Not to be cited without
permission of the authors[1]

Canadian Atlantic Fisheries
Scientific Advisory Committee

CAFSAC Research Document 92/104

Ne pas citer sans
autorisation des auteurs[1]

Comité scientifique consultatif des
pêches canadiennes dans l'Atlantique

CSCPCA Document de recherche 92/104

Expected yield for the southern Gulf of St. Lawrence Cod Stock with and without a Winter Fishery

by

G.A. Chouinard
Department of Fisheries & Oceans
Science Branch, Gulf Region
P.O. Box 5030
Moncton, New Brunswick
E1C 9B6

Abstract

Simulations using modified catch equations, observed average weights at age and fishing patterns were conducted to determine the expected yield for the southern Gulf of St. Lawrence cod stock with and without a winter fishery. Results show that there is essentially no difference in expected yield under these two conditions.

Résumé

Des simulations réalisées avec des équations de capture modifiées, les poids moyens et les patrons de pêche (recrutement partiel) observé ont été effectuées pour déterminer le rendement attendu pour le stock de morue du sud du Golfe du St. Laurent avec et sans pêche d'hiver. Les résultats indiquent qu'il n'y a essentiellement pas de différence dans le rendement sous ces deux conditions.

1) Introduction

Growth, geographic distribution of fish according to size and selectivity of gears are all factors that can affect the yield that can be obtained from fish stocks. For example, exploiting a stock later in the year after growth has taken place may produce an increase in yield providing that the fishery at that time is not prosecuted with less selective gears and that the size-structure of the population available to the fishery is not characterized by more small fish. If the rate of growth is low then losses due to natural mortality may also outweigh any gains in yield.

The southern Gulf of St. Lawrence cod stock (4T-Vn (J-A)) undergoes an extensive annual migration. During the late spring, summer and fall, the population is found in the southern Gulf of St. Lawrence where it is exploited by inshore vessels (less than 15 m L.O.A.) and midshore vessels (15 - 30 m L.O.A.) fishing with otter trawls, Danish and Scottish seines and fixed gears (longlines and gillnets). In recent years, this fishery has accounted for between 70 and 80% of the landings. During the fall (October - December), the population migrates from the western sections of NAFO 4T (4Tkln) to the eastern areas (4Tfg) and then to the Sydney Bight area (4Vn). During the winter, the stock is primarily exploited in 4Vn by offshore vessels from Canada and France. In 1992, the original allocations in 4Vn amounted to 7,024 t (including 1,600 t for France), or 16.3% of the total TAC of 43,000 t for the stock. The remainder of the quota was allocated to fleets fishing in 4T.

A study conducted in 1987 (Chouinard and Sinclair 1987) examined the implications of a closure of the winter fishery (4Vn (January-April)) in terms of the yields that could be obtained from the stock. It was concluded at the time that an increase in yield of about 3% could be expected if the fishery was conducted exclusively in 4T. This increase was considered marginal and given the expected year-to-year variations, it was concluded that a fishery conducted only during the summer would not significantly increase the yield from the stock.

Data used in the earlier work covered the early 1980's. Since then, many changes have occurred; there have been significant changes (reduction) in average weight-at-age, the proportion of the catch caught by fixed gears has decreased markedly, the proportion taken by France has also decreased and an Enterprise Allocation (EA) program has been introduced for many fleets. Given these changes, it was considered appropriate to revisit this issue to provide current information.

2) Methods

The yields with and without a winter fishery were examined by conducting long-term projections using modified catch equations. Average weight at age and partial recruitment (PR) vectors were first derived for each fishery (4Vn (January to April) and 4T (May - December)) separately using data for the years 1988-1990 (Chouinard and Sinclair 1989; Chouinard et al. 1990; Hanson et al. 1991). It should be noted that average weights are calculated with a single length-weight relationship derived from data collected during September and therefore differences in average weight-at-age are due to differences in the length-at-age in the commercial samples. Data for the first quarter were used in the calculations for 4Vn. Average weights by year and fishery are presented in Table 1. Partial fishing mortalities (see below) were obtained by multiplying fishing mortalities (F) for the years 1988-1990 (Hanson et al. 1991) by the ratio of the fishery catches to the total catches (4Vs catches in 1990 were excluded).

4Vn

	Year		
Age	1988	1989	1990
3	0.000	0.000	0.000
4	0.030	0.001	0.000
5	0.008	0.006	0.003
6	0.028	0.016	0.024
7	0.029	0.030	0.037
8	0.037	0.029	0.055
9	0.045	0.035	0.053
10	0.070	0.048	0.051
11	0.141	0.025	0.046
12	0.070	0.058	0.063
13	0.006	0.099	0.044
14	0.014	0.033	0.065

4T

	Year		
Age	1988	1989	1990
3	0.001	0.001	0.003
4	0.017	0.016	0.030
5	0.061	0.080	0.108
6	0.175	0.205	0.192
7	0.199	0.239	0.266
8	0.244	0.235	0.248
9	0.201	0.209	0.192
10	0.253	0.254	0.166
11	0.390	0.266	0.156
12	0.573	0.370	0.129
13	0.555	0.359	0.186
14	0.216	0.229	0.142
15	0.285	0.154	0.278
16	0.249	0.199	0.278

A two-way analysis of variance of these partial F's was then used to derive age and year effects; age effects represent fishing patterns (partial recruitment) while the year effects indicate the changes in fishing mortality from one year to the next.. For the 4Vn fishery, catches of ages 15 and 16 were minimal and therefore F's for these ages were not included in the analyses. The analysis of variance tables are presented below:

For 4Vn:

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Ages	0.017058	11	0.001551	2.349586	0.042414	2.258517
Years	0.000412	2	0.000206	0.311952	0.735201	3.443361
Error	0.01452	22	0.00066			
Total	0.03199	35				

For 4T:

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Ages	0.447666	13	0.034436	4.89667	0.000285	2.119165
Years	0.039309	2	0.019655	2.794841	0.079536	3.36901
Error	0.182845	26	0.007033			
Total	0.669821	41				

The age effects derived from these analyses were then normalized to obtain partial recruitment vectors for each of the two fisheries. The resulting PR vectors (following) indicate that cod are recruited earlier (at a smaller size) to the fishery in 4T than in 4Vn (see also Figure 1). The partial recruitment vector is dome-shaped in 4Vn where the fishery is almost exclusively prosecuted by mobile gears.

Partial recruitment

Age	4Vn	4T
3	0.001	.005
4	0.017	.079
5	0.093	.312
6	0.40	.737
7	0.578	.902
8	0.712	1.000
9	0.807	1.000
10	1.000	1.000
11	1.000	1.000
12	1.000	1.000
13	0.540	1.000
14	0.540	1.000
15	0.540	0.741
16	0.540	0.891

Using these PR for each fishery, a constant recruitment of 10,000 fish, a natural mortality (M) rate of 0.2 and the average weights for the years 1988 - 1990 , stock projections were conducted using two scenarios.

The first simulation represented the status quo with a winter fishery in 4Vn during January to April and a fishery in 4T during the remainder of the year. In this scenario, F for each fishery were allowed to vary so that two conditions would be satisfied: 1) the fully-recruited F for the entire year would be equal to 0.2 and, 2) the catch biomass in 4Vn would amount to 16.3 % of the total catch (1992 allocation from 1992 Groundfish Management Plan). In the second simulation, the fishery was restricted to 4T from May to December and the fully-recruited F was set equal to 0.2. In this case, the only removals from January to April were caused by natural mortality.

3) Results

The results (see table below) indicate that the yields from this stock with or without a winter fishery are essentially the same. Although there is no basis to calculate confidence intervals, the yields of the two exploitation strategies are not considered to be significantly different.

	Catch ('000)	Yield (t)	% of *status quo yield*
Status quo fishery (F =0.2)	*2672*	*3558*	*100*
4T fishery only (F= 0.2)	*2854*	*3672*	*103*

4) Discussion and Conclusion

There are several reasons why the yield of a summer fishery only is not significantly higher than a fishery starting in January. First, observer data tend to indicate that a larger mesh size is used in the winter fishery. Secondly, cod from this stock do not appear to grow before spawning and may lose weight during the winter and spring (K. Schwalme, Dept. of Fisheries and Oceans, P.O. Box 5030, Moncton, N.B. E1C 9B6; pers. comm.). This loss of weight could not be modeled here, however it would apply to both simulations. The spring (April-June) fishery in the southern Gulf of St. Lawrence is prosecuted mainly by mobile gears and in the period 1988-1990 accounted for between 25 and 38% of total landings on the stock (Chouinard and Sinclair 1989; Chouinard et al. 1990; Hanson et al. 1991; 1992). The summer fishery no longer has a large fixed gear component which used to catch larger fish at age. In 1990, fixed gear catches in the southern Gulf of St. Lawrence accounted for about 10% of the landings (Hanson et al. 1992). Finally, at least some of the young cod appear to remain in 4T during the winter (Clay 1991) and consequently more small fish are probably available to the fishery in the summer. All of these observations are consistent with the higher partial recruitment for young ages observed in the fishery conducted in 4T. In the calculations, this higher partial recruitment had the effect of countering the gains in weights at age and therefore did not produce appreciable gains over the current situation.

In general for this stock, increases in yield could likely be obtained by using more selective gears. Although increasing mesh size is one method of improving selectivity, modifications to the mobile gears used such as adding shortened lastage ropes or square mesh panels to facilitate escapement or changing twine size may have a similar effect. Harvesting when fish are in better condition (i.e., after the growing season) could also increase the yield in terms of biomass. In this case and more generally, the economic dimension will need to be examined closely to determine the effect of a varying supply of fish.

5) References

Chouinard, G.A. and A.F. Sinclair 1987. Impact of the 4Vn winter fishery on the yield of the southern Gulf of St. Lawrence cod stock. CAFSAC Res. Doc. 87\92, 10p.

Chouinard, G.A. and A. F. Sinclair 1989. Assessment of the 4T and 4Vn (Jan.-Apr.) cod stock for 1989. CAFSAC Res. Doc. 89/51, 50 p.

Chouinard, G.A., G. A. Nielsen, L. G. Currie and J. P. Murphy 1990. Stock status of the southern Gulf of St. Lawrence cod stock (4T and 4Vn (Jan.-Apr.)) in 1990. CAFSAC Res. Doc. 90/46, 58 p.

Clay, D. 1991. Seasonal distribution of demersal fish (Osteichthyes) and skates (Chondrichthyes) in the southeastern Gulf of St. Lawrence p. 241-259 In J.-C. Therriault (ed.) The Gulf of St. Lawrence: small ocean or big estuary ? Can. Spec. Publ. Fish. Aquat. Sci. 113

Hanson, J.M., G.A. Chouinard, G.A. Nielsen and L.G. Currie. 1991. Stock status of the southern Gulf of St. Lawrence cod stock (4T and 4Vn (Jan.-Apr.) in 1991. CAFSAC Res. Doc. 91\49, 70 p.

Hanson, J.M., G.A. Chouinard, G.A. Nielsen and L.G. Currie. 1992. Status of the 4T-Vn (Jan.-Apr.) .cod stock in 1992. CAFSAC Res. Doc. 92/55, 76 p.

Table 1. Average weight (kg) and catch at age ('000) for the 4T-Vn (J-A) cod fishery (from Chouinard and Sinclair 1989, Chouinard et al. 1990 and Hanson et al. 1991)

1988						
	Entire Fishery		4Vn		4T	
Age	Average Weight	Catch	Average Weight	Catch	Average Weight	Catch
3	0.382	99	0.133	5	0.395	94
4	0.583	1474	0.419	229	0.613	1245
5	0.760	4414	0.576	533	0.785	3881
6	0.923	10156	0.842	1509	0.937	8647
7	1.045	7908	1.039	1057	1.046	6851
8	1.139	10968	1.127	1519	10141	9449
9	1.322	6066	1.280	1156	10332	4910
10	2.032	1636	1.927	350	2.061	1286
11	2.457	965	1.721	242	2.703	723
12	3.156	487	4.761	48	2.981	439
13	3.931	216	10.000	2	3.874	214
14	5.480	54	5.873	3	5.457	51
15	8.591	64			8.591	64
16	12.106	18	14.961	1	11.938	17

Table 1 - (continued)

1989						
	Entire Fishery		4Vn		4T	
Age	Average Weight	Catch	Average Weight	Catch	Average Weight	Catch
3	0.531	56			0.531	56
4	0.629	1368	0.482	76	0.638	1292
5	0.771	5089	0.602	376	0.784	4713
6	0.901	10547	0.781	740	0.910	9807
7	1.082	9340	0.974	1028	1.095	8312
8	1.215	6215	1.150	688	1.223	5527
9	1.236	6391	1.153	919	1.250	5472
10	1.415	4779	1.286	754	1.439	4025
11	1.948	881	2.093	75	1.935	806
12	2.322	371	1.865	50	2.393	321
13	2.580	148	1.694	32	2.824	116
14	3.620	48	2.198	6	3.823	42
15	3.268	37	1.690	16	4.470	21
16	2.955	15	2.133	4	3.254	11

Table 1 - (continued)

1990						
	Entire Fishery		4Vn		4T	
Age	Average Weight	Catch	Average Weight	Catch	Average Weight	Catch
3	0.563	460	0.383	5	0.565	455
4	0.725	259	0.584	83	0.730	2514
5	0.850	6907	0.852	386	0.850	6521
6	1.031	9982	1.106	2186	1.010	7796
7	1.174	10233	1.218	2423	1.160	7810
8	1.280	7599	1.282	2528	1.279	5071
9	1.336	4432	1.313	1713	1.351	2719
10	1.388	4535	1.321	1869	1.435	2666
11	1.468	2494	1.352	1026	1.549	1468
12	1.791	493	1.604	262	2.003	231
13	2.448	12	1.748	49	2.829	90
14	2.880	51	1.566	26	4.247	25
15	2.801	32			2.801	32
16	8.044	29			8.044	29

Table 2. Average weights (kg) (1988-1990) used in the simulations.

Age	4T	4Vn
3	0.497	0.258
4	0.660	0.495
5	0.807	0.677
6	0.952	0.910
7	1.101	1.077
8	1.214	1.186
9	1.311	1.249
10	1.645	1.511
11	2.062	1.722
12	2.459	2.743
13	3.176	4.481
14	4.509	3.212
15	5.287	1.690
16	7.745	8.547

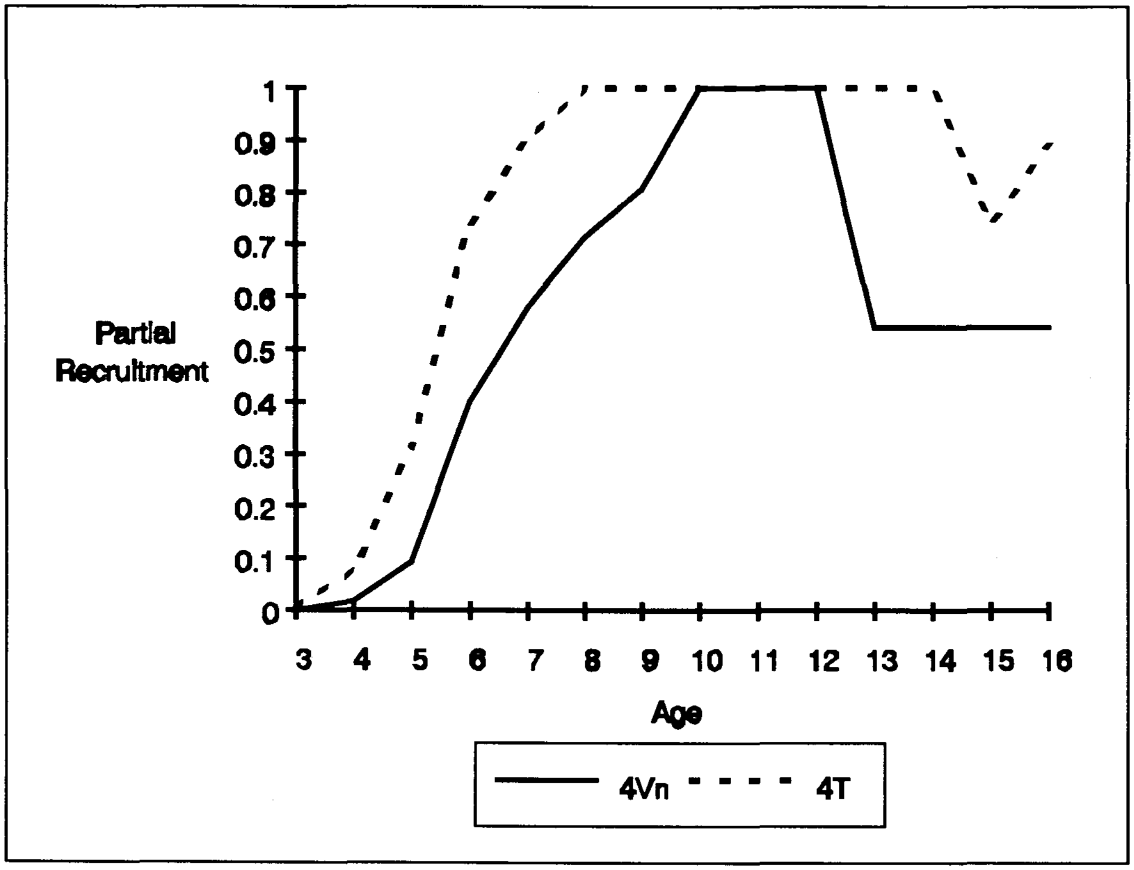

Figure 1. Partial recruitments used in the simulation