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On addressing the optimal size of first capture for American Plaice in Division 3LNO

by

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Introduction

At the 17th Annual Meeting of NAFO, the Fisheries Commission requested advice on management in 1997 of Certain Stocks in Subareas 3 and 4 (NAFO/FC Doc. 95/22). Item 6c referring to optimal fish sizes requests the following:

"Taking into account the implications on conservation of the stocks and long-term harvest of alternative sizes at first entry into the fishery, recommend optimal (in terms of maximum yield per recruit) minimum fish sizes for regulated species in the NRA, and advise on the corresponding minimum mesh sizes for trawls and other gears".

In an attempt to partly address this request, yield-per-recruit calculations for the American plaice (*Hippoglossoides platessoides*) stock in NAFO Divisions 3LNO are presented and discussed in relation to optimal size of first capture.

Methods and Data

Exploitation pattern (partial recruitment or PR)

Three different input exploitation (partial recruitment) patterns were used. These were derived from different time periods during the history of the fishery and were as follows:

1. An average of the pattern observed for the years 1989-91, corresponding to the most recent period of the fishery available from the sequential population analysis in Brodie (1992).

2. An average exploitation pattern taken from the period 1985-88, covering the expansion of the Spanish and Portuguese trawl fisheries in the regulatory area.

3. An average exploitation pattern for the period 1975-84 when the greatest proportion of the catch was taken by Canadian trawlers.

All exploitation (partial recruitment) patterns were derived from the tables of fishing mortality (F) from the assessment (ADAPT, RV tuned), presented at the Scientific Council meeting in 1992 (Brodie *et al*, 1992). Average Fs at age for ages 5-17 for each time period were normalised to the observed mean F on the oldest true age group.

F values

For the yield-per-recruit (YPR) calculations, an age range 5-18 was used with F on the plus group (age 18) set equal to that on age 17. The exploitation patterns, expressed as observed mean F over the relevant time period, are given in Table 1 and Figure 1.

Natural Mortality

M was set to 0.2 for all ages as described by Pitt (1972) and is the value used in previous assessments.

Mean weight and mean length at age

Input mean weights at age were an unweighted average of those given in Brodie et at (1992) for the years 1974 to 1991. Approximate mean length at age was derived from the input mean weights using the length-weight relationship given in Brodie (1985) *viz*

logW = ((3.3247 x (logL)) - 5.553

where W = weight (g)
L = length (cm)

Mean weights and corresponding mean lengths at age are given in Table 1.

Maturity ogives
Proportions mature at age were estimates for sexes combined derived from Canadian research vessel data collected in 1992. The input values are given in Table 1.

Yield- and spawning stock biomass-per-recruit calculations

Two sets of YPR calculations were performed

1. YPR calculations were performed using the exploitation patterns corresponding to the time periods 1975-84, 1985-88 and 1989-91. The values of F input were those observed for the respective time period. Since the results are sensitive to the absolute value of input F, values of YPR relative to an F multiplier of 1.0 were calculated to allow direct comparison between yield curves.

2. Using the 1989-91 exploitation pattern, YPR calculations were performed to examine the effects of delaying the age of recruitment to the fishery. Comparisons were made between recruitment at age 5 (as observed historically), age 7 (approximately 50% mature) and age 13 (100% mature). As for the calculations in 1 above, the results were expressed relative to an F multiplier of 1.0 to allow direct comparison between yield curves.

SSB per recruit calculations were carried out using the exploitation patterns for the periods 75-84 and 89-91, with terminal F set at 0.5 in both cases. Successive calculations increasing the age at recruitment for ages 5 to 13 were carried out.

Results and Discussion

Relative yield curves for the exploitation patterns corresponding to the different time periods in the fishery are given in Figure 2. The data indicate that all three curves are flat-topped with F_{max} poorly defined.

The results in terms of yield, of delaying the age of recruitment to the fishery assuming the 1989-91 exploitation pattern are shown in Figure 3. For simplicity, age is used as a proxy for size at recruitment. The results as shown, represent absolute values of input terminal F ranging from F=0 to F=2. Even over this rather large range, the three yield curves are very similar in shape with Fmax only barely defined for recruitment at age 5.

The effects of delaying the age of recruitment to the fishery on SSB are shown in Figures 4 and 5. Unlike the relative yield curves (Figures 2 and 3) these results are expressed in terms of absolute F and care must be taken in their interpretation. Figure 4 shows the results for the exploitation pattern observed for the period 1975-84. Mean terminal F (0.54 on age 17) over this period is indicated on the Figure (vertical arrow). This indicates that if the fishery were prosecuted with the 1975-84 exploitation pattern and level of F, SSB would increase by 60% in the long-term from 1.2 kg-per recruit to 2.0 kg-per recruit, if recruitment was delayed until age 13.

The SSB-per-recruit level for the 1989 exploitation pattern and level of F is also shown on Figure 4 (horizontal arrow). The data therefore indicate that for any value of terminal F between 0.0 and 1.0, the 1975-84 exploitation pattern gives a higher SSB-per-recruit value than that which would be achieved with the exploitation level observed for the period 1989-91 for an equivalent value of terminal F. In addition, at the 1975-84 exploitation level, SSB-per-recruit is approximately 70% higher than the 1989-91 exploitation level.

Similar information is given in Figure 5, which shows the effect of delaying the age of recruitment from ages 5 to 13 using the 1989-91 exploitation pattern. Observed terminal F for the 1989-91 period is indicated (vertical arrow) together with the 1975-84 exploitation level (horizontal arrow). The data indicate that at the 1989 exploitation level, delaying recruitment to the fishery to age 13, SSB-per-recruit would increase by some 270%, from about 0.7 kg-per-recruit to about 2.0 kg-per-recruit. The figure also indicates that if the fishery continued at the 1989-91 exploitation level, fishing mortality would have to be reduced by about 60% to achieve the same SSB-per-recruit level that would be realised for the 1975-84 exploitation level.

The results indicate that although there is little to be gained in terms of yield-per-recruit, significant gains in SSB-per-recruit can be achieved by changing the exploitation pattern, and/or reducing the level of fishing mortality on American plaice in 3LNO. Hence, if a positive relationship between spawning stock biomass exists, and recruitment to the fishery can be delayed there may be long-term benefits in absolute yield from the fishery because of increased recruitment.

The aim of this paper was to address the point of an optimum minimum size for American plaice in Divisions 3LNO. It is clear form the results of this analysis that an optimum size of first capture cannot be defined in terms of maximum yield-per-recruit with any of the average exploitation patterns that have been observed in the fishery to date. In each case the resulting yield curve is flat over a wide range of levels of fishing mortality and age/size at recruitment.

We must therefore consider optimum size in relation to a management objective that corresponds to some safe minimum level of spawning stock biomass-per-recruit. We suggest that one management objective would be to maintain the spawning stock above a level that on average would allow the stock to replace itself. Unfortunately, the time-series of data on spawning stock size and recruitment available at present is insufficient to define a stock-recruitmemt relationship. Consequently it is unclear which level of spawning stock biomass-per-recruit would allow the stock to replace itself.

It seems therefore, that without any indication of what level of spawning stock biomass per-recruit would be optimal for this stock, it is not possible to define a specific optimal size at 1st capture. Nevertheless, the data in Figure 4 indicate that the exploitation pattern generated in the recent period when an incresed proportion of the catch was taken in the regulatory area, is less favourable than the pattern generated in the 1975-84 period.

Using the accepted mesh selection factor for trawl gears (2.4) and approximate selection range (5), we can calculate the effective mesh size that corresponds to different size at recruitment for the trawl fishery (Table 2). The data indicate that the 25% selection length for a 130 mm codend mesh size is approximately 32 cm, corresponding to fish aged 7-8 years old. From the data, the observed age at 1st capture however, is age 5.

Using the data in Table 2 and the information in Figure 5, it is clear that assuming exploitation largely by trawl (89-91 exploitation pattern and level of F), in order to achieve a level of spawning stock biomass-per-recruit equivalent to that observed using the 1975-84 exploitation pattern and level of F, fishing mortality would have to be reduced by about 60% or the trawl mesh size would have to be increased considerably to exclude fish less than age 10 (mean length = 37.1 cm). The size at 1st capture is equivalent to fish 2-3 years younger than those at the 25% selection length, and it seems reasonable to assume that with an increase in mesh this relationship will remain. Hence the minimum effective mesh size required would be about 160 mm to achieve the equivalent levels of spawning stock biomass per-recruit calculated for the 1975-84 exploitation pattern and level of F.

The data presented here with regard to spawning-stock-biomass per-recruit deal with specific levels of fishing mortality generated using different average exploitation patterns observed through the relatively recent history of the fishery (post 1975). The results present no qualitative surprises and illustrate that an equivalent level of spawning stock can be achieved in more than one way. The results also indicate that for this stock, which is slow-growing, significant increases in effective minimum mesh size for trawls is required to achieve a level of spawning stock biomass-per-recruit equivalent to that achieved with more selective gears at the same level of fishing mortality.

References

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Table 1. American plaice 3LNO: input exploitation patterns, mean weight, mean length and proportions mature at age input to the yield- and spawning stock biomass-per-recruit analysis

AGE	F at age 1975-84	F at age 1985-88	F at age 1989-91	Mean weight (kg)	Mean length (cm)	Proportion mature
5	0.002	0.023	0.113	.571	26.3	0.239
6	0.017	0.053	0.157	.693	29.1	0.389
7	0.046	0.088	0.183	.816	31.4	0.558
8	0.090	0.145	0.223	.946	33.3	0.717
9	0.144	0.260	0.360	1.094	35.4	0.842
10	0.223	0.418	0.530	1.256	37.1	0.924
11	0.330	0.588	0.673	1.420	39.4	0.968
12	0.450	0.753	0.777	1.582	42.2	0.989
13	0.520	0.788	0.607	1.689	45.5	0.997
14	0.624	0.805	0.563	1.814	48.6	0.999
15	0.786	1.260	0.677	2.016	51.6	1
16	0.733	1.693	0.887	2.191	55.1	1
17	0.540	0.838	0.660	2.148	57.6	1
18	0.540	0.838	0.660	2.259	60.7	1

Table 2. American plaice 3LNO, mean length at age and corresponding mesh size at the 50% (L50) and 25% (L25) selection lengths assuming a selection factor of 2.4 and L25 set at 2.5 cm less than L50.

AGE	Length (cm)	Mesh L50(mm)	Mesh L25(mm)
5	26.3	109.6	107.1
6	29.1	121.2	118.7
7	31.4	130.9	128.4
8	33.3	138.7	136.2
9	35.4	147.5	145.0
10	37.1	154.7	152.2
11	39.4	164.2	161.7
12	42.2	175.9	173.4
13	45.5	189.6	187.1
14	48.6	202.5	200.0
15	51.6	215.0	212.5
16	55.1	229.6	227.1
17	57.6	240.2	237.7
18	60.7	252.9	250.4

Figure 1. American plaice 3LNO: Input exploitation patterns: average F at age for each time period indicated on the Figure. AM = arithmetic mean.

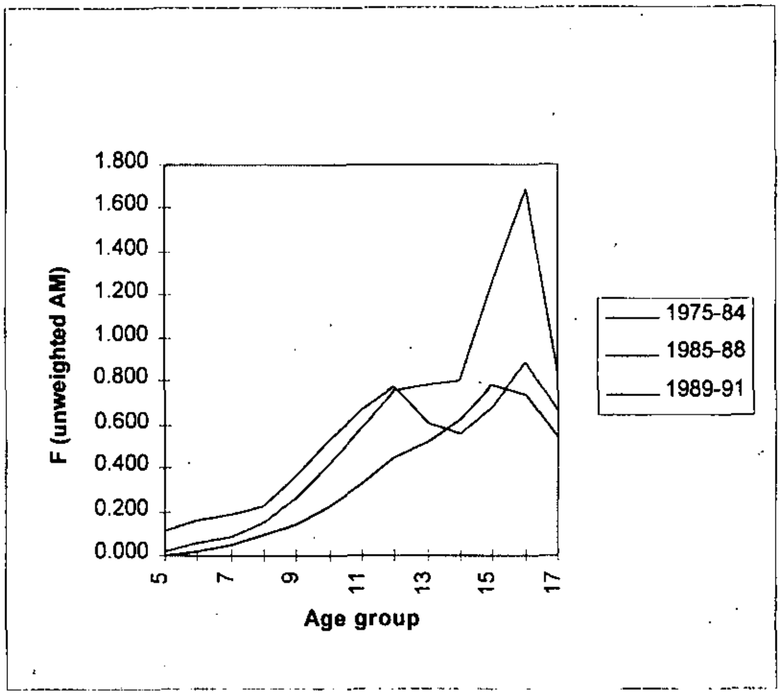

Figure 2. American plaice 3LNO: relative yield per recruit corresponding to exploitation patterns from different time periods

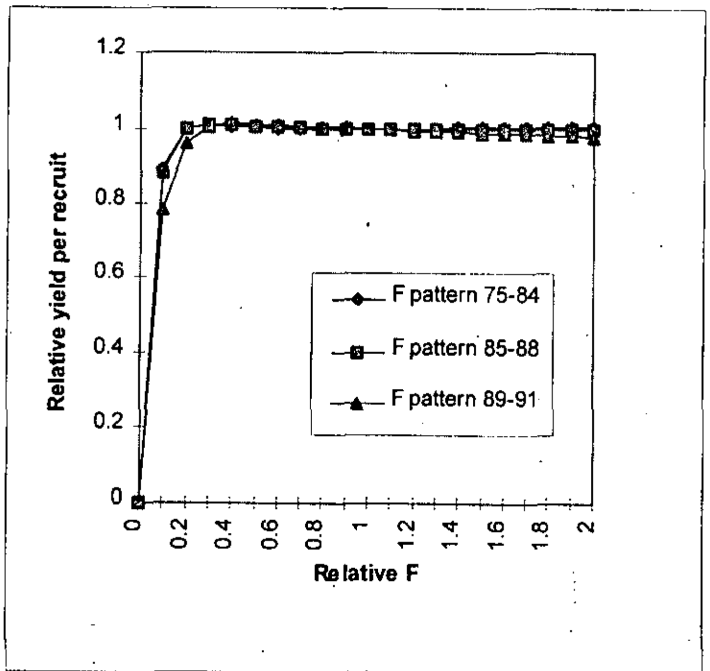

Figure 3. American plaice 3LNO: relative yield-per-recruit assuming average exploitation pattern from 1989-91. Effects of delaying age of recruitment.

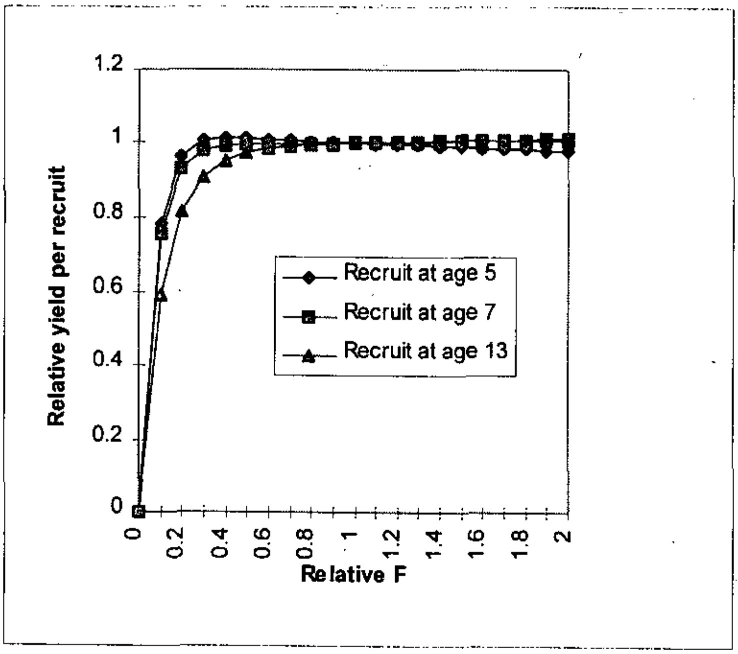

Figure 4. American plaice 3LNO: effects on spawning stock biomass-per-recruit of increasing the age of 1st capture assuming an average exploitation pattern from the period 1975-84.

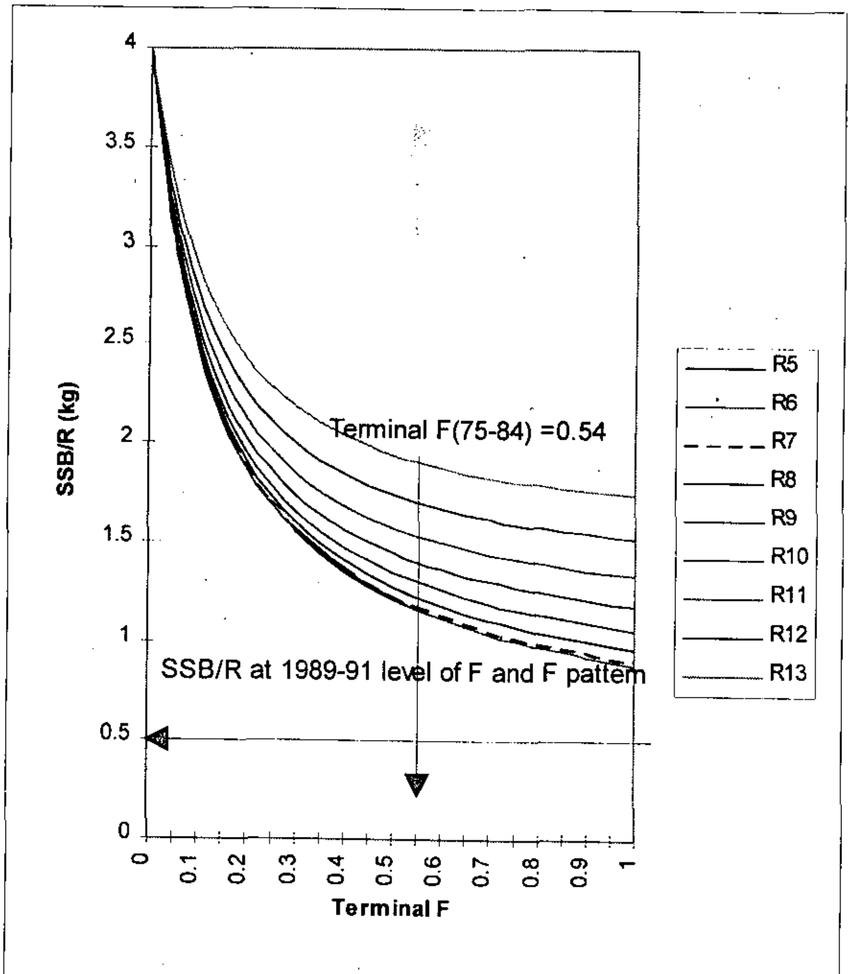

Figure 5. American plaice 3LNO: effects on spawning stock biomass-per-recruit of increasing the age of 1st capture assuming an average exploitation pattern from the period 1989-91.