Northwest Atlantic Fisheries Organization

Serial No. N5384 **NAFO SCR Doc. 07/32**

SCIENTIFIC COUNCIL MEETING – JUNE 2007

On minimal trawl codend mesh size in redfish fishery in Div.3O of NAFO Regulatory Area

by

S.Lisovsky, A.Pavlenko, S.Golovanov and A.Vaskov

Polar Research Institute of Marine Fisheries and Oceanography
(PINRO), 6 Knipovich Street, Murmansk, Russia, e-mail: inter@pinro.ru

Abstract

In Div.3O, primarily, redfish of two species, *S. mentella* and *S. fasciatus*, are harvested by trawls with 90-130 mm mesh size. The bulk of catches (85%) is made up by *S. fasciatus*.

Calculations of consequences as a result of changes of mesh size in the codends of midwater trawls allowing for the traumatic mortality of redfish due to barotraumas show that decrease in mesh size in the midwater trawls in redfish fishery in Div.3O from 130 to 90-100 mm will not do any harm to the other stocks and will enlarge the efficiency to a great extent. With diminishing mesh size the average yield per recruit allowing for traumatic mortality and with the fishing one, F, being equal to 0-0.3 would increase in 1.3-7.8 times, respectively. In prospect, this diminishing of mesh size would be profitable for fishery.

Introduction

According to STATLANT 21A statistical report, in recent decade, in Div.3O, the catch of redfish species varied from 5.1 x 10^3 t (1997) to 22.6 x 10^3 t (2001), in 2005, the catch was estimated at 10.5 x 10^3 t.

One of the technical measures for rational exploitation of fish commercial stocks is limitation of minimal mesh size in the trawl codends that permits young fish catch to be minimized and the excessive escape of commercial size fish to be avoided.

At present, in international waters of Div.3O in NAFO Regulatory Area, redfish trawl fishery is limited by minimal mesh size of 130 mm in codends and TAC (Anon., 2005). Measure for redfish species fishery has not been established.

In 200 mile zone of Canada, in this area, the minimal mesh size in trawls is much less than 130 mm (Anon., 2004).

Therefore, it is important to determine the optimal mesh size in the fishery of redfish species in the entire Div.3O of NAFO Regulatory Area, in both the international waters and 200 mile zone of Canada.

1. Material, methods and results

1.1 Selectivity

The selectivity of trawl codends with 90-130 mm standard mesh size in bottom redfish fishery was studied aboard Russian trawler “Leonid Galchenko”, in August-October 2006. The vessel is classified as the middle tonnage trawler of the Atlantic-333 type.

The main details of the vessel are: the largest length – 62.2 m; width – 13.8 m; draft – 5.22 m; overall displacement – 2,458 t; tonnage – 722 t; power of the main engine – 2,040 kWt.

During investigations, Russian 36.5/37.4 m four panel demersal trawl rigged with exchangeable codends with standard inner mesh size of 90, 120 and 130 mm was applied. Four panel trawl codends were made of polyethylene netting from the double cord with 4 and 6 mm diameter (PE-DBL–4–90; PE-DBL-6-130) with 90 and 120 mm inner mesh size as well as from the single cord (PE-8-120) with 120 mm inner mesh size. To open the trawl the boards of Thyborøn 7 type with an area of 6.19 m^2 were used. The length of trawl codend cylindrical part was equal to 20 m.

The hauls were made at 280-600 m depths. The speed of trawlings varied from 3.6 to 3.8 knots. Fishing duration was determined by fishing conditions and varied within the limits of 0.5-4.0 hours.

The trawl codend selectivity was determined by method of the small mesh cover with 40 mm inner mesh size which completely covered the codend and was fastened to its conic part at the distance of 4 m in front of the site of seaming with cylindrical part. The perimeter of the cover was 50% more than that one of the codend cylindrical part. After mounting it was 3 m standing out behind the codend.

Codend mesh size was measured using a wedge gauge, a cuneal plate of the ICNAF type, putting into mesh with the effort of 49 N and determined as the arithmetic average of measurements of 20 meshes one after another along its upper panel. The measurements of mesh were made before the start of each trial series and after its completion.

The research data were collected and processed in accordance with ICES advice to study trawl selectivity (Anon., 1996). All the fish from the codend and cover were poured into tanks separately and measured with dividing into species. Measured were 300-400 redfish from catches by the trawl codend and a cover. The rest fish having not been measured were completely counted or measured by volume and the size series were corrected aptly. When analyzing the catch was reduced to standard one hour duration of hauls.

The analysis of obtained data was made with the aid of the software based on SELECT model and the task was solved by method of successive approximating, Solversel (Tadashi Tokai, 1997; Tadashi Tokai and Takahisa Mitsuhashi, 1998), which allowed us to estimate the parameters of selectivity by logistic or generalized logistic function of studied fish retention likelihood depending on fish length on the basis of optimizing solution.

The equation of generalized logistic Richard’s function is described by the equation (1):

$$r(l) = \{\exp(a+bl) / [1 + \exp(a + bl)]\}^{1/d}, \qquad (1)$$

where r(l) – the likelihood of the fish retention by length, l;
a, b, d – parameters of the function;
l – retained fish length.

Fish length corresponding to 50% retention by the codend with B-mesh was calculated by the equation (2):

$$\mathbf{L_{50\,\%}} = \frac{\log \boldsymbol{it}\,(0{,}5)^{\boldsymbol{d}} - \boldsymbol{a}}{\boldsymbol{b}}. \qquad (2)$$

Selectivity range was calculated by the equation (3):

$$\mathbf{SR = L_{75\,\%} - L_{25\,\%}} = \frac{\log \boldsymbol{it}(\ 0{,}75^{\boldsymbol{d}}) - \log \boldsymbol{it}(0{,}25^{\boldsymbol{d}})}{\boldsymbol{b}}, \qquad (3)$$

where $L_{75\%}$ and $L_{25\%}$ - fish length, corresponding to 75% and 25% retention.

The estimates were derived by minimizing of likelihood function (AIC). All the calculations were made using parameters derived in generalized logistic or logistic function having the estimating function criterion which was smaller (AIC).

The selectivity coefficient K_S was calculated by the formula (4):

$$K_s = \frac{L_{50\%}}{B}, \qquad (4)$$

where B – the inner mesh size

1.2 Morphometric characteristics of redfish species

To estimate morphometric parameters of redfish species *S.fasciatus* and *S.mentella* the fish total length and maximal body girth were measured. The girth was determined by flexible band with 1 mm discreteness.

1.3 Determination of catch size of the other fish species when fishing by bottom trawl with different mesh size

The catch of each trawl was poured to separate tanker, later the catch was counted and measured with dividing into species. Measured were 300-400 redfish from catch. The rest redfish which had not been measured and the bycatch were completely counted or measured by volume and the size series were corrected aptly.

1.4 Yield per recruit

In September-October 1990, in the Barents Sea, aboard the trawler “Krenometr”, PINRO conducted the researches to estimate the number of redfish escaped from the codend when lifting trawl. At that, it was assumed that based on that work the estimation of redfish traumatic mortality caused by the abrupt change of hydrostatic pressure as a result of fish ascending to surface layers would be possible. The mentioned reason of possible redfish mortality was pointed out by many researchers (Konstantinov, 1981; Konstantinov et al., 1983; Lisovsky et al., 1995, 1996; Lisovsky, 1997, 2001; Drevetnyak et al., 2004). The results of observations during commercial fishing have corroborated the assumptions. Indeed, when lifting a codend the dying redfish with traumatized internal organs can be observed on the sea surface.

In the research by that trawler, it was found that, when lifting the trawl, escaping were, on the average, 30 ± 4% of redfish as long as 20-36 cm of the total number of fish escaped from the codend with 121 mm mesh size during the entire period of haul. More probably the fish die as a result of barotraumas. In relation to all redfish caught by the trawl the portion of fish with that size range escaped during the trawl lifting was 19 ± 3%.

Later all the redfish escaped from the codend during the trawl lifting were considered as dead. The mortality of fish escaped from the trawl codend when hauling has not been studied in the paper. The contribution of different size groups to the total mortality as a result of traumas is different, therefore it is assumed that, due to this the total mortality because of this reason will depend on the trawl codend mesh selectivity.

The mortality portion of redfish from 20-36 cm length groups as a result of selectivity variation of codends was calculated by formula:

$$\varphi'_{Ftr\ i\,mesh} = \sum_{l=20}^{l=36} \frac{n'_{l_i}}{N'_{l_i}} \times \frac{S_{121}}{S_{i\,mesh}} \qquad (5)$$

where n'_{li} - the number of fish with li-length died as a result of going through the mesh when trawl lifting;

$N'_{li,}$ - the number of fish with li-length caught by trawl (catch by codend and cover);

S_{121}, $S_{i\ mesh}$ – portions of retention of fish by the trawl codend with 121 mm mesh and with that one which is different.

Allowing for made assumptions the variation of possible death portion of redfish with different length when trawl lifting depending on codend mesh size is shown in Fig.1.

Calculated in such a way mortality portion, φ'_{Ftr}, shows variation of traumatic death percentage when fishing with different mesh in relation to initial redfish abundance N_0 . Making comparisons with estimation of commercial stock reduction by different reasons, such as fishing, natural conditions and others the reduction in commercial stock because of traumatic death $\varphi'_{Ftr.}$ is calculated by equation (6) (Zasosov, 1976):

$$\varphi_{Ftr.} = n/N_0, \qquad (6)$$

where n – number of fish died as a result of traumas when going through the mesh when trawl lifting in the fishery by whole fleet;

N_0 - initial abundance of commercial stock.

We believe that there is a dependence between the reduction in φ-individuals and total mortality rate, Z, which is determined by equation (Zasosov, 1976):

$$\varphi = 1 - e^{-Zt}, \qquad (7)$$

where t – duration of studied time interval (taken as 1);

e – base of hyperbolic logarithm.

We assume that there is the same dependence between the reduction as a result of traumatic death $\varphi_{Ftr.}$ and traumatic mortality rate $F_{tr.}$, and then:

$$\varphi_{Ftr.} = 1 - e^{-F_{tr.}\,t}, \qquad (8)$$

The equation shows that traumatic mortality rate, $F_{tr.}$, with t = 1, is determined as:

$$F_{tr.} = Ln\,(1+\varphi_{Ftr.}) \qquad (9)$$

Since the initial stock size, N_0, is not known, it is not possible to derive actual value of commercial stock reduction, $\varphi_{Ftr.}$, and, accordingly, mortality, $F_{tr.}$. Therefore we accept that $\varphi'_{Ftr.}$ – value characterizes variation of traumatic death (and, respectively, reduction), $\varphi_{Ftr.}$, of all the stock and take it conditionally as $\varphi_{Ftr.}$. Further placing $\varphi'_{Ftr.}$ to formula (9) we derive a conditional value of traumatic death, $F_{tr.}$. The results of these mortality calculations are given in Table 1.

The effect of traumatic death can be estimated having considered variation of possible yield per recruit with and without the allowance of additional mortality. To do this the Beverton-Holt's equation on calculation of catch presented as the number of individuals is used (Beverton; Holt, 1957):

$$Y_N = R \times e^{-M(t_c - t_r)} \times \frac{F}{F+M} \times \left[1 - e^{-(F+M)(t_\lambda - t_c)}\right], \qquad (10)$$

where Y_N - catch;

R - abundance of one year-class subjected to fishing;

M - natural mortality;

F - fishing mortality;
t_r - fish age at the start of fishing gear influence;
t_c - minimal fish age registered in catch;
t_λ – maximal fish age registered in catch.

In Div.3O, in the catches by trawl with the small mesh cover occurring *S.fasciatus* were 3-15 years old that corresponded to the age of fish in the fishing area. The age of fish at the start of t_r-fishing gear effect was taken to be equal to 3 years as redfish at that age were found in the catches of trawls with different mesh. To do further calculation we assume that the minimal age, t_c , of fish in catch will be 10% corresponding to the length of fish retained by mesh since the number of fish with this length is minor in the catch and fish abundance is within the error limits.

The t_c-value will vary with variation of mesh size (selectivity), its calculation values are shown in Table 2. The maximal age, t_λ, of fish occurring in catch was 15 years. Since the value of fishing mortality, F, for redfish from Div.3O is not known, we assume it may be from 0 to perpetuity hypothetically. In calculation of possible catch we take its value as from 0 to 0.3. Fish weight and length in each age group was calculated using Bertalanffy's equation the parameters of which were determined with the aid of the length-age key (Vaskov, 2007).

The catch value of equation (11) is expressed in weight units by the formula:

$$Y_W = FRW_\infty \times e^{-M(t_c - t_r)} \times \sum_{n=0}^{n=3} \Omega_n \frac{e^{-nK(t_c - t_0)}}{F + M + nK} \times e^{-(F+M+nK)(t_\lambda - t_c)}, \qquad (11)$$

where – K; t_0; W_∞ - the coefficients of Bertalanffy's growth equation (K = 0.1285484; W_∞ - 837.6692; t_0 = -0.7201649);
Ω_n – difference cube decomposition of Bertalanffy's growth equation characterizing variation of fish weight in time. Ω_n - $\Omega_0 = +1$; $\Omega_1 = -3$; $\Omega_2 = +3$; $\Omega_3 = -1$.

The calculation result is presented in Table 3 and Fig.2a.

Further, we assume that natural M and traumatic F'_{tr} mortalities influence fish from three years old to the age equaled to that one of 10% of fish retained by trawl codend mesh. More than 10% of older fish retained by trawl will be also affected by fishing mortality. Then, the catch equation by Beverton may be presented as follows (Beverton R.J.H., Holt S.J., 1957):

$$Y_N = R \times e^{-(M+F'_{tr.})(t_c - t_r)} \times \frac{F}{F+M+F_{tr}} \times \left[1 - e^{-(F+M+F_{tr.})(t_\lambda - t_c)}\right], \qquad (12)$$

where Ftr – traumatic mortality of all fish which are influenced by fishing gear;
$F'tr$ – traumatic mortality of fish at age of start of t_r –fishing gear to t_c–age at which 10% of fish is retained
by trawl codend mesh;
t_c – age of 10% of fish retained by trawl codend mesh.

The size of catch in the weight units allowing for traumatic mortality may be shown as:

$$Y_W = FRW_\infty \times e^{-(M+F'_{tr.})(t_c - t_r)} \times \sum_{n=0}^{n=3} \Omega_n \frac{e^{-nK(t_c - t_0)}}{F + M + F_{tr} + nK} \times e^{-(F+M+F_{tr.}+nK)(t_\lambda - t_c)} \qquad (13)$$

where - Ω_n - coefficient of Bertalanffy's growth equation difference cube decomposition characterizing variation of fish weight in time. $\Omega_0 = +1$; $\Omega_1 = -3$; $\Omega_2 = +3$; $\Omega_3 = -1$.

Taking that the traumatic mortality varies proportionally to variation of mesh selectivity and knowing selectivity parameters *F'tr* and *Ftr* in fishing with preset mesh may be calculated. Table 2 shows calculation values concerning different mesh.

Placing these data into the equation (13) we calculate the catch size per a recruitment unit for fishing mortality F of 0-3. The obtained result is given in Table 3 and Fig.2b.

2. Results and discussion

2.1 Experimental trials of bottom trawl selectivity with 86, 120 and 130 mm codend mesh size

Length composition of catches of taken redfish without dividing into species and sex, by 86.0; 121.4 and 130.3 mm mesh is given in Fig.3a, the selectivity curves for trawl codends with such size of mesh are shown in Fig.3b. (Among taken redfish *S.fasciatus* accounted for 74%, the portion of *S.mentella* was to 26%).

In September-October 2006, the selectivity of trawl codend with standard 90 mm mesh size was studied at 400-500 m depth. In the period of research, the average mesh size of trawl codend was 86,0 mm. In the catches, the redfish species accounted for 82-96%.

Redfish as long as 15-44 cm were caught; the average length was 26.6 cm. In the codend, the mean length of fish amounted to 27.1 cm. In the cover, fish mean length equaled to 24.8 cm.

Fig.5 shows selectivity parameters. At that, the trawl codend with 86.0 mm mesh size retained 75.2% of catch by the number of redfish individuals. The results of selectivity estimation, its parameters, standard error and estimative criterion of function (the sum of likelihood logarithm) are presented in Table 5.

Experimental hauls to study selectivity of the trawl codend with 120 mm mesh size were also carried out at 280-650 m depths in September-October 2006. In the research period, the mean mesh size of the codend amounted to 121.4 mm. Redfish accounted for 76-98% in catches.

Redfish species as long as 15-44 cm with the average length of 25.9 cm were fished. In the codend, the average length was equal to 27.5 cm, in the cover it was less, 25.5 cm.

Table 5 presents selectivity parameters. The analysis of the research results showed that trawl codend with 121.4 mm mesh only retained 17.8% of catch by the number of redfish specimens.

Experimental hauls to study selectivity of the trawl codend with standard 130 mm mesh size were conducted at 340-600 m, in August 2006. In the trial, the average codend mesh size amounted to 130.3 mm. In the catches, the portion of redfish was equal to 87-99%.

Redfish species with 16-43 cm length and the average one, 27.4 cm, were taken. In the codend, the average length was 28.7 cm. In the cover, it equaled to 27.0 cm.

Selectivity parameters calculated by Richard's function were: $K_S = 2.4$; $L_{50} = 31.7$ cm; SR = 7.7 cm (Table 5). The analysis of the results from experimental trials showed that the trawl codend with 130.3 mm mesh size only retained 22.1% of catch by the abundance of redfish species.

2.2. Biometric characteristics of redfish species

Sebastes fasciatus. In the period of research, the average index of stomach fullness varied from 0.7 to 1.0 (about 85% of studied specimens had everted stomachs). In the catches, the length of fish was from 15 to 35 cm. The dependence of the largest girth of redfish body on its length is satisfactorily described by linear regression equation of the second degree, the determination coefficient is equal to 0.94 (Fig.4).

Sebastes mentella. In the period of research, the mean stomach fullness varied from 0.7 to 0.8. In the catches, redfish length was from 15 to 39 cm. The dependence of the largest girth of redfish body on its length is described well by linear regression equation of the second grade, determination coefficient is equal to 0.92 (Fig.4).

The comparison of value of the largest body girth of *S.mentella* and *S.fasciatus* has proved the similarity of their biometric parameters that undoubtedly permits the data on selectivity to be mutually used. So, the mean largest body girth within 15-35 cm length range, with the confidence level of 95%, is 14.87 cm ± 0.77 for deep-water redfish and 14.94 cm ± 0.80 for *S.fasciatus*. Since the values of the largest body girth of *S.mentella* and *S.fasciatus* with the same length are not very different they are geometrical similar (Baranov, 1969).

2.3. Yield per recruit

In Div.3O, primarily two redfish species, *S.mentella* and *S.fasciatus*, are harvested. *S.fasciatus* prevail in catches (85%) (Vaskov, 2004). The special feature of this species is smaller length and earlier maturing than in the deep-water redfish *S.mentella* (Vaskov, 2005; Vaskov, 2007).

According to our data, in Div.3O, *S.fasciatus* with the average length of 24.4 cm aged 6-7 is distributed.

As *S.mentella* and *S.fasciatus* are geometrically similar, the selectivity parameters of the trawl codends in relation to these species are taken as the similar when calculating possible catch per recruit.

Our calculations of possible yield per recruit of *S.fasciatus* in Div.3O of NAFO Regulatory Area, with and without regard for traumatic mortality, showed the following. Without traumatic mortality, with the mesh size change from 130.3 to 121-86.0 mm, the average yield per recruit, with fishing mortality being from 0 to 0.3, will decrease in 0.96-0.66 times, respectively (Fig.2a, Table 3). At the same time, it was mentioned before that the length of fish escaped from those codends and retained in them was the same (Lisovsky et. al., 1995, 2005; Lisovsky,1997). Thus, taking into account the change of traumatic mortality value with the change of trawl codend mesh size the yield per recruit will significantly decrease with the increase in inner mesh size. So the average yield per recruit, with fishing mortality of 0-0.3 will rise in 1.3-7.8 times, respectively, for the studied 130-121-86 mm mesh size range in trawl codends (Fig.2b; Table 4).

We have no data on the extent of redfish escape from the trawl codends when trawl lifting during the midwater fishery. However as the escape of fish from the codends of midwater trawls is greater than that one of bottom trawls it may be assumed that when using midwater trawls the traumatic mortality will be, at least, not lower than when using the bottom ones. Therefore we believe it is possible to use the calculation of yield per recruit for bottom trawls in the calculation of that one for midwater trawls.

It was noticed before also that the long-term positive effect for fishery of redfish by midwater trawls with the enlarging of mesh size from 90-100 to 130 mm as in Div.3O as in the other areas of the North Atlantic during 15-20 years will not be achieved under any acceptable fishing mortality (Lisovsky et al., 2005; Lisovsky, 1997, 2001). As it was mentioned above, in Div.3O *S.fasciatus* prevail. In Divs.3LMN, the species portion in catches is lower and *S.mentella* predominates. Therefore redfish fishery by trawls with 90-100 mm mesh will not have a significant effect on structure of the other commercial stocks of redfish in NAFO Regulatory Area.

The analysis of catches by bottom trawls with 86-130 mm mesh size made on the basis of PINRO data indicated that the bycatch of each regulated fish species did not exceed 3%. The same results without dividing into species have been presented in the other materials (Lisovsky et al., 2005) where it was shown that the total catch regulated fish species by those pelagic trawls was not higher than 0,3%.

Thus the decrease in mesh size in midwater trawls in the fishery of redfish species in Div.3O from 130 to 90-100 mm would not be harmful for the other stocks, but significantly increase its efficiency. The yield per recruit will rise in more than 5.9 times and, in the long-term prospect, this diminishing of mesh will lead to higher efficiency of fishing in this division.

Conclusion

In the fishery of redfish species in Div.3O of NAFO Regulatory Area, the size of mesh in the midwater trawls is reasonable to diminish from 130 to 90 mm. This change will not do any harm to the other stocks, but will allow the yield per recruit to be significantly increased and lead to the long-term profits for fishery.

References

ANON, 1996. Manual of methods of measuring the selectivity of towed fishing gear. *ICES Coop. Res. No.215, 126 p.*

ANON, 2007. Conservation and Enforcement Measures. Doc. NAFO/FC, Doc. 07/1, Serial No 5335, 78 p.

ATKINSON, D.B. 1986. The redfish resources off Canada's east coast. Proc. Int. Rockfish Symp. Oct. 1986, Anchorage, Alaska. 15-33 p.

ATKINSON, D.B., and D.POWER. MS 1986. The Stock Complex of Redfish in NAFO Divisions 3KLMNOPs. NAFO SCR Doc.86/38, Serial No. N1152, 30 p.

BEVERTON R.J.H., and S.J. HOLT. 1957. Dynamics of exploited fish population. “Fish. Invest.”, 1957, Ser. II, N 19, p. 533.

ANON., 2004. Conservation Harvesting Plan (CHP) Atlantic-Wide for Licence Holders that are Member Companies of GEAC Effective April 1, 2004, 6 pp.

BARANOV, F.I. 1969. Relative catchability of net. Selected papers. Volume 1. Pishchpromizdat, Moskva, 1969 (in Russian)

DREVETNYAK, K., H. K . NEDREAAS, and A.KLUEV. 2004. Spatial migration pattern deep-sea redfish (*Sebastes mentella* Travin) of the Norwegian-Barents population from survey data. ICES C.M. K:13, 28 pp.

KONSTANTINOV, K.G. 1981. On some problems of selectivity of a commercial trawl. NAFO SCR Doc.81/VI/72, Serial No 357, 8 pp.

KONSTANTINOV, K.G., KOVALENKO V.G., LUGOVAJA L.S., LUKMANOV I.G., NIKESHIN I.G. and V.L.TRETJAK. 1983. Data for substantion of the trawl beg mesh size used during the specialized redfish (*Sebastes mentella*) fishery. ICES C.M., B: 13, 42 pp.

LISOVSKY, S.F. 1997. PINRO investigation on selectivity of trawl codends with different mesh size in relation to deepwater redfish. In: “Gear Selection and Sampling Gear: (Processing of the seventh IMR – PINRO Symposium Murmansk, 23-24 June 1997)”. PINRO Press, Murmansk, p. 93-102.

LISOVSKY, S.F. 2001. On optimal Mesh Size When Fishing Redfish in the Atlantic. NAFO SCR Doc. 01/21, Serial No. 4389, 16 p.

LISOVSKY, S. F., Yu. A. KONDRATYUK, A. A. PAVLENKO and A. A. VASKOV, 2005. On the Minimal Trawl Codend Mesh Size in the Fishery of Redfish Species in Division 3O of the NAFO Regulation Area. NAFO SCR Doc. 05/18, Serial No. N5099, 17p.

LISOVSKY, S.F., TRETYAK V.L., KISELEVA V.M., and S.M.KOTLJAROV. 1995. On Minimum Mesh-size During Deepwater Redfish Fishery with Mid-water Trawl in NAFO Division 3NO. NAFO SCR Doc. 95/25. Serial No 2533, 9 p.

LISOVSKY, S.F., A.A.PAVLENKO and A. A.VASKOV. 2006. On Minimal Codend Mesh Size in Mid-water Redfish Fishery in Division 3O of NAFO Regulatory Area. NAFO SCR Doc. 06/17. Serial No. N5233, 8 pp.

NIKOLSKAYA T.L. MS 1981. Isolation of deepwater redfish (*Sebastes mentella Travin*) stocks on the Grand Newfoundland Bank. NAFO SCR Doc.81/VI/57, Serial No. N341, 9 p.

POWER, D. MS 2003. Distribution of Redfish in NAFO Divisions 3LN Based on Canadian Research Surveys from 1991-2002. NAFO SCR Doc.03/60, Serial No. N4879, 8 p.

POWER, D., 2003. An Assesssment of the Status of the Redfish in NAFO Division 3O. NAFO SCR Doc. 03/63, Serial No. N4882, 29 p.

RUSSEL, E.S. 1942. The Overfishing Problem. Cambridge University Press. London.

VASKOV, A.A.. 2004. On the Issue of Redfish management in Division 3O. NAFO SCR Doc. 04/8, Serial No. N4953, 13 p.

VASKOV, A.A.1994. Assessment of redfish stock in Division 3LN and 3M from trawl-acoustic survey data. NAFO SCR Doc.94/13 Serial No.N2376, 9 p.

VASKOV, A.A. 2004. On the Issue of Redfish management in Division 3O. NAFO SCR Doc.04/8, Serial No. N4953, 13 p.

VASKOV, A.A. 2007. On introduction of the new measures of redfish fishery regulation in Division 3O. NAFO SCR Doc. 07/07, Serial No. N5348, 12pp.

ZASOSOV, A.V. 1976. Dynamics of abundance of commercial fish species. Pishchevaya promyshlennost. 311 p. (in Russian)

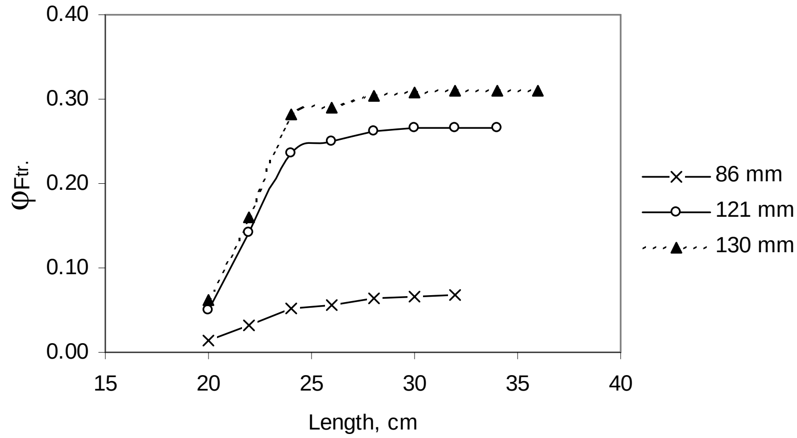
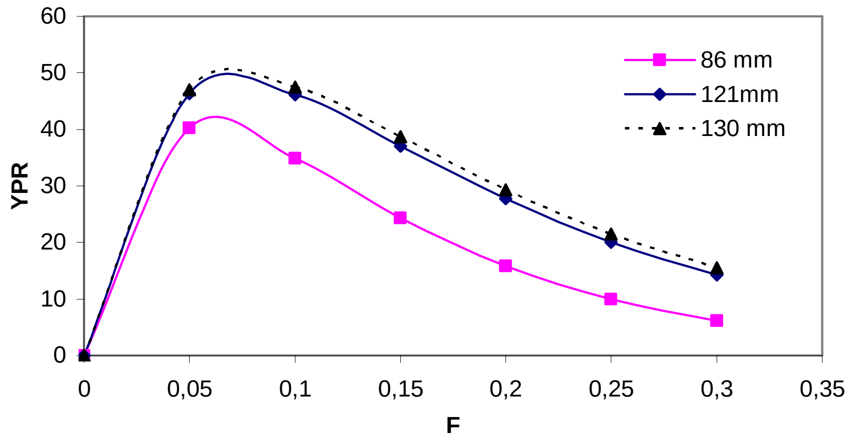


Fig. 1. Portion of possible death of redfish as long as 20-36 cm as a result of traumas in relation to all the caught fish (sum of catches by codend and cover) when fishing by bottom trawls with 86-130 mm mesh size.

a.



b.

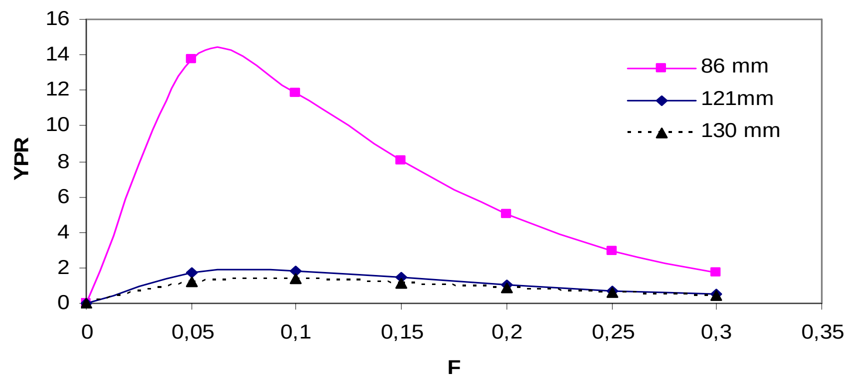


Fig.2 Possible yield per recruit of *S.fasciatus* redfish without (a) and with (b) allowance for traumatic mortality by trawls with 86, 121 and 130 mm mesh size

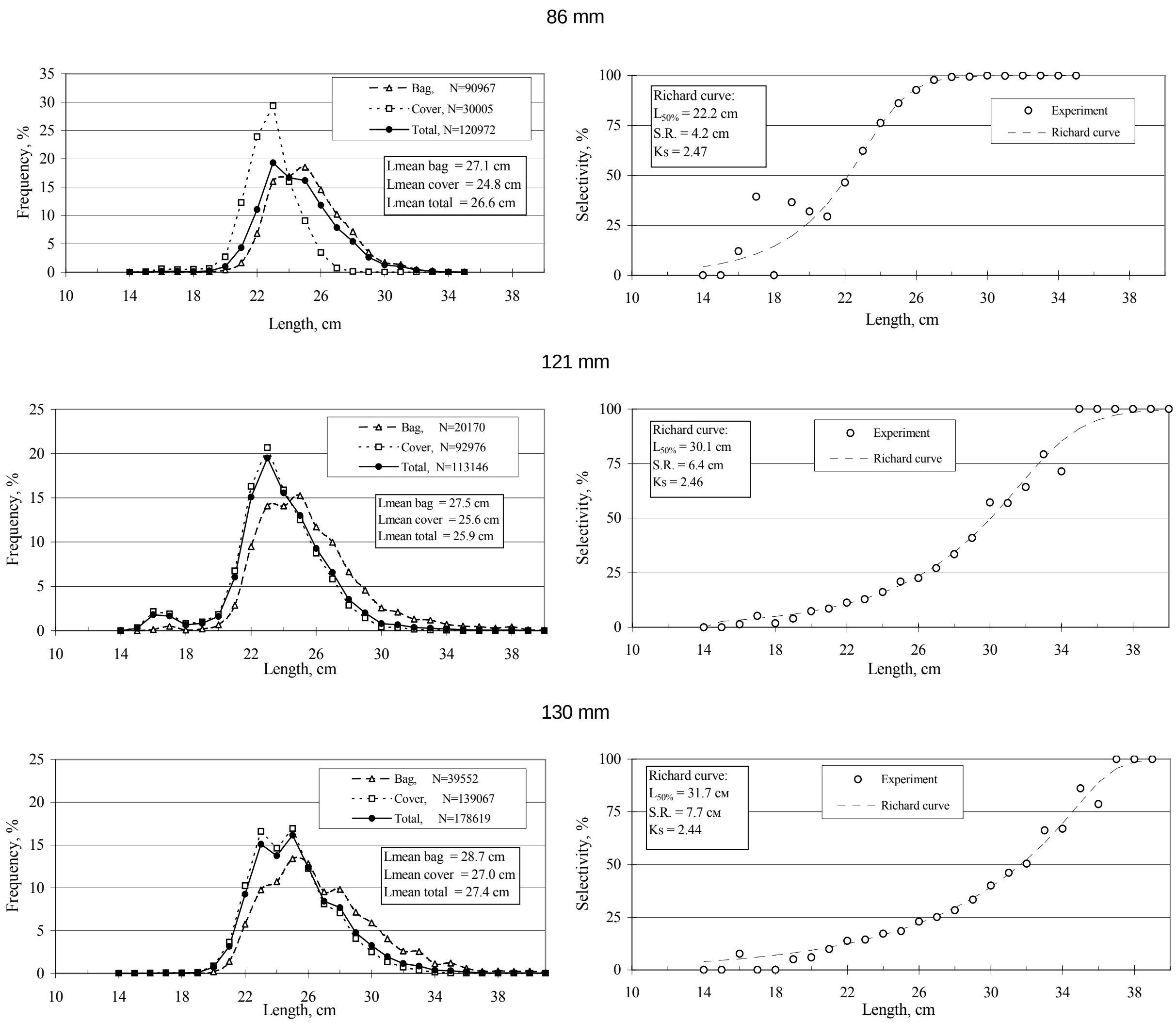


Fig.3 Size composition of redfish (a) and selectivity of trawl codends with 86, 121 and 130 mm (b) in relation to redfish in Div.3O of NAFO Regulatory Area, August-September 2006

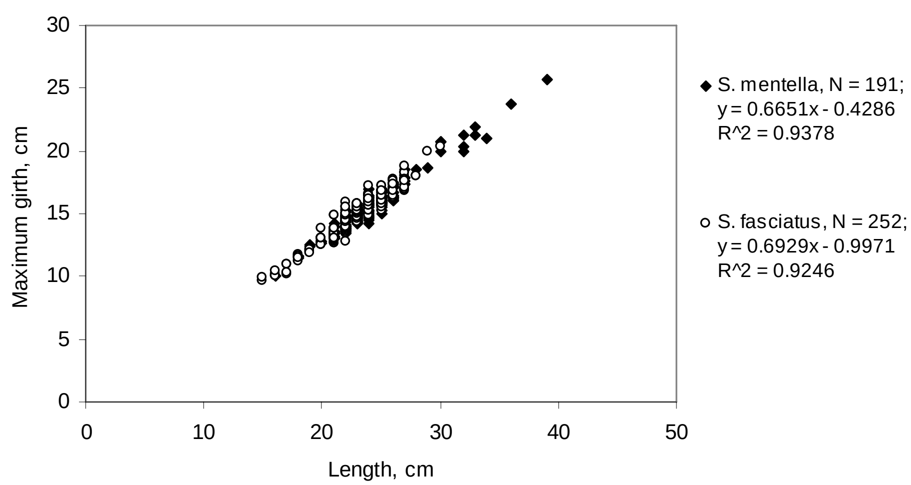
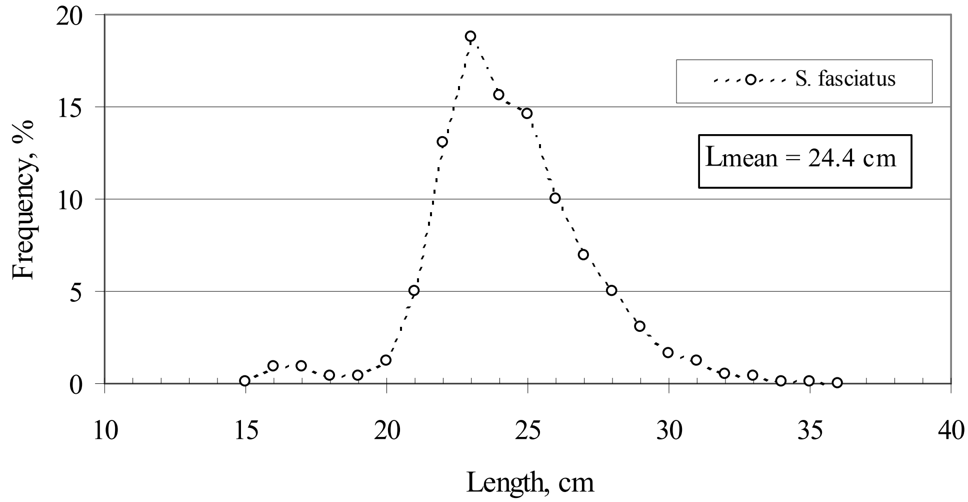


Fig.4 Dependence of maximal body girth of *S.mentella* and *S.fasciatus*

a



b

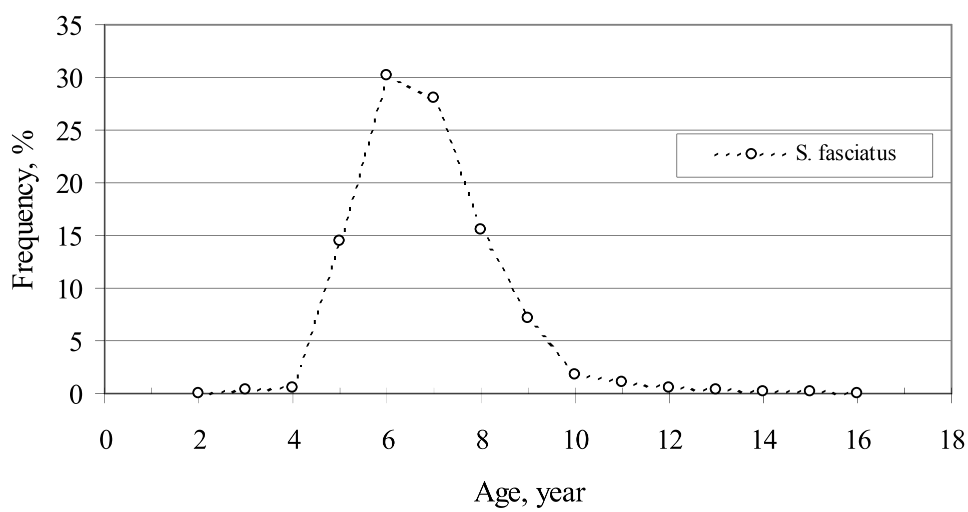


Fig.5 Frequency of *S.fasciatus* occurrence in the catches by bottom trawl with the small-meshed cover in the trawl codend by lengths (a) and age (b) in Div.3O of NAFO Regulatory Area

TABLE 1 Portion of redfish traumatic death as a result of trawl lifting calculated as the portion of total abundance of fish caught when hauling in bottom trawl fishing with 86, 121 and 130 mm mesh size in Div.3O of NAFO Regulatory Area.

Length, cm	Fish portion φ'_{Ftr}.			Traumatic death Ftr		
	86 mm	121 mm	130 mm	86 mm	121 mm	130 mm
20	0,01	0,05	0,06	0,0132	0,0471	0,0570
22	0,03	0,13	0,15	0,0293	0,1210	0,1369
24	0,04	0,21	0,25	0,0440	0,1887	0,2224
26	0,05	0,21	0,25	0,0472	0,1938	0,2214
28	0,05	0,22	0,26	0,0520	0,1991	0,2276
30	0,06	0,22	0,26	0,0538	0,1996	0,2287
32	0,06	0,22	0,26	0,0543	0,1991	0,2282
34	0,06	0,22	0,26	0,0542	0,1985	0,2275
36			0,26			0,2274

TABLE 2 Calculation values of possible traumatic mortality of redfish escaped from trawl codends with 86-130 mm mesh size when heaving up

Inner mesh size, mm	$L_{10\%}$, cm	t_c, age	F'_{tr}	F_{tr}
86 mm	16,8	3,5	0,0132	0,0541
121mm	21,6	5,1	0,1210	0,1982
130 mm	22,0	5,5	0,1369	0,2274

TABLE 3 Catch per *S.fasciatus* recruitment without allowance for traumatic death

F	Inner mesh size, mm		
	90 mm	121mm	130 mm
0	0	0	0
0.05	40,28	46,35	46,99
0.1	34,88	46,17	47,47
0.15	24,35	37,08	38,66
0.2	15,82	27,72	29,30
0.25	9,95	20,05	21,50
0.3	6,15	14,26	15,50

TABLE 4 Yield per recruit of *S.fasciatus* with regard for possible traumatic mortality caused by the fish escape from trawl during its heaving up

F	Inner mesh size, mm		
	90 mm	121mm	130 mm
0	0	0	0
0.05	13,79	1,76	1,25
0.1	11,89	1,84	1,36
0.15	8,04	1,47	1,12
0.2	4,98	1,06	0,84
0.25	2,96	0,73	0,59
0.3	1,72	0,48	0,40

TABLE 5 Selectivity parameters of trawl codends with 86-130 mm mesh size in relation to redfish in bottom fisheries from Div.3O of NAFO Regulatory Area by the results of research aboard the trawler "Leonid Galchenko" in August-October 2006

Parameter		Estimate, cm	Standard errors
		Mesh size 86 mm	
	$L_{50\%}$ =	*22.2*	*0.38*
	SR =	*4.2*	*0.65*
	Ks =	*2.5*	
Sum of log-likelihood		*-11.6*	
		Mesh size 121 mm	
	$L_{50\%}$ =	*30.0*	*1.5*
	SR =	*6.4*	*2.3*
	Ks =	*2.46*	
Sum of log-likelihood		*-21.5*	
		Mesh size 130 mm	
	$L_{50\%}$ =	*31.7*	*3.3*
	SR =	*7.7*	*1.9*
	Ks =	*2.4*	
Sum of log-likelihood		*-25.8*	