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On the possibility of assessing stock size and catch quota for Subarea 1 cod

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Introduction.

This paper is not intended to be more than a basis for the discussion on the possibility of estimating present and future stock size by age groups and future catch (eventually catch quota) of Subarea 1 cod. A work sheet for such calculations is proposed. This proposal may not, however, be the only practicable approach to the problem. It is therefore hoped that the paper will initiate further studies on catch quota assessment.

Present knowledge and future work required on the biological side of catch quota management.

The fundamental knowledge necessary for setting a catch quota with any accuracy of practical interest consists of

a. Complete, reliable and prompt statistics on catches, landings and effort.
b. Adequate knowledge of age composition of catches by division, gear and quarter (or month).
c. Current knowledge of parameters on growth and mortality including analysis of such parameters' dependence on changes in environment and stock density.
d. Some broad knowledge of the strength of the pre-recruit cod year-classes. The closer these pre-recruit year-classes are to enter the fishery the more accurate knowledge is required.

Re. a. Statistics: Present quality of data seems sufficient good although improvement could and should still be achieved. The speed by which data are available has, however, by mid May 1969 not allowed the author to make more than a rough calculation of the probable 1968 catch and a partly arbitrary assessment of the 1969 stock size and catch leaving for 1970 nothing more than a feeling of the trends in stock size changes.

If the Commission by June in any given year wishes to have reasonable accurate proposals for next year's catch quota and some guidance on the next 2-3 years' catch it is obviously necessary to speed up the circulation of sampled data and statistics.

Re. b. Sampling: Although present knowledge of age composition of catches seems rather good more intensive and especially better planned and co-ordinated sampling is required for the management of a quota system. Considering,

however, the very great progress already made in sampling it seems most likely, that an adequate international sampling routine can be achieved. Again, however, speedy analysis and exchange of data is required.

Re. c. Parameters: The knowledge of parameters is, of course, closely connected with items a. and b. mentioned above.

Re. d. Pre-recruits: Previous and present surveys on fish larvae and youngest age-groups of cod have given some knowledge of the strength of the pre-recruit year-classes enabling us to predict recruitment of "poor", "medium", "rather good", "strong" etc. year-classes and to predict upward and downward trends in stock size. For catch quota management this broad knowledge may not be sufficient. It will, therefore, be necessary to extend field work on the pre-recruit, for example by research vessels trawling with fine meshed trawls at selected stations each year at a certain time. Field work of this kind has been started by Denmark in 1968. Preliminary results seems promising but cannot be fully evaluated before the present pre-recruits have been exploited some years.

From what is said above the best possible way of handling the biological side of the catch quota management may be to form a working group for each regulated subarea. Such a working group would probably consist of one expert from each member country fishing in the subarea. If the group meets in April every year national statistical offices and national fisheries laboratories should be able to provide data for the preceding year which their member of the working group could bring to the meeting. The findings of the working group could then be circulated in due time before the annual meeting of the Commission allowing countries to study the report and discuss the practical side of the catch quota management before and during the annual meeting.

Proposal for a model and a work sheet for stock size and catch quota assessment

The work sheet for calculating stock size and catch shown in this paper has been worked out and filled in by the following procedure:

Annual landings broken down by age-groups have been calculated from existing samples and statistics as mentioned in paper by Horsted (1967a). These figures are given for the years 1962-67 in line headed "5", giving numbers x 10^{-3} landed.

Supposing the annual value of F (taken from Horsted, 1968) given in uppermost heading of the sheet applies to all age-groups and setting in this example M=0.20 for all exploited age-groups one can readily calculate the initial numbers present per year-class at the beginning of the year (t),

$$N_t = \frac{C_t}{(1-e^{-Z_t}) \cdot E_t}$$

This calculated value (in thousands) is shown in line headed "2".

The numbers left of the respective year-class at the beginning of next year (t + 1) is then

$$N_{t+1} = N_t \cdot e^{-Z_t}$$

This figure is given in line headed "1".

For years on which information on catch and stock composition exists (the latest year at present being 1967) N_{t+1} can, however, also be calculated in the same manner as just mentioned for N_t

$$N_{t+1} = \frac{C_{t+1}}{\left(1-e^{-Z_{t+1}}\right)E_{t+1}}$$, again given in line "2".

The initial numbers present of the respective year-classes is thus (for years up to and including 1967) arrived at in two ways, one figure (line "1") derived from observed catch and F last year, the other (line "2") from observed catch and estimated F in the considered year itself. These two figures should by adequate sampling and statistics be rather equal if all age-groups regarded were fully recruited and if our values of F and M applied to all age-groups in the respective years. The two values are, however, not equal. The ratio between them is given in line "3" and also shown in separate table at the bottom of the sheet. It will be noted that while the accordance between "1" and "2" is extremely good for age-groups 7 and older this is not the case for younger age-groups. In all cases younger age-groups are underestimated when the estimate is based on figures for the preceding year. The explanation for this may be a combination of the following possibilities

i) a considerable migration of small cod from Greenland coastal waters to offshore banks (Horsted 1967b) and in some years also from SE Greenland waters to West Greenland banks (e.g. Hansen, 1967; Meyer, 1965),

ii) the slowest growing individuals of each year-class may not have reached the l_c value when data for calculation of figure "1" were sampled but so have when data for figure "2" were sampled,

iii) information (sampling) on discard and industrial fish is insufficient,

iv) F and M have quite other values for the younger cod than those used in the calculations. Long lines, for example, tend to catch rather big fish although set on places where also smaller fish are known to be present (being caught by trawl or by hand line).

The ratio between the two figures ("2"+"1") is close to but in all cases less than 1 for age-groups 9 and older. This could probably be explained by spawning migration of big cod from West Greenland waters to East Greenland - Iceland.

Some analyses should be made on these theories but lack of time and partly of data has not permitted this for the present meeting. In an attempt to estimate the 1968 and 1969 catch by a given overall value of F the author has nevertheless used the mean ratio values given at the bottom of the sheet plus an arbitrary figure for recruits from the 1965 year-class which from most recent surveys seems a promising year-class.

Taking numbers present at the beginning of 1967 as given in line "2" and supposing F = 0.75 in 1967, (M = 0.20) the numbers present at the beginning of 1968 is readily calculated. These figures (line "1") are then multiplied by the mean ratio value thus giving initial exploitable stock in 1968 (line "4"). Same procedure is then followed from 1968 to 1969 but of course with decreasing liability in the result since the figure for age-group 4 is quite abitrary.

Supposing F = 0.80 in 1968 and 1969 and taking mean weight of the various age-groups as in paper by Horsted (1967a) the estimated 1968 catch is app. 349,000 tons while the 1969 catch with present rather poor knowledge of pre-recruits is expected to be 293,000 tons only, the reason for the decline being the apparent relative poor recruitment in most recent years.

Supposing one would aim at achieving a fishing mortality of F = 0.60 (corresponding to a 25% reduction in the estimated present effort) by means of a catch quota the 1968 quota would have been recommended to be app. 285,000 tons (possibly expressed as "not more than 300,000 tons") and the 1969 quota as "not more than 300,000 tons". A 25% reduction in effort in 1968 would thus have lead to a 14-18% reduction in catch while already in 1969 (provided 25% effort reduction did occur in 1968) the stabilized reduced effort would mean a catch nearly equal to what would have been taken by maintaining the estimated actual effort.

The uncertainty by which coming years' stock of youngest age-groups is set seems not to be a serious matter as long as this stock is not very overestimated because it has been demonstrated (Anon., 1967) that the highest bio-mass in a year-class occurs at an age of 6-7 years. A quota set too low due to underestimated recruitment will thus be compensated by higher output in the next years.

It must also be born in mind that introduction of a quota system could lead to some changes in the fishing operation, e.g. to concentrate fishery on special seasons and hence on special age-groups thus giving another variation in F between age-groups than presumed in the calculations here. Also the existence of more than just one stock and possible density dependent changes in growth parameters and recruitment must be taken into account.

References:

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Ibid., 1967b. Possible effect of a closure of Div. 1B to trawling judged by tagging experiments and other relevant data. ICNAF Redbook 1967, III:48-81.

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SIMPLIFIED WORK SHEET FOR STOCK SIZE AND CATCH, SUBAREA 1 COD

1: Numbers x 10^{-3} present at the beginning of the year according to preceding year's catch and F.
2: Numbers x 10^{-3} present at the beginning of the year according to same year's catch and F.
3: Relation 2÷1.
4: Estimated numbers x 10^{-3} present at the beginning of the year based on figures in 1 and 3, the figure in 3 being mean of previous years.
5: Numbers x 10^{-3} landed. 1962-67 based on samples and statistics, 1968-69 on estimated stock and assumed F.
A: Nominal catch (thousand metric tons) in Stat.Bull.
B: Nominal catch calculated from 5 and Table 2, Horsted, 1967.
+ including older year-classes.

Year-class		Year 1962 F .48	1963 .54	1964 .59	1965 .65	1966 .70	1967 .75	1968 .80	1969 .80	1968 .60	1969 .60
1953	1										
	2	51605+									
	3										
	4										
	5	18078+									
1954	1		33627+								
	2	14772	32983+								
	3		0.98								
	4										
	5	5175	12590+								
1955	1		9965	22982+							
	2	19671	15187	21833+							
	3		1.52	0.95							
	4										
	5	6891	5797	8944+							
1956	1		40785	27317	23067+						
	2	80507	57257	28998	20444+						
	3		1.40	1.06	0.89						
	4										
	5	28203	21856	11879	8897+						
1957	1		137553	71500	29653	25045+					
	2	271522	149865	65344	38155	24209+					
	3		1.09	0.91	1.29	0.97					
	4										
	5	95118	57206	26768	16604	11205+					
1958	1		15493	32859	21178	9642	13534+				
	2	30555	68873	46669	22560	9076	12772+				
	3		4.45	1.42	1.07	0.94	0.94				
	4										
	5	10714	26290	19118	9818	4201	6188+				
1959	1		2105	14455	14678	8900	5856	7732+			
	2		30297	32345	20824	14404	7222				
	3		14.39	2.24	1.42	1.62	1.23	0.94			
	4							7268+			
	5	1456	11565	13250	9062	6667	3499	3675+		3002+	
1960	1			8424	51391	53291	35210	19648	11420+		13947+
	2	A 451		113245	24687	86596	50810				
	3	B 435		13.44	2.42	1.62	1.44	1.21	0.94		
	4							23774	10735+		13110+
	5		6740	46391	54261	40081	24618	12020	5427+	9819	5414+
1961	1				4866	51627	47131	46834	22227		27145
	2		A 406		120793	115916	121113				
	3		B 345		24.82	2.25	2.57	1.29	1.21		
	4							60416	26895		32845
	5			4393	52566	53652	58680	30546	13598+	24951	13565

Year-class	Year / F	1962 .48	1963 .54	1964 .59	1965 .65	1966 .70	1967 .75	1968 .80	1969 .80	1968 .60	1969 .60
1962	1					1076	6904	23954	14276		17435
	2			A 350		16980	61945				
	3			B 350		15.78	8.97	1.62	1.29		
	4							38805	18416		22491
	5				1096	7859	30013	19620	9311	16026	9289
1963	1						334	16467	24232		29594
	2				A 359		42583				
	3				B 367		127.49	4.07	1.62		
	4							65868	39256		47942
	5					380	20632	33308	19848	27203	19800
1964	1							2449	15416		18827
	2					A 366					
	3					B 352		17.11	4.07		
	4							41902	62743		76626
	5						3069	21186	31723	17306	31646
1965	1										
	2						A 419				
	3						B 414				
	4								60000		62000
	5							3000	30340	2500	25608
1966	1										
	2							B 349		B 285	
	3										
	4										
	5								3000		2500
									B 293		B 286

Relation 2+1	Year / age	1963	1964	1965	1966	1967	mean	± S
	9	0.98	0.95	0.89	0.97	0.94	0.94	0.04
	8	1.52	1.06	1.29	0.94	1.23	1.21	0.22
	7	1.40	0.91	1.07	1.62	1.44	1.29	0.29
	6	1.09	1.42	1.42	1.62	2.57	1.62	0.56
	5	4.45	2.24	2.42	2.25	8.97	4.07	2.90
	4	14.39	13.44	24.82	15.78	(127.49)x	17.11	5.23

x not incl. in mean.