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Estimating Fleet Specific F Given Catch Quotas

by

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**Introduction**

The 1993 TAC's for several cod stocks in Atlantic Canada were greatly reduced from previous years to reduce fishing mortality to the  $F_{0.1}$  target. Following basic fishing theory, a reduction in F would translate into a proportional reduction in effective fishing effort. Fishing effort may be reduced by reducing the efficiency of fishing operations by directing effort to periods when fish are less aggregated and thus harder to catch, or by reducing the efficiency of the gear (e.g. by increasing mesh or hook size). Fishing effort may also be reduced by reducing the time at sea, either by reducing the number of days fished per unit or by reducing the number of units.

This paper presents a methods for estimating the relative change in fleet specific F that is implied by a reduction in stock-wide F. The approach assumes that fleet quotas will be set based on a proportional sharing of the TAC. It requires fleet specific catch at age data as well as estimates of F at age for the population. Data from Div. 4TVn(J-A) cod were used as an example. In this case there are two main fleets, fixed gear, made up of gillnets, longlines and handlines; and mobile gear, made up of otter trawls and seines. The results of such calculations may be useful in planning fleet effort reduction strategies.

**Methods**

Estimates of F at age (i) in a given year (j) from SPA were partitioned among gears (k) using the gear specific catch at age.

$$F_{ijk} = \frac{F_{ij} C_{ijk}}{\sum_k C_{ijk}}$$

The average F at age for the gear was calculated over a suitable range of recent years. In this case the average over three years, 1989-91 was used.

The current management plan for Div. 4TVn cod shares the TAC among the fleets as 25% fixed and 75 % mobile. Assuming a 1993 TAC of 13,000 t, the fleet quotas ( $Y_k$ ) would be 3,250 t and 9,750 t respectively.

The relative change in F needed by fleet sector to attain the 1993 TAC was estimated in the following manner. Catch at age by gear ( $C_{ik}$ ) and the yield to each gear sector ( $Y_k$ ) in 1993 were calculated as

$$C_{ik} = N_i \frac{(1 - e^{-(M + \sum_k F_k)}) F_{ik}}{M + \sum_k F_{ik}}$$

$$Y_k = \sum_i C_{ik} W_i$$

where  $N_i$  = the population at age i at the beginning of 1993  
 $M$  = 0.2  
 $W_i$  = the average weights used in catch projections

I used an iterative approach to find the gear specific F vectors which satisfied the yield constraints. This consisted of starting with the average F for both gears, then calculating

the catch at age and yield for one gear. The yield was compared to the target quota. The gear specific F was adjusted by the ratio of the target yield to the estimated yield. The process was repeated until the correct F for that gear was found. While holding this F constant, F for the second gear was adjusted to satisfy the respective quota. If the estimated yields differed from the targets, the procedure was repeated. A flow chart is given in Figure 1. The methodology is described in Sinclair (1993).

#### Example

An example using data for the Div. 4TVn cod stock is given below. Catch at age and by gear sector were obtained from the relevant assessment documents (Chouinard, et al. (1990), Hanson, et al. (1991), Hanson, et al. (1992)). Winter catches of 4TVn cod in 4Vs were taken from Hanson and Nielsen (1992). These are given in Table 1. The most recent estimates of F for the stock are also given in Table 1 (G. Chouinard, pers. comm.), as well as the annual gear specific F at age.

Table 2 presents the results of the calculations of gear specific F at age, catch at age, and yields from 1993-1997 at fishing mortalities needed to attain a 25%-75% fixed/mobile gear sharing of the 1993 TAC. The line labeled "Mult." in Table 2 gives the effort multiplier needed to attain these catch quotas. The results indicate that fixed gear F needs to be reduced to .98 the 89-91 average. Mobile gear F needs to be reduced to .27 the 89-91 average. The difference in the required reductions is consistent with the recent trend of the fixed gear fleet not catching its quota.

#### References

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Table 1: Gear specific catch and F at age for 4TVn cod from 1989-91.

Catch at age	Fixed Gear			Mobile Gear			Total		
	Age	1989	1990	1991	1989	1990	1991	1989	1990
3	2	14	27	54	442	203	56	460	232
4	96	99	345	1268	2516	4245	1368	2638	4634
5	282	203	693	4838	6570	8492	5134	6833	9273
6	619	489	504	10100	9431	8120	10748	9999	8703
7	783	520	399	8885	9041	6816	9693	9642	7278
8	609	431	355	6141	6140	3934	6767	6628	4329
9	645	341	242	6393	3921	2494	7055	4294	2761
10	772	448	152	4100	3955	1315	4885	4435	1480
11	223	296	146	705	1661	750	930	1975	905
12	103	79	97	326	282	435	430	364	537
13	50	37	30	98	77	56	148	115	87
14	18	21	10	30	17	15	48	38	25
15	13	27	3	24	5	14	37	32	17
16	2	19	5	13	10	3	15	29	8
Total	4217	3024	3008	42975	44068	36892	47314	47482	40269

F at age	Fixed Gear			Mobile Gear			Total		
	Age	1989	1990	1991	1989	1990	1991	1989	1990
3	0.000	0.000	0.000	0.001	0.006	0.002	0.001	0.006	0.002
4	0.002	0.002	0.006	0.028	0.045	0.071	0.030	0.047	0.078
5	0.007	0.006	0.017	0.115	0.196	0.211	0.122	0.204	0.230
6	0.019	0.018	0.025	0.318	0.345	0.402	0.338	0.366	0.431
7	0.035	0.031	0.027	0.401	0.542	0.466	0.438	0.578	0.498
8	0.045	0.040	0.046	0.456	0.566	0.509	0.502	0.611	0.560
9	0.052	0.056	0.049	0.518	0.640	0.506	0.572	0.701	0.560
10	0.114	0.090	0.058	0.603	0.795	0.498	0.719	0.892	0.560
11	0.184	0.110	0.072	0.581	0.616	0.371	0.767	0.733	0.448
12	0.209	0.174	0.081	0.661	0.621	0.363	0.872	0.802	0.448
13	0.247	0.166	0.154	0.484	0.345	0.288	0.731	0.515	0.448
14	0.277	0.461	0.179	0.462	0.373	0.269	0.739	0.834	0.448
7+	0.145	0.141	0.083	0.521	0.562	0.409	0.668	0.708	0.496

Table 2: Estimates of gear specific F at age, catch at age, and yields for fixed and mobile gears fishing 4TVn cod in 1993-97.

	Mean F 89-91		F required for TAC of 13 kt			Wt	M
	Fixed	Mobile	Fixed	Mobile	Total		
3	0.000	0.003	0.000	0.001	0.001	0.536	0.2
4	0.003	0.048	0.003	0.013	0.016	0.666	
5	0.010	0.174	0.010	0.047	0.056	0.823	
6	0.021	0.355	0.020	0.095	0.115	0.980	
7	0.031	0.470	0.031	0.126	0.156	1.154	
8	0.044	0.510	0.043	0.136	0.179	1.302	
9	0.052	0.555	0.051	0.148	0.200	1.372	
10	0.087	0.632	0.086	0.169	0.255	1.478	
11	0.122	0.523	0.120	0.140	0.260	1.709	
12	0.155	0.548	0.152	0.147	0.299	1.934	
13	0.189	0.372	0.186	0.100	0.285	2.467	
14	0.306	0.368	0.300	0.098	0.399	3.659	

Mult 0.982 0.267

Population	Catch	
	Fixed	Mobile
1993		
3	70000	9 48
4	57116	163 660
5	45295	392 1858
6	35176	615 2864
7	17572	454 1858
8	6787	242 771
9	4386	186 536
10	2137	147 290
11	1363	131 153
12	730	87 84
13	595	88 47
14	353	80 26
Weight	3250	9750

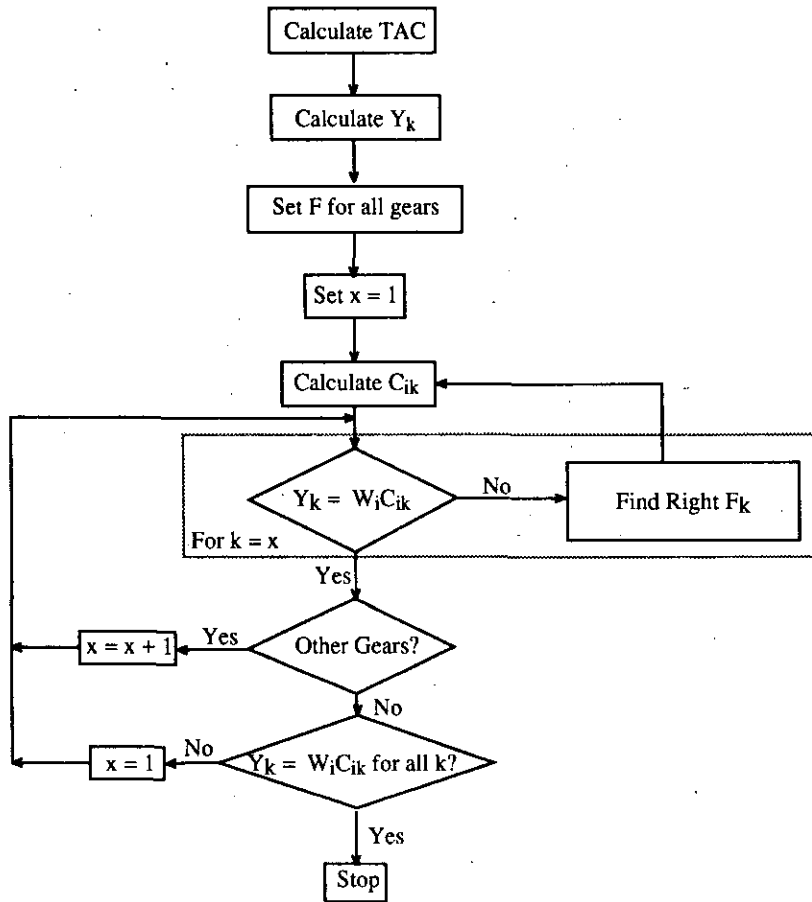


Figure 1: Flow chart for calculating gear specific catch quotas under the fixed percentage yield allocation regime. Gear specific fishing mortalities ( $F_k$ ) which satisfy the yield constraints ( $Y_k$ ) were found with an iterative procedure described in the methods section.