Northwest Atlantic Fisheries Organization

Serial No. N2581

NAFO SCR Doc. 95/66

SCIENTIFIC COUNCIL MEETING - JUNE 1995

Yield-per-recruit Approximation for Greenland Halibut in Subareas 2 and 3

by

J. Casey

Ministry of Agriculture, Fisheries and Food, Directorate of Fisheries Research,
Fisheries Laboratory, Pakefield Road, Lowestoft, Suffolk, NR33 0HT, UK.

Introduction

Special question number 2 from Canada to the Scientific Council on Greenland halibut in SA 2+3 asks:

What are the implications for the conservation of the stock and long-term harvest in terms of yield-per-recruit and spawning stock biomass-per-recruit of fishing under three assumptions about the sizes of entry/full recruitment as:

a) associated with current NAFO regulated mesh size.
b) harvesting practices that delayed significant recruitment until 60 cm fish.
c) harvesting practices that permitted significant recruitment at 30 cm.

In principle this is not a difficult question to answer. However the practical reality is somewhat different if we wish to be quantitative with any degree of scientific rigour.

Materials and Methods

Mean weight at age

Canadian mean weight at age data for 1993 for ages 5 and older, and from Spanish data for ages 2-4. The latter were derived using mean length at age provided from Spanish sample data and converted to mean weight using $w = a * L^{\wedge b}$ with the following parameters:

a= 0.006393
b= 3.073363

I shall make the following assumptions.

a) Current NAFO regulated mesh sizes are those being used and that the current exploitation pattern is a result of these mesh sizes.

b) 60 cm in length approximately equates to the mean length of age group 10 in the population.

c) 30 cm approximately equates to the mean length of age group 5 in the population.

Exploitation pattern (partial recruitment or PR)

Catch curves were derived from Canadian catch at age data for the period 1988-1993 (Bowering *et al.*, 1995) and from Spanish trawl catch at age data for 1993 and 1994 (De Cardenas, *et al.*, 1995).

Three different PR patterns for the Canadian catch at age data based on the periods 1988-90, 1991-1993 and for the whole series 1988-1993, together with the catch curve derived from Spanish trawl data for 1993 and 1994 are presented in Table 1 and Fig. 1.

F values

Input F was derived using each of the above PR's. Each PR was normalised to the mean Log value in the catch curve over ages 7-12. Z values for each fully recruited age were derived directly from the catch curves and the mean Z over ages 7-12 was calculated. Looking at the catch curves this age range seemed to be the most appropriate. Mean F over the same age range was calculated by subtraction of M (0.15). F at age was obtained by multiplying the calculated mean F (7-12) by the relative catch curve values. The derived partial recruitment patterns are given in Table 2 and Fig. 2.

The initial input values F, M, proportions mature and mean weight at age are given in Table 3.

Since the Canadian PR's come from a period which is essentially history, I have proceeded on the basis that the PR derived from Spanish trawl data is the most appropriate to use for the calculations.

Yield per recruit

In order to avoid tedious selectivity calculations using rather imprecise data, to investigate how yield per recruit varies with different mesh sizes, I have simply simulated yield and stock biomass per recruit values allowing for recruitment to the fishery to occur at different ages. Note that for comparative purposes, the calculations are on the basis of a single recruit at age 2 in all calculations ie. allowing M = 0.15 to occur on each age group not subjected to F. A completely different picture emerges if each calculation is carried out by imputing 1 recruit at the age of recruitment to the catches (Not shown).

Results

The results are presented in Table 4 and Fig. 3 and 4 for restricting entry to the fishery to ages 2 (current), 5, 7 and 10. The data indicate that at the current level of fishing, long-term gains in yield of the order of 3 times the current level may be expected if the age of first capture in the fishery is delayed to age 10. The long-term gains to the spawning stock would be approximately 6-7 times the estimated current level if the age at first capture is delayed to age 10.

Discussion

The results should be regarded with a certain degree of caution since the derived input parameters are not considered precise. Nevertheless, the results are in line with what we would expect, and although the levels of yield and Spawning stock biomass estimated may be imprecise, unless errors in the true level of input fishing mortality are large, the relative changes in yield and Spawning stock biomass should be of the order indicated.

References

Bowering, W. R., W. B. Brodie, D. Power, and M. J. Morgan. 1995. An assessment of the Greenland halibut resource in NAFO Subarea 2 and Divisions 3KLMN. *NAFO SCR Doc.*, No. 64, Serial No. N2579.

De Cardenas, E, S. Junquera, and A. Vazquez. 1995. Spanish research report for 1994. *NAFO SCS Doc.*, No. 15, Serial No. N2555.

Table 1. Catch curves (log(e) catch No)

Age	SP. 93/94	Can 88-90	Can 90-93	Can 88-93 Sp catch
2	4.532599			
3	7.801391			
4	8.79103			
5	8.984694	5.872118	5.347108	6.336826
6	9.186355	8.850947	7.705262	9.127067
7	9.24213	9.863238	8.781709	10.15522
8	8.964951	8.859363	8.123261	9.250714
9	8.753056	7.170888	7.278629	7.919356
10	8.302514	5.697093	6.659294	6.982863
11	7.884577	4.356709	6.272877	6.410175
12	7.574558	3.555348	6.226537	6.293419
13	6.782192	2.70805	5.509388	5.568345
14	6.315358	2.772589	4.976734	5.081404
15	5.736572	2.397895	4.26268	4.406719
16	4.718499	1.386294	3.044522	3.218876
17	4.276666	0.693147	1.94591	2.197225
18	4.406719			

Table 2. Calculated F at age

Age	SP. 93/94	Can 88-90	Can 90-93	Can 88-93
2	0.139399			
3	0.23993			
4	0.270366			
5	0.276322	0.929842	0.292671	0.383433
6	0.282524	1.401535	0.421744	0.552267
7	0.28424	1.56183	0.480663	0.614479
8	0.275715	1.402868	0.444623	0.559749
9	0.269198	1.1355	0.398392	0.47919
10	0.255342	0.902127	0.364493	0.422524
11	0.242488	0.689879	0.343343	0.387871
12	0.232954	0.562984	0.340807	0.380807
13	0.208585	0.428816	0.301554	0.336933
14	0.194227	0.439036	0.272399	0.307469
15	0.176427	0.379703	0.233316	0.266645
16	0.145116	0.219518	0.16664	0.19477
17	0.131528	0.109759	0.106508	0.132951
18	0.135528			

3

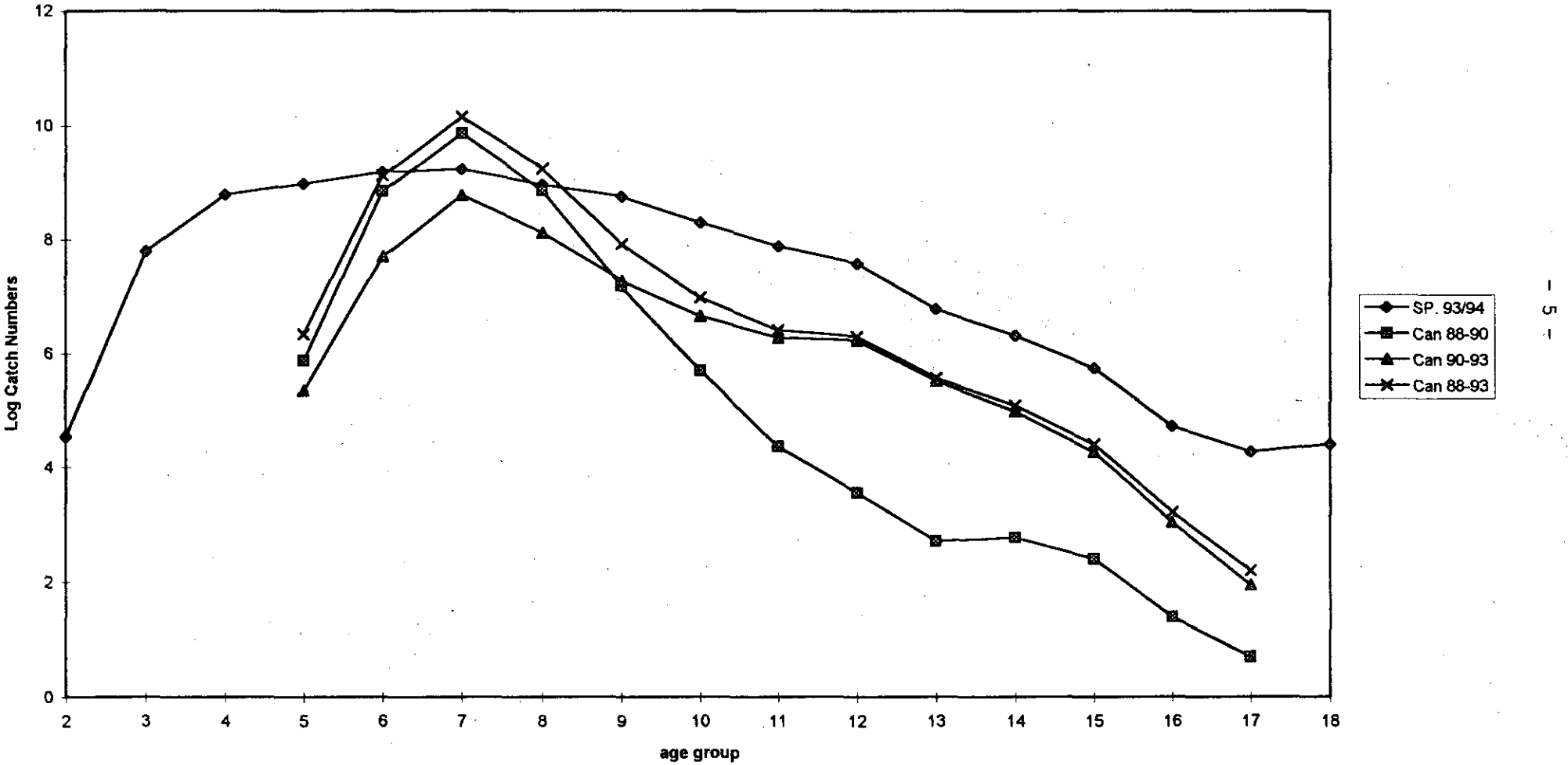
Table 1. Initial input values for yield-per-recruit for Greenland halibut in SA 2

Age	Recruits	F	M	Proportion Mature	Mean Weights CATCH	STOCK
2	1	0.139399	0.15	0	0.064	0.064
3	0.698305	0.23993	0.15	0	0.087	0.087
4	0.419373	0.270366	0.15	0	0.208	0.208
5	0.240618	0.276322	0.15	0	0.398	0.398
6	0.136829	0.282524	0.15	0	0.580	0.580
7	0.077088	0.28424	0.15	0	0.814	0.814
8	0.043319	0.275715	0.15	0	1.196	1.196
9	0.024656	0.269198	0.15	0	1.815	1.815
10	0.014171	0.255342	0.15	1	2.445	2.445
11	0.008316	0.242488	0.15	1	3.064	3.064
12	0.004975	0.232954	0.15	1	3.984	3.984
13	0.003019	0.208585	0.15	1	5.120	5.120
14	0.001901	0.194227	0.15	1	6.091	6.091
15	0.001222	0.176427	0.15	1	7.125	7.125
16	0.000807	0.145116	0.15	1	8.462	8.462
17	0.000559	0.131528	0.15	1	8.462	8.462
18	0.001327	0.135528	0.15	1	9.763	9.763

Table 4. results of YPR calculations for Greenland halibut in 2+3

F factor	F(7-12)u	Catch Weight Spain 93-	Sp.Stock Weight Spain 93-	F(7-12)u	Catch Weight R5	Sp.Stock Weight R5	F(7-12)u	Catch Weight R7	Sp.Stock Weight R7	F(7-12)u	Catch Weight R10	Sp.Stock Weight R10
0	0.000	0.000	13.710	0.000	0.000	13.710	0.000	0.000	13.710	0.000	0.000	13.710
0.1	0.026	0.203	9.609	0.026	0.211	10.254	0.026	0.207	10.844	0.012	0.185	11.781
0.2	0.052	0.308	6.803	0.052	0.337	7.746	0.052	0.346	8.663	0.024	0.325	10.225
0.3	0.078	0.355	4.859	0.078	0.411	5.905	0.078	0.437	6.982	0.037	0.431	8.954
0.4	0.104	0.369	3.499	0.104	0.450	4.537	0.104	0.497	5.674	0.049	0.512	7.906
0.5	0.130	0.365	2.539	0.130	0.468	3.513	0.130	0.534	4.645	0.061	0.575	7.032
0.6	0.156	0.350	1.855	0.156	0.473	2.739	0.156	0.556	3.830	0.073	0.622	6.298
0.7	0.182	0.332	1.363	0.182	0.469	2.149	0.182	0.567	3.177	0.085	0.659	5.677
0.8	0.208	0.311	1.008	0.208	0.460	1.696	0.208	0.571	2.652	0.097	0.687	5.148
0.9	0.234	0.291	0.750	0.234	0.449	1.346	0.234	0.571	2.226	0.110	0.708	4.694
1	0.260	0.272	0.561	0.260	0.437	1.074	0.260	0.567	1.878	0.122	0.724	4.303
1.1	0.286	0.254	0.421	0.286	0.424	0.861	0.286	0.561	1.592	0.134	0.736	3.963
1.2	0.312	0.238	0.318	0.312	0.411	0.693	0.312	0.554	1.356	0.146	0.745	3.668
1.3	0.338	0.223	0.241	0.338	0.399	0.561	0.338	0.546	1.160	0.158	0.752	3.409
1.4	0.364	0.210	0.184	0.364	0.388	0.456	0.364	0.537	0.996	0.171	0.756	3.181
1.5	0.390	0.198	0.140	0.390	0.377	0.372	0.390	0.529	0.859	0.183	0.759	2.980

Figure 1. Comparative Catch Curves



Can + Sp catch Chart 7

Figure 2. Fishing mortality

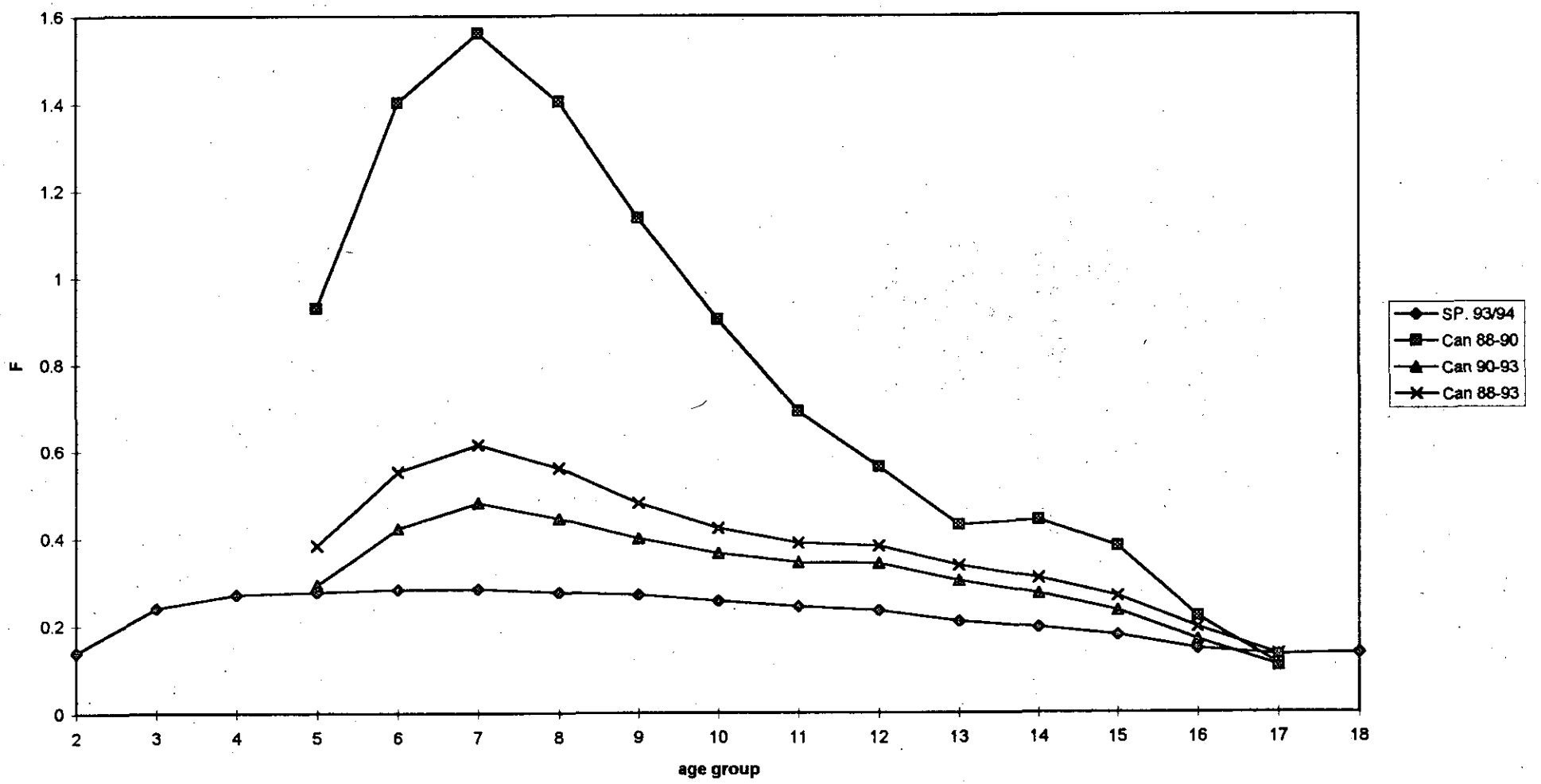


Figure 3. Comparative YPR curves for Greenland *halibut in* 2+3

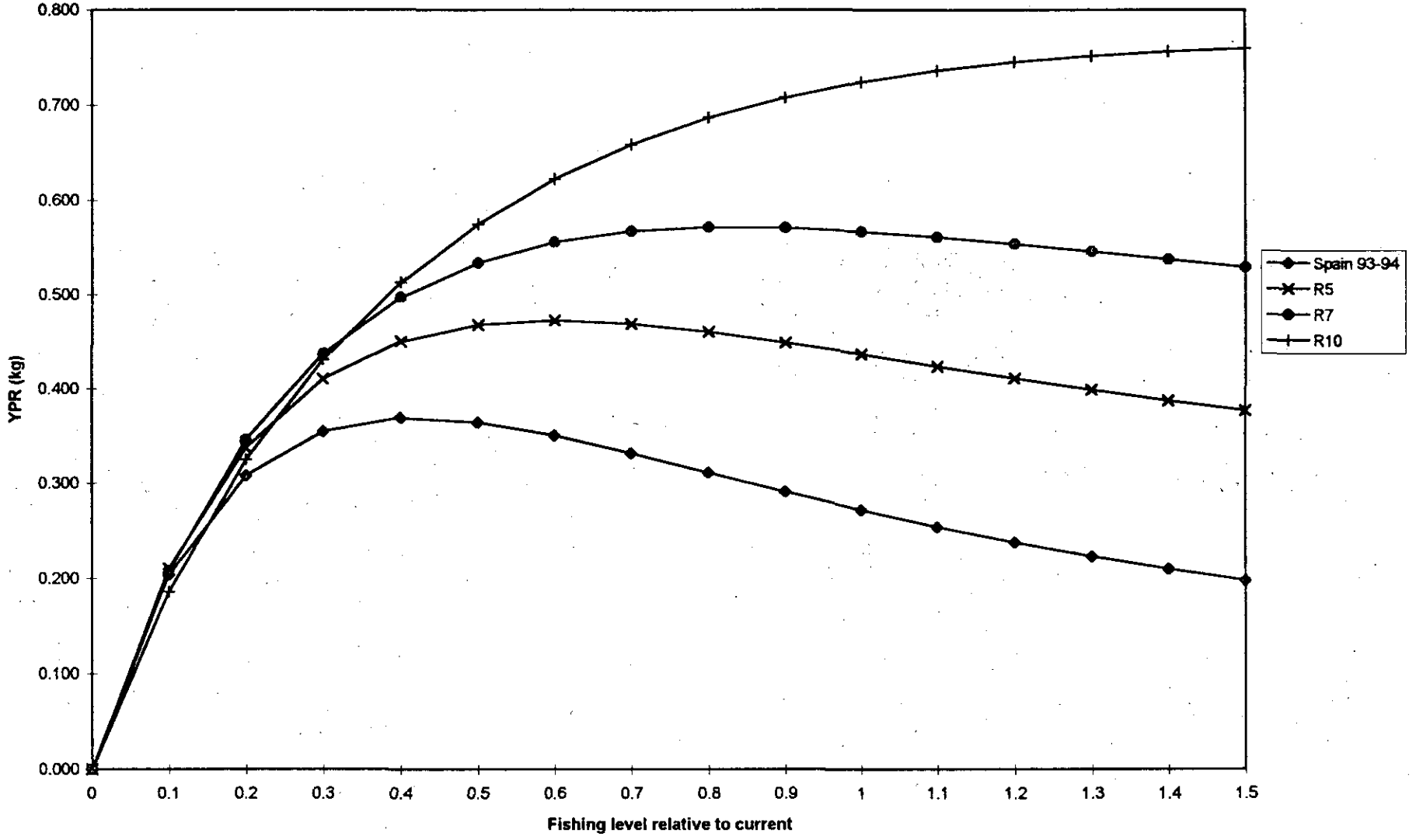


Figure 4. Comparative SSB/R curves for Greenland halibut from 2+3