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Minimum landing size for cod and flatfish in NAFO Area
corresponding to a cod end mesh size of 120 millimeters

by

A. Vazquez

Instituto de Investigaciones Marinas
Muelle de Bouzas, Vigo, Spain

The selectivity by length sizes of the fish by bottom trawling gear does not have a "knife edge" shape but is like a sigmoid curve (see Figures 1 and 2). Owing to this feature some fish of size greater than the 50% selection length escape the cod end; also fish of size smaller than that length are retained to same degree. The reduction of mesh size by fishermen would be induced initially, not to catch more small fish, but to reduce escape of large fish. The purpose of this paper is to illustrate the under size catch and the quantify of such under size fish in several scenarios if a minimum landing size were introduced.

Once a mesh size regulation is established there is no defined criterium to fix a minimum landing size and the corresponding percent of undersize fish permissible in the catch. It seems reasonable that the minimum landing size be smaller than 50% selection length. But, nevertheless even if the minimum landing size is equal to the length of the fish for a low selection percent such 5 to 25 %, the proportion of under size fish in the catch will depend on its abundance at sea and will change constantly with variation of length distribution of the stock.

Cod

Selection curves of manilla cod end for cod in Newfoundland Banks were calculated by Hodder in the 1960's (Wells, 1981) (Figure 1). The selection factor obtained, 3.49, agrees with the mean value of all values published for that material in the ICES area: S.F. = 3.47 (Holden, 1971).

Nylon (polyamide) is now the most common material for trawling cod ends; its selection factor is somewhat greater than the manilla one that is usually taken as reference. A selection curve of polyamide for 2J3KL cod was calculated by Minet et al. (1980) and the selection factor was 3.81. The selection factor of polyamide for ICES area presented by Holden (1971) is S.F. = 3.96, with a range from 3.66 to 4.09 depending of the type of polyamide used.

For this paper we use a selection factor for nylon: S.F. = 3.81 and a cod end mesh size of 120 mm. Corresponding 50% retention size is 46 cm. The selection curve for 120 mm mesh size is that of 140 mm polyamide (Minet et al., 1980) moved in parallel up to 50% selection size coincide with 46 cm. We think that this procedure is acceptable with the scope of this analysis because mesh sizes differences are not so large. Cod lengths corresponding to several retention percents were calculated from the selection curve and are presented in the following table. Selection curves of double manilla (Figure 1) have higher slopes and lengths for the same retention percents (< 50%) would be larger.

To calculate the percent of the cod catches with size under

previous reference lengths on total catch, the Flemish Cap cod stock in July 1990 (Table 1) was chosen. There are two reasons: the stock length structure was calculated in the survey with a 35 mm mesh size cod end, and Flemish Cap must presently be the worst scenario due to the large abundance of juveniles in relation to adults. The percent of the fish catches with sizes under a certain length is equal to the accumulated trawlable biomass up to that length. Results are:

selection percent	length cm	percent of undersize catch
5	28	0
10	32	0
15	35	0
20	37	1
25	40	2
50	46	10

In commercial fishing, the cod end is often full which reduces escapement of small size fish; this situation is not considered in the theoretical model used, the effect of which is to increase retention percentage.

American plaice

The most recent selectivity experiments are those of Walsh et al. (1989) that calculate selection factors of 2.4 and 2.3 for mesh sizes of 140 and 155 millimeters respectively (Figure 3). Konstantinov et al. (1982) obtained similar values with polyamide: 2.2 and 2.3 for mesh sizes of 127 and 134 millimeters respectively; to explain large juvenile retention these authors fit empirical data to a particular model (figure 4), different from the general one based on a sigmoid function.

The 50% selection length for 120 mm mesh size and a selection factor: S.F. = 2.3, is 28 centimeters; that for S.F. = 2.4 is 29 cm. In our calculations we use the former selection factor; S.F. = 2.3 and move in parallel the selection curve shown by Walsh et al. (1989). We considered five months of 1990 as five different scenarios and used Spanish commercial length distributions (Vazquez et al., 1991) as the best approach to stock size structure. Those months were selected because sampling was very extensive in them. As in the case of cod, the results presented in the following table are only illustrative because they belong to particular situations.

retention percent	length cm	percent of undersize catch in scenarios described in Tables:				
		2	3	4	5	6
13	20	-	4	-	-	-
20	22	1	13	-	-	-
30	24	4	33	-	1	1
40	26	7	47	2	4	3
50	28	10	53	7	8	6

Results in scenario "3" are derived from a fishery based almost exclusively on juveniles, a situation that must be avoided and not be considered representative of a acceptable fishing strategy.

Witch flounder

Selection factors of 2.16 and 2.15 were calculated by Konstantinov et al. (1982) for 127 and 134 mm polyamide mesh size respectively. Selection curves (Figure 5) were used to calculate the retention percents presented in Tables 7 to 10 following the same procedure described for cod and American plaice. These tables are different possible scenarios and length distributions came from commercial catch sampling of Spanish freezers (Vazquez et al., 1991). Four months with more intensive sampling were chosen:

retention percent	length cm	percent of undersize catch in scenarios described in Tables:			
		7	8	9	10
15	18	-	-	-	-
20	20	1	2	1	1
26	22	6	6	3	3
38	24	17	19	9	7
56	26	36	42	20	19

The method used Spanish catch as representative of stock size structure, which is obviously an approximation, and has a large effect on the results of witch flounder presented in the preceding table. Here we compare Spanish catch at age frequencies (Vazquez et al. 1991) with Canadian survey results for Divisions 3LNO in the same year (Brodie et al, 1991):

age	Spanish catch	Canadian survey	rate
1	-	4,6	0
2	1,7	50,2	10
3	11,9	83,5	45
4	32,8	106,6	100
5	39,6	147,5	87
6	10,0	48,5	68
7	3,5	24,1	48
8	0,5	15,6	10
9	0,0	2,2	0
10	-	0,2	0

"Rate" means the quotients Spanish catch/Canadian survey multiplied by a factor to make the largest equal 100. These results seem indicate that the Spanish fleet was less efficient than the Canadian survey in fishing small American plaice, due to the smaller mesh size used in the survey. But also Spanish vessels were less efficient in fishing large American plaice due to the scarcity of the oldest age groups in the area where that fleet operates. The conclusion is that the proposed scenarios are the worst possible ones because the proportion of undersize catch must be reduced for vessels fishing in the complete area of the species distribution.

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Table 1 - Cod stock length distribution on Flemish Cap according to 1990 survey (Vazquez, 1991) using a 35 mm mesh size in the cod end. Trawlable biomass corresponding to a polyamide mesh size of 120 mm. (frequencies and biomass divided by 10000).

length	frequency	mean weight (gr)	Accumulated total biomass		selection (%)	Accumulated trawlable biomass	
			(Kg)	%		(Kg)	%
9-11	7	9	0	0	0		
12-14	248	20	5	0	0		
15-17	1846	37	73	0	0		
18-20	595	62	110	0	0		
21-23	930	97	201	0	0		
24-26	4736	143	876	2	1	7	0
27-29	5884	201	2059	4	3	42	0
30-32	2410	273	2718	5	7	88	0
33-35	1599	361	3295	6	12	158	0
36-38	2217	466	4329	8	18	344	1
39-41	2848	590	6011	11	27	798	2
42-44	3715	734	8739	16	37	1807	5
45-47	4292	900	12604	23	50	3740	10
48-50	5207	1090	18279	34	60	7145	19
51-53	4858	1304	24615	45	70	11580	30
54-56	4446	1545	31484	58	80	17075	44
57-59	3086	1814	37082	68	86	21889	57
60-62	2585	2112	42542	78	92	26913	70
63-65	1747	2442	46809	86	95	30966	80
66-68	973	2805	49538	91	97	33613	87
69-71	414	3202	50863	93	99	34925	91
72-74	109	3634	51259	94	100	35322	92
75-77	69	4105	51543	95	100	35605	92
78-80	152	4614	52244	96	100	36306	94
81-83	86	5164	52688	97	100	36750	95
84-86	69	5756	53085	97	100	37147	96
87-89	26	6392	53251	98	100	37313	97
90-92	39	7073	53527	98	100	37589	98
93-95	33	7801	53785	99	100	37847	98
96-98	32	8578	54059	99	100	38121	99
99- 1	33	9405	54369	100	100	38432	100
102- 4		10283	54369	100	100	38432	100
105- 7		11215	54369	100	100	38432	100
108-10		12202	54369	100	100	38432	100
111-13	7	13245	54462	100	100	38524	100

Table 2 - American plaice catches sampled on board Spanish fleet in Division 3NO in January 1990. Trawlable biomass corresponding to a polyamide mesh size of 120 mm.

length	frequency	mean weight(gr)	Accumulated total biomass		selection (%)	Accumulated trawlable biomass	
			(Kg)	%		(Kg)	%
10-11		10	0		0		
12-13	52	18	1	0	0		
14-15	358	28	11	0	1	0	0
16-17	975	42	52	1	4	2	0
18-19	2491	60	202	3	7	12	0
20-21	4053	83	540	7	13	56	1
22-23	5571	112	1163	16	20	181	4
24-25	3309	147	1648	22	30	326	7
26-27	1902	188	2006	27	40	470	10
28-29	1636	237	2394	32	50	664	14
30-31	1760	294	2912	39	60	974	21
32-33	2426	360	3787	51	68	1569	33
34-35	1524	436	4451	60	76	2074	44
36-37	1248	522	5103	69	82	2609	55
38-39	816	619	5609	76	86	3043	64
40-41	530	728	5995	81	90	3391	71
42-43	479	850	6402	86	93	3769	79
44-45	288	985	6685	90	95	4039	85
46-47	163	1134	6870	93	97	4218	89
48-49	111	1298	7014	95	98	4359	92
50-51	133	1477	7211	97	99	4554	96
52-53	81	1674	7346	99	100	4689	99
54-55	29	1887	7401	100	100	4744	100
56-57		2118	7401	100	100	4744	100
58-59		2369	7401	100	100	4744	100
60-61		2639	7401	100	100	4744	100
62-63		2930	7401	100	100	4744	100
64-65		3242	7401	100	100	4744	100
66-67		3577	7401	100	100	4744	100
68-69		3935	7401	100	100	4744	100

Table 3 - American plaice catches sampled on board Spanish fleet in Division 3NO in February 1990. Trawlable biomass corresponding to a polyamide mesh size of 120 mm.

length	frequency	mean weight(gr)	Accumulated total biomass		selection (%)	Accumulated trawlable biomass	
			(Kg)	%		(Kg)	%
10-11		10	0		0		
12-13	4727	18	83	1	0		
14-15	9492	28	349	3	1	3	0
16-17	18096	42	1109	9	4	33	1
18-19	19066	60	2258	19	7	113	4
20-21	27023	83	4510	38	13	406	13
22-23	29448	112	7805	66	20	1065	33
24-25	9614	147	9215	78	30	1488	47
26-27	2645	188	9712	82	40	1687	53
28-29	1531	237	10076	85	50	1869	59
30-31	1063	294	10388	88	60	2056	64
32-33	1217	360	10827	92	68	2355	74
34-35	612	436	11094	94	76	2558	80
36-37	444	522	11326	96	82	2748	86
38-39	220	619	11462	97	86	2865	90
40-41	140	728	11564	98	90	2957	93
42-43	99	850	11648	99	93	3035	95
44-45	89	985	11736	99	95	3118	98
46-47	50	1134	11793	100	97	3173	99
48-49	3	1298	11797	100	98	3177	100
50-51	2	1477	11800	100	99	3180	100
52-53	1	1674	11801	100	100	3182	100
54-55	1	1887	11803	100	100	3184	100
56-57	2	2118	11807	100	100	3188	100
58-59	1	2369	11810	100	100	3190	100
60-61	1	2639	11812	100	100	3193	100
62-63		2930	11812	100	100	3193	100
64-65		3242	11812	100	100	3193	100
66-67		3577	11812	100	100	3193	100
68-69		3935	11812	100	100	3193	100

Table 4 - American plaice catches sampled on board Spanish fleet in Division 3NO in March 1990. Trawlable biomass corresponding to a polyamide mesh size of 120 mm.

length	frequency	mean weight (gr)	Accumulated total biomass		selection (%)	Accumulated trawlable biomass	
			(Kg)	%		(Kg)	%
10-11		10	0		0		
12-13		18	0		0		
14-15		28	0		1		
16-17	54	42	2	0	4	0	0
18-19	24	60	4	0	7	0	0
20-21	243	83	24	0	13	3	0
22-23	624	112	94	1	20	17	0
24-25	2228	147	420	5	30	115	2
26-27	3368	188	1054	14	40	368	7
28-29	3600	237	1908	25	50	795	14
30-31	3336	294	2890	37	60	1384	25
32-33	2382	360	3749	48	68	1968	36
34-35	1799	436	4533	59	76	2565	47
36-37	1068	522	5091	66	82	3022	55
38-39	921	619	5662	73	86	3513	64
40-41	498	728	6024	78	90	3839	70
42-43	714	850	6631	86	93	4403	80
44-45	345	985	6971	90	95	4726	86
46-47	127	1134	7115	92	97	4866	89
48-49	43	1298	7171	93	98	4921	90
50-51	108	1477	7330	95	99	5079	92
52-53	77	1674	7459	96	100	5207	95
54-55	44	1887	7542	97	100	5290	96
56-57	22	2118	7589	98	100	5337	97
58-59	16	2369	7627	98	100	5375	98
60-61	37	2639	7724	100	100	5473	100
62-63	7	2930	7745	100	100	5493	100
64-65		3242	7745	100	100	5493	100
66-67		3577	7745	100	100	5493	100
68-69		3935	7745	100	100	5493	100

Table 5 - American plaice catches sampled on board Spanish fleet in Division 3NO in April 1990. Trawlable biomass corresponding to a polyamide mesh size of 120 mm.

length	frequency	mean weight (gr)	Accumulated total biomass		selection (%)	Accumulated trawlable biomass	
			(Kg)	%		(Kg)	%
10-11		10	0		0		
12-13	3	18	0	0	0		
14-15	6	28	0	0	1	0	0
16-17	108	42	5	0	4	0	0
18-19	391	60	28	0	7	2	0
20-21	957	83	108	2	13	12	0
22-23	1953	112	327	6	20	56	1
24-25	2919	147	755	13	30	184	4
26-27	2004	188	1132	20	40	335	8
28-29	1534	237	1495	26	50	517	13
30-31	1370	294	1899	33	60	759	19
32-33	1359	360	2389	42	68	1092	27
34-35	1198	436	2911	51	76	1489	36
36-37	867	522	3364	59	82	1861	45
38-39	520	619	3686	64	86	2138	52
40-41	572	728	4103	71	90	2513	61
42-43	345	850	4396	77	93	2785	68
44-45	327	985	4718	82	95	3091	75
46-47	229	1134	4978	87	97	3343	82
48-49	98	1298	5105	89	98	3468	85
50-51	79	1477	5221	91	99	3583	87
52-53	61	1674	5324	93	100	3685	90
54-55	83	1887	5480	95	100	3842	94
56-57	24	2118	5531	96	100	3893	95
58-59	16	2369	5569	97	100	3931	96
60-61	26	2639	5638	98	100	3999	98
62-63	28	2930	5720	100	100	4081	100
64-65	3	3242	5729	100	100	4091	100
66-67	3	3577	5740	100	100	4102	100
68-69		3935	5740	100	100	4102	100

Table 6 - American plaice catches sampled on board Spanish fleet in Division 3NO in August 1990. Trawlable biomass corresponding to a polyamide mesh size of 120 mm.

length	frequency	mean weight (gr)	Accumulated total biomass		selection (%)	Accumulated trawlable biomass	
			(Kg)	%		(Kg)	%
10-11		10	0		0		
12-13	4	18	0	0	0		
14-15	15	28	0	0	1	0	0
16-17	77	42	4	0	4	0	0
18-19	110	60	10	1	7	1	0
20-21	190	83	26	2	13	3	0
22-23	251	112	54	5	20	8	1
24-25	371	147	109	10	30	25	3
26-27	325	188	170	15	40	49	6
28-29	301	237	241	22	50	85	10
30-31	173	294	292	26	60	115	13
32-33	151	360	347	31	68	152	18
34-35	115	436	397	36	76	190	22
36-37	134	522	467	42	82	248	29
38-39	79	619	516	46	86	290	33
40-41	86	728	578	52	90	346	40
42-43	103	850	666	60	93	428	49
44-45	77	985	742	67	95	500	58
46-47	65	1134	815	73	97	571	66
48-49	32	1298	857	77	98	612	71
50-51	38	1477	913	82	99	667	77
52-53	33	1674	968	87	100	723	83
54-55	16	1887	998	90	100	753	87
56-57	14	2118	1028	93	100	783	90
58-59	15	2369	1064	96	100	818	95
60-61	18	2639	1111	100	100	866	100
62-63		2930	1111	100	100	866	100
64-65		3242	1111	100	100	866	100
66-67		3577	1111	100	100	866	100
68-69		3935	1111	100	100	866	100

Table 7 - Yellowtail flounder catches sampled on board Spanish fleet in Division 3NO in January 1990. Trawlable biomass corresponding to a polyamide mesh size of 120 mm.

length	frequency	mean weight (gr)	Accumulated total biomass		selection (%)	Accumulated trawlable biomass	
			(Kg)	%		(Kg)	%
10-11		9	0		10		
12-13		16	0		10		
14-15	126	26	3	0	10	0	0
16-17	364	39	18	0	10	2	0
18-19	1046	56	77	2	15	11	0
20-21	1631	78	204	5	20	36	1
22-23	3933	105	618	15	26	144	6
24-25	5560	138	1386	34	38	436	17
26-27	4655	178	2213	55	56	899	36
28-29	2907	224	2865	71	74	1381	55
30-31	1375	279	3248	80	88	1718	68
32-33	1072	342	3614	89	98	2077	83
34-35	528	414	3833	95	100	2296	91
36-37	155	496	3910	96	100	2373	94
38-39	112	590	3976	98	100	2439	97
40-41	56	694	4015	99	100	2478	98
42-43	21	811	4032	99	100	2495	99
44-45		940	4032	99	100	2495	99
46-47	21	1084	4055	100	100	2518	100
48-49		1242	4055	100	100	2518	100

Table 8 - Yellowtail flounder catches sampled on board Spanish fleet in Division 3NO in March 1990. Trawlable biomass corresponding to a polyamide mesh size of 120 mm.

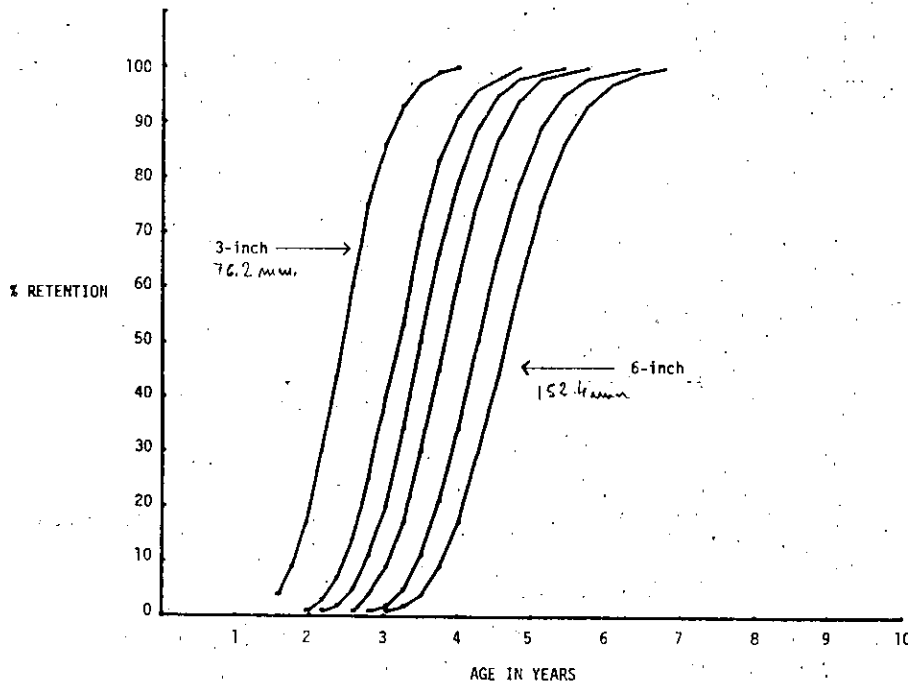
length	frequency	mean weight (gr)	Accumulated total biomass		selection (%)	Accumulated trawlable biomass	
			(Kg)	%		(Kg)	%
10-11	2	9	0	0	10	0	0
12-13		16	0	0	10	0	0
14-15	54	26	1	0	10	0	0
16-17	490	39	21	0	10	2	0
18-19	1702	56	117	1	15	16	0
20-21	4718	78	486	5	20	90	2
22-23	10538	105	1595	16	26	379	6
24-25	13504	138	3460	35	38	1088	19
26-27	13537	178	5864	60	56	2434	42
28-29	6531	224	7329	75	74	3517	60
30-31	2984	279	8160	83	88	4249	73
32-33	1641	342	8721	89	98	4799	82
34-35	993	414	9133	93	100	5210	89
36-37	299	496	9281	95	100	5359	92
38-39	318	590	9468	97	100	5546	95
40-41	243	694	9637	99	100	5715	98
42-43	75	811	9698	99	100	5776	99
44-45	73	940	9767	100	100	5844	100
46-47		1084	9767	100	100	5844	100
48-49	6	1242	9774	100	100	5852	100

Table 9 - Yellowtail flounder catches sampled on board Spanish fleet in Division 3NO in November 1990. Trawlable biomass corresponding to a polyamide mesh size of 120 mm.

length	frequency	mean weight (gr)	Accumulated total biomass		selection (%)	Accumulated trawlable biomass	
			(Kg)	%		(Kg)	%
10-11		9	0		10		
12-13	71	16	1	0	10	0	0
14-15	1315	26	35	0	10	4	0
16-17	710	39	63	0	10	6	0
18-19	4175	56	299	1	15	42	0
20-21	7778	78	907	4	20	163	1
22-23	12636	105	2237	10	26	509	3
24-25	16687	138	4542	21	38	1385	9
26-27	17846	178	7712	35	56	3160	20
28-29	15701	224	11232	51	74	5765	36
30-31	11971	279	14569	66	88	8701	54
32-33	7269	342	17053	77	98	11136	69
34-35	5081	414	19158	87	100	13240	82
36-37	2329	496	20314	92	100	14397	89
38-39	1183	590	21011	95	100	15094	94
40-41	766	694	21543	98	100	15626	97
42-43	460	811	21916	99	100	15999	99
44-45	123	940	22032	100	100	16114	100
46-47		1084	22032	100	100	16114	100
48-49		1242	22032	100	100	16114	100

Table 10 - Yellowtail flounder catches sampled on board Spanish fleet in Division 3NO in December 1990. Trawlable biomass corresponding to a polyamide mesh size of 120 mm.

length	frequency	mean weight (gr)	Accumulated total biomass		selection (%)	Accumulated trawlable biomass	
			(Kg)	%	(%)	(Kg)	%
10-11		9	0		10		
12-13		16	0		10		
14-15	580	26	15	0	10	2	0
16-17	1040	39	56	0	10	6	0
18-19	1718	56	153	1	15	20	0
20-21	4258	78	486	3	20	87	1
22-23	8017	105	1330	8	26	306	3
24-25	10641	138	2800	17	38	865	7
26-27	14319	178	5343	32	56	2289	19
28-29	15473	224	8812	54	74	4856	40
30-31	12469	279	12287	75	88	7914	66
32-33	6363	342	14462	88	98	10046	83
34-35	2641	414	15556	95	100	11140	93
36-37	1087	496	16096	98	100	11679	97
38-39	317	590	16283	99	100	11866	99
40-41	156	694	16391	100	100	11974	99
42-43	38	811	16422	100	100	12005	100
44-45	38	940	16457	100	100	12041	100
46-47		1084	16457	100	100	12041	100
48-49		1242	16457	100	100	12041	100



Retention at age by various mesh sizes of cod on the Flemish Cap (3, 4, 4-1/2, 5, 5-1/2, and 6 inches).

Figure 1 - Selection curves of double manilla for cod with different mesh sizes (from Wells, 1979).

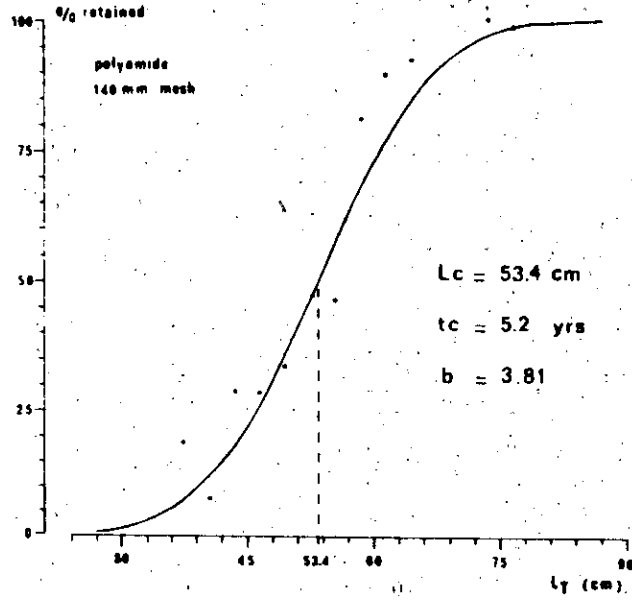


Figure 2 - Selection curves of polyamide 140 millimeters mesh size for cod (from Minet et al., 1980).

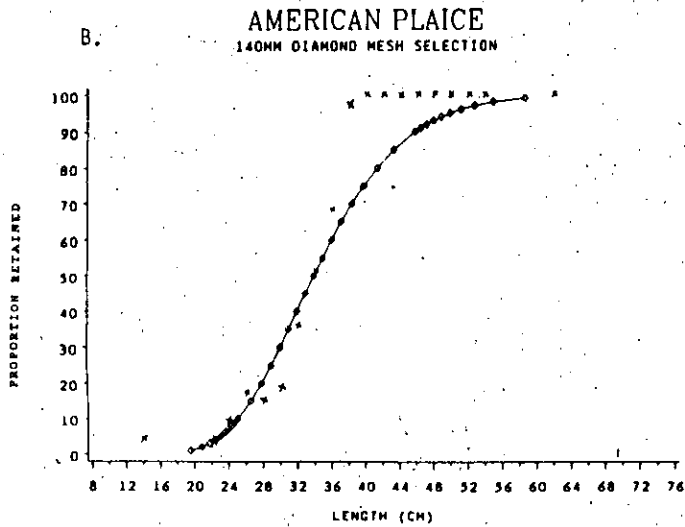


Figure 3 - Selection curves for American plaice with 140 millimeters mesh size (from Walsh et al., 1989).

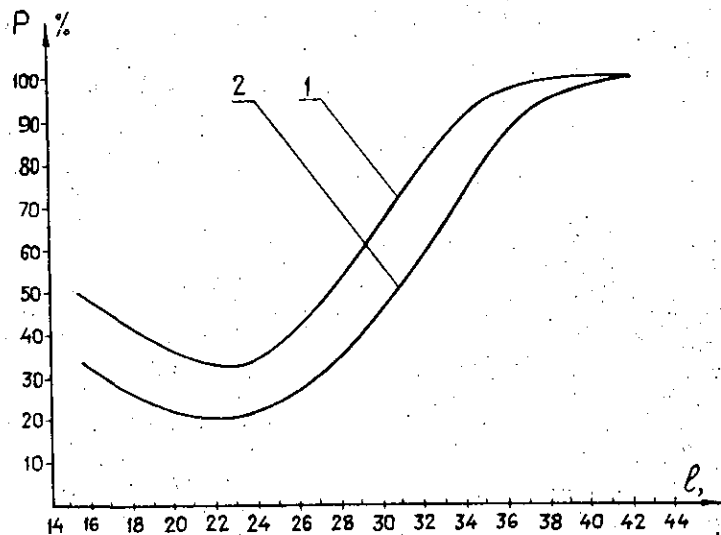


Figure 4 - Selection curves of polyamide 127 and 134 millimeters mesh size for American plaice (from Konstantinov et al., 1982).

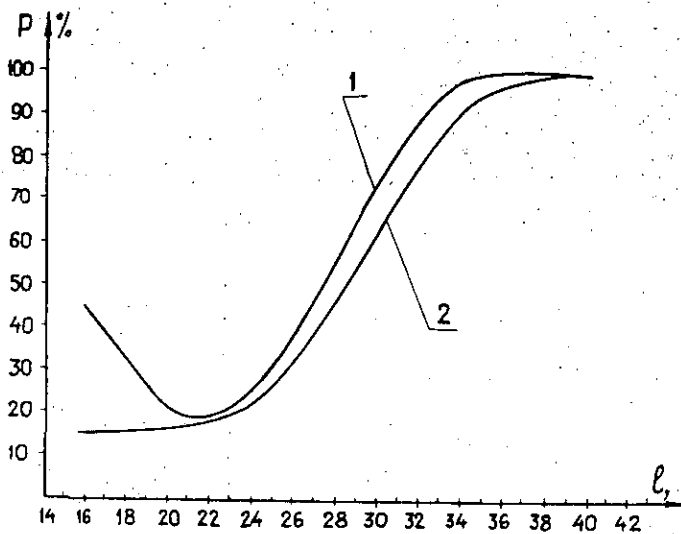


Figure 5 - Selection curves of polyamide 127 and 134 millimeters mesh size for yellowtail flounder (from Konstantinov et al., 1982).