INTERNATIONAL COMMISSION FOR THE NORTHWEST ATLANTIC FISHERIES

RESTRICTED

Serial No. 2511
(B.G.7)

ICNAF Res.Doc.71/11

ANNUAL MEETING - JUNE 1971

The status of stocks and the prospects of cod fisheries in the Northwest Atlantic

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A. The Labrador Cod

Regular studies conducted by Soviet fisheries biologists made it possible to reveal a very important feature peculiar to the Labrador cod, i.e. relatively slight fluctuations in the strength of year-classes.

Table 1 shows average numbers of young cod caught per hour trawling on the North Newfoundland Bank (where young cod brought from the Labrador spawning grounds are to be found). These data are compared to data for the Barents Sea cod in the same years.

It is easy to see that the abundance of young cod in the Barents Sea is much more variable than that of young cod in the Labrador area. This is undoubtedly caused by more stable conditions of the development of eggs, larvae and young fish in the Labrador area and on the North Newfoundland Bank. The spawning in the Labrador area usually takes place under the ice cover before the water warms up in spring, and the eggs and larvae are carried by the Labrador Current to southward areas characterized by relatively favourable conditions. The eggs and larvae of the Barents Sea cod drift to colder areas where mass mortality is likely to occur.

The relative stability of the annual recruitment makes it possible to see the effect of heavy fisheries on the stock of the Labrador cod, which would have been much more diffcult to do had the fluctuations been sharp. Indeed, by producing extremely

strong year-classes at intervals the population obscures the traces of the earlier removals by fisheries. A classic example is the North Sea haddock the abundance of which, in spite of fairly intensive fisheries, increases sharply at intervals in accordance with clearly defined fluctuations.

Table 2 shows a gradual decline in the average catch per hour trawling in the South Labrador area, particularly by Portuguese and Spanish trawlers. The data show an inverse relationship betweer the sum total cod catch in four years and the catch per hour trawling in the following (fifth) year: the correlation factor is - 0.57 for the Portuguese trawlers and - 0.41 for the Spanish trawlers.

Table 3 shows a decrease in the proportion of large cod of older age groups in commercial catches. The mean age of the Labrador cod has decreased one full year over the past ten years. If the present annual catch is maintained (or increased further) the mean length, age and weight of the Labrador cod will follow a downward trend. The dynamic equilibrium between the annual recruitment to the stock and the annual catch is unlikely to be established until the mean age of cod in trawl catches has dropped to about 6 years. Younger cod are not likely to become predominant in trawl catches. Four-year-olds remain mainly outside the Labrador area and it can be seen from Table 3 that their proportion in trawl catches has been very small. Besides, considering that the 20-th ICNAF meeting has taken a decision to increase the codend mesh size to 130 mm (manila) the four- and five-year-old cod are not likely to be caugh in a commercial trawl. Thus, six-year-olds may be expected to from the bulk of trawl catches. In 1962 Hodder and May studied the selectivity of the manila codend with the mesh size of 130 mm in the South Labrador area. It was found that the fifty percent escapement length of cod was 45 cm and according to the Polar Institute data this is the length of the six-year-old fish. It follows that six-year-old cod will not be fully protected from capture. With a sufficiently high number of hauls it

is practically possible to fully remove any concentration of six-year-old fish.

Consequently, by increasing the mesh size without limiting the catch it will not be possible to prevent a further decline in the total biomass of the Labrador cod resulting form the persistent decline in the mean weight. When six-year-olds become the predominant part of the trawl catch (instead of seven-year-olds which are predominant now) the mean weight of one fish will drop from 1208 to 948 gr, or by 21%. This drop will only partly be compensated by the capture of the fish which would have died in their severth year of life from natural causes.

Pinhorn and Wells suggest that the catch of cod in the South Labrador area should be limited to 268-278 thousand tons while the actual catch was 366 thousand tons in 1968 and still higher in 1969. We have already seen that the productivity of the fisheries follows a downward trend. Needless to say the decline is not absolutely uniform: in 1968, for example, the operations of Soviet, Portuguese and Spanish trawlers were more productive than in 1967 (Table 2). Such deviations from the general trend are partly caused by fluctuations which, slight as they are, still occur in the Labrador cod. Young fish surveys showed that the abundance of the 1961, 1962, and 1963 year-classes was somewhat higher than the long term mean level. The same conclusion is suggested by the analysis of the age composition of commercial catches: it is seen from Table 4 that the cod of the above three year-classes were numerically predominant in catches, especially among five-year-olds. It is also evident from Table 4 that prior to the intensification of the fisheries the Labrador cod were caught at an older age than at present. For example, the strong 1956 and 1957 year-classes did not reach the peak of the commercial utilization until the age of 7-8 years.

Thus, the abundance of the Labrador cod can increase or decrease as a result of fluctuations (though not so sharply as that of the West Greenland or the Barents Sea cod). For example, in 1972 some increase in

the abundance of the Labrador cod may be expected mainly as a result of the relatively strong 1966 and 1967 year-classes.

However, the productivity of the Labrador cod fisheries is influenced not only by the fluctuations in the strength of year-classes. A fairly important role is played by another factor, i.e. by the distribution of commercial concentrations. It was observed (Table 5) that lower water temperatures in the Labrador area before the onset of winter as a rule corresponded to the higher productivity of the trawl fisheries at the beginning of the following calendar year. The reason is obvious: intensive cooling of water masses in the Labrador area contributes to the formation of the winter cod concentrations in the southern areas of the continental slope, which results in the success of the trawl fisheries. The ice conditions and bottom configuration off South Labrador are more favourable to the bottom trawl operations than off Central Labrador. The reverse is observed at higher water temperatures: the cod tend to concentrate in the northern areas of the continental slope. In the Canadian report to the 15-th ICNAF meeting Dr.Templeman points out that in 1964 the bottom temperatures at depths where cod are likely to occur were higher and the spawning concentrations seemed to be found further to the north than in 1963. The warming up of the mater masses in the Labrador area which started at that time continued to 1967 and was accompanied by a persistent decline in the productivity of the trawl fisheries. Then a cooling down period set up and the productivity of trawl fisheries increased. Besides, lower water temperatures in the Labrador area seem to drive the cod offshore to areas where the continental slopes is steeper. The zone between the 300 and 400 m isobaths has a much smaller area than that between the 200 and 300 m isobaths. Hence by moving to deeper waters the cod are concentrated in a smaller space and the density of the concentrations increases.

There are reasons to believe that hydrological conditions rather than fluctuations were chiefly responsible for the increase

in the productivity of fisheries in 1968. Indeed, an appreciable increase in the stock would have had a favourable effect on the Canadian coastal fishery. However, the cod catch obtained by the Canadian fishermen at the Labrador coasts was 27,753 t in 1967 and only 18,112 t in 1968 and this was the result of the lack of fish rather than of fishing effort (Canadian Research Report, 1969).

Thus, the Labrador cod stock follows a trend of gradual decrease despite temporary increases in the productivity of the trawl fisheries chiefly caused by favourable distribution of concentrations.

B. The Southern Newfoundland Cod.

Two cod stocks occur in southern Newfoundland waters. The more numerous stock keeps to the southwestern and southeastern slopes of the Grand Bank (Div. 3O) and to the adjacent part of the northeastern slope (Div. 3L). The other stock inhabits the waters over the St.Pierre Bank. The distribution areas of the two stocks are separated by the coastal branhh of the Labrador Current but some mixing of the Grand Bank and the St.Pierre Bank cod is observed. For convenience the term "southern Newfoundland cod" will be used implying both the cod of the southern Grand Bank and those of the southern St.Pierre Bank. The Gulf of St.Lawrence cod also migrate to these waters in winter but only for a short time and in insignificant quantities.

In the southern Newfoundland cod the fluctuations of the strength of year-classes are very pronounced. It is seen from Table 6 that a strong year-class may be 40 to 50 times more abundant than a poor one. For comparison the same table shows the abundance indicies for the Labrador cod (young fish survey data in Div. 3K).

Wide fluctuations in the southern Newfoundland cod are associated with extremely unstable environmental conditions and with sharp hydrological contrasts. Here the warm Gulf Stream Current meets with the cold Labrador Current. The conditions for

the development of eggs, larvae and young fish vary sharply by years.

In thinking over the conditions which may be particularly favourable for the formation of strong year-classes of the southern Newfoundland cod the following should be borne in mind. This is one of the southernmost populations of the Atlantic cod; all the other large populations occur futher north. With the cooling down of the water masses in the Newfoundland area the environmental conditions appoximate the optimum conditions for the species (i.e. conditions predominating in the centre of the distribution range), thus contributing to the formation of strong year-classes. Hence the occurrence of strong year-classes in 1963, 1964 and 1965, i.e. soon after the onset of the cold period. Particualrly abundant was the 1964 year-class (Table 6). If it is assumed that the cooling down is associated with the weakening of the Gulf Stream then its effect should later be seen in the North European seas. In 1965-1968 very poor year-classes of boreal species (herring, cod, haddock) and strong year-classes of Arctic species (capelin, polar cod) appeared in the Norwegian and the Barents Seas. In subsequent years the heat transfer increased again (Table 7); the young fish survey showed that in the southern Newfoundland waters the 1969 cod year-class was poor while a strong year-class of cod was recorded in the Barents Sea in 19', .

Sharp fluctuations in the abundance of the southern Newfoundland cod complicate the regulation of fisheries and first of all the establishment of the catch quota. While in the Labrador area the quota could remain practically unchanged for a number of years in the southern Newfoundland waters it would be necessary to alter the quota very often. Pinhorn and Wells mention the situation in Div.3O. In this area the recruitment may vary, the survival of cod in any year being many times higher or lower than in the preceding or in the subsequent year. The maximum sustainable yield estimated by the ICNAF Subcommittee for 1968 was 75 thousand tons. However in 1967 the catches increased sharply and reached 220 thousand tons and in 1968 the catch was 160 thousand

tons as compared to 80 thousand tons in 1963-1966. This increase was possible due to the extremely strong 1964 year-class.

It may be added that very sharp abundance fluctuations are also characteristic for the year-classes of the Newfoundland haddock but in this case the reproduction is better in the hydrologically warm years (the Grand Bank is the northern limit of the mass distribution of haddock).

C. The West Greenland Cod.

In order to have an idea of the future condition of the stock of the West Greenland cod it is necessary to know the abundance of young fish. Soviet fishery biologists conduct regular young fish surveys in the Labrador - Newfoundland area but do not make similar studies in the West Greenland waters. Danish scientists classify West Greenland cod year-classes as "poor", "moderate" and "strong" without giving numerical estimates (the numbers of young fish caught per unit effort by a survey gear).

However, a regularity has been established which helps in obtaining a fairly reliable idea of the strength of the West Greenland cod year-classes. The fluctuations in the strength of the year-classes of the West Greenland cod are known to be opposite in phase to those of the Barents Sea cod. For example, the 1960 and 1961 year-classes were very strong in the West Greenland area and poor in the Barents Sea; the 1963 and 1964 year-classes were found to be poor in the West Greenland waters and fairly strong in the Barents Sea; the 1965 year-class was poor in the Barents Sea and strong in the West Greenland area.

Hence, properly ocnducted young cod surveys in the Barents Sea may help in estimating the future abundance of cod in the West Greenland area. The 1970 cod year class was expected to be extremely poor in the West Greenland area and it is highly probable that the 1971 year-class will also be poor. Consequently, the mid-seventies will be characterized by a relatively low level of the abundance of the West Greenland cod. On the basis of the periodicity in the fluctuations the abundance of the West Greenland cod may be expected to increase again by the end of this decade.

Table I

Mean numbers of young cod per hour trawling in Div. 3K and in the southern Barents Sea.

Area	Age	Year-class											
		1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
North Newfoundland Bank (3K)	1		-	-	1	1	1	1	1	1	1	1	1
	2	-	-	5	3	2	1	3	1	3	8	6	-
	3	-	21	11	21	15	36	8	15	27	32	-	-
	4	10	15	11	24	24	17	28	22	36	-	-	-
Southern Barents Sea	1	-	-	-	3	14	74	47	1	1	1	1	2
	2	-	-	4	3	5	11	56	1	1	1	1	-
	3	-	18	9	2	6	20	47	1	1	1	-	-
	4	15	19	3	1	4	18	1	1	1	-	-	-

Table 2

Commercial catch of the Labrador cod and the productivity of trawl fisheries

Year	Total catch by all countries in the preceding four years (th.tons)	Mean catch per hour trawling (t) in the South Labrador area in the earlier six months of the year		
		Soviet BMRT	Portuguese trawlers	Spanish trawlers
1960	541	2.97	3.55	2.25
1961	734	2.87	2.97	2.33
1962	976	3.02	3.24	3.01
1963	1205	3.80	3.42	2.96
1964	1345	3.79	2.45	2.48
1965	1404	3.38	2.64	2.11
1966	1453	3.34	2.40	1.87
1967	1538	2.41	2.40	1.82
1968	1599	3.83	2.64	2.03
1969	1841	3.02	3.13	-

Table 3

Age composition of cod in the South Labrador area in the earlier six months of the year (calculated from length data)

Age	1961	1962	1963	1964	1965	1966	1967	1968	1969
3		0.6	0.2					0.2	0.2
4	5.6	1.9	3.6	1.1	5.8	8.5	2.3	2.1	3.0
5	6.4	15.2	4.7	7.9	5.8	34.7	15.4	21.0	14.7
6	19.3	22.4	11.7	13.5	12.1	21.3	25.5	20.5	30.1
7	21.2	15.5	32.8	32.6	16.3	16.1	17.6	19.6	22.0
8	11.7	13.2	16.6	27.7	23.4	8.8	17.0	16.4	15.1
9	12.5	6.9	8.3	6.6	20.4	3.3	8.7	8.9	6.8
10	9.4	6.2	7.1	2.7	7.4	4.2	5.2	4.2	3.2
11	2.9	4.8	3.4	2.8	2.9	0.4	3.0	3.1	0.9
12	3.7	2.4	3.5	2.0	1.7	2.0	0.9	2.9	1.9
13	2.9	3.1	1.9	1.1	2.0	0.7	0.6	0.4	1.4
14	1.7	1.2	1.5	0.6	1.0	-	0.7	0.4	0.2
15	1.6	1.5	1.1	0.6	0.4	-	0.1	0.3	0.3
16	0.9	1.3	1.2	0.2	0.8	-	0.3	-	0.2
17	0.2	2.2	0.8	0.3	-	-	0.4	-	-
18	-	0.9	0.4	0.1	-	-	0.1	-	-
19	-	0.4	0.8	0.2	-	-	-	-	-
20	-	0.1	0.2	-	-	-	-	-	-
21	-	0.2	-	-	-	-	-	-	-
22	-	-	0.2	-	-	-	-	-	-
Mean age	8.0	8.1	8.2	7.6	8.0	6.3	7.3	7.1	7.0
Numbers	9670	23037	69610	64654	9844	6737	21579	61.07	3973

Table 4

Numbers of cod by age groups in the mean catch per hour trawling in the South Labrador area in the earlier six months of 1961-1969

Year-class	Age 4	5	6	7	8	9	10	11	12	13
1952						234	123	93	55	51
1953					219	137	194	78	43	20
1954				398	262	227	75	74	57	14
1955			362	307	453	184	188	11	21	11
1956		120	444	896	477	518	120	116	80	31
1957	105	301	320	910	595	95	121	85	42	
1958	38	128	377	414	252	202	116	20		
1959	96	221	307	462	395	245	70			
1960	31	147	611	409	452	150				
1961	147	995	593	540	332					
1962	244	358	565	485						
1963	53	578	662							
1964	58	324								
1965	66									

Table 5

Water temperatures and the productivity of trawl fishery in the South Labrador area.

Year	Water temperature in the 50-200 m layer along Section 8-A, November 1.	Year	Mean catch per day fishing by BMRT in February (t)
1964	-0.18	1965	49.2
1965	1.06	1966	46.1
1966	1.44	1967	37.4
1967	0.89	1968	50.5
1968	-0.18	1969	57.7
1969	0.56	1970	44.4

Table 6

Mean numbers of young cod per hour trawling by the survey trawl

Year-class	1			2			3			8	4	
	3K	3N	3O	3K	3N	3O	3K	3N	3O	3K	3N	3O
1958										10	1	0
1959							21	8	1	15	1	1
1960				5	3	0	11	1	2	11	1	0
1961	1	1	1	3	4	3	20	5	1	24	4	1
1962	1	1	7	2	8	2	15	18	2	24	6	1
1963	1	1	1	1	5	1	36	30	1	17	7	3
1964	1	41	24	3	137	13	8	73	42	28	16	7
1965	1	1	1	1	14	12	15	23	20	22	60	9
1966	1	2	15	3	27	17	27	37	34	37	10	4
1967	1	1	2	8	3	4	32	32	14			
1968	1	6	18	6	109	28						
1969	1	2	4									

Table 7

Water temperatures at the southern end of the Grand Bank

Year	Month, day	Temperature (C^{o}) in the 0-200 m layer along Section 2-A between 43°10'N and 42°35'N
1958	May 25-26	3.78
1959	May 28-29	1.10
1960	June 19-20	1-28
1961	May 26-27	1.52
1962	May 24	0.88
1963	May 15-16	0.99
1966	June 13	2.77
1967	May 7-13	2.70
1969	May 24-25	3.47