Forecasting of Annual Catch of Cod and Haddock in the Barents Sea

by

V.P.Ponomarenko

Abstract

Equations are derived for :

1) forecast of the absolute abundance of the cod and haddock before the entering a fishing stock;

2) forecast of possible catches of cod and haddock at the present level of fishing intensity;

3) estimation of the portion of the catch to be taken by the Soviet Union from the total limit of the catch provided that there remains long-term mean level of fishing effort, observed in 1956-- 1973.

Probability that an error of these forecasts does not get out beyond 20 % of amplitude of a forecasted value is about 80 %.

It was calculated that the abundance of cod in 1974--1976 will be at the level of maximal years and provides for an annual catch of fish not less than 900 thousand--1 million tons.

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Abundance of cod of the Lofoten-Barents Sea stock fluctu-
ates steadily. Fluctuations in stocks,amplitude of which is
rather high,are due to constant changes in the size of recruit-
ment connected with the crop of fishes. Increase in the fishing
stocks and hence in catches in 1968-1969 in the southern Barents
Sea and in the Bear Island-Spitsbergen shelf area,and in 1971-
1972 off the north-western coast of Norway was due to 1963 and
1964 year classes. The succeeding 1965,1966 and 1967 year classes
were poor. This fact was responsible for the decrease in catches
in the feeding areas of cod until 1972. Catches increased again
when the abundant 1970 year class of cod and two rich year classes
of haddock (1969 and 1970) entered the fishing stock. Thus fluc-
tuations in strength of the year classes fished for,lead to fluc-
tuations in the catch size. This fact should be taken into account
when forecasting the raw material for fishery. Accuracy of the
fishery forecasts,in addition to strength fluctuations,depends
both upon the decrease in the abundance of the carry-over of the
fish stock,as a result of extermination by the fishery in previous
years,and by natural mortality. Absolute values of fishing morta-
lity,calculated by the existed methods,undoubtedly,depend on
fishing efforts,while accuracy of calculations depends on the
quality of fishery biological statistics. When using various data
and calculating fishing mortality by the same method,at best,the

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tendencies coincide but not the absolute estimation of the morta-
lity. This could not but effect the accuracy of fishery forecasts
if they are calculated by the methods,where influence of absolute
values of fishing (and natural) mortality adverse the same effect
on the final result of calculations as fluctuations in the size
of recruitment do. Consequently,forecasting of a possible catch
of fish by the existed methods is hampered by the lack of a relia-
ble estimation of the decrease in the catch-over abundance and
absolute values of the recruitment of stocks with young fishes.
Shortage of these knowledge is the weakest point in the theory
and practice of fishery forecasting. In the present paper equa-
tions are suggested for : 1.forecasting of absolute values of
cod and haddock crop before a year class enters the fishing
stock;2. forecasting of possible catches of cod and haddock at
the present fishing intensity,i.e. on the retention of the pre-
sent level of fishing effort;3. determination of the portion of
the catch to be taken by the Soviet Union from the total limit
of the catch (at the retention of the present level of fishing
effort as well).

   Strength of cod and haddock year classes of the Lofoten-
Barents Sea stocks is estimated by relative indices,which are
derived on the basis of determining the abundance of the bottom
fry in the autumn-winter period by research vessels of the Polar
Institute in the southern Barents Sea and in the Bear Island-
Spitsbergen area. Strength of cod and haddock year classes is
best reflected by the catch of the young at the age of three
years (24) per trawling hour. In the present paper this catch

is taken as a relative index of the abundance of cod and haddock year classes of the Lofoten-Barents Sea stocks (Table 1).

Equations (1),(2) and (3),suitable for forecasting of absolute abundance of the fish species mentioned before their entering the fishing stocks,are derived from the relative estimations of the strength,given in Table 1,and quantity of cod and haddock at the age of three years for the 1950-1970 year classes, calculated by VPA method and given in the North-East Arctic Fisheries Working Group papers (Fig.1).

$$y=46x+386, R=0.81 \qquad (1)$$

where x is a relative index of the cod year class strength,catch of the young at the age of 2+ years per trawling hour taken by a PINRO research vessel in the autumn-winter period, y is an absolute quantity of cod at the age of three years of the same year class, 10^{-6}

$$y=4.59x+155, R=0.70 \qquad (2)$$

where x is an relative index of the year class strength of cod, catch of the young at the age of 2+ years per trawling hour by a PINRO research vessel in the autumn-winter period, y is an absolute quantity of haddock at the age of three years of the same year class, 10^{-6}

$$y=4.64x+135, R=0.79 \qquad (3)$$

where x is a relative index of the year class strength of haddock, catch of the young at the age of 1+ per trawling hour by a PINRO research vessel in the autumn-winter period, y is an absolute quantity of haddock at the age of three years of the same year class, 10^{-6}.

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The following method can be used for compiling forecasts of a possible catch of cod and haddock. At the present level of fishing intensity, the fishery is based on removals of fishes at the age of 3 to 7 years in the feeding areas and those at the age of 7 to 10 years on the spawning grounds. The year classes that were fished for in 1960,1961 and 1962 are shown in Table 2

Table 2

Year of fishery	Age, year class							
	3	4	5	6	7	8	9	10
1960	1957	1956	1955	1954	1953	1952	1951	1950
1961	1958	1957	1956	1955	1954	1953	1952	1951
1962	1959	1958	1957	1956	1955	1954	1953	1952

Estimations of the strength of these year classes are shown in Table 1. Cod at the age of 4,5 and 6 years were of the greatest importance in catches in the feeding areas. Haddock were caught together with cod and made up about 20% of the long-term mean weight of their catch. Fishes at the age of 3,4 and 5 years made up the bulk of haddock catches in the feeding areas. When defining a relative index of the abundance of the fishing stocks of cod, haddock and gadidae (cod and haddock), the ratio between representation of cod and haddock and their age composition were taken into account (Table 3). The indices of the abundance were correlated then with cod and haddock catches on the computer "Mir-2" (Tables 4 and 5). The method of forecasting of catches can be used only in the case if we assume that the fishing effort

will change within the ranges it changed during 1952-1973. As a result, the following prognostic equations were obtained:

$$y = 4.1x + 402, R = 0.70 \qquad (4)$$

here x is the abundance index of cod stocks all over the area,

y is the catch of cod taken by all the countries (thousand tons) in the feeding areas

$$y = 4.25x + 268, R = 0.77 \qquad (5)$$

where x is the abundance index of cod stocks in Subarea I,

y is the catch of cod taken by all the countries in Subarea I, thousand tons

$$y = 1.22x + 51, R = 0.95 \qquad (6)$$

where x is the catch of cod taken by all the countries in Subarea I, thousand tons

y is the catch of cod taken by all the countries in the feeding areas, thousand tons

$$y = 3.41x + 158, R = 0.80 \qquad (7)$$

where x is the abundance index of cod stocks all over the area,

y is the catch of cod taken by the USSR, thousand tons

$$y = 1.3x + 179, R = 0.93 \qquad (8)$$

where x is the catch of cod taken by the USSR, thousand tons

y is the catch of cod taken by all the countries in the feeding areas, thousand tons

$$y = 0.995x + 184, R = 0.96 \qquad (9)$$

where x is the catch of cod taken by all the countries in the feeding areas, thousand tons

y is the catch of cod taken by all the countries all over the fishing area, thousand tons

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$$y=3.38x + 24, R=0.64 \qquad (10)$$

where x is the abundance index of haddock stocks

y is the catch of haddock taken by the Soviet Union, thousand tons

$$y=1.2x + 77, R=0.96 \qquad (11)$$

where x is the catch of haddock taken by the Soviet Union, thousand tons

y is the catch of haddock taken by all the countries all over the fishing area, thousand tons

$$y=0.6x-146, R=0.87 \qquad (12)$$

where x is the catch of cod taken by all the countries all over the fishing area, thousand tons

y is the catch of cod taken by the Soviet Union, thousand tons

$$y=0.61x-181, R=0.89 \qquad (13)$$

where x is the catch of gadidae taken by all the countries all over the fishing area, thousand tons

y is the catch of gadidae taken by the Soviet Union, thousand tons

$$y=0.77x-54, R=0.96 \qquad (14)$$

where x is the catch of haddock taken by all the countries all over the fishing area, thousand tons

y is the catch of haddock taken by the Soviet Union, thousand tons.

Scientists of the Polar Institute make fishery forecasts according to the equations of this type during last 6-8 years.

Accuracy of forecasts is satisfactory : approximately in 80%
the departure of the virtual index from the forecasted one
does not get out beyond 20% of amplitude of fluctuations in
the total catch. Relative indices of the abundance and catch
of cod are compared in Figure 2. Relationship between total
catch and the abundance is clearly seen. Prognostic catches of
cod for 1974, 1975 and 1976 are given in the same figure. Figures
for 1976 should be refined. It is clearly seen that the abundance
of cod in 1974-1976 will be at the level of maximal years and
provides for an annual catch of fish not less than 900 thousand-
one billion tons; 760-980 thousand tons will be taken in the feed-
ing areas.

Headings for Figures

to the paper by V.P.Ponomarenko "Forecasting of Annual Catch
of Cod and Haddock in the Barents Sea"

Fig.1. Relationship between catch of cod and haddock at
the age of three years per trawling hour by a PINRO
research vessel and absolute abundance of fishes of
the same year classes at the same age.

I - cod, 2 - haddock.

Fig. 2.Relationship between relative index of the abundance
and annual catch of cod.

1 - a relative index of cod abundance in Subarea I;

2 - a relative index of cod stocks all over the sea;

3 - catch of cod taken by all the countries all over
the fishing area;

4 - catch of haddock taken by all the countries in
the feeding areas;

5 - catch of cod taken by all the countries in Sub-
area I;

6 - catch of cod taken by the Soviet Union.

Table 1

Number of cod and haddock at the age of three
years per trawling hour in the autumn-winter
period taken by the PINRO research vessel, specimens

| Year class | Cod | | | Haddock |
	Subarea I	Division IIb	All over the area	Subarea I
1946	5,8	-	5,8	-
47	21,0	3,7	17,5	I
48	18,I	19,7	19,2	32
49	29,4	5,9	23,6	I
50	76,I	40,2	74,5	247
51	6,5	2,2	6,4	19
52	2,8	I,0	2,8	5
53	10,6	1,7	8,8	40
54	5,6	4,9	5,6	7
55	8,7	12,3	9,2	3
56	10,3	21,0	13,6	18
57	11,8	16,3	13,1	9
58	15,7	24,3	18,9	4
59	17,6	14,4	16,2	14
60	9,3	18,7	13,2	40
61	2,3	I,8	2,0	50
62	7,0	3,6	5,5	3
63	21,3	120,3	75,6	9
64	49,0	45,3	46,3	12
65	0,5	0,2	0,4	I
66	I,5	0,0	I,0	I
67	I,4	0,3	I,0	13
68	6,8	I,0	4,6	I
69	10,5	6,0	8,9	69
70	74,3	85,5	78,8	38
71	37	24	32	(3)
72	(34)	(15)	(27)	(2)
73	(32)	(10)	(24)	(2)

note: Figures that should be refined
are shown in brackets

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Table 3

Relative indices of the abundance of the fishing stocks
of cod and haddock

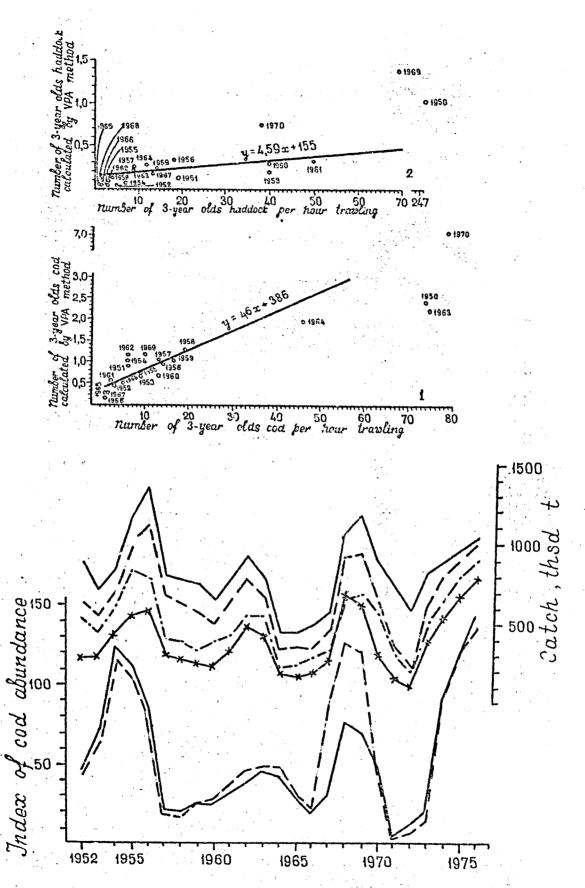| Year of fishery	Subarea I			Division IIB Cod	All over the fishing a		
	Cod	haddock	Total		Cod	Haddock	Total
1952	45	7	52	24	43	7	50
53	69	56	125	29	60	56	116
54	124	53	177	66	117	53	170
55	112	54	166	48	105	54	159
56	85	13	98	43	84	13	97
57	20	10	30	5	18	10	28
58	19	10	29	8	17	10	27
59	25	6	31	19	24	6	30
60	25	6	31	38	28	6	34
61	31	6	37	50	36	6	42
62	38	6	44	62	46	6	52
63	45	12	57	55	48	12	60
64	43	21	64	57	48	21	69
65	29	19	48	35	31	19	50
66	19	12	31	24	21	12	33
67	31	5	36	126	83	5	88
68	77	4	81	169	127	4	131
69	71	3	74	166	122	3	125
70	51	3	54	46	48	3	51
71	3	3	6	1	2	3	5
72	10	17	27	1	7	17	24
73	19	22	41	7	15	22	37
74	92	22	114	93	92	22	114
75	(122)	(9)	(131)	(116)	(120)	(9)	(129)
76	(145)	(1)	(146)	(125)	(138)	(1)	(139)
77	(103)			(49)	(83)		

note: Figures that should be refined are shown in brackets

Table 4

Catches of the Lofoten-Barents Sea cod, thousand tons

Year of fishery	all over the fishing area	In the fee- ding areas	In Subarea I	Taken by the Soviet Union
1952	874	630	524	285
53	697	547	443	296
54	827	697	598	435
55	1149	985	831	552
56	1345	1112	787	582
57	794	657	400	283
58	764	611	388	268
59	745	566	323	235
60	631	476	381	214
61	781	632	410	325
62	910	770	549	477
63	778	660	547	418
64	438	329	203	181
65	444	345	241	152
66	484	349	292	170
67	573	444	323	262
68	1074	911	642	676
69	1191	936	670	611
70	876	636	551	276
71	705	369	312	142
72	569	230	197	94
73	801	587	501	387

Table 5

Catches of the Barents Sea haddock, thousand tons

Year of fishery	all over the fishing area	In Subarea I	Taken by the Soviet Union
1952	127	104	47
53	124	106	47
54	157	126	73
55	203	157	95
56	214	164	93
57	124	88	34
58	113	78	26
59	88	59	13
60	156	126	57
61	193	165	85
62	188	161	92
63	147	125	63
64	99	79	44
65	118	99	42
66	161	124	49
67	137	108	57
68	182	141	76
69	130	89	24
70	87	59	27
71	78	56	16
72	265	221	176
73	299	257	187

Upper scatter plot — axes labeled: vertical "Number of 3-year olds haddock calculated by VPA method" (scale 0,5 – 1,0 – 1,5); horizontal "Number of 3-year olds haddock per hour trawling" (10 20 30 40 50 60 70). Equation on plot: $y = 4,59x + 155$. Data points labeled by year (1952–1970). Marked "2" and "247".

Middle scatter plot — axes labeled: vertical "Number of 3-year olds cod calculated by VPA method" (scale 0,5 – 1,0 – 1,5 – 2,0 – 2,5 – 3,0 – 7,0); horizontal "Number of 3-year olds cod per hour trawling" (10 20 30 40 50 60 70 80). Equation on plot: $y = 46x + 386$. Data points labeled by year. Marked "1".

Lower graph — vertical left axis "Index of cod abundance" (50, 100, 150); vertical right axis "Catch, thsd. t" (500, 1000, 1500); horizontal axis years 1952 1955 1960 1965 1970 1975.