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Preliminary estimates of sustainable yield for roundnose grenadiers (Macrourus rupestris) in ICNAF Subareas 2 and 3[1]

by

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Introduction

Catches of roundnose grenadiers were first recorded in the ICNAF Statistical Bulletin in 1967, although quantities were probably caught before that time in conjunction with the cod and redfish fisheries in Subarea 2 and the northern divisions of Subarea 3 and included under unspecified groundfish. Catches fluctuated around 13000-30000 tons in 1967-72 except for 1970 when the catch was 75000 tons (Table 1).

Podrazhanskaya (1971) summarized material on feeding and migration of roundnose grenadier in the Northwest Atlantic while Savvatimsky (1971) presented studies on the age and growth of this species. Because of the growing interest in the fishery for this species and since the Commission proposes to consider a quota for 1974 at its Midterm Meeting, January, 1974 (Comm. Doc. 74/1), data from the above papers have been used to derive preliminary yield curves and estimates of sustainable yield.

Materials and Methods

Parameters necessary to construct yield curves using the FAO tables of yield functions were estimated as follows: Average lengths at age were calculated using the formulae from Savvatimsky (1971):

$$Y = 14.90\ X^{0.59} \quad \text{for males}$$
$$\text{and } Y = 17.20\ X^{0.57} \quad \text{for females}$$

where Y = length of fish
and X = age of fish.

A Bertalanfy growth curve was then fitted to the mean of these calculated average lengths for males and females. The following parameters resulted (Fig. 1):

$$L_\infty = 121 \text{ cm}$$
$$K = 0.062$$
$$t_0 = -1.29$$

The mean selection length (l_c) for the fishery was estimated by calculating the l_c for each year during 1967-1970 from the length frequencies presented in Fig. 7 of Savvatimsky (1971) and from Fig. 2 of Konstantinov and Noskov (1972). The l_c for each of these years was then weighted by the catch in each year to produce a weighted average l_c (46.71 cm) for the fishery during 1967-71. The parameter c of the FAO tables was then calculated from $c = \frac{l_c}{L_\infty}$ as 0.39.

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To estimate the parameter M/K for the FAO yield tables, two values of M were assumed: M = 0.20 and M = 0.30. Then, given estimates of c and M/K, yield per nominal recruit curves could be constructed using FAO tables.

To estimate the level of fishing mortality, data of Savvatimsky (1971) from Fig. 5 were used to obtain estimates of Z(Fig. 2). Since Z values obtained for males and females were different and since sex ratios in the fishery were also different, a value weighted by the sex ratios (males:females = 2:1) was used as representative of the total fishery in 1969 and several years previous to this (Fig. 2).

The effort and catch per unit effort figures in Table 2 are based on USSR catch and effort statistics from Table 4 of the Statistical Bulletins for 1967-71. Grenadier catches are reported under other groundfish but are easily recognizable when the criterion of other groundfish being greater than 50% of the total fish catch is used as in this study. No other species could have normally been taken in this area under the other groundfish category in such quantities as reported.

Results

The yield per nominal recruit curves constructed with M = 0.2 and M = 0.3 are presented in Fig. 3. With M = 0.2, maximum yield per recruit occurred at F/M = 3.0, implying F = 0.6 and Z = 0.8. With M = 0.3, yield per recruit curve has no realistic maximum but is almost flat-topped. The level of Z = 0.44, which represents total mortality in some years prior to 1969, occurs at about 93% of the maximum yield per recruit for M = 0.2 and 53% of the maximum at M = 0.3. Beverton and Holt (1966) indicate that an index of catch per unit of effort change at different levels of fishing effort can be obtained by the ratio of yield per nominal recruit (Y^1) to F/M. Considering M = 0.2 first, the yield per nominal recruit at the level of F_{max} is 0.0148 and F/M = 3.0. Thus the index of catch per unit of effort is 0.0049. At the level of F/M (1.2) corresponding to Z = 0.44, the level of the fishery in 1967-69, Y^1 = 0.0138 and the index of catch per unit of effort is 0.0115. The average level of catch per unit of effort in 1967-69 was 1.33 tons/hour (Table 2). Therefore sustained fishing at F_{max} would produce a catch per unit of effort of $1.33 \times \frac{0.0049}{0.0115} = 0.57$ tons/hour.

The average fishing effort during 1967-69 was 16745 hours. At F_{max} this would increase 2.5 times or 41862 hours. At a catch per unit of effort 0.57 tons, this would produce a sustained catch of 24000 tons. Similar calculation for M = 0.3, considering fishing to be again stabalized at F/M = 3.0 since no realistic F_{max} exists, and the 1967-69 level of fishing to be at F/M = 0.47, produces an estimate of maximum sustained yield of 37000 tons. From a straight comparison of Y^1 values at the 1967-69 level of fishing and at F_{max}, 22000 tons and 38000 tons are the estimates of maximum sustainable yields for M = 0.2 and 0.3, respectively.

Discussion

Since Savvatimsky's (1971) data indicate that grenadiers have a life-span and growth rate approximately similar to the cod stocks in the northern area (Fig. 1), it is reasonable to assume that the natural mortality of grenadiers would be similar to that of cod (i.e. 0.20). In fact, it is probably unreasonable to assume that a species with individuals surviving to 20 or more years would have a natural mortality much higher than this. Thus, one assumed value was 0.20. However, to provide an upper limit to the estimate, a value of 0.30 was also assumed.

The fact that the MSY estimated with the lower M was lower than the estimate with the higher M is because with a given Z a lower M implies a higher F and a higher exploitation rate ($E(1-e^{-Z})$) and hence with a given level of catch a lower stock size than the higher M with the same Z and level of catch.

With yield curves as flat-topped as those in Fig. 3, it is undesirable from the point of view of efficiency of the fishery to even fish as high as the point of maximum sustainable yield since for example doubling the level of fishing mortality (and hence fishing effort) from F/M = 1.5 to F/M = 3.0 in the curve for M = 0.2 implies increases in long-term yields of only about 4%. Estimates of 24000 and 37000 tons were obtained as preliminary limits of MSY. Thus it seems prudent to limit the removals from the grenadier stocks in Subareas 2 and 3 to no more than 30000 tons which is approximately the average level of catches since 1967.

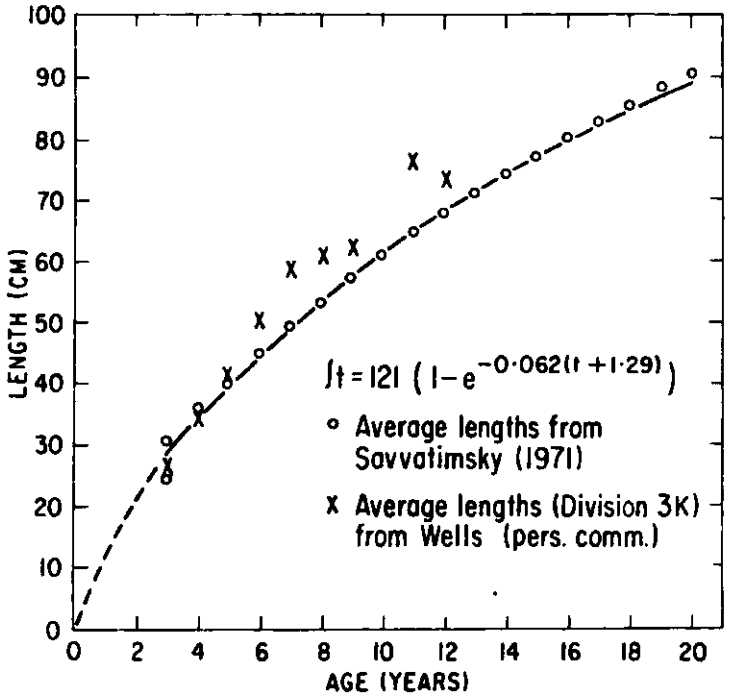

Fig. 1. Bertalanffy growth curve for roundnose grenadiers in Subareas 2 and 3 (data from Savvatimsky, 1971). Average lengths for cod in Division 3K are shown for comparison.

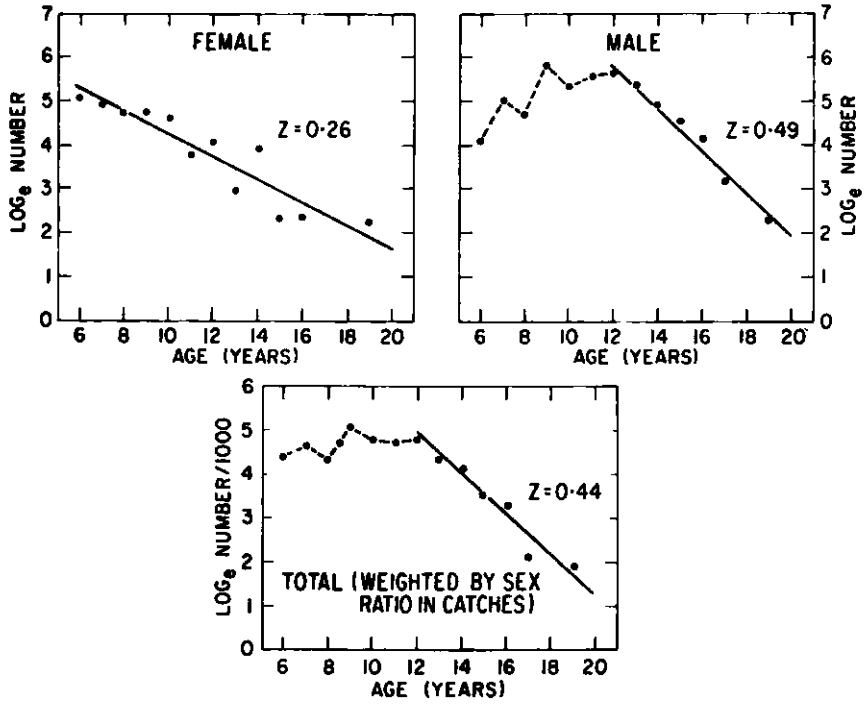

Fig. 2. Catch curves for roundnose grenadiers in Subareas 2 and 3. (Data from Savvatimsky, 1971).

Previous preliminary estimates of sustainable yields for cod stocks in Subareas 2 and 3 were based on yield per nominal recruit calculations similar to those used in this study. Yield per nominal recruit curves derived for 2J-3KL cod, 3NO cod and 3Ps cod were almost identical to yield per recruit curves later calculated using partial recruitment estimates from virtual population studies, and maximum sustainable yield estimates were within 10-15% of those finally calculated from detailed virtual population analyses.

References

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Table 1. Nominal catches of roundnose grenadier reported in Statistical Bulletins, Subareas 2 and 3, 1967-1972.

YEAR	POLAND	U.S.S.R.	JAPAN	TOTAL MEMS	NON-MEM.	TOTAL STOCK
1967	-	15902	-	15902	1402	17304
1968	-	26696	-	26696	4567	31263
1969	-	12333	-	12333	446	12779
1970	-	22864	-	22864	1564	24428
1971	105	74169	-	74274	1171	75445
1972	123	24024	6	24153	239	24392

FOOTNOTE: Roundnose grenadiers did not appear in the Statistical Bulletin's list of species until 1967 although amounts were probably caught before this time and included with other groundfish.

Table 2. Catch per unit effort and effort figures for roundnose grenadiers in Subareas 2 and 3.

YEAR	CATCH	CATCH/HOUR	HOURS
1967	17304	1.69	10239
1968	31263	1.05	29774
1969	12779	1.25	10223
1970	24428	2.04	11975
1971	75445	1.89	39918
1972	24392	(2.0*)	(12196)

*Average of 1970 and 1971.

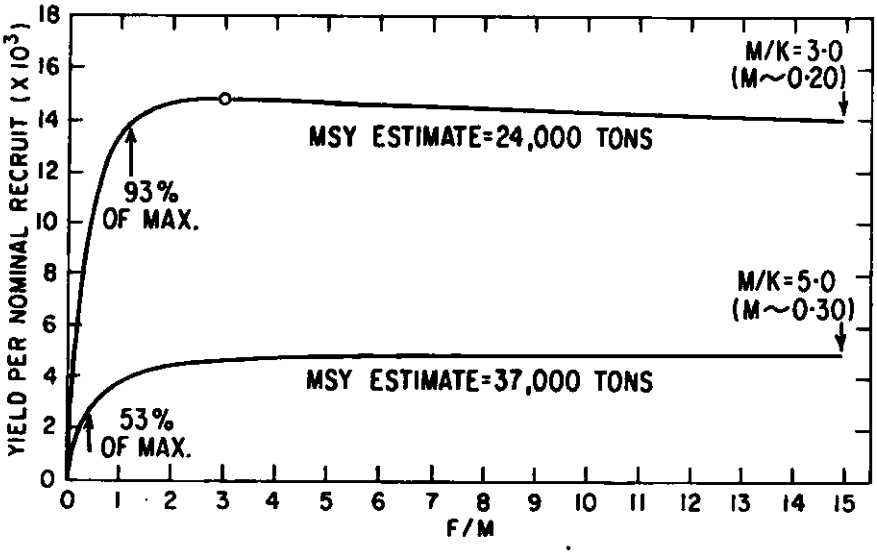

Fig. 3. Yield per recruit curves for roundnose grenadiers in Subareas 2 and 3.