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On Optimal Mesh Size When Fishing Redfish in the North Atlantic

by

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Abstract

The data on selectivity of bottom and midwater trawls obtained in the areas of the Northeastern, Northwestern Atlantic and the Irminger Sea by method of covers adviced by ICES or bag type are presented.

The abundance of fish held with midwater trawls with mesh size from 88 to 137 mm in the areas of the Northwest Atlantic varied from 52.8 to 3.1%. For bottom trawls with 98-156 mm mesh size the retention was more and fluctuated from 90.2 to 47.9% because of by-catches of flatfish preventing redfish from escaping. ICES type cover had significantly more "masking effect", than those ones of the bag type. The redfish from the catches in the Northeast and Northwest Atlantic under the similar length had the similar girth, that made it possible to disseminate the results on selectivity to these both areas. Calculations of profit from the substitution of 103 mm mesh size for 132 mm when fishing redfish showed, that a minute positive effect appeared 7-10 years after the mesh size having been changed. Summary losses of catch after the mesh size having been changed will not be compensated after 12-15 years in all the cases. The analogous results were obtained for fishing by midwater trawls in NAFO Div. 3N.

When fishing redfish in the Irminger Sea augmenting the mesh size to more than 120 mm under the different allowable intensity of fishing does not lead to the positive result.

Introduction

Nowadays fisheries represent an important factor having an impact on biological resources and may lead to disastrous consequences without due management. Regulatory measures for fishery are versatile and may include very variable demands and conditions limiting and restraining fishery activity within the certain scientifically substantiated bounds. One of the necessary conditions of rational utilizing fish commercial stocks is selective fishery on the basis of restricting the minimu m mesh size in the trawl codend, that makes it possible to limit the catch of immature fishes and avoid an excessive escapement of large fish. Groundless increase in allowable mesh size may cause the loss of practical sence of fisheries because of low fishery efficiency.

Scientific substantiation of optimum mesh size is based on experimental determining trawl codend selectivity, evaluating immediate and long-term losses and profits due to changing one mesh size to another.

The optimal mesh size should be regarded as one providing maximum escapement of small fish under the minimum one of commercial size fish. If the number of commercial size fish escaped from a codend with a certain mesh size surpasses considerably the number of relatively small fish the efficiency of this mesh size ought to be doubted. In any case, criterium of efficiency coming from changing to any new mesh size will be a value of long-term profit for fishery.

When determining minimum mesh size in the trawl codends for redfis h fishery the main diffuculties are connected with the lack of data on the survival of fish escaping from a trawl during hauling. Some authors (Konstantinov, 1981; Konstantinov *et al*., 1983) consider that the fish escaping from trawl when heaving up dye. The main reason of mortality is, apparently, connected with quick change of hydrostatic pressure due to lifting the trawl. According to some data, the number of redfish escaping from the trawl when heaving up is 18-30% (Lisovsky *et al*., 1995).

In the present paper PINRO's data obtained in the previous years from the results of determining the selectivity of trawl codends relatively deepwater redfish of the North Atlantic, published by ICES and NAFO, are generalized, some our results having not been published before, as well as the data obtained by the other scientists, are given.

Material and Methods

Investigations were carried out by PINRO's research vessels in the Bear and Spitsbergen Islands, in the Irminger Sea and the Northwest Atlantic in 1978-1994.

When conducting experimental works selectivity properties of trawl codends in bottom and midwater trawls with actual mesh size of 88-154 mm were determined, a catcher influence on the character of fish escapement from codend was estimated.

To determine selectivity of trawl codends fish catchers having smaller mesh size than in the codend and retaining the fish escaping through mesh were used. Both ICES type covers fixed only to the upper panel of codend, and those ones of the bag type enveloping the codend from each side were applied. The design of fish catchers provided for fish free passage from the trawl codend and the repeated retention in the catcher. In the paper by Walsh (Walsh, 1995) the results obtained with the aid of two codend trawl were given, and Korotkov (Korotkov, 1995, 1998) applied small-meshed catchers installed on the midwater trawl surface.

When analysing catches the number of caught fish having escaped from trawl through mesh was estimated.

The influence of catcher on fis h escapement from the codend was estimated by comparing size series and ratios of the size groups of fish from separate haul series applying codends with a cover and those ones with a blinder.

Advantages and losses of catches due to mesh size changes were calculated using Beverton-Holt and Gulland methods.

The main principles of methods mentioned above are presented in the monograph of Treschev (Treschev, 1974).

In 1990 the experiments to estimate the number of redfish escaping from the codend during trawling and when lifting trawl were carried out by RV "Krenometr" in the Barents Sea. The methods were based on dividing the cover into two parts by length. During trawling redfish having escaped from the codend concentrated in the end part of the cover. Before heaving up trawl it had been closed by the order from the vessel and fish escaping during lifting concentrated in the second part. After having heaved up the codend with a cover the catches in every part of the cover were measured and counted. The number of fish having escaped from the codend when lifting the trawl was estimated.

When conducting experimental works commercial trawls were used. Trawl codends were made of polyamid materials. The fishing regime corresponded to that one when fishing. Haulings were made from vessels with the main engine powered 1500-1700 kW.

Results

The materials obtained during experimental trawlings in the Northeast Atlantic are given in Table 1, in the Northwestern Atlantic – in Tables 2, 5 and in the Irminger Sea – in Table 3. In total, 29 series of valid trawlings were examined including 18 ones conducted in in the Northwest Atlantic, 8 – in the Barents Sea and 3 – in the Irminger Sea. Size series moda varied from 25-30 cm to 35-38 cm and the mean weight of fish caught – from 0.35 to 0.55 kg. Mean length of the fish caught in the areas of the Northwestern and Northeastern Atlantic were almost the same. Majority of tests were conducted using the covers of ICES type. Selectivity coefficient of the codends with such type of cover ranged from 0.7 to 2.4. In many cases it was impossible to determine the coefficient since according to the results of experimental works the retention of all size fish exceeded 50%. In this case selectivity

coefficients are given for fish length corresponding to 75% retention. Due to these reasons selectivity range is not given in Tables 1 and 2 for many cases.

It should be noted, that in all the cases of applying cover of bag type the retention of fish including the large individuals much less than when using the ICES type cover. So, when testing selectivity of the trawl codends with 98-156 mm mesh size and ICES type cover regarding deepwater redfish in the Northwest Atlantic the retention was equal to 90.2-66.7% and mean selectivity coefficient K_S - to 1.9: while the analogous indices for trawl codends with 88-137 mm mesh size obtained by the method of small-meshed cover were 52.8-3.1% and K_S = 2.7, respectively (see Table 2). The same indices were obtained for the redfish *Sebastes marinus* in the Barents Sea (see Table 1). This proves the important effect of ICES type cover on fish escapement from the trawl codend.

Length range of fish selected by 98-156 mm mesh includes, practically, the whole range of fish caught. So, for instance, for 98 mm mesh it made up from 14 to 40 cm, for 134 mm mesh – from 17 to 44 cm and for 156 mm mesh – from 22 to 42 cm, i.e. through the mesh of trawl codend fish from the whole range of fish caught may escape. Length composition of escaped and held fish is presented in Table 4.

During the investigations by Korotkov (Korotkov, 1995; 1998) it was revealed, that over the half of redfish caught by the trawl mouth when fishing in the Irminger Sea escaped through the side and lower panels of large-meshed rope surface of trawl and only small number was subjected to ordinary selection.

The analysis of measuring the largest girth of redfish in the Northwestern and Northeastern Atlantic (Konstantinov et al., 1983; Valdes and Fraxedas, 1981) showed that fish were geometrically similar with high reliability (Fig.1).

In December 1991 investigations to assess the number of fish escaped from the trawl bag with 128 mm mesh size during heaving up the trawl were carried out. The investigations showed that from 18 to 30% of the total amount of fish escaping when trawling escaped during the heaving up of the trawl (Lisovsky *et al*., 1995; Lisovsky, 1997a, 1997b). As it was revealed, that redfish were very sensitive to rapid change of hydrostatic pressure, there were some pre-conditions, that those fish would die (Konstantinov, 1981; Konstantinov *et al*., 1983).

Discussion

The analysis of data by Konstantinov *et al*. (Konstantinov K.N. *et al*., 1983; Valdes and Fraxades, 1979) showed, that redfish from the Northeastern and Northwestern Atlantic of the similar length had the same girth. This fact makes the basis to extend, in the first approximation, the data on selectivity to both these areas.

When conducting the investigations the selectivity coefficient of the trawl codends fluctuated from 1.7 to 3.1 (Tables 1-3). Such fluctuations are, primarily, conditioned, by the type of the trawl by which the materials on selectivity were collected. In all the cases selectivity of midwater trawls was higher than of the bottom ones. The type of cover influenced much the retention of fish. Apparently, the cover of ICES type produces a greater «masking effect» than the bagtype cover does. Obviously, in order to check the value of «masking effect» the selectivity should be estimated using another method, for instance, the method of alternate hauls.

When using available materials on selectivity the results obtained with the aid of bag type cover should be preferred.

Comparing deepwater redfish retention in midwater trawls with different mesh size in the codend in the Northwest Atlantic it may be noted that fish retention by abundance with mesh of 88, 118, 124, 126, 132, 137 mm equaled to 52.8, 24.0, 28.5, 12.7, 10.0 and 3.1%, respectively.

For bottom trawls with mesh from 98 to 156 mm fish retention fluctuated from 90.2 to 47.9%, correspondingly. It was, probably, conditioned by bycatches of flatfishes, which could close mesh and prevent redfish from escaping.

Specimens with length from 25 to 32 cm made up the bulk of the catches (more than 50%), and the portion of fish over 32 cm long was within the 19.5-46.5% limits (Table 5). Trawl codends with mesh larger 98 cm tended to reduce retention of fish from all the size groups. It will be noted that size composition of beaked redfish in the catches under 133 mm mesh differs slightly from that one with mesh size of 88 mm.

Deepwater redfish escapement from trawl codends with mesh size of 88-133 mm practically includes the whole length range of fish caught. Only insignificant group of fish 41-47 cm in length, total amount of which in catches

makes up about 5-8%, is unaffected by sifting out. Majority of fish escaped making up the basis of fishery have the length of more than 25 cm. The number of this size fish among escaped specimens ranges from 42 to 92%.

In the Barents Sea the selectivity of only bottom trawls has been investigated. The materials obtained using the cover of ICES type fully correspond to those from the Northwest Atlantic. The retention of beaked redfish in the codend with 114-126 cm mesh size varied from 94.7 to 70.0%. The retention of fish by codend rigged with a bag type cover was lower than with ICES type cover and varied from 61.0 to 9.4%. In our view, so large fluctuations of retention are caused, along with the other reasons, by various bycatches of flatfishes by bottom trawls.

In the Irminger Sea the selectivity of only midwater trawls was tested. During the investigations redfish with length of 28-46 cm at 35-38 cm length moda were caught (Table 3). Fish of 40, 44 and 45 cm long escaped from the codends with mesh size of 104, 130, 140 mm, respectively. For this, escapement constituted 3.4, 32.1 and 42.8% by number.

As Korotkov showed (Korotkov, 1995, 1998) more than a half of redfish caught by midwater rope trawl escape through its cover. These results require, apparently, new approaches to the estimation of mesh changing after-effects, as before the selectivity of only trawl codends on which fish retention in trawl (catch) depended has been determined.

Codend design also significantly influences the selectivity. So, the selectivity of trawl codend with lastridge is by 5-10% higher, than without it (Walsh, 1995). This circumstance should also be taken into consideration when working out fishery regulation measures.

Calculations of benefits and losses of catches done for bottom trawls (Konstantinov, 1981; Konstantinov *et al*., 1983; Lisovsky *et al*., 1995) (Figs. 2, 3, 4) show, that any increase of mesh size higher than 100 mm for bottom trawls in the Northeast Atlantic and Northwest Atlantic during redfish fishery will not lead to a positive result . Annual catches by bottom trawls during 5-12 years after the mesh size having been increased were lower, than those obtained by mesh less than 98 mm. A small positive result after 7-12 years does not compensate during 15-20 years the losses because of its increase. The analogous conclusions on mesh size increase efficiency were obtained by Blinov (Blinov, 1981).

In the Irminger Sea any increase higher than 120 mm will not lead to the positive result, at least, during 15 years (Tables 6 and 7) (Kondratyuk *et al*., 1988). During the fishery for redfish by midwater trawls in NAFO Div.3N any increase of a mesh size higher than 88 mm will not give a sufficient benefit (Lisovsky *et al*., 1995, Lisovsky, 1997a, 1997b) (Fig. 5, 6). When increasing the mesh size from 88 to 118 and 132 mm the benefit of fishery during the transitional period of 10 years will constitute from 0.9 to 9.7%, and during the transitional period of 15 years it will fluctuate from 5.6 to 11.5% depending on the intensity of fishery.

The change to fishery for redfish by bottom trawls with mesh size more than 100 mm, by midwater trawls in the Irminger Sea - more than 120 mm and by midwater trawls in Div. 3N - more than 90 mm will lead to reduction in fishing efficiency. To reach TAC it will be necessary to increase the fishing efficiency, that will result in the repeated catch of small redfish and, correspondingly, their escapement through the mesh and possible traumatic death of fish escaped from the trawl codend when heaving up the trawl due to quick change of hydrostatic pressure (Konstantinov, 1981; Konstantinov *et al.*, 1983; Lisovsky *et al*., 1995; Lisovsky, 1997a, 1997b).

It should be noted, that trawls with mesh size of not less than 100 mm have been applied during the fishing of beaked redfish in the Barents Sea since 1983.

Having the same length redfish from the catches in the Northeastern and Northwestern Atlantic have the same maximum girth, that gives the reason to use the obtained data on selectivity for these both areas.

Conclusions

ICES type covers prevent deepwater redfish clear escaping off the trawl codend. Bag type covers enveloping trawl codend and coming 40-45 cm behind it excercise much lower influence on the number of fish escaped from the trawl codend.

Bottom trawl codend selectivity is much lower, than that one of midwater trawls. It is conditioned by bottom trawl bycatches of flatfishes, which close trawl codend meshes and prevent small fish from escaping.

Length ranges of fish both held and sifted out by trawl codend were almost equal. Only 40-50 cm long fish which abandance made up 5-8% in the catches in the Northwestern and Northeastern Atlantic did not escape. Majority of fish escaped have the length of more than 25 cm, the age of 8-9 years and more, i.e. they are of the same length and age as the fish retained in trawl codends and making the basis of fishery. This size fish number made up 44-98% of fish escaped from codends with the mesh of 88-133 mm. The number of mature individuals longer than 32 cm sifted out from trawl codends rises from 6% for 98 mm mesh to 24% under that one having the length of 133 mm. I.e., the increase in mesh size from 88 to 134 mm leads to essential losses of catches because of the escapement of individuals more than 25 cm in length, which have the commercial importance. It will result in the necessity to augment fishing efforts in order to exhaust quotas. When fishing by bottom trawls this increase will make up 25%, 47% and 133% for mesh of 119 mm, 124 mm and 133 mm, respectively. Increase in fishing efforts to exhaust the quota will make more possible repeated escapement of redfish through trawl nets and their death caused by injuries obtained while escaping during heaving up the trawl and, probably, during trawling. All this will augment mortality of deepwater redfish and have a negative impact on its stocks.

Calculations of profits from changing the mesh size from 103 to 132 mm in fishing the deepwater redfish show, that a slight positive effect only appears 7-10 years after this substitute. Total losses of catch after the mesh size having been changed will not be compensated during 12-15 years in all the cases. It should be taken into consideration that calculations do not cover probable mortality of deepwater redfish connected with the escapement from trawl codends.

Thus, applying the trawls with mesh size exceeding 100 mm when bottom fishing the deepwater redfish practically do not improve length-age structure of the stock and their stock reproduction. These conclusions, in the first place, relate to fishing deepwater redfish in the Northeast Atlantic, where already in 1983 the specialized fishery of deepwater redfish is executed by trawls with mesh of not less than 100 mm in the codend.

The analogous results were obtained in calculating the benefit from fishing by midwater trawls with mesh more than 90 mm in NAFO Div. 3N.

In the Irminger Sea there is no point in fishery for redfish by midwater trawl with mesh more than 120 mm, since under any intensity of fishing the positive result will not be reached.

When establishing measures to regulate fishery for deepwater redfish the effect of the trawl codend design and the type of trawl, primarily, of the midwater one, should be also taken into consideration.

Nuance, for fishing deepwater redfish by bottom trawls a mesh with the size of 100 mm and by midwater trawls – of 120 mm in the Irminger Sea and 90 mm in NAFO Div. 3N may be recommended.

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Table 1. Results from investigations on determination of selectivity of trawl bags with different mesh size in relation with redfish, carried out in the Barents Sea.

Name of vessel		"Krenometr"				"Menzelinsk"		"Zemljansk"	
Inner bag mesh size, mm		115	121	123	126	124	133	128	
Type of cover		ICES				Bagtype			
Number of fish in the catch, spec.	In bag	19103	13694	24817	46676	141065	18650	2196	343
	In cover	1074	4401	10302	18806	90189	34475	4053	3297
	Total	20177	18095	35119	65482	231254	53125	6249	3640
Length range offish, cm	retained	21-48	19-50	19-50	21-50	15-44	19-44	23-44	23-46
	escaped	21-46	19-46	19-44	19-46	15-44	17-40	17-42	17-42
	caught	21-48	19-50	19-50	19-50	15-44	17-44	21-44	17-46
Size series mode, cm		31-32	31-32	31-32	31-32	25-30	27-32	31-32	31-32
Mean weight of one spec., kg	Retained	0.444	0.498	0.450	0.413	0.282	0.412	0.402	0.429
	Escaped	0.317	0.317	0.350	0.358	0.278	0.343	0.346	0.343
	Caught	0.440	0.454	0.420	0.397	0.280	0.367	0.366	0.351
Mean length offish, cm		33	33	32.3	32.0	28.0	31.2	30.9	30.6
Retention by number, %		94.7	75.7	70.7	71.3	61.0	35.1	35.1	9.4
Selectivity coefficient		-	2.33	Ks75%- 2.73	Ks75%- 2.70	2.1	2.2	2.6	2.9
Selectivity range, cm		-	-	-	-	-	10.0	10.0	7.0

Table 2. Results from investigations on determination of selectivity of trawl bags with different mesh size in relation with redfish, carried out in the Northwest Atlantic.

Name of vessel*		S.	K.	M.	S.	S.	M.	M.	M.	M.	M.	V.	V.	Vg.		
Inner mesh size in codend, mm		98	119	124	125	127	127	133	134	133	156	126	137	88	118	132
Type of trawl		bottom trawl		midwater trawl	bottom trawl									midwater trawl		
Type of cover		ICES	ICES	Bagtype	ICES	w/c	ICES	ICES	w/c**	ICES	ICES	Bagtype		Bagtype		
Working area		2H	3M	3M,3N	2H	3M	3M	3M	3M	3L	3M	3M	3M	3N	3N	3N
Number of fish in the catch, spec.	In codend	21278	6117	46974	20778	28056	88049	53415	28271	46349	21131	2948	557	12767	2144	2119
	In cover,	2322	3060	117937	8977	12133	15501	10641	30807	21640	10391	20222	17133	11412	6784	18073
	Total	23628	9179	154911	29755	40189	103550	64056	59078	67989	31522	23170	17690	24179	8928	20192
Length range offish, cm	retained	18-43	19-52	22-47	20-48	22-48	22-47	21-46	22-49	17-50	21-44	21-43	24-46	17-45	17-47	16-45
	escaped	14-40	14-45	22-40	20-42	21-45	21-41	21-43	20-40	21-47	22-42	14-38	14-40	15-34	16-39	16-43
	caught	14-45	14-52	22-47	20-48	21-48	21-47	21-46	20-49	17-50	21-44	14-43	14-46	15-45	16-47	16-45
Mean weight of one spec., kg	retained	0.440	0.660	0.350	0.510	0.490	0.950	0.510	0.330	0.504	0.550	0.437	0.497	0.294	0.328	0.351
	escaped	0.225	0.340	0.190	0.270	0.350	0.430	0.410	0.236	0.389	0.450	0.294	0.282	0.149	0.189	0.205
	caught	0.420	0.550	0.230	0.470	0.450	0.530	0.500	0.259	0.470	0.510	0.312	0.289	0.224	0.225	0.220
Mean length of one spec. of caught fish, cm		30.6	33.2	28.8	31.8	31.3	33.5	32.6	28.1	31.9	33.0	31.2	33.1	27.2	27.8	28.9
Size series mode of caught fish, cm		30-32	35-37	30; 35	26-28; 32	32-35	31-36	31-32; 35-36	27-28	27-30	31-36	23-26; 29-32	24-30	18-20; 23-29	18-20; 23-29	18-20; 23-29
Retention by number, %		90.2	66.7	28.5	69.8	69.8	85.1	83.4	47.9	68.2	67.0	12.7	3.1	52.8	24.0	10.0
Selectivity coefficient		Ks75% 2.2	2.4	2.4	1.8	1.9	Ks75% 2.1	Ks75% 2.0	2.00	1.8	1.7	2.9	2.9	2.8	2.5	2.6
Selectivity range, cm		-	8.0	8.4	-	-	-	-	-	-	-	5.6	4.3	4.4	6.6	9.0

Notes: * The names of vessels are as follows: S. - "Suloy", K. - "Kononov", M. - "Menzelinsk", V. - "Vilnius", Vg. - "Vaigach".
** Method testing of selectivity – alternative trowling.

Table 3. Characteristics catches trawl bags used for deepwater redfish fishery in the Irminger Sea.

Mesh size, mm	40	104	130	140
Minimum length offish caught, cm	28	29	28	29
Maximum length offish caught, cm	46	45	46	45
Length mode offish caught, cm	35-38	35-38	35-38	35-38
Maximum length offish in cover, cm	-	40	44	45
Number of escaped fish, %	-	3.4	32.1	42.8
Selectivity coefficient	-	Ks75%-3,0	2.6	2.5
Selectivity range	-	-	5.8	6.6

Table 4. Content of deepwater redfish size groups in trawl codend and cover with different mesh in trawl codend.

Place of fish retention	Fish length, cm	Number offish, %, with mesh size, mm					
		88	98	119	124	134	133
In trawl codend	1 < 25	12.2	6.9	1.6	9.5	0.8	0.7
	25<1<32	68.3	58.6	52.0	84.8	54.1	52.8
	1>32	19.5	34.5	45.5	5.7	45.1	46.5
In cover	1 < 25	56.3	21.7	3.1	11.7	2.7	1.7
	25<1<32	41.6	72.5	72.5	82.6	91.6	74.4
	1>32	3.1	5.8	24.4	5.7	5.7	23.9

Table 5. Selectivity parameters for trawl codends with mesh size of 90 and 120 mm when fishing redfish by midwater trawls on the Flemish Cap Bank (Valdes and Fraxedes, 1981), as well as by bottom trawls codends with 90 and 105 mm mesh size with lastridge and without it (Walsh, 1995)

Indices	Midwater trawl		**Bottom trawl**			
	mesh 90 mm	mesh 120 mm	mesh 90 mm		mesh 120 mm	
			with lastridge	without lastridge	with lastridge	without lastridge
Total number of fish in the codend	6609	11657				
Fish length corresponding to 50 % retention, $L_{50\%}$, cm	28,1	29,6	26,9	27,2	32,1	28,5
$L_{25\%}$, cm	24,8	24,9	25,3	24,9	30,5	25,2
$L_{75\%}$, cm	29,7	33,0	28,6	30,2	33,8	31,8
Selectivity coefficient	3,1	2,5	3,1	3,0	3,0	2,6
Selectivity range	4,9	8,1	3,3	5,9	3,3	6,6
Length moda, cm	26-29 33-35	26-29 33-35	-	-		

Table 6. Effect from the increase of mesh size from 120 mm to 130 mm under different exploitation rate for deepwater redfish, %.

Year of fishing	Intensivity of fishing				
	0.15	0.20	0.25	0.30	0.35
1	-16.8	-16.8	-16.8	-16.8	-16.8
2	-16.8	-16.8	-16.8	-16.8	-16.8
3	-16.7	-16.7	-16.7	-16.7	-16.7
4	-16.5	-16.4	-16.4	-16.4	-16.4
5	-15.8	-15.7	-15.6	-15.6	-15.5
6	-15.0	-14.8	-14.7	-14.6	-14.5
7	-14.0	-13.7	-13.4	-13.3	-13.1
8	-12.4	-11.9	-11.5	-11.3	-11.1
9	-10.4	-9.7	-9.2	-8.8	-8.5
10	-8.7	-7.8	-7.2	-6.7	-6.3
11	-7.5	-6.4	-5.7	-5.1	-4.7
12	-6.7	-5.6	-4.7	-4.1	-3.7
13	-6.2	-5.0	-4.2	-3.5	-3.0
14	-6.0	-4.8	-4.0	-3.3	-2.8
15	-6.0	-4.8	-3.9	-3.3	-2.8

Table 7. Effect from the increase of mesh size from 120 mm to 140 mm at different intensivity of fishing for deepwater redfish. %

Year of fishing	Intensivity of fishing				
	0.15	0.20	0.25	0.30	0.35
1	-34.7	-34.6	-34.6	-34.6	-34.6
2	-34.6	-34.6	-34.6	-34.6	-34.6
3	-34.5	-34.5	-34.4	-34.4	-34.4
4	-34.1	-34.0	-34.0	-34.0	-33.9
5	-33.0	-32.8	-32.7	-32.6	-32.5
6	-31.8	-31.5	-31.2	-31.1	-30.9
7	-31.1	-29.6	-29.2	-28.9	-28.7
8	-27.4	-26.6	-26.0	-25.6	-25.3
9	-24.0	-22.8	-22.0	-21.3	-20.8
10	-20.8	-19.3	-18.2	-17.3	-16.7
11	-18.4	-16.6	-15.3	-14.3	-13.6
12	-16.8	-14.8	-13.4	-12.4	-11.5
13	-15.8	-13.7	-12.2	-11.1	-10.2
14	-15.4	-13.3	-11.8	-10.6	-9.7
15	-15.4	-13.2	-11.7	-10.6	-9.7

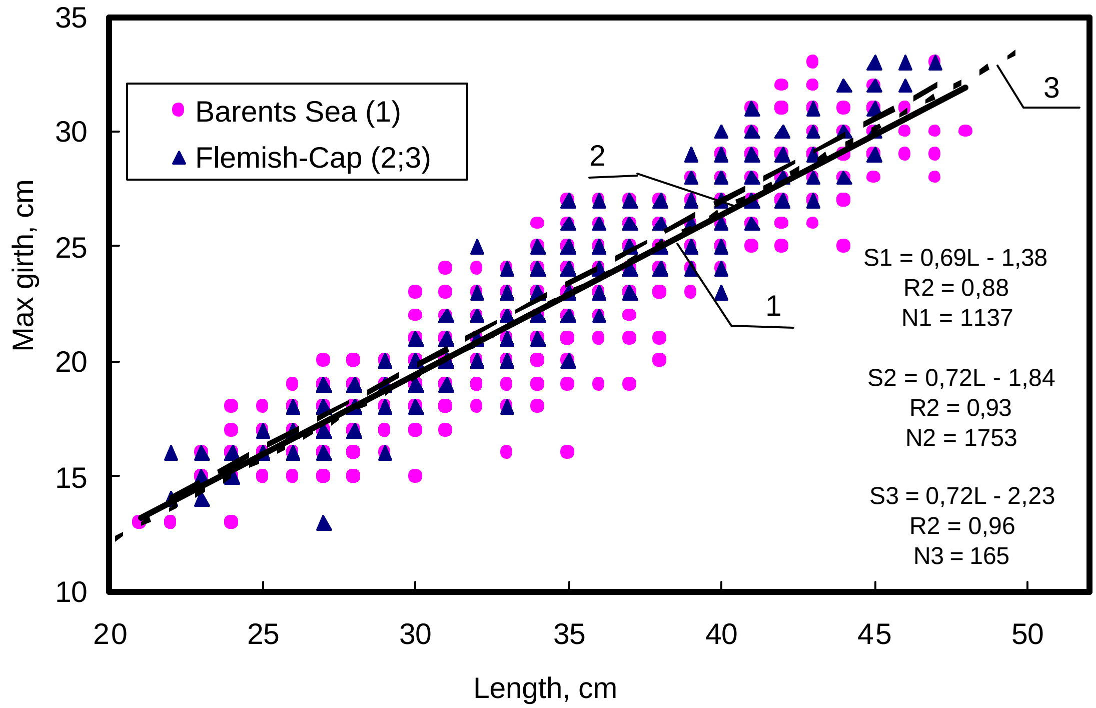

Fig.1. Relationship between the length and maximum girth for beaked redfish in the Barents Sea and Flemish-Cap (Konstantinov *et al*., 1983 /1,2/; Valdes and Fraxedes, 1981 /3/.

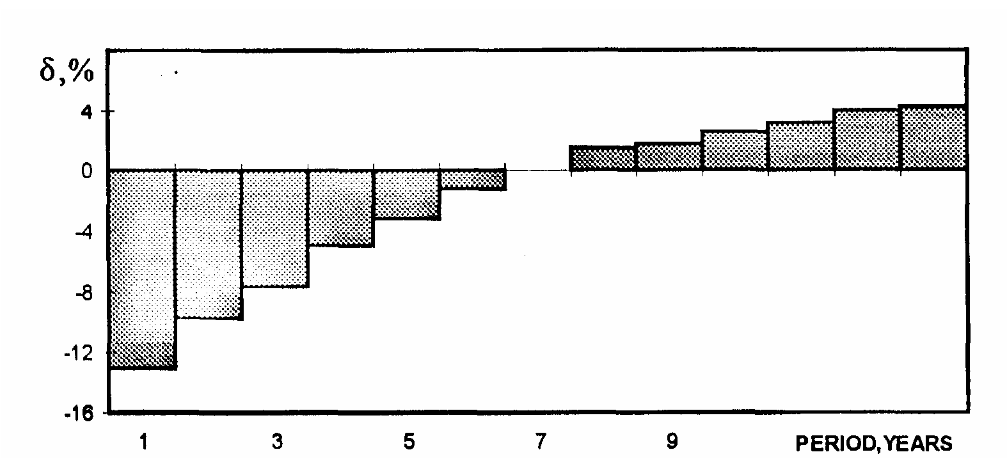

Fig. 2. Longtime effect d(%) of changing 103 mm for 114 mm mesh size in deepwater redfish fisheries.

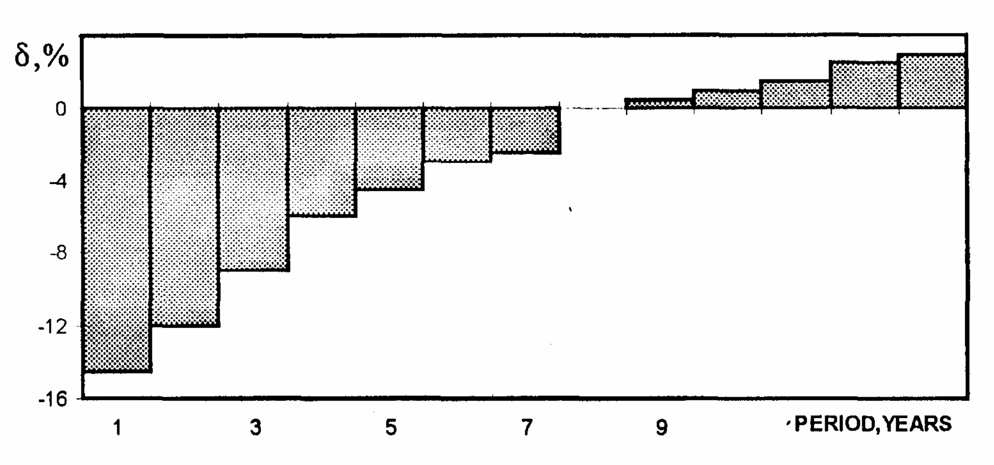

Fig. 3. Longtime effect d(%) of changing 114 mm for 123 mm mesh size in deepwater redfish fisheries.

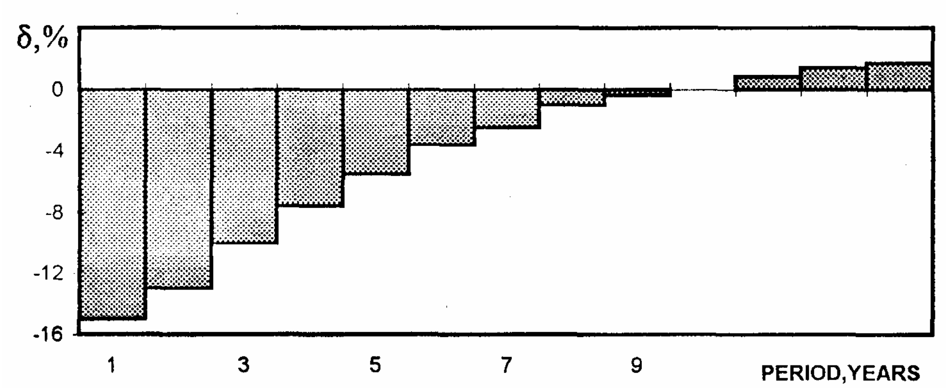

Fig. 4. Longtime effect d(%) of changing 123 mm for 132 mm mesh size in deepwater redfish fisheries.

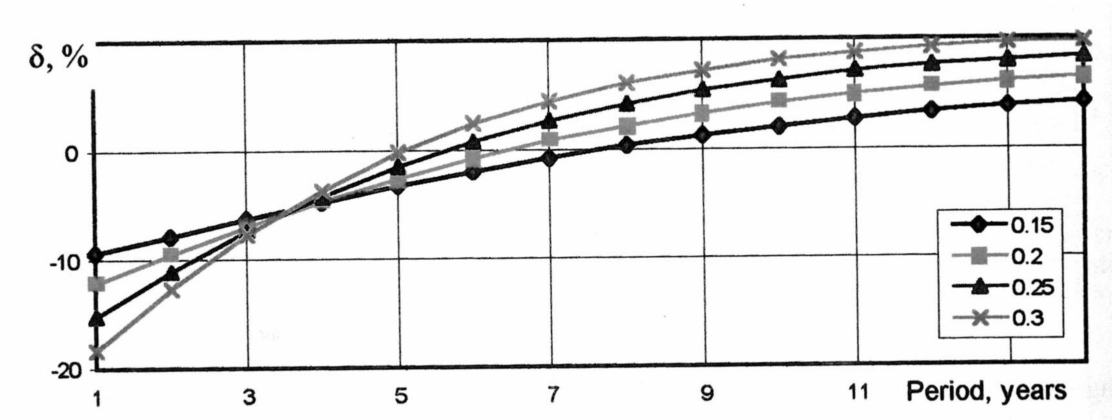

Fig. 5. Longtime effect (d) of variable mesh size from 88 mm to 118 mm and different fishing mortality rate of deepwater redfish fishery in NAFO Div. 3N.

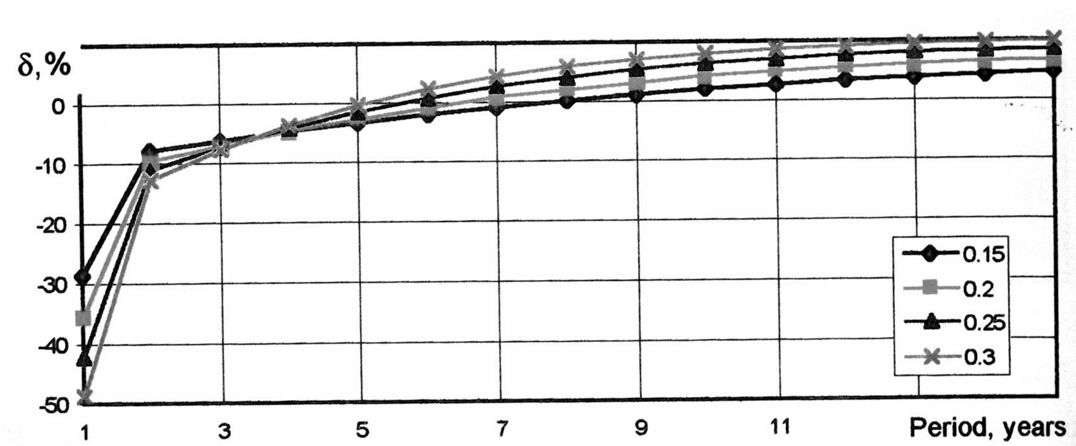

Fig. 6. Longtime effect (d) of variable mesh size from 88 mm to 132 mm and different fishing mortality rate of deepwater redfish fishery in NAFO Div. 3N