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Assessment of Groundfishes on the Flemish Cap by Means of Trawl Surveys

by

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INTRODUCTION

Scientifically grounded fisheries are impossible without a reliable quantitative estimate of parameters of exploited fish populations, which characterize the abundance and biomass of separate age groups, their yearly decrease depending on natural reasons and fisheries.

While studying the groundfish stock status much emphasis is laid on trawl survey as the method of the abundance and biomass direct assessment which permits to obtain the data on length-age and sex composition of separate groups, to estimate quantitatively the level of fisheries and natural mortality of fish of different age, and is not related to catch statistics of commercial ships. However, a wide application of this method for quantitative stock assessment is hampered by some peculiarities in behaviour, distribution, different availability of separate length-age groups for a gear, as well as by its time-consuming character.

The Polar Research Institute started to estimate groundfish stocks in the Northwest Atlantic by means of trawl surveys in 1971 under the guidance of Doctor of Biology K.G.Konstantinov. The trawl survey was performed following the standard grid of stations in Divs. 3KLMNO + 2J.

One of the main objectives of the survey was to obtain comparable data. In order to determine year-to-year fluctuations of abundance, biomass and other biological characteristics of

fish under study, ships of the same type eqipped with standardly rigged bottom trawls were employed at the same positions and time.

The year 1977 marked the commencement of regular stratified random trawl surveys performed by Canada (Doubleday, 1981).

In 1983 by order of the USSR Ministry of Fisheries and in conformity with the advice of the NAFO Scientific Council the stratified random trawl survey of groundfish stocks was carried out in Div. 3M.

The estimates of cod, redfish Sebastes mentella and American plaice stocks, obtained in May 1983 during the trawl survey on the Flemish Cap, are given in the paper and compared with the estimates for 1971 to 1982.

MATERIAL AND METHODS

Until 1978 trawl surveys for groundfish on the Flemish Cap were performed by the RV "Persey III", and from 1979 onwards by other ships of the same type - MB-2645 "Suloy", MB-0422 "Nikolai Kononov". The number of valid hauls and time of surveys are given in Table 1. Methods of analysing the catches are described in the paper by K.G. Konstantinov (Konstantinov, MS 1981). Each valid haul lasted 1 hour at a constant speed 3.5 knots. A bottom trawl of the 1625 type with a 24 mm mesh netting in the codend was employed. The distance between the ends of net wings was 14.3 m and that between trawl boards - 69.2 m. The catchability coefficient in relation to American plaice and redfish was accepted to be 1.0, and while calculating the area swept by the trawl the distance between the ends of net wings alone was taken into account. The stock of cod was estimated with different widths covered by the trawl, as well as catchability coefficients, because it was found out earlier (Chumakov, Serebrov, MS 1978) that cod are concentrated in front of the trawl mouth by cables and trains produced by boards.

On the basis of the stratified random trawl survey carried out on the Flemish Cap in 1983, determined were the errors in stock estimates, the necessary amount of hauls under given values of confidence probability and levels of a relative error.

Fish stock was estimated by the formulae (Cochran, 1976):

$$\hat{Y}_{st} = \sum_{h=1}^{L} \frac{1}{k_1} \cdot N_h \bar{Y}_h \qquad (1)$$

where L - number of strata;

k_1 - trawl catchability coefficient for a given fish species (average for the totality of different length groups);

$$\bar{Y}_h = \frac{\sum_{i=1}^{n_h} Y_{hi}}{n_h} \qquad (2) -$$

selective average catch of a given fish species in in stratum h;

n_h - total number of hauls made in stratum h;

$$N_h = \frac{\rho_h}{C_{av}} \qquad (3) -$$

shows what portion of the area ρ_h in stratum h is occupied by the area covered by one haul C_{av};

ρ_h - area of stratum h (square nautical miles);

C_{av} - area swept by the trawl at a given width covered a and a speed of trawling v (square nautical miles).

The variance of stock estimate is determined by the formula

$$V(\hat{Y}_{st}) = \sum_{h=1}^{L} N_h^2 \cdot \frac{s_h^2}{n_h} \cdot \frac{1}{k_1^2} \qquad (4)$$

where $$s_h^2 = \frac{\sum_{i=1}^{nh} (Y_{hi} - \bar{Y}_h)^2}{n_h - 1} \qquad (5) -$$

the variance of catch sizes of a given species in stratum h.

Absolute and relative errors of the stock estimate were determined by Chebyshev's inequality (Pustylnik, 1968) which

is not related to a certain type of probability distribution. That is why the errors calculated on its basis are not underestimated.

$$P(|\hat{Y}_{st} - Y| < \Delta) > 1 - \frac{V(\hat{Y}_{st})}{\Delta^2} = P \qquad (6)$$

where Δ - absolute error of stock estimate;

Y - actual size of stock;

P - confidence probability.

The working formula for calculating the error of stock estimate is obtained from the inequality (6):

$$\Delta < \sqrt{\frac{V(\hat{Y}_{st})}{(1-P)}} \qquad (7)$$

In order to reveal the trend of stock variations for 1971-1983 relative indices of fish abundance and biomass were smoothed by the formula $\hat{x}_i = \frac{x_{i-1} + 2x_i + x_{i+1}}{4}$ where x_{i-1}; x_i; x_{i+1} - preceding, medium and subsequent members of the succession; $\hat{x}_i$ - calculated one.

RESULTS

The analysis of abundance and biomass relative indices obtained from yearly trawl surveys evidences their significant year-to-year variability (Table 2).

Thus, for example, in 1975 the average catch of redfish Sebastes mentella per 1 trawling hour was 163 kg, in 1976 - 48 kg and in 1977 - 327 kg, i.e. these figures show that the redfish biomass decreased first by a factor of 3.4, and then increased by a factor of 6.8. For fish with a long life cycle, many-aged structure and a relatively constant level of fishery such fluctuations of biomass are unbelievable and, naturally, doubts arise concerning the reliability of obtained estimates. The similar year-to-year variations in abundance and biomass indices are typical of other fish species. The variability of these estimates for American

plaice is somewhat lower than for cod and redfish Sebastes mentella.

However, by the running mean the main tendencies of groundfish stock variations are revealed, possible reasons of these changes are analysed (Fig. 1). During the trawl survey plentiful material on length-age composition of studied fish populations is collected, which permits to complete substantially the knowledge of stock dynamics.

The groundfish stock estimate by the stratified random trawl survey carried out in 1983 is given in Table 3.

The errors of stock assessment are calculated for the area on the whole and with dividing it into separate strata. The highest relative errors are observed in the estimation of cod biomass, the lowest ones - for American plaice. Thus, with 122 valid hauls carried out on the Flemish Cap by the stratified random survey method relative errors of stock assessment with confidence probability 0.95 were no higher than 78.4% for cod, 63.8% for redfish Sebastes mentella, 50.8% for American plaice. Without stratification the errors of groundfish stock estimate grow (Table 4).

Table 5 shows the optimal amount of hauls in each stratum considering the area of strata, variance of catches and total amount of necessary hauls.

To our mind, the stratification of the area, the increase of a number of valid hauls aiming at improving the reliability of groundfish stock assessment by trawl surveys, are not sufficient. The matter is that the increase of valid haul amount will surely demand additional financing, make trawl surveys longer and, finally, will turn out ineffective. Different availability of fish for bottom trawl surveys through 24 hours, in different seasons, and also owing to their constantly changing behaviour depending on biological state, age and environmental factors is a notable source of errors rising the catch variance in strata and reducing the accuracy of estimates. That is why it will be reasonable

to start special biological investigations to improve the accuracy of stock investigations by a trawl survey method.

An important drawback of the trawl survey as the method of groundfish stock assessment results from the fact that the obtained indices give knowledge of a relative size of the stock. The determination of the catchability coefficient of bottom trawls should be considered a key problem in transition from a relative estimate of groundfish abundance and biomass to their absolute values. Bottom trawl catchability in the Northwest Atlantic was studied in 1976-1978 by the RV "Persey III". As a result, total catchability coefficients in relation to cod and Greenland halibut were determined. Later it was found out that trawl catchability varies greatly depending on length composition, but these investigations have not yet acquired a proper development because of the lack of the necessary equipment.

Table 6 presents the results of calculations of cod biomass on the Flemish Cap, which were done with the distance between the ends of net wings being 14.3 m and that between trawl boards - 69.2 m, and different catchability coefficients.

The total biomass of cod on the Flemish Cap in 1983 was, approximately, 77.4 thou. t. The absolute abundance of length groups cannot be determined yet because of the lack of the differentiated catchability coefficient.

Basing on the investigations performed it may be concluded that the trawl survey carried out annually by a standard grid of stations permits to reveal the tendency of stock variations with a relatively small amount of hauls.

The improvement of reliability of groundfish stock estimates is the most complicated and urgent task at present. And the stratified random survey, undoubtedly, serves the purpose.

To make stock estimates more reliable the trawl survey method should be improved in many aspects including:

- cutting down of the survey period due to an optimal number of hauls and the increase of research ship amount;

- standardization of gears, specification of their working parameters;

- determination of differentiated catchability coefficients of trawls in relation to different length groups;

- studies into dynamics of 24 hr vertical migrations in different seasons in order to determine the time favourable for surveys;

- standardization of biological data registration to accelerate the exchange of scientific data and their treatment.

This problem may be solved only by coordinated efforts of the NAFO member countries in joint trawl surveys which will permit to make the necessary amount of hauls for a brief time period, to investigate the entire area of fish distribution, to obtain representative data on abundance and biomass of separate length groups and populations as a whole. Naturally, such collaboration of the NAFO member countries is only possible with proper organization and coordination of research programmes and a wide exchange of primary scientific data.

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Table 1. Number of valid hauls and time of trawl survey on the Flemish Cap (3M) in 1971-1983

Year	Ship, cruise	Date	Number of valid hauls	Depth range, m
1971	"Persey III", 6	II-I3/У	I2	I00-400
1972	"Persey III", 8	4-7/IУ	I9	I00-500
1973	"Persey III",11	I5-I8/УП	20	I00-500
1974	"Persey III",12	22-26/УШ	20	I00-500
1975	"Persey III",14	2I-24/УI	I8	I00-500
1976	"Persey III",15	I0-I6/Ш	I9	I00-500
1977	"Persey III",18	22-25/IУ	24	I00-600
1978	"Persey III",20	26/УП-I/УШ	37	I00-800
1979	"Suloy",2/79	20-26/IУ	33	I00-900
1979	-"- -"-	5-I8/УI	30	I00-900
1980	"Nikolai Kononov",2/80	23/IУ-3/У	25	I00-600
1980	-"- -"-	24/УП-I/УШ	24	I00-600
198I	-"- 4/81	I-7/УI	32	I00-800
1982	"Suloy", 2	I7-30/IУ	70	I00-700
1983	"Suloy", 27	24/IУ-24/У	I22	I00-800

Table 2. Indices of groundfish abundance (A) and biomass (B) on the Flemish Cap, obtained during trawl surveys in 1971-1983 (average catch, spec. and kg per trawling hr)

Year	Cod		Redfish Sebastes mentella		American plaice	
	A	B	A	B	A	B
1971	77	69	66	13	38	26
1972	66	75	449	194	41	22
1973	108	46	484	117	55	37
1974	346	51	314	89	83	74
1975	550	121	516	163	93	53
1976	693	296	103	48	169	127
1977	489	448	660	327	69	30
1978	96	79	816	166	46	29
1979	122	108	4813	710	16	10
1980	34	35	2077	702	30	21
1981	53	91	950	339	34	21
1982	29	36	3030	667	31	14
1983	214	69	2829	432	47	21

Table 3. Biomass estimate for cod, redfish Sebastes mentella and American plaice on the Flemish Cap in May 1983 by strata

Nos. of stratum	Area, sq. miles	Number of hauls	Cod		Redfish		American plaice	
			Biomass, t	Standard deviation of estimate	Biomass, t	Standard deviation of estimate	Biomass, t	Standard deviation of estimate
I	342	4	720	307	2	2	I466	297
2	838	I0	4282	I250	2784	2I34	29I9	826
3	628	6	I542	702	643	324	65I	94
4	348	4	3922	I503	II82	977	338	I00
5	703	7	3544	24I4	42283	I795I	I000	277
6	496	5	I038	383	30I	I05	529	II8
7	822	7	I046	698	873	342	I6I	58
8	646	7	458	I29	I049	583	68	25
9	3I4	3	372	270	2260	I3II	I	I
I0	95I	8	I43I	989	5926	2796	I056	322
II	806	9	2663	II5I	4846	I723	364	94
I2	670	I0	42	30	I6807	4336	I2	5
I3	249	3	2235	I676	60I7	5557	0	0
I4	602	II	48	34	I62I0	5858	63	I8
I5	666	9	I23	62	9654	2590	I23	52
I6	634	7	0	0	3I87I	I0646	0	0
I7	2I6	3	0	0	I2383	5868	5	5
I8	2I0	4	47	47	645I	3283	I	I
I9	4I4	5	0	0	II8I3	46I6	I8	I8
	I0555	I22	23II3	40I0	I73355	7I002	8775	23II

Note: 1. The distance between the ends of wings is 14.3.
2. The catchability coefficient is 1.0.

Table 4. Biomass estimate for cod, redfish Sebastes mentella and American plaice on the Flemish Cap in May 1983 with and without stratification

		Cod		Redfish		American plaice	
		with stratification	without stratification	with stratification	without stratific.	with stratification	without stratif.
Biomass, t		23.1×10^3	21.6×10^3	173.4×10^3	185.2×10^3	8.8×10^3	8.4×10^3
Estimate variance		1.6640×10^7	1.7674×10^7	6.1139×10^8	8.1876×10^8	9.99×10^5	2.0352×10^6
Standard deviation of estimate, t		4010	4204	24726	28614	999	1427
Confidence probability P=0.95	Absolute error, t	18.2×10^3	18.8×10^3	110.6×10^3	128.0×10^3	4.47×10^3	6.38×10^3
	Relative error, %	78.4	87.0	63.8	69.1	50.8	76.0
Confidence probability P=0.90	Absolute error, t	12.9×10^3	13.3×10^3	78.2×10^3	90.5×10^3	3.2	4.5×10^3
	Relative error, %	55.6	61.5	45.1	48.9	35.9	53.6

Note: 1. Trawl of the 1625 type, the distance between the ends of net wings is 14.3 m, speed of trawling 3.5 knots.
2. Catchability coefficient - 1.0.

Table 5. Distribution of valid hauls in strata of the Flemish Cap considering their areas, catch variance and different given total amounts of hauls during the trawl survey for cod and redfish.

Nos. of strata	Area of stratum; sq. miles	Cod							Redfish						
I	342	3	5	6	8	9	I3	I6	I	I	I	I	I	I	I
2	938	I4	2I	28	34	4I	55	69	4	5	7	9	II	I4	I8
3	628	6	9	II	I4	I7	23	29	I	I	I	I	I	2	2
4	348	I0	I5	20	25	30	40	50	I	2	2	3	3	4	6
5	703	2I	32	42	53	64	85	I06	26	40	53	66	79	I06	I32
6	496	3	4	6	7	8	II	I4	I	I	3	3	4	5	6
7	822	6	9	I2	I5	I8	24	30	I	I	I	I	2	2	2
8	646	I	2	2	3	4	4	5	I	I	2	2	3	3	4
9	3I4	II	I6	22	28	33	44	55	I	2	3	4	4	6	7
I0	95I	9	I4	I9	23	28	37	46	4	7	9	II	I3	I8	22
II	806	II	I7	23	29	34	46	58	3	4	6	7	9	I2	I4
I2	670	I	I	I	I	I	I	I	8	II	I5	I9	23	3I	38
I3	249	3	4	6	7	8	II	I4	4	7	9	II	I3	I8	22
I4	602	I	I	I	I	2	2	3	II	I6	22	27	32	43	54
I5	666	I	I	I	I	2	2	3	4	6	9	II	I3	I7	22
I6	634	0	0	0	0	0	0	0	I6	4	3I	39	47	63	78
I7	2I6	0	0	0	0	0	0	0	6	9	II	I4	I7	23	28
I8	2I0	0	0	0	0	0	0	0	4	6	7	9	II	I5	I8
I9	4I4	0	0	0	0	0	0	0	6	9	II	I4	I7	23	29
Total	I0555	I0I	I5I	200	249	299	398	499	I03	I53	203	252	303	406	503

Table 6. Biomass estimate of cod by strata on the Flemish Cap in May 1983 and standard deviations.

Nos. of stratum	Distance between net wings -14.3 m, k_1 - 1		Distance between trawl boards - 69.2 m, k_1 - 0.062	
	Biomass, t	Standard deviation	Biomass, t	Standard deviation
I	720	307	239I	I02I
2	4282	I250	I42I8	4I50
3	I542	702	5I20	2332
4	3922	I503	I3024	4992
5	3544	24I4	II768	80I7
6	I038	383	3447	I273
7	I046	698	3472	2320
8	458	I29	I524	429
9	372	270	I238	897
I0	I43I	989	4753	3284
II	2263	II5I	75I5	3822
I2	42	30	I40	I$_0$0
I3	2235	I676	7425	5564
I4	48	34	I62	II3
I5	I23	62	4I0	205
I6	0	0	0	0
I7	0	0	0	0
I8	47	47	I55	I55
I9	0	0	0	0
Total	23II3	40I0	76762	I33I6

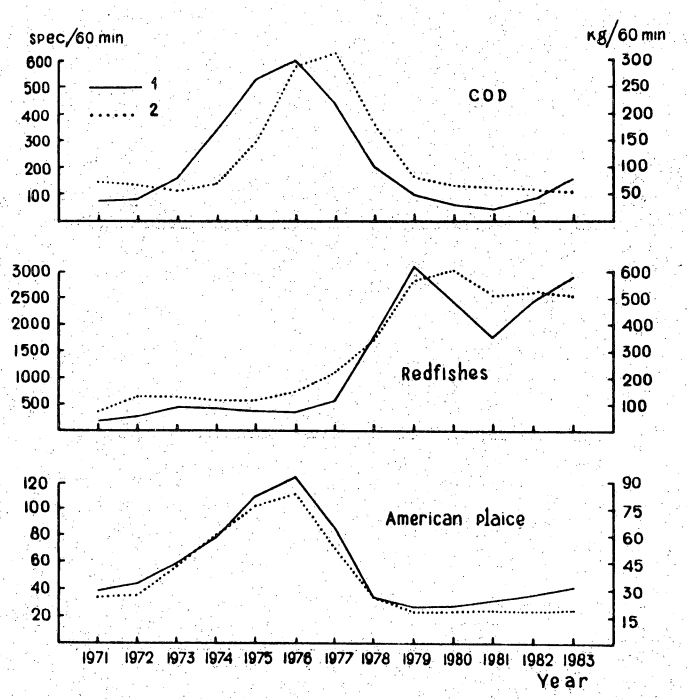

Fig. 1. Relative indices of abundance (1) and biomass (2) of cod, redfish Sebastes mentella, American plaice from the trawl survey on the Flemish Cap in 1971 to 1983.