	75	375	65
"	"	"	"	"	Split-Fibre	5756	174	"	8	94	4	"	122.4	391	3.2	63	1081	1232	5780	1910	925	130	360	60
HYLEN	1969	ICES I	45–300	IX 1969	Braided Split-Fibre	45.0		"	10	80	3.5	"	136	500	3.7	93	167	183	589	453				

[a] Double Codend: Polyester, Double Braided, Plaited, R 5000 tex 112-mm Mesh, Fastened Fore and Aft and along Selvedges.

TABLE C-3. Gear: Bottom trawl Species: Cod Material: Double Polyethylene Area: ICNAF 1,3; ICES I,IIb.

AUTHOR	SOURCE	LOCALITY		DATE	COD-END			METHOD	HAULS		Speed of tow (knots)	Mesh gauge	Mean mesh size (mm)	50% length (mm)	SELECTION		No. of fish in selection range		Total No. of fish studied		Av. weight (kg) of			
		Division	Depth (m)		Material Const.	R Tex (g/1000 m)	Runnage (m/kg)		No.	Average Duration (min)					Factor	Range (mm)	Cod-end	Cover	Cod-end		Fish Cod-end	Fish Cover	Bycatch Cod-end	Bycatch Cover
OLSEN	1962	ICES I	160	III 1962				Cover	1	60	3.5	Aberdeen	122	429	3.5	90	521	460	1461	651				
"	"	"	155-165	"				"	4	60	3.5	"	120	452	3.8	70	560	531	1491	1054				
BRATBERG	1965	ICNAF 1 D	250-295	IV 1964				"	4	90	3	ICES	134	425	3.2	115	461	386	1926	581				
BOHL	1967 c	ICNAF 1 B	180-220	XI-XII 1965	Monofilament	6516	153	"	10	65	4.5	"	114.4	387	3.4	93	2044	1867	10229	3023	1695	155	925	155
"	1967 a	ICNAF 1 F	100-135	X 1966	"	"	"	"	8	80	4.0	"	113.2	385	3.4	68	702	710	4160	1273	755	75	325	90
"	1968 1969	ICES II b	120-210	VII 1968	"	"	"	"	9	107	4.0	"	113.6	377	3.3	72	1082	1078	12104	1793	2165	90	310	40
MONTEIRO	1968	ICNAF 3 L	215-265	IX 1967	Twisted			Cover Chafer[a]	6	180	3.5-5.5	"		409	4.0	81	-3620-		5795	3299	1322	308	233	0

[a]Polish Type Chafer.

TABLE C-4. Gear: Bottom trawl Species: Cod Material: Double Polyester Area: ICNAF 1; ICES I.

AUTHOR	SOURCE	LOCALITY		DATE	COD-END			METHOD	HAULS		Speed of tow (knots)	Mesh gauge	Mean mesh size (mm)	50% length (mm)	SELECTION		No. of fish in selection range		Total No. of fish studied		Av. weight (kg) of			
		Division	Depth (m)		Material Const.	R Tex (g/1000 m)	Runnage (m/kg)		No.	Average Duration (min)					Factor	Range (mm)	Cod-end	Cover	Cod-end		Fish		Bycatch	
																					Cod-end	Cover	Cod-end	Cover
NESTORFF	1958	ICNAF 1 F		VIII 1957	Double		400	Cover	9			ICNAF 4kg	122	470	3.9	90	569	696	2505	1394				
SAETERSDAL	1960	ICES I	145-180	VIII 1960	Twisted		136	"	4	90	(3)	Aberdeen	107.7	415	3.9	60	341	388	1395	1525				
"	"	"	145-170	"	"		"	"	4	90	(3)	"	106.4	426	4.0	70	429	453	1452	1675				

TABLE C-5. Gear: Bottom trawl Species: Cod Material: Double Polyamide Type A Area: ICNAF 1,2,3,4; ICES I,IIb,Va

AUTHOR	SOURCE	LOCALITY		DATE	COD-END			METHOD	HAULS		Speed of tow (knots)	Mesh gauge	Mean mesh size (mm)	50% length (mm)	SELECTION		No. of fish in selection range		Total No. of fish studied		Av. weight (kg) of			
		Division	Depth (m)		Material Const.	R Tex (g/1000 m)	Runnage (m/kg)		No.	Average Duration (min)					Factor	Range (mm)	Cod-end	Cover	Cod-end		Fish		Bycatch	
																					Cod-end	Cover	Cod-end	Cover
SAETERSDAL	1958 g	ICES I	150-220	X 1957	Twisted		260	Cover	11	90	(3)	Aberdeen	140	590	4.2	100	492	495	1623	2049				
ICES	1964	ICES II b	200	1959	"		153	"	10	120	3.5		108	46.0	4.2	100	367	285	3355	1276				
"	"	"	"	"	"		"	"	10	120	3.5		110	48.8	4.4	80	947	776	2767	3262				
"	"	"	"	"	"		"	"	20	120	3.5		90	39.0	4.3	70	770	609	5607	4283				
"	"	"	"	"	"		"	"	20	120	3.5		90	37.0	4.1	50	642	611	4115	7485				
"	"	"	"	"	"		"	"	10	90	3.5		109	45.4	4.2	60	636	815	2118	3600				
"	"	"	"	"	"		"	"	10	90	3.5		108	46.0	4.3	80	614	503	2655	1385				
"	"	"	"	"	"		"	"	10	90	3.5		108	40.6	3.8	50	407	437	1669	10806				
"	"	"	"	"	"		"	"	10	90	3.5		106	46.8	4.4	70	624	622	1491	3013				
"	"	"	"	"	"		"	"	10	120	3.5		98	43.5	4.4	70	546	430	5374	1395				
"	"	"	"	"	"		"	"	10	120	3.5		104	42.0	4.0	80	152	292	645	6127				
"	"	"	"	1960	"		182	"	10	120	3.5		103	43.0	4.2	80	2256	2793	5681	11256				
"	"	"	"	"	"		"	"	10	120	3.5		93	36.8	4.0	60	1709	1610	5426	5519				
"	1965	ICES V a	250	1962	"		"	"	5	80	3.5		125	44.7	3.6	130	440	320	2419	509				
"	"	"	300	"	"		"	Cover Chafer [a]	3	80	3.5		108	44.0	4.1	70	330	390	1613	1068				
"	"	"	300	"	"		"	" [b]	2	85	3.5		126	39.3	3.2	90	340	210	1389	529				
"	"	"	250	"	"		"	" [c]	3	85	3.5		126	45.5	3.7	110	251	286	1609	1009				
TRESCHEV	1967	ICNAF 3 K	300	1963	"	9500	"	Cover	5	90	3.5-4.0		104.8	41.9	4.0	92	3217	2144	26057	16937				
"	"	ICNAF 3 M	350	"	"		"	Cover Chafer [d]	5	90	4.0		104	39.8	3.8	92	1904	1269	9710	7614				
TRESCHEV & STEPANOV	1968	LABRADOR	150	1964	"		153	Cover	26	160	3.5		95	40.0	4.1	130	26289	17246	71756	22362				
"	"	"	200	"	"			"	33	155	3.5		94	35.7	3.8	150	8123	5279	24161	7889				
STRZYZEWSKI	1967	ICNAF 3M to 4W	60-360	VI 1965	"			"	6	90	ND	ICES	114.8	449	3.9	101	2459	1101	320	110				
TRESCHEV	1967	ICNAF 2	300	1965	Twisted	9500		"	5	90	3.5-4.0		102.1	41.4	4.0	115	3869	2579	48899	17985				
"	"	"	"	"	"	8500		"	5	90	3.5-4.0		107.0	42.2	3.9	118	6625	3416	28233	19503				

[a] Modified ICNAF Chafer; [b] Double Codend-Full Length; [c] Double Codend-Half Length; [d] Tight Top Chafer Covering Half Codend Same Mesh Size Fastened Mesh for Mesh.

TABLE C-5 (continued)

AUTHOR	SOURCE	LOCALITY		DATE	COD-END			METHOD	HAULS		Speed of tow (knots)	Mesh gauge	Mean mesh size (mm)	50% length (mm)	SELECTION		No. of fish in selection range		Total No. of fish studied		Av. weight (kg) of			
		Division	Depth (m)		Material Const.	R Tex (g/1000 m)	Runnage (m/kg)		No.	Average Duration (min)					Factor	Range (mm)	Cod-end	Cover	Cod-end		Fish		Bycatch	
																					Cod-end	Cover	Cod-end	Cover
STRZYZEWSKI	1967	ICNAF 3 and 4	60-360	VI 1965	Twisted			Cover Chafer [a]	9			ICES	114.4	409	3.7	91			5693	5371	9053	1731		
"	"	"	"	"	"			Cover Chafer [b]	6			"	117.6	444	3.8	112			3916	3475	7633	1394		
BUCKI ET AL	1968	ICNAF 3 K	330-370	X 1967	"	4700	133	"	2	240		"	110.5	410	3.7	107	509	323	1097	375				

Gear: Bottom trawl Species: Cod Material: Double Polyamide Type B Area ICNAF 1; ICES IIb, Va.

AUTHOR	SOURCE	LOCALITY		DATE	COD-END			METHOD	HAULS		Speed of tow (knots)	Mesh gauge	Mean mesh size (mm)	50% length (mm)	SELECTION		No. of fish in selection range		Total No. of fish studied		Av. weight (kg) of			
		Division	Depth (m)		Material Const.	R Tex (g/1000 m)	Runnage (m/kg)		No.	Average Duration (min)					Factor	Range (mm)	Cod-end	Cover	Cod-end		Fish		Bycatch	
																					Cod-end	Cover	Cod-end	Cover
BRANDT	1956	ICES II b		VII-VIII 1956	Plaited		210	Cover	5			WEDGE 4 kg	107	400	3.7	80	719	841	2156	1270				
"	"	"		"	"		"	"	6			"	132	490	3.7	115	703	514	5556	845				
"	1963	"					380	"	13			ICES TYPE	106	410	3.8		168	172	734	2031				
MESTORFF	1958	ICNAF 1 F		VIII 1957	Double		210	"	14			ICNAF 4 kg	129	520	4.0	150	1005	1968	2672	379				
"	"	"		"	"		280	"	9			"	129	500	3.9	95	515	866	2150	219				
ICES	1964	ICES II b	95-110	VIII 1959	Plaited		191	"	4	60	3.5-4.0		122	539	4.4	70	251	246	962	1675				
"	"	"	90-105	"	"		210	"	2	60			102	390	3.8	50	198	186	1171	538				
"	"	"	100-110	"	"		210	"	1	36			102	355	3.5	(130)	(748)	(646)	1659	800				
"	"	"	100-110	"	"		210	"	1	60			102	370	3.6	90	1005	991	1749	1472				
"	1965	ICES V a	80-110	VI 1962			302	"	5	60	4.0	ICES [c]	89	(310)	(3.5)	(80)	20	40						
BOHL	1967 c	ICNAF 1 B	180-220	XI-XII 1965	Continuous	3962	252	"	8	65	4.4	ICES	125.4	440	3.5	114	1395	1651	4967	2765	1130	225	940	205
"	167 d	ICNAF 1 D	80-110	XII 1965	"	5000	200	"	1	75	4.6	ICES	122.1	402	3.3	100	197	177	574	418	650	190	410	15
"	"	"	"	"	"	"	"	"	1	75	4.6	"	122.2	415	3.4	93	452	423	1557	796	1900	480	375	15
"	"	"	"	"	"	"	"	"	1	75	4.6	"	122.3	421	3.4	87	353	315	1178	658	1300	410	275	35
"	"	"	"	"	"	"	"	"	1	75	4.6	"	122.2	401	3.3	103	252	214	930	374	1080	240	135	15
"	"	"	"	"	"	"	"	Cover Chafer [d]	1	75	4.3	"	121.9	411	3.4	82	381	355	1447	861	1680	455	410	45

[a] Polish Type Chafer with Mesh Size X4 Codend Mesh Size; [b] Polish Type Chafer with Mesh Size X2 Codend Mesh Size;
[c] Spring Loaded Gauge Subsequently Calibrated to ICES ; [d] ICNAF Chafer 127.5-mm Mesh;

TABLE C-5 (continued)

AUTHOR	SOURCE	LOCALITY		DATE	COD-END			METHOD	HAULS		Speed of tow (knots)	Mesh gauge	Mean mesh size (mm)	50% length (mm)	SELECTION		No. of fish in selection range		Total No. of fish studied		Av. weight (kg) of			
		Division	Depth (m)		Material Const.	R Tex (g/1000 m)	Runnage (m/kg)		No.	Average Duration (min)					Factor	Range (mm)	Cod-end	Cover	Cod-end		Fish		Bycatch	
																					Cod-end	Cover	Cod-end	Cover
BOHL	1967 d	ICNAF 1 d	80-110	XII 1965	Continuous	5000	200	Cover	1	75	4.3	ICES	122.4	412	3.4	89	338	353	908	687	975	375	340	70
"	1967 a	ICNAF 1 F	100-135	X 1966	"	3962	252	"	7	75	4.0	"	123.7	437	3.5	110	544	641	2067	952	515	90	110	50
"	1967 b	"	"	"	"	5000	200	Cover	3	105	4.0	"	118.0	436	3.7	73	612	693	3050	2053	1490	410	425	160
	"	"	"	"	"	"	"	Cover[a] Chafer	3	90	4.0	"	118.0	(481)	(4.1)	(122)	(160)	(293)	612	816	310	170	240	15
"	"	"	"	"	"	"	"	"	4	90	4.0	"	118.2	462	3.9	(95)	(313)	(418)	1386	1054	580	170	275	45
"	1968 1969	ICES II b	120-210	VII 1968	"	3962	252	Cover	7	73	4.0	"	122.2	433	3.5	114	1089	1132	2683	1744	510	160	265	55

GROUPED DATA ALREADY TABULATED BY SINGLE HAULS IN PRECEDING TABLE

BOHL	1967 d	ICNAF I D	80-110	XII 1965	Continuous Twisted	5000	200	Cover	4	75	4.6	ICES	122.2	413	3.4	94	1279	1152	4239	2246	1235	325	310	25
"	"	"	"	"	"	"	"	Cover[b] Chafer	2	75	4.3	"	122.2	413	3.4	85	727	705	2355	1548	1325	410	375	50

[a]Polish Type Chafer with Mesh Size X2 Codend Mesh Size; [b]ICNAF Chafer 127.5-mm Mesh.

TABLE C-6. Gear: Bottom trawl Species: Haddock Material: Double manila Area: ICNAF 2,3; ICES I, IIb, Va.

AUTHOR	SOURCE	LOCALITY		DATE	COD-END			METHOD	HAULS		Speed of tow (knots)	Mesh gauge	Mean mesh size (mm)	50% length (mm)	SELECTION		No. of fish in selection range		Total No. of fish studied		Av. weight (kg) of			
		Division	Depth (m)		Material Const.	R Tex (g/1000 m)	Runnage (m/kg)		No.	Average Duration (min)					Factor	Range (mm)	Cod-end	Cover	Cod-end		Fish Cod-end	Fish Cover	Bycatch Cod-end	Bycatch Cover
TEMPLEMAN	1957 d 1963	ICNAF 3L,O,P		1954				Cover	56		3–3.8		102	313	3.1	66 [b]	1105 [b]	2359 [b]	26726	27494	355		614	
"	"	"		1955				"	61				66	194	(2.9)	35 [b]	7 [b]	17 [b]	17770	22	227		377	
BEVERTON	1956	ICES II b		VII-VIII 1956	Twisted Continuous		121	"	1	60	3.5	[a]	109	365	3.4	80	284	275	1022					
"	"	"		"	"			"	1	60	3.5	[a]	109	355	3.3	(80)	72	80	213					
"	"	"		"	"			"	1	60	3.5	[a]	109	355	3.3	(80)	52	44	175					
BRANDT	1963	ICES II b		VII-VIII 1956	"		160	"	17			ICES TYPE	113	340	3.0	60	571	297	3610	727				
TEMPLEMAN	1957 d 1963	ICNAF 3L,O,P		1956	"			"	67		3–3.8		112	222	2.9	105 [b]	1872 [b]	1636 [b]	10348	15903	136	373		
SAETERSDAL	1963	ICES I	117–120	IV 1957	"			Parallel Haul	1	90	(3)	Aberdeen	152	575	3.8	90	82		132					
"	"	"	"	"	"			"	1	90	(3)		100					202		749				
"	"	"	"	"	"			"	1	90	(3)		100		3.6									
"	"	"	"	"	"			"	1	90	(3)		133											
"	"	"	70–240	"	"			Cover	4	90	(3)		144	490	3.4	120	638	544	1014	748				
JONES	1958 b	ICES V a	71	VI 1958	"			"	6	20		Scottish	97	280	2.9	65	1487	956	2175	1068				
"	"	"	69	"	"			"	6	20			97	264	2.7	50	598	308	1380	419				
"	"	"	70	"	"			"	8	20			97	306	3.1	63	1560	1159	2530	1337				
SAETERSDAL	1958 b	ICES I	192	VII 1958	"			"	5	96	3.9	Aberdeen	111	352	3.2	80	90	91	498	775				
HODDER and MAY	1964	ICNAF 3 N	55–73	V - VI 1959	Twisted	6617	151	Alternate Hauls	19	60	3.5	ICNAF	71						38920	Codend + Cover	1685	Codend + Cover	2112	Codend + Cover, Cod + Haddock
"	"	"	"	"	"	9925	101	"	5	"	"	"	94	306	3.3				5880		461		603	
"	"	"	"	"	"	"	"	"	5	"	"	"	94	286	3.0				11490		862		1246	
"	"	"	"	"	"	"	"	"	5	"	"	"	94	298	3.2				19715		1500		1694	
"	"	"	"	"	"	"	"	"	4	"	"	"	94	256	2.7				31312		2965		3254	
"	"	"	"	"	"	"	"	"	5	"	"	"	104	347	3.3				5855		504		694	
"	"	"	"	"	"	"	"	"	5	"	"	"	104	338	3.3				7805		677		1185	
"	"	"	"	"	"	"	"	"	5	"	"	"	104	314	3.0				13835		1112		1444	

[a] Fixed Load Direct Pull Gauge 3 kg; [b] Estimated from Published Graphs and Tables.

TABLE C-6 (continued)

AUTHOR	SOURCE	LOCALITY		DATE	COD-END			METHOD	HAULS		Speed of tow (knots)	Mesh gauge	Mean mesh size (mm)	50% length (mm)	SELECTION		No. of fish in selection range		Total No. of fish studied		Av. weight (kg) of			
		Division	Depth (m)		Material Const.	R Tex (g/1000 m)	Runnage (m/kg)		No.	Average Duration (min)					Factor	Range (mm)	Cod-end	Cover	Cod-end		Fish		Bycatch	
																					Cod-end	Cover	Cod-end	Cover
JONSSON	1960	ICES V a		VI 1960	Twisted				4	60			178	516	2.9				454	789				
"	"	"		"	"				3	"			88	302	3.4				1394	741				
"	"	"		"	"				3	"			90	286	3.2				318	175				
"	"	"		"	"				2	"			90	294	3.3				649	319				
HODDER AND MAY	1964	ICNAF 3 N	46-49	VII 1960	"	8271	121	Alternate Hauls	20	40	3.5	ICNAF	74						235600	Codend + Cover	5991	Codend + Cover	6250	Codend + Cover, Cod + Haddock
"	"	"	"	"	"	"	"	"	5	"	"	"	108	360	3.3				11100		1293		[illegible]74	
"	"	"	"	"	"	"	"	"	5	"	"	"	108	354	3.3				25875		2896		3103	
"	"	"	"	"	"	"	"	"	5	"	"	"	108	340	3.2				37450		4051		4215	
"	"	"	"	"	"	"	"	"	5	"	"	"	108	348	3.2				53050		5086		[illegible]67	
"	"	"	"	"	"	9925	101	"	5	"	"	"	110	378	3.4				12450		1444		[illegible]09	
"	"	"	"	"	"	"	"	"	5	"	"	"	110	370	3.4				30100		3551		3819	
"	"	"	"	"	"	8271	121	"	5	"	"	"	125	408	3.3				7525		1121		[illegible]58	
"	"	"	"	"	"	8271	121	"	5	"	"	"	125	400	3.2				34175		4448		[illegible]36	
SAETERSDAL	1960	ICES I	148-160	VIII 1960	Twisted Continuous		125	Cover	2	90	(3)	Aberdeen	131.5	390	3.0	100	173	141	446	286				
"	"	"	100-180	"	"		"	"	4	"	"	"	131.6	450	3.4	100	655	522	1218	1870				
"	"	"	150-170	"	"		125	"	2	"	"	"	131.6	433	3.3	80	224	208	534	498				
TRESCHEV and STEPANOV	1968	ICES I	150	1960	Twisted		125	"	16	102	3.5		107	310	2.9	91	787	466	4811	2423				
SAETERSDAL	1960	ICES I	120-200	VIII 1960	"		125	Cover Chafer [a]	10	90	(3)	Aberdeen	130.3	420	3.2	90	505	417	1733	1784				
"	"	"	160-185	"	"		"	Cover Chafer [b]	6	90	(3)	"	104	238	2.3	50	36	32	2318	71				
"	"	"	100-165	"	"		"	Cover Chafer [a]	5	90	(3)	"	130.3	440	3.4	70	217	131	877	299				
OLSEN	1962	ICES I	160	III 1962	"			Cover	2	60	(3)		114	367	3.2	91	210	262	413	427				
ICES	1965	ICES V a		III-IV 1962	"		150	"	13	56	3.5	ICES [c]	126	424	3.4	110	940	880	2216	1062			Total Catch	
"	"	"		V 1962	"		151	"	4	48	4.0	ICES	98	310	3.2	(40)	50	50	2392	110	2455	85		
"	"	"		"	"		151	"	2	45	3.0	"	99	(354)	(3.6)	(50)	40	60	550	750	1100	110		

[a] Multiflap Chafer; [b] Double Codend 105-mm Mesh; [c] Gauge Calibrated with ICES Gauge.

TABLE C-6 (continued).

AUTHOR	SOURCE	LOCALITY Division	LOCALITY Depth (m)	DATE	COD-END Material Const.	COD-END R Tex (g/1000 m)	COD-END Runnage (m/kg)	METHOD	HAULS No.	HAULS Average Duration (min)	Speed of tow (knots)	Mesh gauge	Mean mesh size (mm)	50% length (mm)	SELECTION Factor	SELECTION Range (mm)	No. of fish in selection range Cod-end	No. of fish in selection range Cover	Total No. of fish studied Cod-end	Total No. of fish studied (Cover)	Av. weight (kg) of Fish Cod-end	Av. weight (kg) of Fish Cover	Av. weight (kg) of Bycatch Cod-end	Av. weight (kg) of Bycatch Cover
HODDER and MAY	1964	ICNAF 3 N	55-73	V - VI 1959	Twisted	9925	101	Alternate Hauls	4	60	3.5	ICNAF	104	314	3.0				21320	CODEND + COVER	2241	CODEND + COVER	2685	CODEND + COVER + COD + HADDOCK
BEVERTON	1959 1964	ICES II b		VII 1959	Twisted Continuous		101	Cover	5	90	3.5	a	119	390	3.3	70	26	32	102	43				
HODDER	1964	ICNAF	40-46	VII-VIII 1959	Twisted	6617	151	Alternate Hauls	6	60	3.5	ICNAF	70						155220	Codend + Cover	8943	Codend + Cover	9176	Codend + Cover, Cod + Haddock
and MAY	"	"	"	"	"	9925	101	"	3	60	3.5	"	95	340	3.6				15210		2142		2215	
"	"	"	"	"	"	9925	101	"	3	"	"	"	95	320	3.4				59070		7659		8613	
"	"	"	"	"	"	"	"	"	3	"	"	"	104	368	3.5				14685		2125		2250	
"	"	"	"	"	"	"	"	"	2	"	"	"	104	337	3.2				3100		6034		6163	
ICES	1964	ICES II b		VIII 1959	Twisted Continuous	"	125	Cover	4	"	3.5		120	356	3.0	50	34	38	184	172				
"	"	"		"	"		125	"	6	"	3.5		137	447	3.3	80	39	44	214	351				
STEPANOV and TRESCHEV	1968	ICES I	200	1959	Twisted		125	"	5	60	3.5		106	339	3.2	82	41	48	491	382				
BEVERTON	1959 1964	ICES II b		VII 1959	Twisted Continuous		101	Cover Chafer [b]	9	45	3.5	a	118	400	3.4	70	57	90	434	465				
"	"	"		"	"		"	"	3	50	3.5	a	119	390	3.3	70	17	17	101	31				
HODDER	1964	ICNAF 3 O	81-86	V 1960	Twisted	8271	121	Alternate Hauls	15	60	3.5	ICNAF	67						124950	Codend + Cover	4099	Codend + Cover	892	Codend + Cover, Cod + Haddock
and MAY	"	"	"	"	"	9925	101	"	5	"	"	"	94	324	3.4				20475		2090		2521	
"	"	"	"	"	"	8271	121	"	5	"	"	"	94	320	3.4				35100		3530		4176	
"	"	"	"	"	"	"	"	"	5	"	"	"	94	312	3.3				46950		4888		3383	
"	"	"	"	"	"	"	"	"	5	"	"	"	109	345	3.2				11075		1185		1789	
"	"	"	"	"	"	"	"	"	5	"	"	"	109	338	3.1				20875		2177		2836	
HODDER and MAY	1964	ICNAF 3 O	81-86	V 1960	Twisted	8271	121	"	5	60	3.5	"	109	337	3.1				44400		4969		6012	
JONSSON	1960	ICES V a		VII 1960	"				3	"			67	259	3.8					563	173			
JONSSON	"	"		"	"				3	"			104	359	3.5					207	794			
"	"	"		"	"				5	"			110	383	3.5					871	541			
"	"	"		"	"				4	"			117	384	3.3					232	198			
"	"	"		"	"				4	"			112	370	3.3					1482	659			

[a] Fixed Load Direct Pull Gauge 3 kg; [b] Flap Type Chafer;

TABLE C-6 (continued).

AUTHOR	SOURCE	LOCALITY		DATE	COD-END			METHOD	HAULS		Speed of tow (knots)	Mesh gauge	Mean mesh size (mm)	50% length (mm)	SELECTION		No. of fish in selection range		Total No. of fish studied		Av. weight (kg) of			
		Division	Depth (m)		Material Const.	R Tex (g/1000 m)	Runnage (m/kg)		No.	Average Duration (min)					Factor	Range (mm)	Cod-end	Cover	Cod-end		Fish		Bycatch	
																					Cod-end	Cover	Cod-end	Cover
ICES	1965	ICES V a		V 1962	Twisted		151	Cover	3	25	4.0	ICES	103	(340)	(3.3)	(60)	30	40	702	258	825	192		
"	"	"		"	"		151	"	2	45	4.0	"	104	362	3.5	50	90	50	1083	184	1818	238		
"	"	"		"	"		151	"	3	41	4.0	"	120	388	3.2	90	440	360	1009	572	1750	493		
"	"	"		"	"		151	"	2	45	3.5	"	122	412	3.4	(90)	180	120	885	616	1575	363		
"	"	"	138	VI 1962	"	6623	151	"	7	60	4.0	"	112	356	3.2	80	300	390	1747	3416	366	132	Total Catch	
"	"	"	161	"	"	6623	151	"	8	60	4.0	"	127	416	3.3	110	160	180	1492	1767	674	177		
"	"	"		VII 1962	"		100	"	9	60	3.5	West[a] Hoff	120	355	3.0	(100)	390	830	3538	1395	2447	268		
"	"	"	70-150	"	"	6135	163	"	16	83	4.0	Aberdeen	137.7	422	3.1	120	379	339	1674	1381	550	170		
"	"	"	250	"	"		100	"	5	97	3.5	"[b]	141	495	3.5	130	3360	2930	5967	5751	1451	844		
"	"	"	83-147	"	"		151	"	11	60	3.5	ICES[a]	132	460	3.5	100	330	350	1403	577	2640	310		
"	"	"		"	"		150	"	6	60	3.5	"	117	390	3.3	90	270	170	1290	865				
"	"	"		VII-VIII 1962	"		150	"	12	60	3.5	"	138	496	3.6	120	270	320	861	1069				
"	"	"		VIII 1962	"		150	"	14	60	3.5	"	138	480	3.5	180	840	810	2073	2312				
HOLDEN	1966 d	ICES I	165-260	X 1963	"		101	"	5	100	4.0	ICES	125	460	3.7	34	19	33	123	782				
TRESCHEV and STEPANOV	1968	ICNAF 2	250	1963	"		100	"	15	90	4.0	"	109	327	3.0	113	1517	1157	12591	8446				

[a] Gauge Calibrated with ICES Gauge; [b] Pressure Gauge not Calibrated with ICES Gauge.

TABLE C-7a   Gear: Bottom trawl   Species: Haddock   Material: Double Polypropylene   Area: ICES I, Va.

AUTHOR	SOURCE	LOCALITY		DATE	COD-END			METHOD	HAULS		Speed of tow (knots)	Mesh gauge	Mean mesh size (mm)	50% length (mm)	SELECTION		No. of fish in selection range		Total No. of fish studied		Av. weight (kg) of			
		Division	Depth (m)		Material Const.	R Tex (g/1000 m)	Runnage (m/kg)		No.	Average Duration (min)					Factor	Range (mm)	Cod-end	Cover	Cod-end		Fish		Bycatch	
																					Cod-end	Cover	Cod-end	Cover
OLSEN	1966	ICES I	260-265	II 1964				Cover	4	80-120	3.0	ICES	145	497	3.4	107	96	135	268	739				
BOHL	1966 a 1967 a	ICES V a	60-100	VI 1964	Continuous	4905	204	"	14	120		"	125.4	416	3.3	70	252	238	2472	2280	235	60	225	120
"	"	"	"	VII 1964	"	"	"	"	1	60		"	125.0	(380)	(3.0)	(60)	(42)	(42)	167	78	190	40	625	225
"	"	"	"	"	"	"	"	"	1	60		"	124.4	(420)	(3.4)	(56)	(58)	(69)	465	203	565	90	1240	665
"	"	"	"	"	"	"	"	"	1	60		"	124.2	4.9	3.4	(72)	(54)	(73)	353	132	415	65	790	400
"	"	"	"	"	"	"	"	"	1	60		"	124.1	400	3.2	82	128	159	538	225	550	115	425	425
OLSEN	1966	ICES I	290	III 1964	"			Cover Chafer [a]	3	90-120	3.5	"	146	398	2.7	181	1245	1290	1540	1676				
MARGETTS	1965 b	ICES V a		II-III 1965	Plaited		400	Cover	5	120	3.5		114	385 ?	3.4 ?	70 ?	43	34						
"	"	"		"	"		400	"	7	120	3.5		112	380	3.4	80	186	157						
POPE ET AL	1965	ICES V a	172	III 1965	"	2481	403	"	1	70	3.5	ICES	111	402	3.6	69	140	131	398	218				
"	"	"	156	"	"	"	"	"	1	90	"	"	111	411	3.7	61	159	161	500	293				
"	"	"	183	"	"	"	"	"	1	120	"	"	111	423	3.8	50	48	51	166	111				
MARGETTS	1965	"		"	"		400	"	5	120	"		114	(385)	(3.4)	(70)	43	34						
"	"	"		"	"		"	"	7	120	"	"	112	380	3.4	80	186	157						
HYLEN	1969	ICES I	45-300	IX 1966	Split-fibre	4510		"	10	80	3.5	"	136	460	3.4	73	1014	849	2828	4037				
UNPUBLISHED LOWESTOFT		"	248	XI 1966				"	7	75	3.25	Lowestoft	120.2	450	3.7	120	(162)	(107)	711	258				
"		"	"	"				"	6	75	3.25	Scissors	127.9	460	3.6	118	(198)	(156)	764	418				
UNPUBLISHED (LT)		"	"	"				"	6	75	3.25	Lowestoft Scissors	107.4	345	3.2	118	(41)	(42)	658	128				
OLSEN	1968	"	220-250	III 1966		4510		Cover Chafer [b]	3	74	3.0-3.5	ICES	141	463	3.3	130	85	105	145	307				
HYLEN	1967	"	60-360	V 1966		4510		"	10	80	3.5	"	126	410	3.2	86	1274	1515	5740	2358				
UNPUBLISHED (LOWESTOFT)		"	235	XI 1967				Cover	13	60	3.5		105.5	370	3.5	70	184	270	1450	450				
"		"	"	"				"	12	60	"		104.7	380	3.6	105	138	178	1259	350				

[a] Double Codend: Manila Chafer; [b] Polish Type Chafer : Mesh Size Twice that of Codend.

GROUPED DATA ALREADY TABULATED BY SINGLE HAULS IN PRECEDING TABLE

TABLE C-7 (continued).

AUTHOR	SOURCE	LOCALITY		DATE	COD-END			METHOD	HAULS		Speed of tow (knots)	Mesh gauge	Mean mesh size (mm)	50% length (mm)	SELECTION		No. of fish in selection range		Total No. of fish studied		Av. weight (kg) of			
		Division	Depth (m)		Material Const.	R Tex (g/1000 m)	Runnage (m/kg)		No.	Average Duration (min)					Factor	Range (mm)	Cod-end	Cover	Cod-end		Fish Cod-end	Fish Cover	Bycatch Cod-end	Bycatch Cover
BOHL	1967 e	ICES V a	70	VII 1964	Continuous Plaited	4905	204	Cover	4	60		ICES	124.4	408	3.3	79	328	392	1523	638	425	75	770	430

TABLE C-8. Gear: Bottom trawl Species: Haddock Material: Double Polyethylene Area: ICES I.

AUTHOR	SOURCE	LOCALITY		DATE	COD-END			METHOD	HAULS		Speed of tow (knots)	Mesh gauge	Mean mesh size (mm)	50% length (mm)	SELECTION		No. of fish in selection range		Total No. of fish studied		Av. weight (kg) of			
																					Fish		Bycatch	
		Division	Depth (m)		Material Const.	R Tex (g/1000 m)	Runnage (m/kg)		No.	Average Duration (min)					Factor	Range (mm)	Cod-end	Cover	Cod-end		Cod-end	Cover	Cod-end	Cover
OLSEN	1962	ICES I	155-165	III 1962				Cover	5	60	3.5	ICES	121	391	3.2	83	185	245	361	631				
"	1964	"	250	III 1963				Cover[a] Chafer		90	3-4	"	144	293	2.0	120	(309)	(228)	633	282				

[a] Double Codend.

TABLE C-9. Gear: Bottom trawl Species: Haddock Material: Double Polyester Area: ICES I.

AUTHOR	SOURCE	LOCALITY		DATE	COD-END			METHOD	HAULS		Speed of tow (knots)	Mesh gauge	Mean mesh size (mm)	50% length (mm)	SELECTION		No. of fish in selection range		Total No. of fish studied		Av. weight (kg) of			
		Division	Depth (m)		Material Const.	R Tex (g/1000 m)	Runnage (m/kg)		No.	Average Duration (min)					Factor	Range (mm)	Cod-end	Cover	Cod-end		Fish Cod-end	Fish Cover	Bycatch Cod-end	Bycatch Cover
SAETERSDAL	1960	ICES I	145-180	VIII 1960			136	Cover	4	90	(3)	Aberdeen	107.7	350	3.3	50	70	67	463	316				
"	"	"	145-170	"			136	"	4	90	(3)	"	106.4	372	3.5	60	96	101	636	324	570[a]	200[a]		

[a] Total Catch.

TABLE C-10. Gear: Bottom trawl Species: Haddock Material: Double Polyamide Type A Area: ICNAF 2,3,4; ICES I,Va.

AUTHOR	SOURCE	LOCALITY		DATE	COD-END			METHOD	HAULS		Speed of tow (knots)	Mesh gauge	Mean mesh size (mm)	50% length (mm)	SELECTION		No. of fish in selection range		Total No. of fish studied		Av. weight (kg) of			
		Division	Depth (m)		Material Const.	R Tex (g/1000 m)	Runnage (m/kg)		No.	Average Duration (min)					Factor	Range (mm)	Cod-end	Cover	Cod-end		Fish		Bycatch	
																					Cod-end	Cover	Cod-end	Cover
SAETERSDAL	1958 a	ICES I	150-250	X 1957	Twisted		260	Cover	11	90	(3)	Aberdeen	140	540	3.8	90	181	213	506	1420				
TRESCHEV and STEPANOV	1968	"	150	1959	"		182	"	6	90	3.5		103	391	3.8	81	91	62	546	413				
"	"	"	200	1960	"		"	"	4	70	3.5		102	377	3.7	74	55	12	341	72				
ICES	1965	ICES V a	148	VI 1962	"	3311	302	"	5	60	4.0	ICES	89	321	3.6	50	200	360	537	1012				
ICES	1965	ICES V a	300	1962	"		182	"	5	80	3.5		121	436	3.6	110	100	80	1210	671				
"	"	"	300	"	"		"	"	3	80	3.5		105	368	3.5	90	300	200	2891	2784				
"	"	"	300	"	"		"	"	2	85	3.5		122	415	3.4	100	130	110	1294	338				
"	"	"	300	"	"		"	"	3	85	3.5		122	440	3.6	80	95	88	1131	554				
"	"	"	300	"	"		"	"	5	90	3.5		108	432	4.0	110	216	111	2322	1923				
TRESCHEV and STEPANOV	1968	ICNAF 2	250	1963	"		"	"	8	80	3.5		98	353	3.6	98	303	270	1261	983				
STRZYZEWSKI	1967	ICNAF 3M-4W		1965	"			"	5				113.4	429	3.8	91			827	2061				

Gear: Bottom trawl Species: Haddock Material: Double Polyamide Type B Area: ICES IIb,Va.

BRANDT	1963	ICES II b		VII-VIII 1956			210	Cover	5			ICES	107	330	3.1	90	211	127	359	175				
"	"	"		"			380	"	11				104	350	3.4	70	211	242	710	1145				
BOHL	1967 e	ICES V a	80	VI 1964	Continuous	4760	210	"	8	116			131.5	479	3.6	84	465	475	1577	1563	280	115	145	110
"	"	"	70	VII 1964	"	"	"	"	1	60			132.4	456	3.4	104	230	182	517	384	700	240	1390	865
"	"	"	"	"	"	"	"	"	1	60			132.7	476	3.6	88	166	167	415	315	700	250	965	415
"	1966 g	ICES V a	70	VI-VII 1964	"	5000	200	"	7	55			124.1	438	3.5	76	940	1026	3962	2830	695	215	415	225
"	"	"	"	"	"	"	"	Cover Chafer[a]	6	57			124.2	400	3.2	74	514	647	2312	1297	390	100	665	330
"	"	"	"	"	"	"	"	Cover Chafer[b]	8	58			123.9	387	3.1	105	1635	1677	5213	2916	515	140	320	665

GROUPED DATA ALREADY TABULATED BY SINGLE HAULS IN PRECEDING TABLE

BOHL	1967 e	ICES V a	70	VII 1964	Continuous Plaited	4760	210	Cover	2	60			132.6	457	3.5	100	391	358	932	699	700	245	1180	640

[a] Multi-flap Chafer; [b] ICNAF Chafer (German Version)

TABLE C-11. Gear: Bottom trawl Species: Redfish Material: Double Manila Area: ICNAF 1.3; ICES I,IIa,Va,XIV.

AUTHOR	SOURCE	LOCALITY		DATE	COD-END			METHOD	HAULS		Speed of tow (knots)	Mesh gauge	Mean mesh size (mm)	50% length (mm)	SELECTION		No. of fish in selection range		Total No. of fish studied		Av. weight (kg) of			
																					Fish		Bycatch	
		Division	Depth (m)		Material Const.	R Tex (g/1000 m)	Runnage (m/kg)		No.	Average Duration (min)					Factor	Range (mm)	Cod-end	Cover	Cod-end		Cod-end	Cover	Cod-end	Cover
TEMPLEMAN	1957 a 1963	ICNAF 3N,O		V 1954	Twisted		182	Cover	6	30	3.8	ICNAF	106.7	294	2.7	87			3900	10000	850			
"	"	"		VI 1954	"		"	"	4	"	"	"	99.1	269	2.7	52			540	1160	270			
"	"	ICNAF 3N,O,P		V-VII 1955	"		252	"	10	"	"	"	66.4	141	2.1	45			8650	450	380			
SAETERSDAL	1963	ICES II a	190	II 1956	"			"	1	90	(3)	Aberdeen	144	440	3.1	(100)	83	106	98	159				
"	"	ICES I	200-275	IV 1956	"			"	1	120	(3)	"	144	405	2.8	90	39	58	73	291				
TEMPLEMAN	1957 a 1963	ICNAF 3N,O,P		V-X 1956	"		182	"	17	30	3.8	ICNAF	111.8	292	2.6	88			4606	9888	350			
"	"	ICNAF 3P		IX-X 1956	"		202	"	39	30	3.0	"		281	2.5	89			20212	4622	720			
BRANDT	1960	ICNAF I		"	"		160	"	5	60			129	310	2.4	85	495	557	4980	1498				
SAETERSDAL	1963	ICES I	246	XI 1956	"			"	1	105	(3)	Aberdeen	144	380	2.6	145	601	585	741	789				
"	1960	ICES I	200-240	VIII 1960	"		125	"	1	90	(3)	"	131.6	400	3.0	60	537	533	1696	1743				
"	"	"	200	"	"		125	"	1	90	(3)	"	132	383	2.9	90	1076	882	1587	1104				
BOHL	1961	ICES XIV	390-400	VII 1961	"	8300	120	"	5	70	4.2	Westhoff	147.3	384	2.6	150	1557	1168	2076	1261	615	260	185	+
TRESHEV	1966 a	ICES I	350	1961	"		153	"	8	90	3.2		116	292	2.5	100	1185	466	7950	1422				
TRESCHEV SHESTOV and ROGACHEV	1961	"	350	"	"		"	"	8	90	3.2		116	313	2.7	103	349	230	1481	320				
	1961	"	350	"	"		"	"	6	90	"		119.8	352	2.9	111	1645	1274	1811	1546				
"	"	"	350	"	"		"	"	6	90	"		119.8	358	3.0	108	549	301	637	500				
"	"	"	350	"	"		"	"	6	90	"		130.3	380	2.9	67	1520	1306	1800	3495				
TRESCHEV	1966	ICES I	350	"	"		153	"	6	90	"		130.3	383	2.9	78	203	173	316	428				
ICES	1965	ICES V a	142	VI 1962	"	6623	151	"	6	60	4.0	ICES	112	248	2.2	70	40	40	82	56	416	137		
"	"	"	179	"	"		"	"	8	60	4.0	"	127	275	2.2	160	2280	2000	2484	2113	674	177		
"	"	"	161	"	"		"	"	3	60	40	"	132	369	2.8	150	500	830	575	928	552	309		
"	"	"	190-250	VII 1962	"	6135	163	"	11	108	4.0	Aberdeen[a]	138.7	396	2.9	162	2683	3669	3901	4320	350	245	85	50
"	"	"	320-350	"	"	8300	120	"	10	174	4.0	"	149.3	469	3.1	(148)	(2005)	(2702)	2692	2936	485	335	175	330
ICES	1965	ICES V a		IX 1962	"		151	"	2	78	3.0	ICES	108	350	3.2	50	20	20			595	185		
TRESCHEV	1966	ICES V a	400	1962	Twisted		100	Cover	5	90	3.5		92.0	230	2.5	92	1026	625	3124	1914				

Total Catch (weights of the ICES 1965 rows, bracketed)

[a] Calibrated to ICES.

TABLE C-12. Gear: Bottom trawl Species: Redfish Material: Double Polyamide Type A Area: ICNAF 3; ICES Va.

AUTHOR	SOURCE	LOCALITY		DATE	COD-END			METHOD	HAULS		Speed of tow (knots)	Mesh gauge	Mean mesh size (mm)	50% length (mm)	SELECTION		No. of fish in selection range		Total No. of fish studied		Av. weight (kg) of			
		Division	Depth (m)		Material Const.	R Tex (g/1000 m)	Runnage (m/kg)		No.	Average Duration (min)					Factor	Range (mm)	Cod-end	Cover	Cod-end		Fish		Bycatch	
																					Cod-end	Cover	Cod-end	Cover
ICES	1965	ICES V a	161	VI 1962		3311	302	Cover	3	60	4.0	ICES	89	241	2.7	60	70	60	1346	119	475	56	Total Catch	
TRESCHEV	1966 b	ICNAF 3 M	450	VIII 1962	Twisted	8500		"	7	70	"		107.2	289	2.7	72	12771	2981	17874	6988				
"	"	"	"	"	"	9500		"	8	60	"		102.8	278	2.7	32	8509	2104	15090	8104				
STRZYZEWSKI	1967	ICNAF 3M-4W	60-360	IV-VI 965				"	5			ICES	114.6	327	2.9	68			2321	6845				
ICES	1965	ICES V a	400	VIII 1962	Twisted		182	Cover Chafer [a]	3	60	3.5		118	378	3.2	110	510	430	1680	476	258	240	Total Catch	
STRZYZEWSKI	1967	ICNAF 3M-4W	60-360	IV-VI 1965				Cover Chafer [b]	3			ICES	103.9	320	2.9	50			4019	5017				
BUCKI ET AL	1968	ICNAF 3 K	300-330	XI 1967	Twisted	7500	133	Cover Chafer [c]	3	175-300	3.5-4.0	"	110.5	333	3.0	143			1469	457				

Gear: Bottom trawl Species: Redfish Material: Double Polyamide Type B Area: ICES XIV

AUTHOR	SOURCE	Division	Depth (m)	DATE	Material Const.	R Tex (g/1000 m)	Runnage (m/kg)	METHOD	No.	Average Duration (min)	Speed of tow (knots)	Mesh gauge	Mean mesh size (mm)	50% length (mm)	Factor	Range (mm)	Sel. Cod-end	Sel. Cover	Total Cod-end	Total	Fish Cod-end	Fish Cover	Bycatch Cod-end	Bycatch Cover
BRANDT	1960	ICES XIV		1957					12	60				450	3.5		68	121						
"	"	"		"					11	60				420	3.3		95	165						
"	"	ICES XIV		IV-V 1960					7	60				410	3.1		1158	1026						
BOHL	1961 1962 a,b	ICES XIV	340-430	VII 1961	Continuous	4760	210	Cover	1	75	4.2	West-hoff	130.8	407	3.1	(57)	(120)	(156)	276	253	450	180	50	+
"	"	"	"	"	"	"	"	"	1	90	4.2	"	131.5	385	2.9	(115)	(209)	(221)	446	256	630	225	100	+
"	"	"	"	"	"	"	"	"	1	90	4.1	"	131.2	367	2.8	105	169	141	353	170	495	150	225	10
"	"	"	"	"	"	"	"	"	1	90	4.0	"	130.8	360	2.8	(63)	(148)	(87)	576	165	640	135	450	+
"	"	"	"	"	"	"	"	"	1	90	4.0	"	130.2	340	2.6	?	?	?	1160	144	1225	90	475	25
"	"	"	"	"	"	"	"	"	1	90	4.2	"	130.8	340	2.6	?	?	?	866	257	990	215	275	40
"	"	"	"	"	"	"	"	"	1	90	4.2	"	131.1	340	2.6	(80)	(258)	(146)	1010	253	1340	225	400	65
"	"	"	"	"	"	"	"	"	1	90	4.2	"	131.3	337	2.6	(88)	(342)	(213)	1300	360	1540	305	450	25
"	"	"	"	"	"	"	"	"	1	90	4.0	"	131.4	325	2.5	(40)	(276)	(161)	1269	257	1440	250	600	15
"	"	"	390	"	"	4080	245	"	1	90	4.2	"	139.6	392	2.8	(65)	(138)	(118)	342	161	540	145	100	+
"	"	"	"	"	"	"	"	"	1	90	4.2	"	138.7	390	2.8	90	284	189	524	236	810	180	150	25
"	"	"	"	"	"	"	"	"	1	90	4.2	"	138.8	375	2.7	?	?	?	643	198	1340	205	150	+

[a] Modified ICNAF Chafer; [b] Polish Type Chafer, Mesh X4 Codend Mesh; [c] Polish Chafer, Mesh X2 Codend Mesh.

TABLE C-12 (continued). Gear: Bottom trawl Species: Redfish Material: Double Polyamide Type B Area: ICES Va,XIV.

AUTHOR	SOURCE	LOCALITY		DATE	COD-END			METHOD	HAULS		Speed of tow (knots)	Mesh gauge	Mean mesh size (mm)	50% length (mm)	SELECTION		No. of fish in selection range		Total No. of fish studied		Av. weight (kg) of			
																					Fish		Bycatch	
		Division	Depth (m)		Material Const.	R Tex (g/1000 m)	Runnage (m/kg)		No.	Average Duration (min)					Factor	Range (mm)	Cod-end	Cover	Cod-end		Cod-end	Cover	Cod-end	Cover
BOHL	1961 1962 a,b	ICES XIV	390	VII 1961	Continuous	4080	245	Cover	1	90	4.2	Westhoff	138.1	373	2.7	?	?	?	666	252	1045	270	175	+
"	"	"	"	"	"	"	"	"	1	80	4.2	"	137.6	368	2.7	(82)	(262)	(196)	770	255	1150	270	200	+
BOHL	1961 1962 a,b	ICES XIV	390	VII 1961	Continuous	4080	245	Cover	1	90	4.2	Westhoff	139.3	365	2.6	(99)	(337)	(276)	836	344	1015	330	100	50
"	"	"	"	"	"	"	"	"	1	90	4.2	"	139.4	361	2.6	?	?	?	1208	420	2160	385	150	25
"	"	"	400-410	"	"	5000	200	"	1	90	4.2	"	146.4	429	2.9	(135)	(372)	(543)	480	646	595	665	150	+
"	"	"	"	"	"	"	"	"	1	70	4.2	"	144.5	415	2.9	(90)	(243)	(268)	365	379	585	360	125	15
"	"	"	"	"	"	"	"	"	1	70	4.2	"	145.3	416	2.9	?	?	?	357	450	450	405	175	+
"	"	"	"	"	"	"	"	"	1	90	4.2	"	145.0	415	2.9	(137)	(442)	(538)	615	620	900	655	200	25
"	"	"	"	"	"	"	"	"	1	60	4.2	"	146.4	360	2.5	(138)	(881)	(645)	1144	683	1465	630	250	+
ICES	1965	ICES V a	230-250	VII 1962	"	4760	210	"	17	100	4.0	Aberdeen[a]	131.8	385	2.9	160	8076	12494	11062	13254	565	440	90	55
"	"	"	270-400	"	"	5000	200	"	7	137	4.0	"	142.4	439	3.1	(157)	1222	1742	1912	1798	395	250	165	230

GROUPED DATA ALREADY TABULATED BY SINGLE HAULS IN PRECEDING TABLE

AUTHOR	SOURCE	LOCALITY		DATE	COD-END			METHOD	HAULS		Speed of tow (knots)	Mesh gauge	Mean mesh size (mm)	50% length (mm)	SELECTION		No. of fish in selection range		Total No. of fish studied		Av. weight (kg) of			
																					Fish		Bycatch	
		Division	Depth (m)		Material Const.	R Tex (g/1000 m)	Runnage (m/kg)		No.	Average Duration (min)					Factor	Range (mm)	Cod-end	Cover	Cod-end		Cod-end	Cover	Cod-end	Cover
BOHL	1961	ICES XIV	390-430	VII 1961	Continuous Plaited	4760	210	Cover	11	89	4.1	Westhoff	131.0	335	2.6	145	2626	1679	8465	2495	935	190	305	25
"	1962 a	"	390	"	"	4080	245	"	8	85	4.2	"	138.8	372	2.7	120	2275	1648	5483	1983	1090	240	130	15
"	1962 b	"	400-410	"	Continuous Twisted	5000	200	"	6	78	4.2	"	145.7	412	2.8	145	2553	2880	3302	3112	750	510	190	+

[a] Calibrated Against ICES.

PART D

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The Working Group accepted that the minimum mesh size of codends made from different materials should be determined in accordance with the principle of equivalent selectivity.

The selectivity equivalent of a given material is defined here to be the ratio of the average selection factor for that material to the average selection factor for double manila. The basic data available to the Working Group for the calculation of average selection factors were those listed in Tables C-1 to C-12.

Although the Group agreed that more work is needed on this problem, it decided to separate the selection factors in the tables of selectivity results for cod and haddock into two groups, those in which the polyamide used had an elongation of greater than 25% and those which had a lower elongation. The former was called polyamide A and the latter polyamide B. The division was made on the basis of the results given in Part A of this report, and it was necessary to assume for this purpose that the polyamide used was produced in the country conducting the experiment. This breakdown is shown in the tables of selectivity data (Tables C-1 to C-12).

The Working Group spent some time considering the most appropriate method of evaluating the average for each material. Besides the methods described in Parts B and C of this report, two other types of average were considered, namely the unweighted mean and the mean weighted by the number of hauls corresponding to each selection factor. The Working Group decided to use all four methods, and accordingly four mean values were calculated for each material. These mean values are listed in Table D-1, where it will be seen that, in general, they are in close agreement.

The selectivity equivalents for each material, obtained from the results shown in Table D-1, are given in Table D-2.

Unweighted selection factors for the experiments used are given in the form of a frequency distribution in Table D-3.

The Working Group discussed the selection results in relation to the physical properties of the various twines. It considered that there might be a relationship between elongation and selection factor and it noted that in the case of polyamide there is a wide range in elongation as defined in Part I of this report.

Recommendations

The selectivity equivalents for mesh sizes of trawls made from different materials obtained as a result of the analysis of selectivity data and of the tests of the physical properties of trawl twines and mentioned in the conclusions are recommended to be introduced in the Conventions for the North-East and Northwest Atlantic Fisheries in place of the present rules for establishing mesh sizes of trawls made from synthetic materials, insofar as the Commissions consider these groupings enforceable.

The Working Group recommends that for all future selectivity experiments the following information about the codend material used should be tabulated:

TWINE DATA		
*a.	Material	Chemical nature
*b.	Type of fibre	Multi-filament, mono-filament, staple fibre, film (= split fibre)
*c.	Construction	Twisted, plaited
*d.	Rtex	
*e.	Runnage	(m/kg)
f.	Treatment	Untreated, thermo-fixed, chemically treated, etc.
g.	Wet flexibility	
*h.	Wet weaver-knot breaking load	
i.	Wet load elongation curve	(a) during breaking load test, (b) after some repeat loadings
*j.	Wet breaking lengths (based on dry material)	

NET DATA		
a.	Method of manufacture	Hand or machine made (knotted, knotless, single or double braided)
b.	Treatment	Untreated, thermo-fixed, chemically treated, etc.
c.	Wet mesh size using ICES mesh gauge	
*d.	Wet mesh breaking load	
e.	Wet load elongation curve	(a) during breaking load test, (b) after some repeat loadings

These tests are proposed in the present state of knowledge. The list is not exclusive and should be supplemented by other tests as and when they become available.

Tests marked with an asterisk (*) should be carried out according to ISO standards.

The following laboratories are prepared to undertake these tests, free of charge, for those institutions which do not have the necessary facilities:

Institut für Fangtechnik, Hamburg (Germany), Palmaille 9 (marked to the attention of Prof. A. von Brandt);

Laboratorium voor Materiaal Onderzoek TNO, IJmuiden (marked to the attention of Dr J. Reuter).

A sample of 100-m twine (minimum) and a piece of netting measuring 20 meshes by 20 meshes should be sent. To facilitate receipt it is absolutely essential that the customs declaration should be marked "No Commercial Value".

As far as other data are concerned, the Working Group recommended that the modified ICNAF form of tabulation used in this report should be adopted.

Because manila is no longer used commercially and because it is not readily available, the Working Group recommends that a new standard material be introduced.

The standard netting yarn chosen is made of PA-fibres and is manufactured by Apeldoornse Nettenfabriek in Apeldoorn, Netherlands. It is a twisted trawl yarn with the designation 3/500. The following list indicates the properties:

Designation	R 6484 tex
Twist direction	Z
m/kg	154 m/kg (= 77 yards/lb)
Diameter	2.87 mm
Twist level	185 approximately
Breaking load (dry)	355 kp approximately
Breaking load (wet)	315 kp
Knot breaking load (wet)	299 kp
Breaking length (dry)	54.9 km
Breaking length (wet)	48.6 km
1/2 knot breaking length	23.1 km
Extension (1/2 knot breaking load, wet):	23.8%

The factory mentioned above offers this PA standard netting yarn for 7.75 hfl (cif) in bunches of 2.2 kg. Customers are asked to order quantities of not less than 50 kg.

To ensure the uniformity of the properties on the one hand and to avoid deterioration during storage on the other, the factory intends to produce the netting yarn in quantities of 300 kg at a time.

If the relevant committees of ICES and ICNAF agree to adopt the new standard net yarn, the Working Group recommends that the committees take steps to determine whether a standard netting can also be manufactured, and, if so, that it be introduced for selectivity experiments.

The Working Group recommends that further work is needed to determine the relationship between elongation and selection factors.

Table D-1. Mean selection factors.

	Cod					Haddock					Redfish				
	(1)	(2)	(3)	(4)	Mean	(1)	(2)	(3)	(4)	Mean	(1)	(2)	(3)	(4)	Mean
Double manila	3.52	3.48	3.45	3.42	3.47	3.26	3.16	3.09	3.22	3.18	2.71	2.62	2.64	2.62	2.65
Double polyethylene	3.43	3.42	3.37	3.41	3.41	3.20	3.20	3.20	3.20	3.20					
Double polypropylene	3.74	3.70	3.60	3.63	3.67	3.48	3.45	3.42	3.45	3.45	-	-	-	-	-
Double polyester	3.95	3.95	3.95	3.95	3.95	3.40	3.40	3.42	3.39	3.40	-	-	-	-	-
Double polyamide (A + B)	3.92	4.00	4.02	3.89	3.96	3.59	3.66	3.62	3.63	3.63					
Double polyamide A	4.09	4.09	4.03	4.07	4.07	3.67	3.86	3.73	3.67	3.73	-	-	-	-	-
Double polyamide B	3.66	3.66	3.57	3.63	3.63	3.40	3.33	3.51	3.40	3.41	2.92	2.95	2.84	2.87	2.90

(1) = unweighted mean;

(2) = weighted by number of hauls only;

(3) = weighted by method described in Part C;

(4) = weighted by method described in Part B.

Table D-2. Characteristics of different net materials and equivalents.

Material	Characteristics of material: Percentage elongation at the load of the half knot breaking load		Equivalents: Cod	Haddock	Mean
Double manila	6.5- 7.8		1.00	1.00	-
Double polyethylene	8.4-22.2	(1)	0.97	0.98	-
		(2)	0.98	1.01	-
		(3)	0.98	1.04	-
		(4)	1.00	0.99	-
		Mean	0.98	1.00	0.99
Double polypropylene	10.4-21.3	(1)	1.06	1.07	-
		(2)	1.06	1.09	-
		(3)	1.04	1.11	-
		(4)	1.06	1.07	-
		Mean	1.06	1.08	1.07
Double polyester	8.3-12.3	(1)	1.12	1.04	-
		(2)	1.14	1.08	-
		(3)	1.14	1.11	-
		(4)	1.15	1.05	-
		Mean	1.14	1.07	1.10
Double polyamide	15.5-47.0	(1)	1.11	1.10	-
		(2)	1.15	1.16	-
		(3)	1.17	1.17	-
		(4)	1.14	1.13	-
		Mean	1.14	1.14	1.14
Double polyamide A	>25.0	(1)	1.16	1.13	-
		(2)	1.18	1.22	-
		(3)	1.17	1.21	-
		(4)	1.19	1.14	-
		Mean	1.18	1.18	1.18
Double polyamide B	$\leqslant 25.0$	(1)	1.04	1.04	-
		(2)	1.05	1.05	-
		(3)	1.03	1.14	-
		(4)	1.06	1.06	-
		Mean	1.04	1.07	1.06

(1) = unweighted mean;

(2) = weighted by number of hauls only;

(3) = weighted by method described in Part C;

(4) = weighted by method described in Part B.

Table D-3. Frequency distributions of unweighted selection factors for cod, haddock, and redfish.

	Cod					Haddock					Redfish	
S.F.	Manila	PP	PE	PES	PA	Manila	PP	PE	PES	PA	Manila	PA
2.1											1	
2.2											2	
2.3											0	
2.4											1	
2.5											3	
2.6											3	1
2.7						1					3	4
2.8	3					0					2	1
2.9	3					4					5	2
3.0	2					5					2	0
3.1	2					3				1	2	2
3.2	2	3	1			7	1	1		0	1	0
3.3	4	5	1			11	2		1	0		1
3.4	15	0	2		1	6	6		0	2		0
3.5	7	4	1		5	6	1		1	3		1
3.6	7	1	0		2	2	3			5		
3.7	6	1	0		3	1	2			1		
3.8	8	1	1		4	1	1			3		
3.9	0	0		1	2					0		
4.0	5	3		1	5					1		
4.1	3	3			2							
4.2	0	4			4							
4.3	2	1			2							
4.4		1			3							
Total	69	27	6	2	33	47	16	1	2	16	25	12

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